St. Mary‘s University

School of Graduate Studies

Master of Arts in Project Management

Assessment of the Practices and Challenges of Implementing Earned Value Management System in Selected Ethiopian Megaprojects

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Approved by Board of Examiners

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Declarative Statement

I Aklog Shiferaw Mihrete here declare that my research work is original and all works from other researchers are appropriately cited.

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Name	Signature	Date

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Abbreviations and Acronyms

AC	Actual Cost
ACC	Accounting
ANA	Analysis
BAC	Budget At Completion
BEN	Benefits
CHA – ACP	Challenges - Acceptance
CHA – PER	Challenges - Performance
CHA – USE	Challenges - Use
CPI	Cost Performance Index
CPM	Critical Path Method
CR	Critical Ratio
CV	Cost Variance
EAC	Estimate At Completion
ED	Earned Duration
EDM	Earned Duration Method
EEP	Ethiopian Electric Power
ERA	Ethiopian Roads Authority
ERC	Ethiopian Railways Corporation
ES	Earned Schedule
ESM	Earned Schedule Method
ETC	Estimate To Complete
EV	Earned Value
EVM	Earned Value Management
EVMS	Earned Value Management System
M&E	Monitoring and Evaluation
MR	Management Reserve
OBS	Organization Breakdown Structure
ORG	Organization
PBB	Project Budget Base
PMBOK	Project Management Body of Knowledge
PMI	Project Management Institute
PMP	Project Measurement Baseline
PSB	Planning, Scheduling and Budgeting
PV	Planned Value
REV	Revision
SAC	Schedule At Completion
SFI	Schedule Forecast Indicator
SLPB	Summary Level Planning Budget
SPI	Schedule Performance Index
SV	Schedule Variance
TCPI	To Complete Performance Index
TEAC	Time Estimate At Completion
UB	Undistributed Budget

VAC	Variance At Completion
WBS	Work Breakdown Structure
WBSD	Work Breakdown Structure Dictionary

Table of Contents

ABSTRACT

This research explored the practices and challenges of implementing earned value management system in selected Ethiopian megaprojects. It assessed on the benefits realized as a result of both implicit and explicit use and implementation of earned value management system by the megaprojects in Ethiopia. It also attempted to highlight the software solutions available for implementing earned value management system. This research also attempted to discover the extent that earned value management system is implemented in Ethiopian Information Technology projects such as in Ethio telecom projects. To meet these research objectives, both qualitative and quantitative research methods were employed. A structured questionnaire and interviews, a thorough literature review and document analysis were also employed. The simplified version of the 32 earned value management system criteria defined by ANSI/EIA-748 *was used to assess the practices of earned value management system in Ethiopian megaprojects. Author's slightly modified version of Kim's et.al, (2003) earned value management implementation model was applied to assess the challenges of implementing earned value management system in Ethiopian megaprojects. Literature reviews were applied to design the questionnaire on the benefits that could be realized as a result of implementing EVMS in Ethiopian megaprojects, and the same was employed to find information on currently available software solutions for earned value management system implementation. A total of 50 respondents from 12 selected megaprojects were expected to be participated in completing the questionnaire including four open-ended questions, only 20 respondents from 9 selected megaprojects who also have participated in a number of other road, railway and hydroelectric power generation projects informed this research with Cronbach's alpha value of 0.944 reliability. The questionnaire designed also collected data from the open-ended questions and a few other interview sessions provided information including from program managers in Ethio telecom multi-site megaprojects. The findings of the research pointed that practices of earned value management system in Ethiopian megaprojects, with the measure of 32 criterion in five categories such as organization, planning, scheduling and budgeting, accounting, analysis, and revision, have a relatively low score in organization and accounting system criteria, and a relatively higher score in planning, scheduling and budgeting, analysis, and revision criterion. This indicated that because of compounding factors on project activity and management issues, the practice is yet poor that it requires comprehensive move towards implementing earned value management system at full scale; however, megaprojects currently have practiced some elements of earned value management system and their current project management practices have features that resemble earned value management system but not as 'hard facts'. In the same view however, megaprojects through the lens of author's slightly modified Kim's et. al., (2003) earned value management system implementation model, faced significant challenges with factors related to the acceptance, performance and use and in that order. Moreover, it was found that Ethiopian megaprojects could be benefited from a full scale and comprehensive implementation of earned value management system and the prominent software solutions currently available for Ethiopian megaprojects to implement EVMS are primavera from Oracle and Microsoft Project and Portfolio Management from Microsoft Inc.*

Keywords: Earned Value Management System Practices, Challenges and Benefits, Ethiopian Megaprojects,

CHAPTER ONE
INTRODUCTION

1.1: Background of the Study

Nowadays, megaprojects are becoming very important and increasingly used as the preferred delivery model for goods and services across a range of businesses and sectors, like infrastructure, water and energy, information technology, industrial processing plants, mining, supply chains, enterprise systems, strategic corporate initiatives and change programs, mergers and acquisitions, government administrative systems, banking, defense, intelligence, air and space exploration, big science, urban regeneration, and major events of across the world (Asnakew, 2017).

Because of the fact that megaprojects have become increasingly common across many sectors of the capital projects industry in the country, and by nature every project is different one to the other and because of various reasons, understanding them at better level has become critical (Asnakew, 2017).

In Ethiopia, infrastructure mega projects have been going on to a great number in the last 20 years and continue to do so to meet a variety of development goals. Nikwane et al. (2016) stated that with large infrastructure backlogs in Africa, well-controlled projects will play a significant role in African infrastructure development. Most of the infrastructure development projects are developed against a backdrop of urgent need, with pressure to deliver. A common attribute to these projects is that they often address needs rather than opportunities, and as such are executed with beneficiaries and other stakeholders already waiting and demanding delivery. Thus, project and project management are going to play a huge role in infrastructure development in Africa. Project control is one of the biggest challenges that project managers face in the construction industry. Delivery dates are continually pushed back and costs invariably rise. Project control tools and their effective use are key to deliver projects within the triple constraints of cost, time, and quality. Among the various models developed for project control are earned value analysis. Nikwane et al. (2016) also emphasized the need for project management skill to control and direct projects, pointed the earned value method as widely accepted best practice for project control and continue to evolve to suit to all project types sizes. Anbari et.al also found that EVM was more applicable to large projects.

However, in Ethiopia no or little researches have been conducted to investigate earned value management system implementation practices and challenges in Ethiopian megaprojects. The same is true in assessing EVM contributing factor in project success in Ethiopian megaprojects. This research attempted to fill this gap and sought to investigate the practices and challenges of implementing earned value management as a project monitoring and evaluation tool in Ethiopian selected mega projects.

1.2: Statement of the Problem

Ethiopian projects have long suffered from budget and schedule overruns due to lack of well-trained project management professionals and project management practices (Nega, 2008; Tekalign, 2014; Asnakew, 2019). However, equally important to these critical issues are corruption through lack of accountability, transparency, poor project tracking and control system in project implementation. The increasingly devastating issue in project planning and implementation in Ethiopia is also unstable economic situation, shortages in foreign currency and the alarmingly increasingly changing inflation that has experienced in inputs of productions, materials and equipment etc. Project managers and consultants have the tools and techniques in project management to detect early such variations and risks and make corrective actions timely and appropriately. In traditional project management, project managers and consultants have the plan or the budget and the performance output to compare and measure project performance. This however provides limited information about the project performance to take corrective actions accordingly; hence, earned value management (EVM). Earned value management adds 'earned value of the project at the given time or period' to the equation of the traditional project management. This fills the gap in the traditional project management and provides an integrated project control on the scope, budget and cost of the project. This further can provide the basis for reducing project risk and meeting project quality objectives.

Limited research has been done in the construction industry to investigate megaprojects and to improve their performance (Brookes and Locatelli, 2015). Despite their impact and significance to the overall growth and development of any national economy, limited research has been done in the construction industry to investigate megaprojects and to improve their performance (Naomi et.al, 2015). In Ethiopian case, some known projects have been either delayed, have had cost overruns, poor in quality, poor user satisfaction or did not meet the initial objectives (Tekalign,2014). Studies show us, more than 50% of time wasted during construction is attributable to poor management practices (Koskela, 2000).

Asnakew (2017) affirmed that in these days project management knowledge and practices becomes very essential due to the fact that managing projects have been emerged complex and challenging from time to time. The other fact is that many development and investments for the purpose of transformation or growth plans have had been intended to be passed through project activities. In particular, megaprojects are becoming very important and increasingly used as the preferred delivery model for goods and services of many businesses and development sectors across the globe. World Bank (2008) stated that more than 20 % of global economic activity takes place as projects, and in some emerging economies, it exceeds 30 %. For instance, in India it is 39 % and in China it is 43 %. This data shows, 22 % of the world's $55 trillion gross domestic product (GDP) goes to capital formation, which is almost entirely project-based. Global megaprojects are spending to beat $6 to 9 trillion per annum or 8% of global GDP (Asnakew, 2017). Studies revealed that, 80% of all government policies are delivered through large-scale projects and programs (Research Excellence framework, 2014). Trends show that the volume of projects grows alarmingly year by year which

needs highly organized project management practices. Ethiopia is one of the developing countries having good economic annual growth. World Bank estimates showed that public infrastructure spending of Ethiopia was approximately more than 19% of its total GDP in fiscal year 2011-2012 (The US Department of State, 2015). For instance, the Ethiopian government has been working hydroelectric infrastructure projects with an estimated amount of more than US$ 11billion including those projects commenced recently (World Bank, 2008) and railway construction projects with more than US$17 billion (Ethiopian Railway Corporation (ERC), 2017). However, literature shows that 65% of megaprojects end up fail, either over budgeted and/or behind schedule to be completed (Taylor, 2015). Other Studies show us, more than 50% of time wasted during construction is attributable to poor management practices (Koskela, 2000). This concludes, delivery of megaprojects is an expensive, highly complex task that entails the combination of leading-edge technology and multiparty governance that demands high stakeholder commitment and multi-dimensional project leadership skills (Brookes and Giorgio, 2015). In Ethiopian case, some known projects have been either delayed, have had cost overruns, poor in quality, poor user satisfaction or did not meet the initial objectives (Nega, 2008; Tekalign, 2014).

Report showed that 79.1 % of the construction projects fail to meet its objectives in Ethiopia and if completed it is with an average cost overrun of more than 26.2%. We must know that, project failures have significant effect from economic as well as political points of view. If the project takes longer time, it requires additional resources, and budgets and this increases labor, material, machinery and equipment cost. This affects the budget of other projects and in general, it affects the economy of the country and results in dissatisfaction of the society at large (Asnakew, 2017 cited Tekalign, 2014). This means projects are required to be completed within the time frame, budgeted cost and required quality so as to achieve its objective and satisfy stakeholders and users as well. In Ethiopian case, there are problems that result in delay, poor quality and overrun of projects. Among others are absences of well trained and professionally qualified staff. Given their size and scale, megaprojects are important not only to the immediate project stakeholders, but also to the societies, economies, and environments affected by them.

Gadisa & Zhou (2019) studied critical causal factors affecting public infrastructure projects performance in Ethiopia and identified top 8 critical specific factors affecting government-financed infrastructure projects performance in Ethiopia that among them are poor project planning and administration system, weak project management leadership skills, inadequate project design, poor project schedule and cost management system.

Delay or time overrun will affect all parties involved in the project. It will affect the profits that would be obtained if the project can be completed on the schedule. However, due to the time overrun, contractors had to spend more money on labor, plant and may lose the opportunity to get the next project. Hence, effective time management is very important and crucial to achieve successful completion of construction projects (Aftab et al, 2014).

Negussie (2015) studied the work programming and implementation practice in Ethiopian federal road projects and found that there remain a number of challenges experienced in the program including problems observed at monitoring of progress and delay. Negussie found that work programs submitted do not assist in project monitoring and delay analysis and do not assist to track deliverables and milestones.

Mega projects (MP) require efficient management of risks during their construction. Therefore, it is crucial to identify any possible deviations towards meeting their objectives. Such deviation forced MP to be delivered behind schedule and over budget. According references, MP does not require only qualitative analysis but requires an accurate quantitative analysis based on knowledge and practice.

Construction projects are subjected to different types of uncertainties throughout their life cycle. While managing such risks are nowadays the responsibility of the contractor and the project manager, there is a responsibility for managing risks on each of the projects stakeholders. In consequence with increasing the scale of projects and the increased sophistication of their systems to cope with contemporary users' needs and technological boosts, the role of risk management in such Mega Projects (MP) is quite challenging (Nabawy & Khodeir, 2021).

There is a lack in knowledge and awareness related to infrastructure project and risk analysis practice in Africa. Nabawy & Khodeir (2021) emphasized the importance of interrelating quantitative analysis with a standard procedure. In practice, there is no standard procedure, and the awareness and skills of practitioners vary a lot (Nabawy & Khodeir, 2021).

Venkata used the technique of earned value in quantitative risk analysis. The technique proved its effectiveness in recognising cost variance and schedule variance. It was observed that construction risks related to schedule impact can invariably impact the project cost due to the resources needed to manage mega projects (Nabawy & Khodeir, 2021). Rathna integrated the technique of earned value management with risk management to prevent delay and improve mega projects performance. The author used this technique in order to improve the ability of mega projects to analyze risks during construction and to proactively be able to analyze risks in the presence of large amount of resources(Nabawy & Khodeir, 2021)..

Idoko (2008) noted many projects in developing countries encounter considerable time and cost overruns fail to realize their intended benefit or even totally terminated and abandoned before or after their completion (Gebreegziabher, 2019).

Despite the construction sector has high standing, several defects are being noted in the sector that require immediate action (Nega, 2008). One substantial problem is significant delay of infrastructure and construction projects that impair planned economic development (ECIDP, 2014; Li-Yin et al, 2006). Abadir (2011) found out that among the knowledge areas of project in Ethiopia, project time management is considered the critical one with only 24% projects managed well.

The construction industry is one of the industries that have significant contribution to the economy of developing countries. Despite the critical role the construction industry plays in these countries' development, the performance of the industry remains generally poor. Idoko (2008) noted many projects in developing countries encounter considerable delay to realize their intended benefit or even totally terminated and abandoned before or after their completion. Due to the challenges in different areas, there is a need for a better understanding of the constraints to follow structured approach in identifying and modeling constraints. Project delay is one of the problems of construction project performance in selection, planning, execution or control phase of the project. According to Richard (2012) one of the main reasons of project failure in developing countries is time overrun, only rare projects completed on the estimated time, a number of major projects fail in meeting the schedule deadline. Construction project schedule is considered as a measurable indicator of performance criteria for successful project completion.

Gebreegziabher (2019) concludes from his summary of empirical literature review that construction projects schedule management practices are affected due to different reasons.

- Mostly construction projects in Ethiopia suffer from delays, have poor scope management, run out of budget and face serious quality defects.
- Lack of knowledge and awareness of the importance of projects schedule management tools and techniques found to be the major obstacles towards the efficient utilization of such tools.
- Identified the effective time management technique and software package used based on their specific study.
- Construction projects continue to face the challenge of delays even in this current phase of knowledge.

Damoah et al. (2015) conducted a study to identify the causes of government project failures in developing countries, specifically in Ghana. Their study identified several factors that led to the failure of government projects in Ghana, with the top 10 causes of such failures identified as M&E, corruption, political interference, change in government, bureaucracy, lack of continuity, fluctuating prices, planning and delays in payment and release of funds. Out of these ten factors, Damoah et al. (2015) identified issues relating to M&E to be the most influencing factors. From this finding, it can be inferred that effective M&E can have an influence on project success.

Monitoring and evaluation of projects in Ethiopia is very critical because a lot of government resources are provided to organizations to implement various megaprojects. Not only does best practices require that projects are monitored for control but also project stakeholders require transparency, accountability for resource use and impact, good project performance and organizational learning to benefit future projects.

An exhaustive literature review made by the author showed that no research has been conducted in Ethiopia and little has been done in other parts of the world to investigate EVM as a monitoring

system in megaprojects. This research is therefore undertaken to establish the practices and challenges of implementing EVM as a monitoring system in Ethiopian 9 selected megaprojects. However, the researcher found research outputs that discussed prevalence of problems in project delay, cost overrun, delivery and quality on projects of different sizes and scale that substantiate the need to investigate more on the practices and challenges of EVM implementations in Ethiopian megaprojects. For example, (Jembere, Mitikie and Yigzaw, 2020) conducted a case study and applied earned value analysis method on Bole Arabsa 20/80 condominium construction projects and found out that almost all sample blocks suffered delays and few cost variation; they found out that material shortage, unit rate change, and work variation were the main reason for the negative cost and schedule variations.

Flyvbjerg (2017) noted that despite the increasing number of megaprojects globally, management is 'strikingly poor and has not improved for the 90-year period for which comparative data is available'.

Hwang, Shan, Zhu and Lim (2018) studied 32 Singapore-based construction companies having experiences in megaprojects and the results showed that on average 44.22% of megaprojects in Singapore experienced cost overrun, which is about 6% higher than that for general projects; and megaprojects are facing a lower efficacy in cost control than general projects.

Brass (2007) reports how earned value management used for overseeing the cost, schedule, and performance of major capital investments during the investment process (e.g., information technology systems, structures, weapons systems).

Flyvbjerg et al. (2003) characterize megaprojects as "animals". Grün (2004) speaks of the "taming of the unruly" using a similar terminology. Grün (2004) clarifies what "taming of the unruly" means by calling megaprojects the "giants among projects" and by concluding "big projects – big problems," which leads to the consequence of giant projects as gigantic problems.

Given the above studies, gigantic problems require effective and efficient tools and techniques to solving them; hence the researcher indulged to investigate the practices and challenges of EVMS in Ethiopian megaprojects in which the research found it to be very scarce if not none. Moreover, the researcher also sought to assess the EVM if it contributes to project success.

1.3: Research Objectives

1.3.1: General Research Objectives

The following general research objectives are set:

- To assess the current practices and challenges of implementing EVMS in selected Ethiopian megaprojects

- To assess the contribution of EVMS implementation for project success in selected Ethiopian megaprojects.

1.3.2: Specific Research Objectives

- To assess to what extent the current project management practices in Ethiopian megaprojects meet the 32 earned value management system criteria defined by ANSI/EIA-748 with respect to the organization, planning, scheduling and budgeting, accounting , analysis and revision categories.
- To assess the challenges of implementing earned value management system through the lens of author's slightly modified version of Kim's et.al, 2003 EVM implementation model: acceptance, use and performance.
- to confirm specifically identified benefits that are/could be realized through the implementation of EVMS in Ethiopian megaprojects

1.4: Significance of the Study

Most projects in Ethiopia are overruns. Project progress are not tracked, communicated and reported appropriately. Most projects in Ethiopia are run by not well defined project management techniques and methods. Even the traditional project management systems are well practiced and tracked, monitored, and controlled and reported. There is no published evidence, as far as the author's best knowledge, that examines the practices and challenges of implementing EVMS in Ethiopian mega projects. The author thinks that this is the first of the kind. The author thinks this research becomes a spring board where other researchers develop and conduct further research and call for government policy action for mandating the use and implementation of EVMS in public major projects to the least. It provides a strong and comprehensive conceptual base for Ethiopian project managers, project consultants, and project clients by providing deeper understanding about EVMS and its development, a framework for instituting EVMS in their project organization and tailoring and implementing EVMS to the context of their projects. It informs actions that need to be taken by project organizations and governments in terms of policy, training development areas and needs, available information technology solutions, thresholds and requirements basis for tailoring EVMS.

The findings of this research might contribute to customers' satisfaction with the final products because program managers could use them to improve business effectiveness and efficiency (Voss, 2012). Another significant contribution is also to help project organizations and government agencies improve their business practices by informing them to employ EVM during the development and execution of projects and programs so that they reduce cost and save tax payers money (Plumer, 2010). Hence, this research has implications for social change.

Given their size and scale, mega-projects are important not only to the immediate project stakeholders, but also to the societies, economies, and environments affected by them. Because mega-projects have become increasingly common across many sectors of the capital projects industry, understanding them at a better level and depth has become critical (Asnakew, 2017).

1.5: The Scope and Limitation of the Study

Delimitation is an established limit or boundaries of a study (Domingos et al., 2014).This research primarily focused on assessing the practices and challenges of implementing EVMS in Ethiopian megaprojects and if implementing EVMS contribute to the project success. It sought for insights and opinions of project managers, consultants or clients (government officials related to projects such as engineers, architects, sponsors etc.). This research investigated megaprojects in Ethiopia that are already completed and ongoing between the years 2000 – 2021. Only 9 megaprojects were considered directly but respondents involved in a number of other projects which are not listed in Appendix A.

This research assessed the overall experience of project managers, consultants and clients on the practices and challenges of EVMS implementation; it did not specifically assess on the particular project in a specific sector as the sample in the same considered be being limited in this research undertaking. This might impact the overall findings of the research one can conclude from data found in the particular project and sector. This research solely depended on the opinions of project managers, consultants and clients collected through questionnaire and interview; the research endeavor did not to attend any of the project activities in any of the megaprojects understudy and only had limited investigation of documents related to sample megaprojects to draw conclusions.

CHAPTER TWO
LITERATURE REVIEW

2.1: Introduction

This chapter discussed both the theoretical and empirical literatures in project and project management of megaprojects specifically EVM as a project monitoring and evaluation tool. It attempts to review the current practices and challenges of implementing EVM projects with particular emphasis on megaprojects in Ethiopia. It seeks to reveal the justification for the research problems identified in this research.

2.2: Project and project management

A project is a temporary endeavor undertaken to create a unique product, service, or result continuous business operations, and Project management is the application of knowledge, skills, tools, and techniques to project activities to meet the project requirements (PMI, 2013). Furthermore, a project has a fixed budget and schedule, and projects can be different in size, large or small and involve one person or thousands of people. Every project is constrained in different ways, but the most typical are scope, time and cost constraints. These three elements are sometimes referred to in project management as the triple constraint. Project management can be thought of as the process of leading a project from its initiation through its performance to its closure (PMI, 2013).

A successful project achieves the objectives set for the end product in accordance with the planned schedule and the agreed costs. The success of the project must be assessed both in terms of the end product and production process. It is easy to see how well project's schedule and budget objectives were achieved, because they are reported using measurable units. On the other hand, the success of quality and scope objectives is a bit trickier to be measured as they are more depended on what is valued. In addition, the achievement of them is finally defined outside of the project (PMI, 2013).

The project can deliver a product that is one to one with the descriptions, but the customer is not satisfied because the description was defined inadequately. Thus, a project is often considered to be unsuccessful if the expectations for the project have not been met. The Figure below, Figure 2.1, illustrates the general problem in defining the end product.

Yrjölä (2017) stated that good communication between the company and the customer is one effective way to minimize this gap. Can this gap also be minimized by implementing EVM?

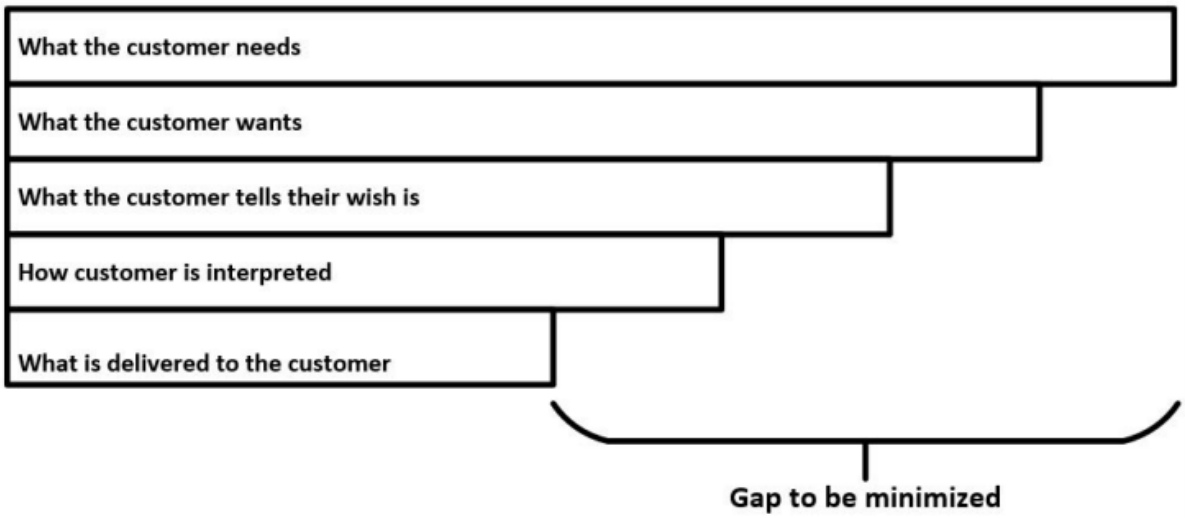

Figure 2.1: The problem definition of end product (Adapted from (Yrjölä, 2017/14))

2.3: Project Monitoring and Evaluation

Every project requires a method to control and manage the execution and delivery of the project. Project managers across the globe have followed different methods of monitoring a project.

In today's world, planning and controlling are essential issues in project management that have numerous effects on the different fields of the projects, such as lowering the project duration and cost (Ghorbani et al., 2019 cited by Soltana & Ashrafi, 2020). Measuring project performance and determining project progress comparing to its baseline has always been a concern of project managers. They are enthusiastic about finding simple ways to denoting project performance. One of the most effective project management methods is the earned value management method (Soltana & Ashrafi, 2020).

2.4: Earned Value Management System

Earned value management (EVM) is a management methodology for integrating scope, schedule, and resources, and for measuring project performance and progress (Anbari, 2003; Project Management Institute, 2008).

Historically started as cost/schedule control system criteria (C/SCSC) by the U.S. Department of Defense in the 1960s, it is now mandated for many U.S. government programs and projects (Abba, 1997, 2001; Christensen, 1994; Kim, 2000; Kim, Wells & Duffey, 2003). A basic form of EVM can be traced back to industrial engineers on the factory floor in the late 1800s (Kwak & Anbari, 2011).

To encourage wider use of EVM, the U.S. federal government decided to discard C/SCSC by the end of 1996 and turned toward a more flexible EVM system (EVMS). The American National Standards

Institute (ANSI)/Electronic Industries Alliance (EIA) published guidelines for EVMS initially in 1998(Kwak & Anbari, 2011).

The private sector has also shown greater interest in applying EVM in recent years thanks to numerous publications promoting EVM principles and advanced project management software packages that incorporate EVM methods and analysis(Kwak & Anbari, 2011)..

EVM is an industry best practice for program management in the commercial sector as well as the government. EVM is a systematic process that finds variances in projects by providing quantitative contract performance data. It compares actual work performed against work planned. In traditional management the structure only compares the budget to the actual expenditures completed on a project. Unlike EVM, traditional management does not provide the Earned Value of the physical work completed. The application of EVM uses primary data points, derived data points, variances, and performance indices to track a project (Schneider, Randy; Sparks, Joseph; Yerkovich, Pamela, 2017).

Schneider, Randy; Sparks, Joseph; Yerkovich, Pamela (2017) affirmed that nowadays, EVM has become a widely used tool for different sizes projects in both private and public sectors. It was found that most EVM users either fully or partially have implemented an automated computer system to assist EVM processes (Kim et al., 2003). In recent years, a number of EVM software programs that incorporate other widely used project management programs such as Microsoft Project and Project Server, wInsight, Cobra and Open Plan have emerged to facilitate the analysis processes. Moreover, a number of commercial companies have focused on providing the EVM service package that includes staff augmentation, tools implementation and training, and web-based EVM training.

2.5: Basic Concepts of Earned Value Management System

Earned value management is a management methodology for integrating scope, schedule, and resources; for objectively measuring project performance and progress; and for forecasting project outcome. The application of earned value in the early initiation and planning phases of a project increases the validity and usefulness of the cost and schedule baseline and is an excellent verification of the project scope assumptions and the scope baseline. Once established, these baselines become the best source for understanding project performance during execution. A comparison of actual performance (both cost and schedule) against this baseline provides feedback on project status and data, not only for projecting probable outcomes, but also for management to make timely and useful decisions using objective data(PMI, 2011).

PMI (2011) stated that EVM provides organizations with the methodology needed to integrate the management of project scope, schedule, and resources. This standard uses the term project scope to mean the work that must be performed to deliver a product, service or result with the specified

features and functions. EVM can play a crucial role in answering management questions that are critical to the success of every project, such as:

- Are we delivering more or less work than planned?
- When is the project likely to be completed?
- Are we currently over or under budget?
- What is the remaining work likely to cost?
- What is the entire project likely to cost?
- How much will we be over or under budget at the end of the project?
- What is driving the significant cost and/or schedule variances?

EVM contributes to project success by providing early warnings when programs deviate from cost and schedule plans (Moy, 2016). EV provides an early warning signal to program managers and to customers (Byung-Cheol, 2015; Fleming & Koppelman, 2005).The EVM triangle consists of project scope, schedule, and cost (Kwak & Anbari, 2012). The project scope refers to the requirements of a program (Cantwell et al., 2013) or refers to what work must be done, and is critical to the concept of employing earned value (EV) (Kwak & Anbari, 2012). Scope management is vital to the efficient management of any program (Farmer, Mazzuchi & Sarkani, 2014). Because a program's scope affects EVM use, program managers must measure performance from the program's beginning until the program's closeout (Cantwell et al., 2013; Kwak & Anbari, 2012; Plumer, 2010). If there is a schedule delay or cost overrun, program managers needed to reduce the program scope and address the risks (Kwak & Anbari, 2012; E. Kim, 2000).

EVM is a program management technique with the EV, or the completion of authorized work and budget, as its focus (Plumer, 2010). Program managers use EV to monitor performance and predict the final required costs and time necessary to finish programs (Hunter, Fitzgerald & Barlow, 2014). In addition to basic cost and schedule baseline development and performance feedback, EVM also emphasizes the importance of many other considerations necessary for project management, such as organizational structure, cost collection strategies, and the incorporation of approved project changes (PMI, 2011).

Lemilia &Mokaya (2018) stated that the Earned Value Management technique evaluates the performance of a project during its execution by monitoring the integrated management of its scope, schedule, and costs. Specifically, this technique compares baseline performance with actual performance in terms of duration and costs. To do so, the technique takes a series of fundamental measurements as the basis. The Plan Value (PV) refers to the sum of the planned costs for each task in each time period, from day 1 or the commencement of project implementation up to completion. The Earned Value technique considers this cost planning as the baseline that will serve for future performance comparisons. At another level, Actual Cost (AC) refers to the sum of the costs actually incurred in each task and for each time period. Earned Value (EV) refers to the work actually performed, expressed as a cost. This measurement is calculated by multiplying the percentage of the

actual physical progress of each task by its budgeted cost. Finally, Budget at Completion (BAC) is the total budget as estimated in the project plan.

Lemilia &Mokaya (2018) stated that in addition, the Earned Value technique calculates indicators that numerically represent the performance of the project in terms of cost and schedule over a given period of time. The main measurements are Cost Variance (CV), Cost Performance Index (CPI), Schedule Variance (SV), and Schedule Performance Index (SPI).

Lemilia & Mokaya(2018) stated that the Earned Value technique analyzes the trends in project performance in terms of cost and duration, i.e., based on the historical performance readings calculated for each period (CV, CPI, SV, and SPI); it makes forward-looking statements and compares them to the initial budget and schedule. The main measurements for forecasting are Estimate at Completion (EAC) and Estimate to Complete (ETC). Figure 2 is a Cost/Time graph showing the main indicators and predictors the EVM technique calculates.

Lemilia &Mokaya (2018) stated that an important extension to EVM is the technique called Earned Schedule. This technique consists of calculating new values for SV and SP but based on the variable Time and not on Cost, which the Earned Value technique normally calculates. This is achieved by calculating projections on the Earned Value curve for the Plan Value compared to the abscissa of the Time variable. Lemilia &Mokaya (2018) This technique is based on the variables Schedule at Completion (SAC), Earned Schedule (ES), and Actual Time (AT). In addition, the main indicators are Time Estimate at Completion (TEAC) and the Schedule Performance Index (SPI(t)). Figure 2.2 presents a Cost/Time graph showing the main indicators and predictors that the Earned Schedule technique calculates.

2.5.1: Definition of terms

The terminology of EVM has been criticized by a number of researchers and practitioners. Rose (2003) thought that the terminology of earned value is historically arcane and ponderous. Cioffi (2006) believed that “only the actual cost remains unambiguous”. Subsequently, PMBOK Guide (2004) made an effort to improve the terminology and reduce the number of words to two per key parameter. For example, the budgeted cost of work performed (BCWP) is referred to as the earned value (EV). Cioffi (2006) presented a new formalism and a corresponding notation for EVM.

The description and derivation of EVM elements have been comprehensively described in many sources (PMI, 2005 or Anbari, 2003). The practice standard (PMI, 2005) classifies the terminology into two categories: key parameters of EVM, including planned value (PV), earned value (EV) and actual cost (AC), and EVM measures (variances, indices and forecasts). Additionally, the evolution of EVM concepts raised the variances of basic parameters such as earned schedule (ES) (Lipke, 2003) and earned duration (ED) (Jacob, 2003).

Performance indices play an important role in EVM. Two widely used indices in the EV technique are the schedule performance index (SPI) and the cost performance index (CPI).

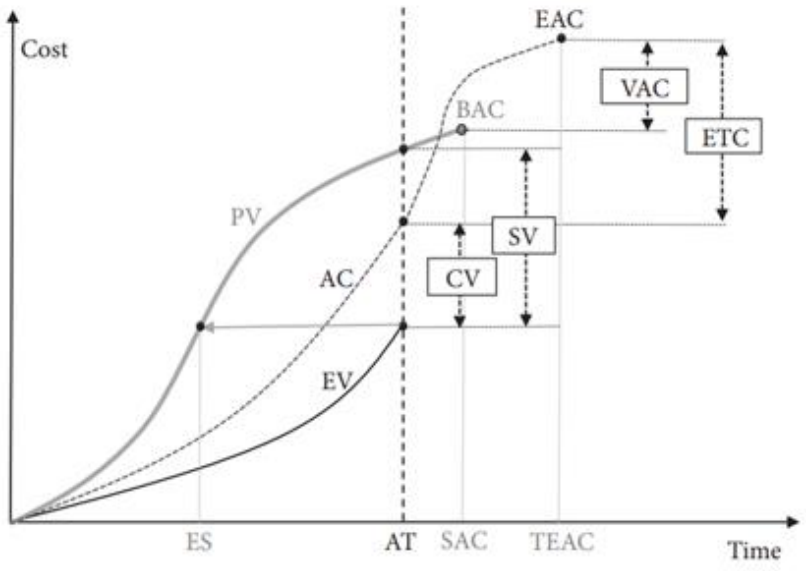

Figure 2.2: Cost/Time graph showing the main variables in EVM and in the Earned Schedule technique (Adopted from Urgilés, Claver, and Sebastian (2019:4))

The critical ratio (CR) as the product of CPI and SPI is a composite index, which indicates cost management and schedule management are inseparable (Barr, 1996; Meredith and Mantel, 2000; Anbari, 2001; Lewis, 2001; Kerzner, 2001). Additionally, the weighted performance index is the weighted sum of SPI and CPI, which acknowledges the influence of cost performance and schedule performance, may be different (Christensen, 1996).

PMI (2011) defines that it refers as the basic EVM terminology that one need to have a solid understanding before progressing further into the general concepts of EVM, and these are:

- **Planned Value (PV).** The authorized budget assigned to scheduled work as of a given reporting date. At any point in time, planned value defines the work that should have been accomplished. Planned value can be reported for cumulative work to date or for a specific reporting period. May also be known as the budgeted cost for work scheduled.
- **Earned Value (EV).** The measure of the work performed, expressed in terms of the budget authorized for that work. Earned value can be reported for cumulative to date or for a specific reporting period. May also be known as the budgeted cost for work performed (BCWP).
- **Actual Cost (AC).** The realized cost incurred for the work performed on an activity during a specific time period. This can be reported for cumulative to date or for a specific reporting period. May also be known as the actual cost of work performed (ACWP).

- **Budget at Completion (BAC).** The sum of all the budgets established for the work to be performed on a project, work breakdown structure component, control account, or work package. The project BAC is the sum of all work package BACs.
- **Contingency Reserve.** Budget within the performance management baseline that is allocated for identified risks that are accepted or for which contingent responses are devised. While not often used on ANSI-748-compliant projects, these contingency reserves can fund contingency plans, fall back plans, or address the residual risk that remains after the risk response planning process. Unlike management reserve, which is not in the performance measurement baseline (PMB) but is a part of the project budget base (PBB), contingency reserves are considered to be within the PMB. In commercial environments, the explicit use of contingency reserves in the EVM method is quite common. In more traditional and government-based EVM environments, the only budget within the PMB that is outside of the WBS and is not time-phased is the undistributed budget (UB). In this case, contingency reserve can be treated as a special application of UB with the difference that it will only be distributed when a risk occurs or a contingency plan is implemented. Because contingency reserve is a budget within the PMB that may be without identifiable scope, the application of contingency reserves on projects with an ANSI-748 compliance requirement may not be acceptable.
- **Control Account.** A management control point where scope, budget, actual cost, and schedule are integrated and compared to earned value for performance measurement. Each control account may be further decomposed into work packages and/or planning packages. Control accounts can belong to only one WBS component and one organizational breakdown component.
- **Distributed Budget.** The budget for project scope that has been identified to work breakdown structure (WBS) control accounts. This budget also has an identified responsible manager (control account manager). The distributed budget forms the basis for the planned value (PV).
- **Estimate at Completion (EAC).** The expected total cost of completing all work expressed as the sum of the actual cost to date and the estimate to complete (ETC).
- **Estimate To Complete (ETC).** The estimated cost to finish all the remaining work. Adding the ETC to the actual cost (AC) will result in the estimate at completion (EAC) at any level of the project.
- **Management Reserve (MR).** An amount of the project budget base (PBB) withheld for management control purposes. These are budgets reserved for unforeseen work that is within scope of the project. The use of management reserve requires special authorization from management. It is used in special circumstances where the project manager sees the need to change the performance measurement baseline, but doesn't change the project's budget as defined in the contract or project charter.
- **Performance Measurement Baseline (PMB).** An approved integrated scope-schedule-cost plan for the project work against which project execution is compared to measure and manage performance. The PMB is formed by the budgets assigned to control accounts plus budgets with identified scope that have not been distributed to control accounts (undistributed budget).

The PMB is the equal to the distributed budget plus the undistributed budget. It does not include management reserve.

- **Planned Value (PV).** The authorized budget assigned to scheduled work as of a given reporting date. At any point in time, planned value defines the work that should have been accomplished. Planned value can be reported for cumulative work to date or for a specific reporting period. May also be known as the budgeted cost for work scheduled.
- **Planning Package.** Work and budget that have been identified to a control account but are not yet defined into work packages. This is a future effort for which detailed planning may not have been accomplished. Prior to beginning the effort within a planning package, work and budget must first be converted to one or more work packages.
- **Project Budget Base (PBB).** The starting point upon which original budgets are built. This represents the total budget for the project, including any management reserve and estimated costs for work that has been authorized but is not yet fully defined. When the project is chartered by a contract, this is known as the contract budget base (CBB).
- **Summary Level Planning Budget (SLPB).** A time-phased budget for future work that cannot be reasonably planned down to control accounts. Budget and scope held in SLPB should be moved to control accounts as soon as practicable, but before the work within them begins. Not all projects will use an SLPB, but it is an available tool in certain circumstances. May also be known as a summary level planning package (SLPP).
- **Undistributed Budget (UB).** The budget for project scope that has not yet been identified to WBS elements and, below those, to control accounts. This budget has not yet been distributed to a responsible control account manager (CAM). An undistributed budget is generally not time-phased.
- **Work Package.** The work defined at the lowest level of the work breakdown structure for which cost and duration can be estimated and managed. Each work package has a unique scope of work, budget, scheduled start and completion dates, and may only belong to one control account.
- **Work Breakdown Structure (WBS).** The work breakdown structure (WBS) is a hierarchical decomposition of the total scope of the work to be carried out by the project team to accomplish the project objectives to create the required deliverables. For EVM, the work breakdown structure is a deliverable-oriented hierarchical decomposition of the work to be executed by the project team in order to accomplish the project objectives. It organizes and defines the total scope of the project.
- **Work Breakdown Structure Dictionary.** A document that provides detailed deliverable, activity, and scheduling information about each component in the work breakdown structure.

PMI (2011) depicts the relationship between these terms in chart form using Figure 2.3 and the relationship between budget elements in Figure 2.4.

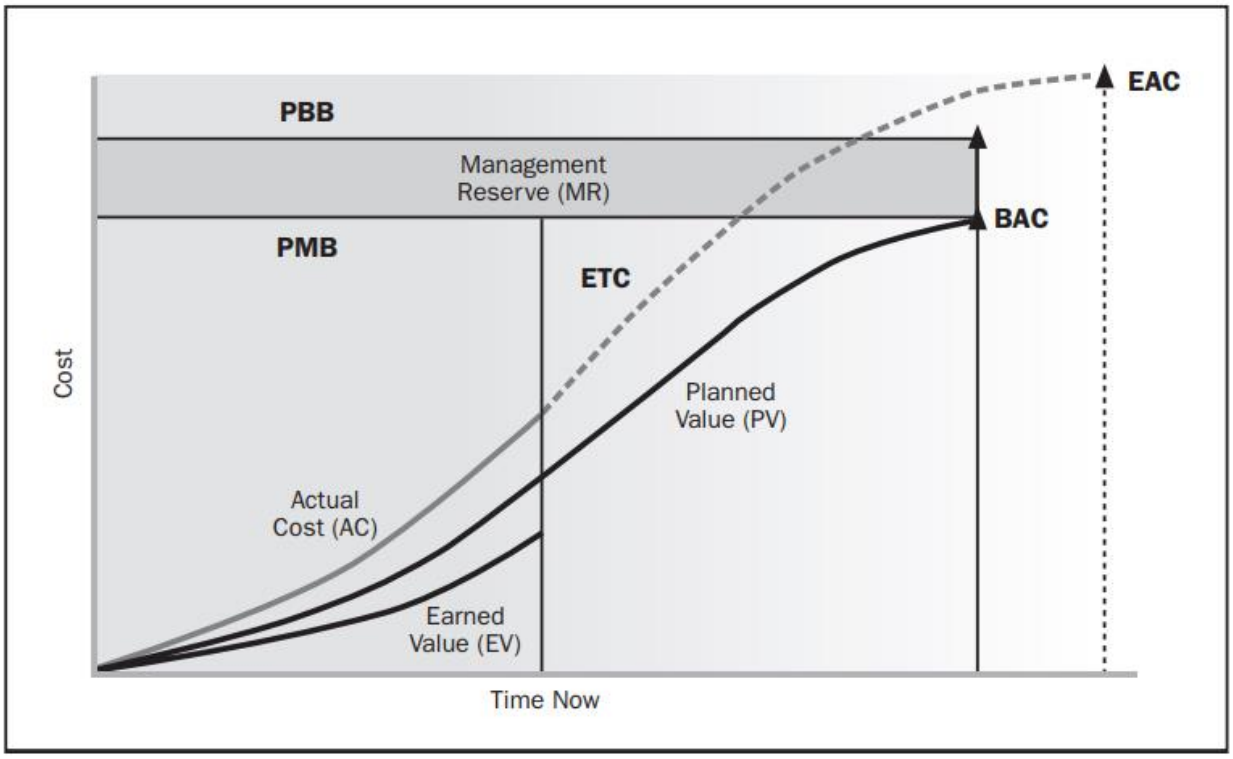

Figure 2.3: EVM Basic Concepts: Chart Form (Adopted from PMI (2011:10))

EVM facilitates the planning and control of cost and schedule performance, thus improving project management visibility and understanding. PMI (2011) identifies 13 key practices of EVM for planning, executing, and controlling a project and they are:

1. Define product and project scope and decompose work to a manageable level.
2. Assign clear management responsibility for discrete work elements.
3. Plan the activities of the project into a logical schedule.
4. Develop a time-phased budget for each element of the WBS.
5. Select EV measurement techniques for each work package prior to execution.
6. Establish a performance measurement baseline based on the previous five steps.
7. Develop a structure for collecting costs into the same accounts and time periods where performance is being measured.
8. Determine earned value by objectively measuring the physical work progress according to the earned value technique selected for the work.
9. Analyze cost/schedule performance.
10. Forecast cost /schedule performance.
11. Project the estimates at completion.
12. Report performance problems and take appropriate corrective action.
13. Maintain integrity of the PMB.

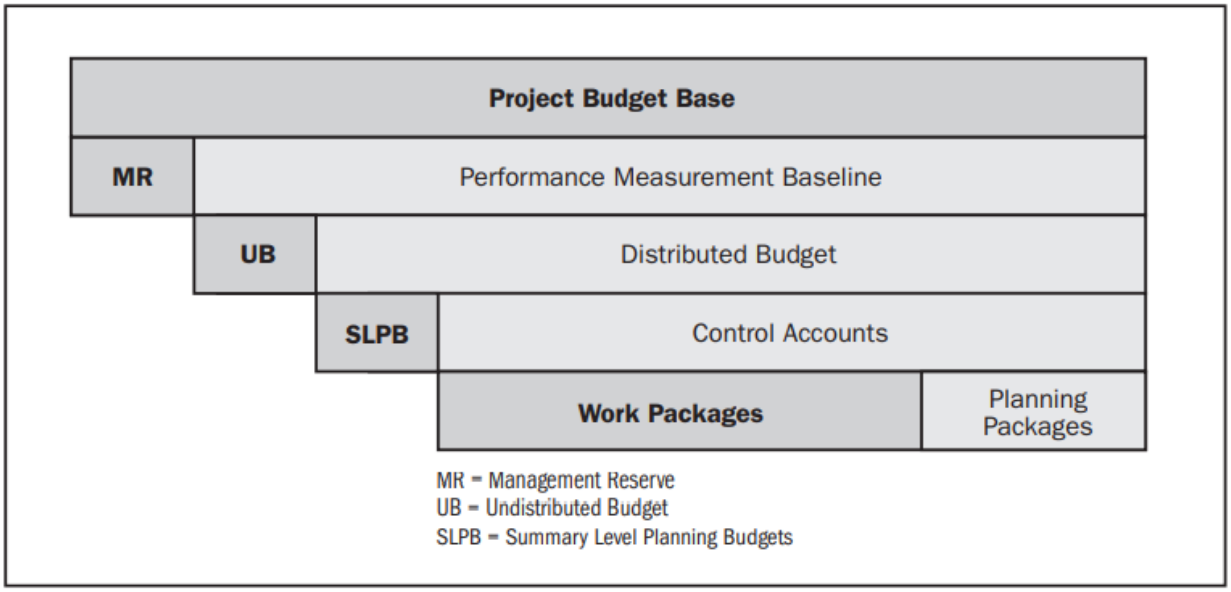

Figure 2.4: EVM Budget Elements (Adopted from PMI (2011/10))

EVM uses the cost and schedule baseline contained within the project management plan to assess project progress and any variations from that baseline throughout the life of the project.

1. **Budget At Complete (BAC)** – The budget values established for the work to be performed. How much should the work cost when done?
2. **Actual Cost of Work Performed (ACWP)** – The total costs actually incurred in accomplishing the work performed during a given time period. How much did the completed work actually cost? Sometimes, it simply also referred as Actual Cost (AC).
3. **Percent Complete (% complete)** – An estimate, expressed as a percentage, of the amount of work that has been completed. % Complete is the ratio of cumulative BCWP to the BAC multiplied by 100. It shows the overall status of the project. Here % Schedule and % Spent can also be considered and shown with formulas below.

% Schedule = (BCWS$_{Cumulative}$ / BAC) x 100
% Complete = (BCWP$_{Cumulative}$ / BAC) x 100
% Spent = (ACWP$_{Cumulative}$ / BAC) x 100

Once these three measures have been identified, the following calculations can be determined.

- **Earned Value (EV)** – EV is budgeted cost of work performed (BCWP) during a given period of time (**BAC x % Complete**). How much work is actually done?
- **Planned Value (PV)** – PV is the budgeted cost of work scheduled (BCWS) to be completed up to a given point in time. How much work should be done?

Once EV and PV have been determined they can then be used to determine schedule and cost variances and to calculate overall project performance using the following formulas.

Schedule Variance (SV) – SV is an efficiency indicator that reflects the schedule performance of the project. It measures the difference between what was planned to be completed and what has actually been accomplished. SV will ultimately equal zero when the project is completed because all of the planned values will have been earned. (SV = EV- PV). The Schedule Variance in percentage (SV %) is the ratio of SV to the PV multiplied by 100. [SV% = (SV/PV) x 100].

Cost Variance (CV) – CV is an efficiency indicator that reflects the cost performance of the project. It measures the difference between the budget (BCWP or EV) and the actual amount spent for the work completed (ACWP or AC). (CV = EV – ACWP or AC). The Cost Variance in percentage (CV %) is the ratio of CV to the AC multiplied by 100. [CV% = (EV/BCWP) x 100]

Schedule Performance Index (SPI) – The SPI is used, in addition to project schedule status, to predict the project's completion date and is sometimes used in conjunction with CPI (Cost Performance Index) to forecast the project's estimate at completion (EAC). SPI is simply the ration of the EV to the PV. A SPI below 1.0 indicates the project is behind schedule, a SPI above 1.0 is ahead of schedule, a SPI of 1.0 indicates the project is on schedule. (SPI = EV/PV).

Cost Performance Index (CPI) – The CPI is used to monitor project cost and to predict cost overruns. The CPI is a commonly used cost-efficiency indicator and is simply the ratio of the EV (BCWP) to AC (ACWP). A CPI below 1.0 indicates the project's cost is over the planned cost for the work performed. A CPI above 1.0 indicates the project's cost is under planned cost for the work performed and a CPI equal to 1.0 indicates the project' cost is spent as budgeted. (CPI = EV/AC)

Estimate To Complete (ETC) – ETC is the expected cost needed to complete the remaining planned work.

Estimate At Completion (EAC) – EAC is the expected total cost of the planned work at completion of that work. (EAC = ACWP + ETC). Schneider, Randy; Sparks, Joseph; Yerkovich, Pamela (2017) indicated variants of EAC formula.

EAC = Actuals to Date + [(Remaining work) / (Efficiency Factor)]

$EAC_{CPI} = ACWP_{Cumulative} + [(BAC - BCWP)_{Cumulative} / CPI_{Cumulative} = BAC/CPI_{Cumulative}$

$EAC_{Composite} = ACWP_{Cumulative} + [(BAC - BCWP)_{Cumulative} / (CPI_{Cumulative} x\ SPI_{Cumulative})$

To determine a contract level EAC, they indicated that it is possible to replace BAC with TAB (Total Allocated Budgeted) which may consists of the sum of negotiated contract cost (NCC), authorized unpriced work (AUW), and recognized overrun.

Schneider, Randy; Sparks, Joseph; Yerkovich, Pamela (2017) also indicated the formula that shows the efficiency needed from 'time now' to achieve an EAC (To Complete Performance Index – TCPI).

To Complete Performance Index (TCPI) = Work Remaining / Cost Remaining

$$= (BAC - BCWP_{Cumulative}) / (EAC - ACWP_{Cumulative})$$

Here, to determine TCPI on the basis of BAC or on the latest revised estimate (LRE), EAC need to be replaced with BAC or LRE.

Variance At Completion (VAC) is the difference between BAC and EAC. (VAC = BAC – EAC).

The following figure, Figure 2.5, depicts the graphical relationship between the EVM metrics.

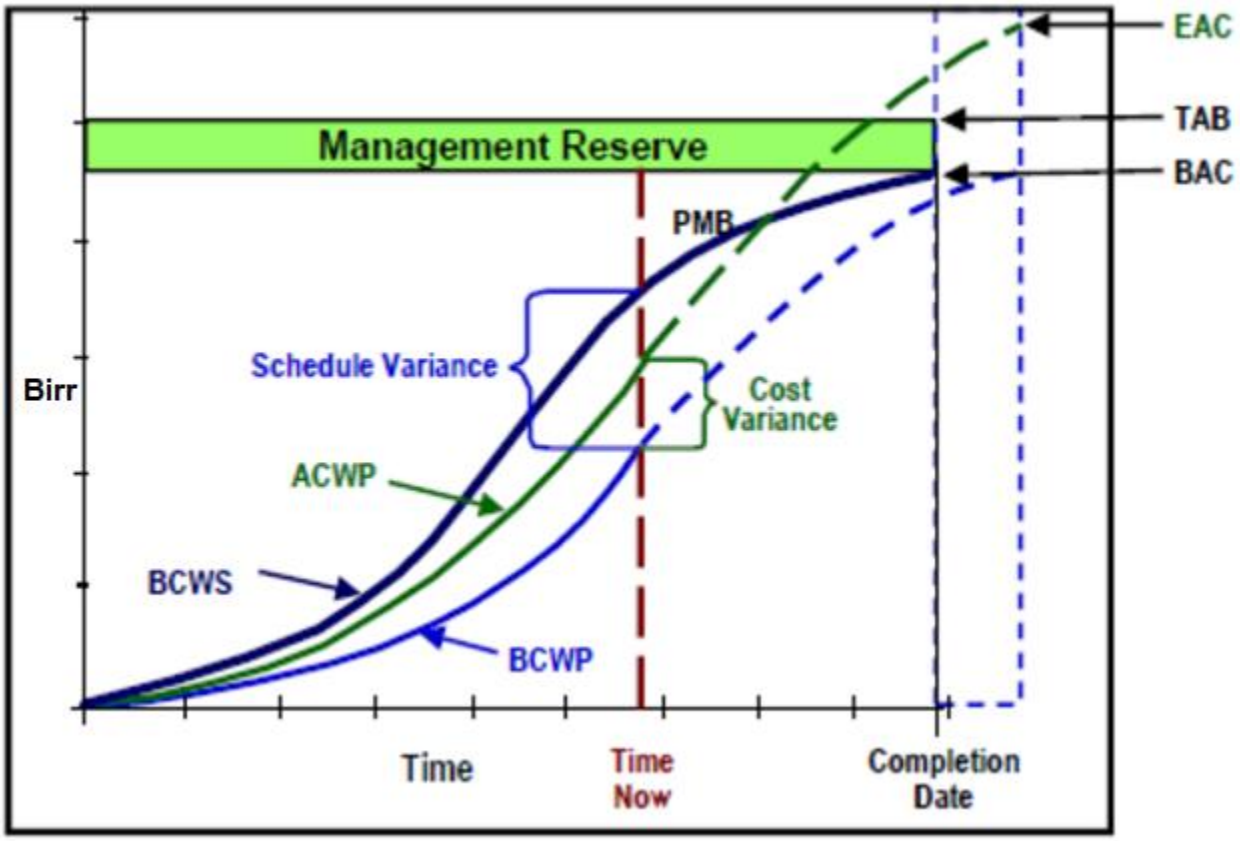

Figure 2.5: EVM Metrics Chart. Source: EVM Reference DAU Toolkit (n.d)

EVMS guidance developed by ANSI/EIA identifies 32 criteria that reliable EVM systems should have. These criteria are organized into the following five categories:

- **Organization**: Activities that define the scope of the effort and assign responsibilities for the work

- **Planning and Budgeting**: Activities for planning, scheduling, budgeting, and authorizing the work. EVM measures defined tasks that meet the "SMART" test—they are Specific, Measurable, Actionable, Results-oriented, and Timely.
- **Accounting**: Activities to accumulate the costs of work and material needed to complete the work
- **Analysis**: Activities to compare budgeted, performed, and actual costs; analyze variances; and develop estimates of final costs
- **Revisions and Data Maintenance**: Activities to incorporate internal and external changes to the scheduled, budgeted, and authorized work

2.3: Limitation of Earned Value Management System

Schneider et al (2017) stated that EVM is a project management practice that offers PMs with many advantages, when properly applied. However, the practice also has its share of limitations. While EVM provides an integrated solution for oversight, it does not necessarily tell the whole story.
Schneider et al (2017) also stated that some limitations of EVM include if the planned baseline is not correct and does not feed into the schedules then data will become garbage in, garbage out. Most stakeholders may not understand the terminology or the advance formulas associated with the actual data points and outputs therefore it is important to focus on the bottom line up front performance metrics. EVM concentrates on cost and schedule, but doesn't include quality measurements. Hence you can be within cost and on schedule, but you don't have a useable product at the end. Different methods of EVM data can be applied in different ways. For instance, you can use budget at completion or cost variances that could depict different favoring outcomes. In most cases there is no tracking of risk management within EVM. Therefore, the actual work completed may not be accurate. Finally, as the data is collected, the actual work completed may have changed drastically (Schulze, 2013).

Data anomalies can manifest when a program is near 65 percent project completion, meaning traditional EVM schedule metrics lose their predictive ability over the last third of project (Lipke, 2007). The Earned Schedule metric retains utility to project completion as it does not automatically return to 1.0. Earned Schedule Indicators are cost-based instead of time-based and can be applied to the total program or critical path work packages to track or validate project performance. The methodology allows schedule-based metrics to be defined in time units and cost based metrics. This is far easier to understand than quantifying time in currency (Schneider et al., 2017).

Henderson (2007) while EVM has many very significant achievements in quantitatively expressing and analyzing project cost performance; this success has not extended to schedule performance. Reasons for the lack of corresponding schedule success include:

- The EVM schedule indicators are, contrary to expectation, reported in units of cost rather than time. Because cost is the unit of measure, the schedule indicators are counterintuitive and require a period of familiarization before EVM users and project stakeholders become familiar with them.
- Because EVM schedule indicators are expressed in units of cost, comparison with the time based network schedule indicators (e.g. the critical path (CP) calculated end date) is very difficult
- The much more serious issue whereby the EVM schedule indicators always return to unity at project completion. The EV always equals the final PV, the BAC. Therefore the SV always returns to zero and SPI always returns to one irrespective of duration based project delay. The schedule indicators also fail for projects which continue to execute beyond the planned completion date.

Numerous widespread deficiencies exist in using EVM schedule variance (SV) and cost variance (CV) (GAO, 2012). Therefore, federal contractors must learn to use the EVM tool correctly to improve federal IT program success (Kwak & Anbari, 2012).

EVM allows program managers to know whether the project has cost or time overruns, but program managers do not know when deviations from planned values are so important that they should take corrective actions or, in the case of a good performance, when they should detect sources of improvement (Naeni et al., 2014; Salari, Bagherpour & Kamyabniya, 2014).

EVM addresses only the quality of work completed (De Marco & Narbaev, 2013). Customers give approval when the program team completes all product requirements and the expected quality (Fleming & Koppelman, 2005). A program manager must use other means to control the technical and quality content of the performed work (Molloy & Stewart, 2013). Thus, suppliers may seem to abide by the EVM guidelines and receive positive results from EVM, even though the program fails to meet the product requirements (Plumer, 2010). With performance-based EV, program managers can integrate the program's technical performance with the use of examining cost and schedule performance by linking work packages to milestones for meeting the product requirements (Acosta, 2015; Naeni et al., 2014; Townsend, 2013).

Although program managers consider EVM a risk management tool, EVM is not helpful for risk management (Fleming & Koppelman, 2005).

2.4: Benefits of Earned Value Management System

Compared to stochastic methods and the fuzzy logic model, EVA has notable advantages in accuracy and flexibility (Mortaji et al., 2013).In many cases, unsystematic cost and schedule tracking practices, as well as inaccurate data collection, cause projects to experience profit loss (Hanna, 2012). An EVM system allows electrical contractors to monitor construction progress, perform forecasts on the

project, uncover problems occurring on site, and respond to problems in projects as early as possible (Hanna, 2012). Early warning signs exist (Acebes et al., 2014; Byung-Cheol, 2015). Using an EVM system can also help detect cost overruns and schedule slippages early in the project, which allows the project team to take corrective action in a timely manner (Hunter et al., 2014).

Valle and Soares (2006) identified the main benefits of EVM: (1) integrated cost, progress and time management; (2) better vision of the project in terms of scope and procurement; (3) early alert to problems; (4) foreseeability of project deviation trends; (4) reduced time to perceive and understand problems and solutions; (5) support for negotiations and the decision making process; and (6) the motivation of people to implement the project control process.

An earned value management system is an aid to both the contractor and customer. The benefits of implementing an EVMS can be summarized as follows. An EVMS:

- Improves the planning process,
- Fosters a clear definition of the work scope,
- Establishes clear responsibility for work effort,
- Integrates technical, schedule, and cost performance,
- Provides early warning of potential problems,
- Identifies problem areas for immediate and proactive management attention,
- Enables more accurate reporting of cost and schedule impacts of known problems,
- Enhances the ability to assess and integrate technical, schedule, cost, and risk factors,
- Provides consistent and clear communication of progress at all management levels, and
- Improves project visibility and accountability

J. Art Gowan Richard G. Mathieu Mark B. Hey (2006) identified the following that EVM has some benefits over other project management control techniques:

- EVM measures actual performance versus budget and schedule at any point in time.
- EVM requires the project manager to track scope creep.
- EVM gives a snapshot to executive management which can be easily understood.
- Historical EVM data can be used for similar projects and improving estimates.

J. Art Gowan Richard G. Mathieu Mark B. Hey (2006) outlined the benefits of using EVM for data warehouse project (1) using EVM to directly tie the budget with the schedule , (2) using EVM to help ensure a meaningful schedule , (3) using EVM to assign manager/team responsibility and improve communication, (4) using EVM to forecast final project results, (5) using EVM to support effective and efficient management of multiple projects and (6) using EVM to allow managers to quantify lessons learned. EVM value management is also very important for better utilization taxpayers' money.

2.5: Improvements and Variants of Earned Value Management System

Czemplik (2014) iterated that the core concept of the EVM is of deterministic nature. Several authors proposed some additional approaches to model the construction works in probabilistic way. More often, the Monte-Carlo simulation has been used to generate the three shapes of the basic EVM curves, referring to: minimum, maximum and most likely of BCWS, ACWP and BCWP values. It should be noted, that even the construction site managers use powerful computers in their daily practice, but correct application of the Monte-Carlo simulation and use of function of distribution of probability which is adequate for particular construction works would be successful provided the software is dedicated for a given type of a construction project. The other group of EVM modification approaches is focused on shaping the original EVM to controlling the project time in better way, than it is possible by use of the original edition of the method. It is worth to notice, that originally the EVM was developed for both, cost and time management, but on the other hand, most of construction project managers use it for cost management, only.

According to EVM, even the measures as SV (schedule variance), which is used to indicate the schedule efficiency, is expressed in a monetary units. Moreover, the EVM does predict future performance of the contractor based on past performance, examined till the status date. But, remaining works of the construction project could be subjected to new risks, not recorded before the status control date. So, the EVM should be modified, taking into account also the future risks, in order to be successfully used for project time management (Czemplik, 2014).

Very practical oriented integration of EVM with risk management tools, considering both past performance and future risks, have been discussed in past literature. Other modification approaches, also focused on project duration forecasting, have been developed and published in papers. So, we have available several modified Earned Value Methods suitable for assessing construction projects, considering to similar extend both, project duration and project cost(Czemplik, 2014)..

Czemplik (2014) also iterated the Earned Value Method could also be used for supporting the decision about implementing design changes in various project phases. It is known, that one design change usually – as a consequence – brings next project changes, which may be difficult to predict before the initial change implementing. (Czemplik, 2014) presented a new formula for Schedule Forecast Indicator (SFI) that can be used by construction project managers as a supplementary managerial tool to be used in conjunction with the EVM.

The objective of SFI is to present a value expressing the chance for successful cancellation of the delay occurred at various phases of the project. The construction project manager before making a decision about implementing a new design change should always consider if the project target cost and the project end date would be met. Certainly, it is much easier to cancel any disturbances generated by the design change in early stages of the project than in its late phases. What's more,

probability of effective cancellation of any delays borne by a design change depends on the number of critical and not critical remaining activities, i.e. activities to be executed after the Status Date and before scheduled end of the project, with respect to all project activities, i.e. activities to be executed during the whole project duration. Obviously the number of critical activities is more important value than number of not critical activities, so the respective weight factor has been proposed for the SFI formula. Effective application of decision supporting SFI value can be possible after the CPM network for the project is ready, and the network should include the same activities as presented in the breakdown of lump-sum prices and the same, as in the cost plan(Czemplik, 2014)..

Lipke (2003) criticized the classic SPI metrics which may provide false and unreliable time forecasts near the end of the project. He introduced the concept of ES that translates the monetary metrics into a time dimension and presents a modified schedule performance indicator [SPI(t)] that can measure the performance along the whole life of the project (Vandevoorde and Vanhoucke, 2006). Jacob and Kane (2004) noted that the SPI and SPI (t) are true indicators for project performance as long as they are used on the activity level, and not on the control account level or higher WBS levels. Vanhoucke and Vandevoorde (2008) further indicated that small delays in critical activities combined with much faster progress in non-critical activities can result in a false SPI value and tested the influence of the false SPI values on the accuracy of three forecasting methods. Vandevoorde and Vanhoucke (2006) and Vanhoucke (2010) argued that using the metrics at higher levels is the only workable approach for practitioners. Lipke et al. (2009) also noted that a detailed schedule analysis will generate heavy burden and disrupting effects on the project team. Vanhoucke (2011) further found that in case the project network in a rather serial structure that contains many critical activities, the accuracy of measuring the project performance on high WBS levels is acceptable. Ding and Zhang (2006), on the other hand, introduced another way to resolve this phenomenon. They proposed a parameter to measure the criticality of each activity based on the amount of float and developed a weighted SPI.

Naeni et al. (2011) and Nanei and Salehipour (2011) introduced fuzzy principles into the "percent complete" method and presented fuzzy-based EV indices and estimates. Solomon and Young (2007) discussed performance-based EVM, which incorporates product quality requirements into traditional EVM and integrates technical performance with cost and schedule performance. Pajares and López-Paredes (2011) proposed new EVM metrics to address the uncertainty of project parameters, which provide early warning towards systemic and structural changes affecting the project risk, cost and schedule. Kim and Reinschmidt (2010) developed the Kalman filter forecasting method that incorporates Kalman filter into ES method, which can provide probabilistic predictions of project duration at completion. Barraza et al. (2004) used the concept of stochastic S-curves (SS curves) to determine forecasted project estimates and evaluate the performance improvement of proposed corrective actions. Nassar et al. (2005) integrated Weibull analysis with the EVM to evaluate stochastically the schedule performance of construction projects. Considering the fact that the studies on cost estimate at completion may be impeded by lack of accessible broad-based data, Lipke (2006) and Lipke et al. (2009) introduced the mathematics of statistics into prediction of final cost and duration.

The traditional EVM time forecasting approaches — the planned value method (PVM) by Anbari (2003), the earned duration method (EDM) by Jacob and Kane (2004) and the earned schedule method (ESM) by Lipke (2003) — have recently been evaluated by Batselier and Vanhoucke (2015) based on the real-life project database constructed by Batselier and Vanhoucke (2015). The said empirical research supported the findings of the simulation study of Vanhoucke and Vandevoorde (2007) by also indicating ESM as the most accurate method.

2.6: Earned Value Management System Criteria

Companies need to meet certain criteria if they want to use EVM as a project management tool. The six listed below give you a general idea of what needs to be in place before using EVM (Fleming and Koppelman, 2000):

(1) An organizational structure is needed to permit both cost and schedule performance to be measured by elements of either, or both, structures. Example: Accounting Department tracks cost charging through cost control numbers (CCNs).

(2) Schedule the authorized work in a manner that describes the sequence of work and identifies the significant task independencies required to meet the project requirements. Example: Work breakdown structure, critical path method, control account plans.

(3) Establish and maintain a time-phased budget base line at the control account level, against which project performance can be measured. Example: Budget work for each task performed on the schedule by a set completion time.

(4) Record direct costs in a manner consistent with the budgets in a formal system controlled by the general book of accounts. There needs to be a process in place for the employee to charge time to the specific project schedule tasks. Example: Each cost account is assigned to a particular project or task and collects the hours and dollars charged by each employee.

(5) At least on a monthly basis, generate reports that compare the amount of planned budget and the amount of budget earned for work accomplished (schedule variance) and the amount of budget earned and the actual direct costs for the same work (cost variance). Example: Stoplight charts, monthly variance reports, estimate at completion.

(6) Provide detailed reasons for schedule and cost variances. Example: Detailed analysis provided with reports mentioned above

Moy(2016) while all the performance indicators planned value, EVM, AC, SV, SPI, CV, CPI, Budget at completion, estimate at completion, and TCPI) can have value to any project, two EVM metrics in particular are critical to project which are TCPI and CPI (Fleming & Koppelman, 2005). Program managers must meet 10 key requirements to implement EVM successfully:

1. EVM requires that program managers must fully understand, define, and scope the project, including 100% of the project efforts.
2. EVM requires that program managers decompose the defined scope, break it down into major management tasks selected as points of management control and planned and scheduled down to the detailed work package level.
3. EVM requires authorization of an integrated and measureable project baseline relating the scope of work directly to an achievable budget and then locking into a specific time frame for performance measurement.
4. EVM requires the accomplishment of only authorized and budgeted work.
5. EVM requires measuring physical performance (the EV) using previously defined schedule metrics.
6. EVM requires that program managers relate the values earned to the planned values to reflect performance against the project baseline.
7. EVM requires the ACs reported to be consistent with the EV measured to allow for an accurate portrayal of cost performance.
8. EVM requires period forecasts (weekly, monthly) to determine how much time and money it took to complete 100% of the project.
9. EVM requires that a full disclosure of actual results to all persons who have an interest in the project.
10. EVM requires that project management, in conjunction with management at all levels, and customer stakeholders decide on the appropriate actions to take to stay within authorized project expectations (Elshaer, 2012; Gershon, 2013; Naeni et al., 2014; Pajares & López-Paredes, 2011).

These 10 requirements are necessary to implement EV on any project successfully (Fleming & Koppelman, 2009).

2.7: Current Practices and Challenges of Implementations of Earned Value Management System

Cost overruns to projects are frequent, regardless of project type and location (Hanna, 2012). Due to increasing global competition and advanced technological developments, many organizational leaders have increased the use of EVM as a way to achieve better control of their projects and better performance (Kwak & Anbari, 2012). However, Moy (2016) identified general problems in IT projects in U.S., that federal contractors use EVM without understanding how to monitor project costs and schedules.

EVM is one of the most widely used and known methodologies for project control and monitoring (Colin, Martens, Vanhoucke & Wauters, 2015; Kwak & Anbari, 2012; Willems & Vanhoucke, 2015). However, this need to considered together with(Fleming & Koppelman, 2002) that the term, Earned value (EV) is rarely used by construction cost engineers and most of the time they don't even realize that when they are putting together a project budget schedule they are in fact unknowingly using earned value management in its purest form.

To apply EVM to projects in various industries and government agencies, Kim addressed the following questions (Moy, 2016):

a) How might implementing EVM methodology within private and public industry be designed and
b) What modifications, if any, did public and private industries make to employ the EVM methodology?

The findings from E. Kim's study were as follows (Moy, 2016):

a) Current EVM methodology is changing and the existing scholarly literature is not current within the EVM methodology area;
b) an approach to consider is to use four factor groups which are EVM users, EVM methodology, implementation process, and project environment as shown in the model developed during E. Kim's research can improve the acceptance and performance of EVM;
c) no difference in applying EVM in projects of private or public industries or small or large projects.

The problem on project management of the construction industry is a global phenomenon, and Ethiopian case is no exception. Sinesilassie, Tabish & Jha (2017) indicates that scope clarity and project manager's competence have positive impact on cost performance in Ethiopian public construction projects. On the other hand, conflict among project participant, and project manager's ignorance and lack of knowledge have negative impact on cost performance of Ethiopian public construction projects.

Gebrehiwot, D. A. (2018) examined in to the key success factors influencing the performance of road construction projects under Ethiopian Roads Authority and found that competence of project participant (time),relationship among project participants(cost),management leadership in promoting high process quality (quality),effective monitoring and feedback (human resource

management),ability to meet the client's deadline (client satisfaction),careful positioning and maintenance of road project site (environment),interrelation between the employee and supervisor (safety) and quality of works to match standards (risk management) and suggested that understanding of these key success factors would help improve project performance.

Gadisa,A.B. , Zhou,H. (2019) examined in to the critical factors affecting public infrastructures performance in Ethiopia and found out what they labeled as the top 8 critical specific factors affecting government-financed infrastructures projects performance in the Ethiopia comprehends: poor project planning & administration system, weak project management leadership skills & institutional capacity, inadequate project design, escalation of construction materials price, lack of integrated project planning system among parties, inadequate capacity of the contractor, poor project schedule and cost management system.

Sinesilassie, Zafar, & Jh (2017) conclude that success factor 'owners' competence' can significantly contribute to schedule performance of Ethiopian public construction projects. On the other hand, 'conflict among project participants', 'poor human resource management' and 'project manager's ignorance and lack of knowledge' are detrimental to schedule performance of Ethiopian public construction project.

Yada and Yadeta (2016) investigate in to the factors that affect cost, time, and quality and leadership style performance during construction projects under Oromia industry and urban development Bureau. They found that factors of affecting time performance were delay to furnish and deliver the site , financial problems and improper planning; factors affecting cost performance were design changes, and fluctuations in the cost; factors affecting quality performance were construction project educated personnel, relevant work experienced personnel, quality of materials and equipment used in the project construction and conformance to specification; factors affecting the leadership performance were leaders professional education, leaders relevant work experience and training.

Mitikie, Lee, & Lee (2017) assessed the impact of risk in Ethiopian construction project performance and found out the risk management practice is poor and conclude that the main risk factors that affect the project performance very high are equipment/material failure, labor poor productivity, the non-availability of equipment and material; the very low identified risk levels are injuries, earthquake & winds; and land slide & rock falls.

EVM has received recognition within the project management community as an effective cost and risk management technique (De Marco & Narbaev, 2013). Individuals within some organizations are not ready to implement EVM due to their lack of project management maturity and organization readiness (Gershon, 2013). Makar (2008) aimed to develop an assessment instrument that could accurately measure organizational skills, capabilities, and critical success factors required to implement EVM successfully.

In the quantitative study, Plumer examined levels of satisfaction of IT projects in customers, developed through the use of the EVM System, which is a project management system in widespread use in IT applications since 2006 (Plumer, 2010). The result of Plumer's study did not show any correlation between customer satisfaction and EVM use. Customer satisfaction is one dimension of project success (Kwak & Anbari, 2012). The other three dimensions are meeting schedule and budget goals, commercial success, and preparing for the future (Gershon, 2013; J. Kim et al., 2015).

The Obama administration developed the federal IT Dashboard to reveal the federal government's performance and expenditures on IT investments (GAO, 2011). The federal IT Dashboard is a website containing details on federal IT investments so that federal agency personnel, business leaders, the public, and stakeholders can monitor the progress of investments (GAO, 2013). With the federal IT Dashboard, the public can determine the amount of money and time spent, as well as the personnel responsible for the federal government IT programs (Linders, 2012; Nam, 2014). Additionally, the public can access the same data that government employees use to determine the performance of federal IT investments (GAO, 2011). By making the federal IT Dashboard available to the public, government leaders made the data transparent so that the government could attend to underperforming programs before the programs fail (Plumer, 2010).

Schneider et al. (2017) stated that Variance Analysis provides the Government with fundamental cost and schedule insights for program execution progress and basic decision making. Variance reporting is necessary in understanding the performance of teams, ensuring appropriate corrective actions are identified and completed, and allocation of resources make the most impact to the project. This process supports root-cause analysis and the conveying of the results upward. When variance analysis is conducted properly (e.g., on time, and at the proper level), it can be an effective control against further cost and schedule problems that may jeopardize the successful completion of a project. Unfortunately, variance analysis can be untimely or excessive and even contribute to project failure

by drawing project managers, engineers, and others away from more urgent problems (Christensen, 1998).

Variance Analysis must sufficiently addresses variance identification, program impacts, and corrective actions while being written at an appropriate WBS level that provides the PM with the visibility it requires. The Variance Analysis report process must provide a checklist for preparing a report to successfully review cost and schedule variances. The structured steps in preparing a Variance Analysis Reporting (VAR) includes, but is not limited to:

- Collecting technical, schedule and cost data
- Validating the information
- Clearly defining the problem
- Determining the cause of the problem (root cause)
- Addressing the technical, schedule, cost impacts to other work scope elements in the project
- Developing a corrective action plan (CAP) to mitigate, eliminate or offset the problem
- Analyzing impacts to the Estimate to Complete (ETC) and the Estimate at Completion (EAC)
- Implementing and tracking the corrective actions
- Monitoring and revising the corrective actions, as needed. (Hyde & Watenpaugh, 2015)

Schneider et al. (2017) iterated that Earned Value analysts should take advantage of commercial off-the-shelf (COTS) EVM tools to view and analyze EVM-Lite submissions, perform data quality checks and performance tripwires, as well as to provide advance reporting and charting. COTS tools provide the best value to the Government because they are inexpensive and customizable to program needs right of the box. Industry standard EVM tools are Microsoft Project, Deltek Cobra, and Deltek wInsight. Microsoft Project is an industry standard tool that can be used to maintain the Integrated Master Schedule. Deltek Cobra allows EVM analysts to directly import the project status for each control account and work package from Microsoft Project, ensuring alignment between the schedule data and cost data. Cobra is a very flexible tool that can fit most programs programmatic needs. Deltek wInsight can be used to take the EVM-Lite data from Cobra and populate charts, graphs, and tables for the project status reports. Deltek wInsight provides a flexible environment to display and distribute the data generated and maintained by the EVM-Lite database. Project Management software delivers a flexible hierarchy that encourages the ability to filter information for fast and insightful data discovery.

Schneider et al. (2017) provides the program life cycle for building, assessing, maintaining, performing, and learning from a successful EVM solution; and proposed an implementation approaches on applying the ANSI/EIA-748 EVM methodologies and software tools.

2.8: Review of Empirical Literature

In addition to implementing the project management principles outlined in PMBOOK Guide in routine project management processes, the successful application of EVM also requires a number of additional critical practices in planning, executing and controlling process (PMI, 2005).

Kim et al. (2008) found existing project control techniques used in Korea could not provide precise cost and schedule integrated data for EVM. Kim et al. (2003) found the successful implementation of EVM is associated with overall organizational approaches and developed three major critical success factors (acceptance, use and performance) for achieving better successful outcomes for EVM implementation in facilitating project success, each of which includes a number of success sub-factors.

The internationally recognized EVM method, when introduced into different countries, should be structurally adjusted to accommodate the existing project control techniques. Particularly, as EVM outputs depend on the collection and processing of cost and schedule integrated data, the appropriate data representation model that is suitable for the domestic market should be developed. Moreover, research should be taken to explore appropriate level of detail of information for various project sizes and types, which influences the efficiency of control during the integration of information (Kim et al., 2008).

Limilia & Mokaya (2018) focused on three factors namely, level of knowledge and application of EVM due to lack of commercial books and articles on the subject, high costs of collecting data for EVM analysis and estimation of percent completion of projects and difficulty of EVM reporting causes resistance of employees and contractors when trying to put EV into practice and found out that all have significant contribution. Limilia & Mokaya (2018) also suggested two strategies for applying EVM in the construction industry (1) Introduction of and continuous training on application of EVM, (2) Establishment of sustainable and effective policy for addressing issues affecting quality of construction projects.

Gebreegziabher (2019) iterated that project activities and management efforts in any of the project phases could affect the success of a given project. This makes the management process more complex

and challenging task, requiring a more comprehensive view in the projects. During the last few decades, numerous project control methods, such as Gantt Bar Chart (GBC), Program Evaluation and Review Technique (PERT) and Critical Path Method (CPM), have been developed (Lester, 2014).

Koshe & Jha (2016) identified the main critical factors that cause construction delays in Ethiopia such as difficulties in financing project by a contractor, escalation of the materials price, ineffective project planning, scheduling or resource management, delay in progress payments for completed work, lack of skilled professionals in the field of construction management in the organization, and fluctuating labor availability season to season/seasonal labors availability. Koshe & Jha (2016) also found out that in Ethiopia only 8.25% projects have been finished to the original targeted completion date; the remaining 91.75% delayed the 352% of its contractual time.

Desta (2015) studied the management of construction process in Ethiopian Roads Authority (ERA) and claimed that the delivery of construction projects in Ethiopia is accused of non-optimum performance. Desta (2015) found out that the phases and core processes ERA employs in its project delivery are comparable to 'accepted practices' but he identified some key deviations from the best practices recommended in the literature in the execution and management of these processes, with the major one such as (1) ERA employs extra-fragmented approach to project delivery, (2) ERA's project delivery approaches and process are not adequately tailored to the specific characteristics and peculiarities of its projects and its environment, (3) the Authority's project quality assurance measures are weak and its performance monitoring and evaluation approaches are self-serving, and (4)externally, the volatile environment, the poor supply chain, unconsolidated knowledge base, and negligent and slack practices in the industry, over which ERA has little control are key factors that affect the Authority's project delivery.

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: (1) estimate cost and time to complete;(2) identify cost and schedule impacts of known problems; (3) accurately portray the cost status of a project; (4) trace problems to their sources; (5) portray the schedule status of a project; (6) provide timely information on projects, and (7) identify problem areas not previously recognized (Kim et al., 2003).

Valle & Soares (2006) identified the main benefits of EVM: (1) integrated cost, progress and time management; (2) better vision of the project in terms of scope and procurement; (3) early alert to

problems; (4) foreseeability of project deviation trends; (4) reduced time to perceive and understand problems and solutions; (5) support for negotiations and the decision making process; and (6) the motivation of people to implement the project control process.

The empirical studies revealed that a number of factors may impede the implementation of EVM, which includes: (1) high cost, complicated and burdensome paper work (The National Security Industrial Association, 1980; Little, 1983 & 1984; Kim et al., 2003); (2) poor understanding of EVM (Brock, 1983; Kim et al., 2003); (3) distrust and conflict between project managers, project consulting and government (Butler et al., 1993; Kim et al., 2003; Fleming and Koppelman, 2010); (4) pressures to report only good news (Fleming and Koppelman, 2010; Kim et al., 2003); (5) contract in fixed price that makes EVM less attractive to client (Kim et al., 2008); and (6) unavailability of cost and schedule integrated data (Kim et al., 2008).

Other than the problems of implementation, practitioners also found that the accuracy of performance indicators may be questionable and the output of EVM analysis not explicitly connected to possible management action (Lipke, 2004).

Kim et al. (2008) found existing project control techniques used in Korea could not provide precise cost and schedule integrated data for EVM. Kim et al. (2003) found the successful implementation of EVM is associated with overall organizational approaches and developed three major critical success factors (acceptance, use and performance) for achieving better successful outcomes for EVM implementation in facilitating project success, each of which includes a number of success sub-factors.

The empirical research on project management identifies several factors related to project failures such as fixed schedules with no iterative processes, ineffective change management, weak requirements, high complexity, erroneous estimation or metrics, insufficient planning, unclear or shifting goals, etc., showing that actual project environment is anything but deterministic (Whittaker 1999; Cooke-Davis 2002; Kappelman et al. 2006; Nelson 2007; Chua 2009).

Researchers also found that the cultural problems such as the reluctance to report adverse information and excessive optimism for recoveries from cost overruns harm the effective management of projects (Grace Commission, 1983; Christensen, 1993; Christensen and Scott, 1993). Particularly, the objective of contractor or government project managers may be to protect the project and the careers of its managers in terms of suppressing the "bad news", rather than to determine the most accurate estimate (Beach, 1990; Fleming and Koppelman, 2010). Christensen et al. (1992) claimed that the accuracy of EAC forecasting is of secondary importance compared with resolving "abiding cultural problems".

Chen & Zhang (2012) founded that most EVM users either fully or partially have implemented an automated computer system to assist EVM processes (Kim et al., 2003). In recent years, a number of EVM software programs that incorporate other widely used project management programs such as Microsoft Project and Project Server, wInsight, Cobra and Open Plan have emerged to facilitate the analysis processes. Moreover, a number of commercial companies have focused on providing the EVM service package that includes staff augmentation, tools implementation and training, and web-based EVM training.

CHAPTER THREE
RESEARCH METHODOLOGY

3.1: Introduction

This chapter attempts to describe the methodology through which the research objectives could be answered. Therefore, it defines the research design used, population and sampling procedures, data collection methods and instruments, validity and reliability of the study etc.

3.2: Research Approach and Design

This research employs both qualitative and quantitative research approaches. The qualitative research approach is employed because the research explores in depth about earned value management, criteria for that need to be met to effectively and efficiently implement earned value. The qualitative research approach includes document review and interview to further understand the earned value management practices and challenges in Ethiopian mega projects. This research applied descriptive statistics to present or report the research findings. The data analysis tools such as percentages, frequency, mean, standard deviations were applied using of IBM SPSS v26.

3.3: Target Population and Sampling

The target population of this research was all project managers, consultants and clients (experts from government side) who closely participated in at least one of the 9 projects selected from 12 projects identified in Appendix A which either completed or ongoing since 2000 year in Ethiopia. The list and brief description of the megaprojects selected is shown Appendix A. However, respondents were also allowed to specify on the ongoing megaprojects they currently participated. Among all project managers, consultants and clients who participated in one of the 12 projects identified, a sample of 50 respondents were taken from 9 selected megaprojects in which 3 hydroelectric power generation projects were dropped as a result of preliminary screening made by the author based on the information given by the Ethiopian Electric Corporation officials. Out of the 50 samples taken, only 23 respondents responded but only 20 were considered in this research. The selection of only 20 respondents out of the total 23 respondents were based on the level of involvement and responsibilities in the projects, the completeness of the filled questionnaire, and the size of the projects. The 3 respondents dropped from analysis were from the road projects. Deliberate sampling, judgment sampling in particular is used for selecting items that the researcher considers as representatives of the population (Kothari, 2004).

3.4: Data Sources and Data Collection Methods

The research outputs and other related publications were the major sources data and information for literature review, for setting research objectives and questions, to establish a basis for assessing the

practices and challenges of EVM implementation, for the design and development of research questionnaire and interview guidelines. The expert opinion of project managers, consultants, and clients from the questionnaire and interview had been a major source for data and information for the majority of research questions and objectives set by the researcher.

The data for this research came from secondary and primary sources. Primary data was collected using structured questionnaire administered using a combination of face-to-face, online using email, and self-administered means. The questionnaire has both nominal and ordinal scale with the 32 criteria measured through a 5-point Likert scale.

3.5: Data Analysis Methods and Software

This research applied descriptive statistics to present or report the research findings. The data analysis tools such as percentages, frequency, mean, standard deviations were applied using of IBM SPSS v26. Descriptive statistics (including the minimum, maximum, mean, and standard deviation), frequency distribution tables, box-plot, histograms, and scatter-plot are a few techniques used in exploratory data analysis (Starkings, 2012). Mean and standard deviation are the basis of descriptive statistics and are valid for normally distributed or normal data (Green & Salkind, 2011). Researchers use these data in tests called parametric statistics (Field, 2009).SPSS is a statistical package produced by IBM (Green & Salkind, 2011) and designed to perform a wide range of statistical procedures (Starkings, 2012).

If the data are ordered or non-normal, the mean and standard deviation of the raw data may not provide accurate information about the central tendency and variability (Starkings, 2012), and the preference would be to use median and a nonparametric test (Morgan, Leech, Gloeckner, & Barrett, 2011).

3.6: Reliability and Validity Analysis Methods

3.6.1: Reliability

It is considered that if the outcome of a measuring process is reproducible, then the measuring instrument is reliable. Reliable measuring scales provide stable measures at different times under different conditions. A Cronbach alpha analysis is to be performed on the success measures. The Cronbach alpha coefficient is a number that ranges from 0 to 1; a value of 1 indicates that the measure has perfect reliability, whereas a value of 0 indicates that the measure is not reliable and variations are due to random error. Ideally the alpha value should approach 1. In general, an alpha value of 0.9 is required for practical decision-making situations, whereas a value of 0.7 is considered to be sufficient for research purposes (Nunnally, 1978). This research adopted a technique called as

Cronbach's Alpha of value 0.7 to check for internal reliability of the questionnaire. The result of this research showed a Cronbach's Alpha value of 0.944.

3.6.2: Validity

The ability of a scale or a measuring instrument to measure what it is intended to measure can be termed as the validity of the measurement. Among this research's objectives are assessing the practices of EVM in Ethiopian megaprojects. This research assessed the practices of EVM in Ethiopian megaprojects by assessing the extent that megaprojects activities are meeting the 32 well defined criteria. These uses of well-defined criteria ensure the validity of the measurement. This research also adopted the effective model of EVM implementation (acceptance, use and performance) to assess the challenges of EVM implementation and elements of project benefit realization or projects success criteria suggested by a variety of literatures which all ensure the validity of the measurement.

To confirm a study is reproducible and the results are generalizable to the population, quantitative researchers must focus on the study's reliability and validity (Wahyuni, 2012). Before considering a study valid for a larger population, the study must be reliable (Chinsongkram et al., 2014). For quantitative research, reliability is the instrument or tool's degree of consistency in collecting and analyzing data regardless of the user (Chinsongkram et al., 2014). Validity is the credibility of the data in regard to the study and the transferability of the results to a larger or different population (Wahyuni, 2012). This research studied 9 'megaprojects' selected and identified in among the list in Appendix A and additional ongoing road projects to ensure the credibility of the data and transferability of the results to a larger or different population; hence ensured validity of the research findings.

Internal and external validity are important for all researchers. Qualitative researchers focus on having strong internal validity in the research, while quantitative researchers focus on having a higher degree of external validity (Susan & Chad, 2013). Internal validity emphasizes the explanation and verification of conclusions made about the causal relationship between variables (Chinsongkram et al., 2014). For qualitative research and experimental studies, high levels of internal validity are necessary because researchers may cause interference from their involvement with the study (Susan & Chad, 2013). This research had no intent to conclude a cause-and-effect relationship exists between practices, and benefits realized.

External validity indicates the ability to apply the results from a sample to a larger population and the ability for other researchers to reproduce the results in a different setting (Wahyuni, 2012). Quantitative researchers have to document the data collection, coding, and analysis procedure meticulously to make the study reproducible (Kratochwill & Levin, 2014).

Using SPSS did not compromise the data because SPSS is one of the most powerful statistical analysis software programs available (Raya et al., 2013). By following the described methods,

precautions, and procedures, I was able to collect and analyze the data without influencing the data with personal interpretations. External validity indicates how well a researcher can generalize theories and data to a larger population (Saunders et al., 2012). The 9 'megaprojects' selected by the researcher in addition to the other on ongoing megaprojects addressed validity issues related to the generalizability of the research findings to the overall practices and challenges that face megaprojects in Ethiopia in implementing EVM. The 12 selected megaprojects descriptions, in which 3 were dropped from, are outlined in Appendix A.

Face validity refers to the collective agreement of the experts and researchers on the validity of the measurement scale. However, this form of validity is considered the weakest form of validity. Here, experts determine whether the scale is measuring what it is expected to measure or not. Content validity refers to the adequacy in the selection of relevant variables for measurement. The scale that is selected should have the required number of variables for measurement. Both issues related to face validity and content validity were addressed in this research because the development of questionnaire and interview guide were developed based on through literature review of distinguished scholar's work and model in EVM implementation practices and challenges and project management identified the reference and bibliographies section.

CHAPTER FOUR
DISCUSSIONS, ANALYSIS AND RESULTS

4.1: Introduction

This research on practices and challenges of implementing Earned Value Management System (EVMS) on selected Ethiopian megaprojects conducted on hydroelectric power generation projects, railways and road projects in Ethiopia. This research also attempted to discover the extent that EVMS is implemented in Ethiopian Information Technology projects such as in Ethio telecom projects. The research collected data from 9 hydroelectric power generation projects, 2 railway projects, and a number of road projects including Addis Ababa – Adama Expressway. Respondents on road projects worked on or have been working in a number of projects such as Dire Dawa – Dewelle Toll Road, Modjo – Hawassa Expressway(Lot 4: Arsinegele-Hawassa), Debre Birhan-Ankober, Debre Birhan-Deneba Lemi Junction, Sodo-omo river, Bilalo-kersa, Malkasa – Matahara, Menebegna-Fincha-Shambu, Shikutie-Chulutie, Avi Town- Wabe river, Bole-Abomsa.

Respondents on railway projects claimed that they also have had also engaged on Awash-Kombolcha-Hara Gebaya Railway, and Haragebeya Mekelle Railway projects.

The Fincha Amerti Neshe (FAN), Gilgel Gibe II, and Genale Dawa IV hydroelectric power generation projects were not considered for analysis in this research because no respondents participated in these projects.

Among the total 20 respondents, 6 of them were from hydroelectric power generation projects (HPGP), 10 of them were from road projects (ROAD) and 4 of them were from railway projects (RAILWAYS).

Only 2 female respondents from road projects had been found. The general education levels of the respondents from all projects are degree and master level qualification with many years of experiences (ranging from 2 to more than 10 years) in planning and executing projects. Their level of educations specifically related to project management consists of degree and master level including project management certification.

The contract type of the projects that respondents participated includes Firm Fixed Price(FFP), Cost Plus Award Fee(CPAF) and other contract types- Design-Bid-Build(DBB)(road), Ad-Measurement Contract Base(road), Lump Sum Contract(road), Fixed Price with Economical Price Adjustment(FP-EPA) and EPC-Turnkey Contract (in Awash-Kombolcha-Hara Gebaya Railway project). The FIDIC suite of contracts have had also been used in Tana Beles and GERD (Hidase) hydroelectric power generation projects. The FIDIC suite of contracts include building and engineering works designed by the employer or monitoring and evaluation , building and engineering works designed by the contractor.

This research also assessed the knowledge level of EVM that among the 20 respondents, 9 of them claimed to have a basic level of EVM, 7 of them claimed to have a working knowledge, 1 expert level and 3 of them are senior expert or professional level. The senior experts are from railway project respondents while expert and working knowledge level are much more distributed among hydroelectric power generation project and railway projects and almost all respondents claimed to have a basic level knowledge of EVM.

This research assessed the practices of EVM in selected in Ethiopian megaprojects using the 32 EVM system criteria as defined by ANSI/EIA 748 Standard. The 32 EVM criteria are divided into five logical major groups – Organization, Planning, Scheduling and Budgeting, Accounting, Analysis and Revisions.

4.2: The Assessment of the Practices of EVMS Implementation in Ethiopian Selected Megaprojects

4.2.1: Ethiopian Megaprojects in Meeting the Organization Criteria

The purpose of the organization criteria is to require that the entire project scope is defined, an integrated project baseline(scope, schedule and cost) is defined using a work breakdown structure(WBS), management control responsibilities using control account plans(CAPs) is established, and all CAPs are assigned to the functional organizations.

In response to the extent that projects have well defined work breakdown structures as shown in Table 4.1, 70 percent of respondents confirmed that a great extent and to a very great extent that their projects have WBS defined. The WBS is the product-oriented, hierarchical family tree which

describes the major segments of a project and is used to specify all deliverables: hardware, software, services and data. The WBS provides for the integration of all project tasks, together with their estimated resources, with each task planned within a specific timeframe for performance. But as shown in the table below only 40 percent of respondents said that 'To a Very Great Extent" that projects defined WBS. This shows a very low rate for EVM readiness and Earned Value measurement cannot take place without some definition of what constitute 100 percent of the project. The WBS is used to specify all of the assumed work, and is perhaps the single most important requirement for the successful employment of earned value. The frequency distribution is shown below. Rozenes et al. (2006) questioned the hierarchical nature of work breakdown structure (WBS), on which EVM is based, and claim that most common success factors include clear goals and effective control mechanisms, which are generally weak in practice. Devanshu et al. (2018) stated that WBS is the most critical part of any project; effective control over project can be achieved by accurate WBS and shorter time interval milestone.

ORG - Define authorized work elements(WBS elements)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not to a Very Great Extent	1	5.0	5.0	5.0
	Not to a Great Extent	1	5.0	5.0	10.0
	Neutral	4	20.0	20.0	30.0
	To a Great Extent	6	30.0	30.0	60.0
	To a Very Great Extent	8	40.0	40.0	100.0
	Total	20	100.0	100.0	

Table 4.1: The response on whether megaprojects define authorized work elements

The identify organizational responsibilities criterion requires that all tasks as defined within the project's WBS be identified and assigned to a specific(internal) functional organization for performance, or designated as an external buy item as a part of the project's make versus buy process. The project's WBS is compared against the company's organizational breakdown structure (OBS) to allow for the assignment of each of the project's tasks to a specific organization for performance. This process will produce what is typically called a project responsibility assignment matrix (RAM). The result showed that 60 percent of respondents confirmed that 'To a Great Extent' and 'To a Very Great Extent' projects identify organizational responsibilities. The frequency distribution is shown below (Table 4.2).

ORG - Identify organizational responsibilities

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not to a Very Great Extent	1	5.0	5.0	5.0
	Not to a Great Extent	2	10.0	10.0	15.0
	Neutral	5	25.0	25.0	40.0
	To a Great Extent	6	30.0	30.0	70.0
	To a Very Great Extent	6	30.0	30.0	100.0
	Total	20	100.0	100.0	

Table 4.2: The response on whether megaprojects identify organizational responsibilities

The integrate system criterion provides for the integration of the company's planning, scheduling, budgeting, work authorization and cost accumulation process with each other, and as appropriate, the project work breakdown structure and project organizational structure. The integrate system requirement of EVM specifies that projects employ a single management control system with a common information database. Megaproject such as our case projects assumed to have large and well-established functional organizations often have had difficulty satisfying this criterion. This is evident in results shown (Table 4.3) that only 60 percent of respondents claimed to have integrated system. The frequency distribution is shown below. EVM is powerful because it is a simple, yet an elegant technique, deriving from basic costing principles. By requiring a baseline, it forces an integrated view of work completion and cost flow over time. Without such a technique, the three parameters of scope, schedule and cost are often monitored independently (Rozenes et al., 2006). Empirical experience from across the world demonstrates that megaprojects frequently suffer from "pathologies" (Primus, 2010), i.e., they fail in the light of the "iron triangle" criteria of project management of delivering projects on time, on budget and to prescribed specification(Flyvbjerg et al., 2003). EVMS can provide valid benefits like the integration of work, schedule and cost (Salikuma and Johny, 2016).

Projects require an efficient and effective overhead cost management which is usually not the responsibilities given to the project manager. These responsibilities are normally assigned to a very senior executive management and the management control can either be centralized or decentralized.

ORG - Integrate system(cost, time, scope)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not to a Very Great Extent	1	5.0	5.0	5.0
	Not to a Great Extent	2	10.0	10.0	15.0
	Neutral	5	25.0	25.0	40.0
	To a Great Extent	4	20.0	20.0	60.0
	To a Very Great Extent	8	40.0	40.0	100.0
	Total	20	100.0	100.0	

Table 4.3: The response on whether megaprojects integrate system (cost, time, and scope)

However, appropriate and documented procedures on how these indirect costs are managed is very important especially when it comes to government projects. As shown in Table 4.4, only 70 percent of respondents claimed that there procedures to identify and document and consistently applied across the project. Because our case projects are government projects, the management of overhead cost management may be affected the contract types of the projects. This is especially true and ascertained that because of the variety of contract types used by different projects across different sectors, a well established procedures is very important. But just less than one third of the respondents claimed that no way of identifying and managing overheads. The frequency distribution is shown below (Table 4.4).

ORG - Identify overhead management

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not to a Very Great Extent	1	5.0	5.0	5.0
	Not to a Great Extent	3	15.0	15.0	20.0
	Neutral	2	10.0	10.0	30.0
	To a Great Extent	9	45.0	45.0	75.0
	To a Very Great Extent	5	25.0	25.0	100.0
	Total	20	100.0	100.0	

Table 4.4: The response on whether megaprojects identify overhead management

The WBS and OBS need to be used as a basis for cost and schedule performance measurement. The intersection of WBS and OBS make up the Control Account Plans (CAPs) which are the basis for cost and schedule performance measurement. As shown in table 4.5, again 70 percent of respondents

claimed that they established CAPs as the basis for performance measurement. Fleming and Koppelman(2020) however stated that EVM techniques are difficult to be applied to dynamic construction projects and do not add much value to project execution, especially when there is absence of adequate project planning and documentation and the construction schedule is compounded by considering the resource constraints such as resource availability limits and multiple calendars.

ORG - Provide for Performance Measurement

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not to a Very Great Extent	1	5.0	5.0	5.0
	Not to a Great Extent	3	15.0	15.0	20.0
	Neutral	2	10.0	10.0	30.0
	To a Great Extent	5	25.0	25.0	55.0
	To a Very Great Extent	9	45.0	45.0	100.0
	Total	20	100.0	100.0	

Table 4.5: The response on whether megaprojects provide for performance measurement

The over statistical response, as shown in Table 4.6, on organization criterion with statistical mean and standard deviation showed that there is somewhat a great extent that our case megaprojects attempted to meet this criterion. This however does not seem to be satisfying provided that EVM requires 100 percent of these criterion need to be met to declare that these megaproject have full-fledged readiness for implementing EVM. Each statistical means and standard deviations with standard error clearly stipulated for each EVM criteria under this category.

4.2.2: Ethiopian Megaprojects in Meeting the Planning, Scheduling and Budgeting Criteria

The planning, scheduling and budgeting criterion requires the employment of a formal planning, scheduling and budgeting system; it requires the formation of a project baseline, which allows performance to be measured.

The schedule the work criterion requires projects have in a place a formal scheduling system, in particular, a comprehensive project master schedule (PMS). The project's planned value will be determined by compliance with this criterion.

Organization

	N	Minimum	Maximum	Mean		Std. Deviation
	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic
ORG - Define authorized work elements(WBS elements)	20	1	5	3.95	.256	1.146
ORG - Identify organizational responsibilities	20	1	5	3.70	.263	1.174
ORG - Integrate system(cost, time, scope)	20	1	5	3.80	.277	1.240
ORG - Identify overhead management	20	1	5	3.70	.263	1.174
ORG - Provide for Performance Measurement	20	1	5	3.90	.289	1.294
Valid N (listwise)	20					

Table 4.6: The overall response on whether megaprojects meet EVMS organization criterion

As shown in Table 4.7, the findings from the responses showed 90 % said that to the great and very great extent that they have scheduling system in place in project they monitored. This finding is irrespective of literatures which highlighted lack of discipline is a common problem.

PSB - Schedule the work

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not to a Very Great Extent	1	5.0	5.0	5.0
	Neutral	1	5.0	5.0	10.0
	To a Great Extent	8	40.0	40.0	50.0
	To a Very Great Extent	10	50.0	50.0	100.0
	Total	20	100.0	100.0	

Table 4.7: The response on whether megaprojects schedule the project works

The identify products, milestones and indicators criterion requires that projects must have the ability to measure their physical performance. Projects must specify what physical products, outputs, metrics, milestones, and technical performance indicators will be used to measure actual work accomplished against the schedule plan. Determining how the earned value will actually be measured is the requirement of this criterion. There are numerous methods with which to measure physical

work accomplished, and the projects must specify of these methods they will employ. Respondents did not respond to this because it was not included as part of the questionnaire. However, in informal discussions with some of the respondents from all category projects ascertained that construction projects usually have discrete form work package which put an ease to measure physical work accomplished. Provided that our case projects are megaprojects, it necessitate the identification of milestones and indicators; as shown in Table 4.8, the 20% response rate which denied this need to be looked at seriously. All government organizations were not willing to disclose their projects master schedule, deliverables and milestones so that the author could not make any analysis. However, an educated assumptions was made that there is a growing tendency among organizations that projects clearly defined deliverables, milestones and indicators however it was not clear how these were utilized for monitoring and evaluation purposes. For instance, in road projects, lots are used as a basis for project bread down which further facilitate identifying products, milestones and indicators.

PSB - Identify products, milestones and indicators

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not to a Very Great Extent	1	5.0	5.0	5.0
	Neutral	3	15.0	15.0	20.0
	To a Great Extent	6	30.0	30.0	50.0
	To a Very Great Extent	10	50.0	50.0	100.0
	Total	20	100.0	100.0	

Table 4.8: The response on whether megaprojects identify products, milestones and indicators

This criterion specifies a time-phased budget baseline which precisely termed in earned value management as the Performance Measurement Baseline (PMB). The ANSI/EIA 748 Standard for Earned Value Management System defined PMB as the total time-phased budget plan against which program performance is measured. It is the schedule for expenditure of the resources allocated to accomplish program scope and schedule objectives, and is formed by the budgets assigned to control accounts and applicable indirect budgets. The PMB also includes budget for future effort assigned higher WBS levels (summary level planning packages) plus any undistributed budget. Management reserve is not included in the baseline as it is not yet designated for specific work scope. As shown in Table 4.9, the response rate of 45% believe that to a very great extent that they plan the PMB is very low given the very importance of PMB for earned value management.

PSB - Plan the PMB

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not to a Great Extent	4	20.0	20.0	20.0
	To a Great Extent	7	35.0	35.0	55.0
	To a Very Great Extent	9	45.0	45.0	100.0
	Total	20	100.0	100.0	

Table 4.9: The response on whether megaprojects plan the performance measurement baseline

All direct labor, the indirect costs, and costs for procuring items (materials, contracts, or subcontractors) must be identified and formally controlled according to internal organizational procedures. The functional organizations receiving the budgets must be identified. Budgeted values must represent the project costs which have been negotiated. If there have been authorized changes which have not yet been negotiated, the budgets must include an estimated values for all such authorized work. Project budgets must be issued in a formal, documented and controlled manner down to the various CAP levels. As shown in Table 4.10, the response to this criterion showed similar pattern to that of the PMB. The gap observed here is confusing because even traditional project management requires well established budgets for work.

PSB - Establish budgets for work

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Neutral	4	20.0	20.0	20.0
	To a Great Extent	7	35.0	35.0	55.0
	To a Very Great Extent	9	45.0	45.0	100.0
	Total	20	100.0	100.0	

Table 4.10: The response on whether megaprojects establish budgets for work

Projects must have a system for identifying work packages; to the extent that it is practical to identify the authorized work in discrete work packages, the projects need to have budgets for this work in terms of birr, hours or other measureable units. The entire control account may not be divided into work packages. When this is the case, the far-term effort in larger planning packages would be identified for budget and scheduling purposes. All far-term time-phased planning packages would be converted into definitive work package as they approach the near term periods for performance. As

shown in Table 4.11, 15 percent of respondents responded that they are neutral about this criterion. Provided that the respondents monitored projects ranging from 2 to more than 10, and most of them participated in more than three projects, the 15 % response rate is significant and need to be addressed.

PSB - Identify work packages

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Neutral	3	15.0	15.0	15.0
	To a Great Extent	8	40.0	40.0	55.0
	To a Very Great Extent	9	45.0	45.0	100.0
	Total	20	100.0	100.0	

Table 4.11: The response on whether megaprojects identify work packages

The summarize work package budget to control criterion requires that the sum of all work package budgets and planning package budgets within any CAP must equal the authorized budget for that CAP. As shown in Table 4.12, 40% of respondents said that either not to a great extent or neutral about when they were asked whether their projects summarize work package budgets to control. This value is very significant provided that it is an important element in earned value management.

PSB - Summarize work package budgets to control

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not to a Great Extent	2	10.0	10.0	10.0
	Neutral	6	30.0	30.0	40.0
	To a Great Extent	5	25.0	25.0	65.0
	To a Very Great Extent	7	35.0	35.0	100.0
	Total	20	100.0	100.0	

Table 4.12: The response on whether megaprojects summarize work package budgets to control

There are different types of work tasks to be measured with earned value. The work tasks can be of discrete, apportioned, or level of effort. Level of effort measurement in earned value management is the least desirable; however, this criterion requires that LOE budgets when used must be formally maintained and controlled, as with any other effort. As shown in Table 4.13, 65 % respondents said that to a great extent or to a very great extent that they identify and control level of effort. LOE tasks

must be identified, time phased, and kept to a minimum. With LOE tasks, the earned value accomplished always equals the planned value, irrespective of whether any work was done. LOE in effect measures nothing but the passage of time, not physical work accomplishment. However not stated by the respondents, literature reported that typical LOE are the project manager and staff, a field support engineer, guard services, scheduling, information-desk help, etc., each of which performs activities more related to time passage than to physical output.

PSB - Identify and control LOE

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not to a Great Extent	1	5.0	5.0	5.0
	Neutral	6	30.0	30.0	35.0
	To a Great Extent	8	40.0	40.0	75.0
	To a Very Great Extent	5	25.0	25.0	100.0
	Total	20	100.0	100.0	

Table 4.13: The response on whether megaprojects identify and control level of effort

Projects have indirect costs of different category which is allocated at different pools. Establishing and managing overhead budgets is an important aspect of project management. Megaprojects under study especially have several pools of indirect costs such as engineering, manufacturing, material, and general and administrative expenses etc. As shown in Table 4.14, having 25 % of respondents said that they are neutral about whether their projects establish overhead budgets, and 5 % never consider establishing overhead budgets, this need to be addressed in Ethiopian megaprojects. Overheads in megaprojects are huge that cause significant damage to the economy; they needed to be appropriately established and managed.

PSB - Establish overhead budgets

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not to a Great Extent	1	5.0	5.0	5.0
	Neutral	5	25.0	25.0	30.0
	To a Great Extent	11	55.0	55.0	85.0
	To a Very Great Extent	3	15.0	15.0	100.0
	Total	20	100.0	100.0	

Table 4.14: The response on whether megaprojects establish overhead budgets

Project costs may include management reserve and undistributed budget. Management reserve, sometimes known as contingency funds, represents an amount of the total budget baseline which is withheld by the project manager to cover the unknowns, or the bad things which are sure to happen but cannot be specified with certainty. Management reserves are held outside of the PMB. No management reserve included in either control account budgets or organizational budgets. All management reserve (MR) must be tightly controlled, and every transaction which either adds or takes from the MR must be documented and approved by the project manager. MR is typically expected to be consumed during performance of the project. If unconsumed at the conclusion of the project, it becomes an underrun.

Undistributed budget must be allocated against a specific statement of work, and it must be time-phased and tightly controlled so as not to be used for other work which could mask an overrun. Typically, there are three situations in which undistributed budget may be used:

1. For authorized project changes which are not yet negotiated, where interim budgets are kept at a higher WBS level until negotiations is concluded.
2. For negotiated changes which have not yet been budgeted into CAPs; and
3. For far-term tasks where it might be pointless to define budgets down to the detailed control account level at the present time(using the rolling-wave budgeting concept)

To provide for the clear picture and progress of projects, MR and UB must be tightly controlled and managed. As shown in Table 4.15, a 10% response that projects have no way of identifying MR and UB and 30% respondents are not decisive about their projects have had a mechanism for identifying and controlling the MR and UB throughout the project life cycle is very concerning. It should be noted that only 15 % think to a very great extent that their projects have the mechanism for identifying MR and UB. In government megaprojects the scale of MR and UB may be of very significant and these issues must be addressed. The majority of construction projects experience variations from 3 to 18% in the form of cost contingencies (Mak and Picken 2000).

PSB - Identify MR and UB

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not to a Great Extent	2	10.0	10.0	10.0
	Neutral	6	30.0	30.0	40.0
	To a Great Extent	9	45.0	45.0	85.0
	To a Very Great Extent	3	15.0	15.0	100.0
	Total	20	100.0	100.0	

Table 4.15: The response on whether megaprojects identify management reserve and undistributed budget

This criterion provides the project target cost goal is reconciled with the sum of all internal project budgets and management reserve. As shown in Table 4.16, only 25% respondents said to a very great extent that they summarize budgets to the target cost while 55% respondents said to a great extent that projects summarize budgets to the target cost. This might have been made easier with the invention of software solutions currently available. In fact, it is likely a carryover from the time when large cost reimbursable type contracts were commonplace and certain unscrupulous contractors would actually over budget the total funds on a contract, thus assuring a cost overrun of the project. Contractors must demonstrate that they have not exceeded the total project costs with their approved budgets, and have such control processes documented with internal company procedures.

PSB - Summarize budgets to the target cost

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not to a Great Extent	3	15.0	15.0	15.0
	Neutral	1	5.0	5.0	20.0
	To a Great Extent	11	55.0	55.0	75.0
	To a Very Great Extent	5	25.0	25.0	100.0
	Total	20	100.0	100.0	

Table 4.16: The response on whether megaprojects summarize budgets to the target cost

As shown in Table 4.17, the planning, scheduling and budgeting criterion has ten items from which the top four items have mean score more than 4 points while the rest are below 4 points. Given the

importance of this category of criterion, megaprojects should improve the planning, scheduling and budgeting system. DeMarco and Narbaev(2013) described the stumbling blocks for EVM such as level of detail in plans/schedules and measurement reliability- especially assessment of work package completion.

Planning, Scheduling and Budgeting

	N	Minimum	Maximum	Mean		Std. Deviation
	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic
PSB - Schedule the work	20	1	5	4.30	.219	.979
PSB - Identify products, milestones and indicators	20	1	5	4.20	.236	1.056
PSB - Plan the PMB	20	2	5	4.05	.256	1.146
PSB - Establish budgets for work	20	3	5	4.25	.176	.786
PSB - Identify work packages	20	3	5	4.30	.164	.733
PSB - Summarize work package budgets to control	20	2	5	3.85	.233	1.040
PSB - Identify and control LOE	20	2	5	3.85	.196	.875
PSB - Establish overhead budgets	20	2	5	3.80	.172	.768
PSB - Identify MR and UB	20	2	5	3.65	.196	.875
PSB - Summarize budgets to the target cost	20	2	5	3.90	.216	.968
Valid N (listwise)	20					

Table 4.17: The overall response on whether megaprojects meet the planning, scheduling and budgeting criterion

4.2.3: Ethiopian Megaprojects in Meeting the Accounting Criteria

The accounting criterion requires that all projects be given accurate and timely cost reports, project costs be recorded as consumed or incurred, and the accounting systems which can measure planned value, earned value and actual costs.

Projects must be able to record their direct costs at the point where performance measurement will take place, typically within the control account plans. As shown in Table 4.18, 75 % of respondents

claim that their projects to a great extent or to a very great extent that they record direct costs. This is very low given the simplicity of recording direct costs, and 15 % claimed that they did not record direct costs appropriately and 10% were not decisive about it.

ACC - Record direct costs

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not to a Great Extent	3	15.0	15.0	15.0
	Neutral	2	10.0	10.0	25.0
	To a Great Extent	8	40.0	40.0	65.0
	To a Very Great Extent	7	35.0	35.0	100.0
	Total	20	100.0	100.0	

Table 4.18: The response on whether megaprojects record direct costs

Direct costs must be capable of being summarized both through the project's WBS as well as the functional organization. The next two criterions require control accounts summarized into WBS and summarize direct costs in organizational breakdown structure. The results that only 70 % respondents assessed that to a great extent or to a very great extent that control accounts summarized into WBS(as shown in Table 4.19), and 75% respondents claimed that they summarize direct costs in to organizational breakdown structure(OBS)(as shown in Table 4.20). Control accounts must be allocated to a single WBS or OBS.

ACC - Summarize WBS

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not to a Great Extent	2	10.0	10.0	10.0
	Neutral	4	20.0	20.0	30.0
	To a Great Extent	8	40.0	40.0	70.0
	To a Very Great Extent	6	30.0	30.0	100.0
	Total	20	100.0	100.0	

Table 4.19: The response on whether megaprojects summarize work breakdown schedule

ACC - Summarize direct costs

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not to a Great Extent	3	15.0	15.0	15.0
	Neutral	2	10.0	10.0	25.0
	To a Great Extent	9	45.0	45.0	70.0
	To a Very Great Extent	6	30.0	30.0	100.0
	Total	20	100.0	100.0	

Table 4.20: The response on whether megaprojects summarize direct costs

Addressing the issue of indirect costs is an important aspect of project management. Projects should apply indirect costs uniformly from the point where they are incurred, perhaps allocated into specified pools if multiple pools are used, and ultimately charged against contract or a project. This criterion establish a formal documented relationship between those persons who have responsibility for the control of indirect budgets and those persons who are able to incur such costs can take place with the allocation of indirect costs between project, or contracts. To prevent possible manipulation, appropriate recoding of indirect costs is very important. The results found here is indicative of this; as shown in Table 4.21, only 65 % believed to a great and very great extent that they record indirect costs appropriately. Even worse, 30% of respondents did say that there are no appropriate recording indirect costs. This is very significant issues that need to be addressed.

ACC - Record indirect costs

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not to a Great Extent	6	30.0	30.0	30.0
	Neutral	1	5.0	5.0	35.0
	To a Great Extent	8	40.0	40.0	75.0
	To a Very Great Extent	5	25.0	25.0	100.0
	Total	20	100.0	100.0	

Table 4.21: The response on whether megaprojects record indirect costs

Projects must be able to distinguish between nonrecurring (developmental) effort and the recurring (production) effort. This criterion requires that the project be able to establish unit, equivalent unit, or lot costs for articles to be subsequently produced in the recurring phase. Unit cost may be developed by direct labor hours, direct labor birr, material birr, or the total unit price. Unit cost may be established by isolating the individual costs for producing one unit, or by equivalent of several units, or by lot costs. As shown in Table 4.22, 80 % respondents claimed that they identify unit/lot costs however, 15% of respondents said they do not identify unit/lot costs while the rest 5% they did not provide decisive answer to this.

ACC - Identify unit/lot costs

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not to a Great Extent	3	15.0	15.0	15.0
	Neutral	1	5.0	5.0	20.0
	To a Great Extent	8	40.0	40.0	60.0
	To a Very Great Extent	8	40.0	40.0	100.0
	Total	20	100.0	100.0	

Table 4.22: The response on whether megaprojects identify unit/lot costs

Project should promote accurate cost accumulation and assignment of costs to control accounts, cost performance measurement at the point in time most suitable for the category of materials involved. Project should also provide for the full accountability of all material purchased including residual inventories. All purchased materials be measured in the same accounting period, reflecting the planned value versus the earned value(to determine any schedule variance) and the earned value versus the actual costs(to reflect any cost variance). Procurements create problems since they do not normally happen at the same time in time. Literatures cites this criterion as the most difficult for most contractors to satisfy, similar results are shown here (Table 4.23) in this finding as well (only 65%). 10 % claimed they do not record material costs, and 25 % are not decisive.

Analyzing the statistical mean of the accounting criterion (as shown in Table 4.24), only the identify unit/lot cost score a mean value of more than 4, the rest is below 4. The standard deviations ranges from 0.968 to 1.118 also showed weak accounting system to support earned value management system.

ACC - Record material costs

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not to a Great Extent	2	10.0	10.0	10.0
	Neutral	5	25.0	25.0	35.0
	To a Great Extent	5	25.0	25.0	60.0
	To a Very Great Extent	8	40.0	40.0	100.0
	Total	20	100.0	100.0	

Table 4.23: The response on whether megaprojects record material costs

Accounting

	N	Minimum	Maximum	Mean		Std. Deviation
	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic
ACC - Record direct costs	20	2	5	3.95	.235	1.050
ACC - Summarize WBS	20	2	5	3.90	.216	.968
ACC - Summarize direct costs	20	2	5	3.90	.228	1.021
ACC - Record indirect costs	20	2	5	3.60	.266	1.188
ACC - Identify unit/lot costs	20	2	5	4.05	.235	1.050
ACC - Record material costs	20	2	5	3.95	.235	1.050
Valid N (listwise)	20					

Table 4.24: The overall response on whether megaprojects meet the accounting criterion

4.2.4: Ethiopian Megaprojects in Meeting the Analysis Criteria

The analysis criteria require the measurement and analysis of actual performance against the authorized baseline and the forecasting of final results based on actual project performance.

The identify schedule variance (SV) and cost variance (CV) criterion is one which clearly separates earned value management from the traditional approach of measuring cost performance by simply relating the planned costs to the actual costs. As shown in Table 4.25, 80% respondents reported that they have mechanism to identify schedule variance and cost variance, and 5 % claimed that they do not have a mechanism to track SV and CV and 15% chose to be neutral.

Analysis on SV and CV is done when its variance threshold exceeds. The analysis should assess the types of costs involved (labor, material and other direct costs, for example) and discuss the causes of such variances. As shown in Table 4.26, only 15% were neutral but 85 % perform analysis on SV and CV.

ANA - Identify SV and CV

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not to a Very Great Extent	1	5.0	5.0	5.0
	Neutral	3	15.0	15.0	20.0
	To a Great Extent	7	35.0	35.0	55.0
	To a Very Great Extent	9	45.0	45.0	100.0
	Total	20	100.0	100.0	

Table 4.25: The response on whether megaprojects identify schedule and cost variance

ANA - Analyze SV and CV

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Neutral	3	15.0	15.0	15.0
	To a Great Extent	8	40.0	40.0	55.0
	To a Very Great Extent	9	45.0	45.0	100.0
	Total	20	100.0	100.0	

Table 4.26: The response on whether megaprojects analyze schedule and cost variance

Analyze indirect costs criterion requires that projects perform an analysis of any variances of indirect expenses against the original budget. The analysis must cover the types of cost involved, and the indirect pool or pools involved, as may be appropriate. The indirect expenses are applied as a percentage of value against a direct cost base, and indirect rates may vary from what was originally planned. This criterion also requires that some management action be taken in response to adverse changes in the indirect rates. As shown in Table 4.27, respondents have claimed relatively low, 65%, when it comes to this, and the response rate of 15% that no mechanisms are in place for analyzing indirect costs is yet a concern because we are talking about megaprojects. Their indirect costs as percentage value of the direct cost base are huge that appropriate attention must be given.

Projects normally analyze all significant variance at the control account level. But, project may not be required to report all types of variances to the customer or senior management.

ANA - Analyze indirect costs

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not to a Great Extent	3	15.0	15.0	15.0
	Neutral	4	20.0	20.0	35.0
	To a Great Extent	8	40.0	40.0	75.0
	To a Very Great Extent	5	25.0	25.0	100.0
	Total	20	100.0	100.0	

Table 4.27: The response on whether megaprojects analyze indirect costs

This is simply because projects can able to bring back the variance to acceptable levels without the involvement of customers or senior management. Therefore, formal customer reporting usually takes place at the higher level of the EBS and at a higher organizational unit. The summarize data elements and variances for reporting criterion requires that a project have the ability to summarize variances upward through the WBS or horizontally by organizational unit. As shown in Table 4.28, a low rate response of 65% said that they summarize variances upward through WBS and horizontally by OBS. The 25 % indecisive response is very significant that they never intend to apply one of the key aspects of earned value management. These needs to be addressed because what they are dealing with are megaprojects.

ANA - Summarize data elements and variances for reporting

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not to a Great Extent	2	10.0	10.0	10.0
	Neutral	5	25.0	25.0	35.0
	To a Great Extent	6	30.0	30.0	65.0
	To a Very Great Extent	7	35.0	35.0	100.0
	Total	20	100.0	100.0	

Table 4.28: The response on whether megaprojects summarize data elements and variances for reporting

The implement managerial actions criterion deal with the issue of whether earned value performance data is being used by management through the organization. The criterion requires that there should be a procedure in a place which initiates actions when variance thresholds have been compromised. Variance thresholds may be set at a number of monitoring points and may have positive and negative values. As shown in Table 4.29, the 65% respondents sought to use performance data for implementing managerial actions, and the rest 35% are indecisive.

ANA - Implement managerial actions

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Neutral	7	35.0	35.0	35.0
	To a Great Extent	7	35.0	35.0	70.0
	To a Very Great Extent	6	30.0	30.0	100.0
	Total	20	100.0	100.0	

Table 4.29: The response on whether megaprojects implement managerial actions

One of the key aspects of earned value management is the ability to estimate cost at completion (EAC). This criterion requires that EACs be performed routinely based on actual performance to date and a reasonable assessment of the work needed to complete all unfinished work. Such estimates to complete must relate to the current authorized statement of work, and are best supported by bottom-up estimates of the remaining tasks. As shown in Table 4.30, 80% respondents claimed that they develop revised estimates of cost at completion while 10% said they never have and the rest 10% are not decisive about it. While the 80% response rate may seem good and given that this criterion is one of key reasons for projects for employing earned value management, the 20% must be looked at seriously and issues needed to be addressed.

ANA - Develop revised estimates of cost at completion

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not to a Very Great Extent	1	5.0	5.0	5.0
	Not to a Great Extent	1	5.0	5.0	10.0
	Neutral	2	10.0	10.0	20.0
	To a Great Extent	7	35.0	35.0	55.0
	To a Very Great Extent	9	45.0	45.0	100.0
	Total	20	100.0	100.0	

Table 4.30: The response on whether megaprojects develop revised estimates of cost at completion

The overall statistical mean and standard deviation for analysis criterion presented here (as shown in Table 4.31) below that projects identify SV and CV (m = 4.15), Analyze SV and CV (m= 4.30) and develop revised estimates at completion (m = 4.10). Other items are below mean value of 4 and have to be addressed. The minimum and maximum statistic for identify SV and CV and Develop revised estimate at completions ranges from 1 to 5, which is very significant to be addressed. The standard deviation which ranges from 0.733 to 1.119 is one which must be seriously dealt with. The analysis criterion is one which clearly separates it from the traditional or other forms of project management. The analysis section is the one which depict the real use of earned value management in the project. This criterion is the very important element of earned value management.

Analysis

	N	Minimum	Maximum	Mean		Std. Deviation
	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic
ANA - Identify SV and CV	20	1	5	4.15	.233	1.040
ANA - Analyze SV and CV	20	3	5	4.30	.164	.733
ANA - Analyze indirect costs	20	2	5	3.75	.228	1.020
ANA - Summarize data elements and variances for reporting	20	2	5	3.90	.228	1.021
ANA - Implement managerial actions	20	3	5	3.95	.185	.826
ANA - Develop revised estimates of cost at completion	20	1	5	4.10	.250	1.119
Valid N (listwise)	20					

Table 4.31: The overall response on whether megaprojects meet the analysis criterion

4.2.5: Ethiopian Megaprojects in Meeting the Revision Criteria

The revision criteria require the management of all changes to the approved project baseline, and also require the timely approval or rejection, and the incorporation of approved changes. Incorporate changes into plans, budgets & schedules is a very important element in earned value management because the quickest way to lost the ability to measure project performance is to ignore changes and work to an obsolete baseline. As shown in Table 4.32, 85 % respondents claimed that they

incorporate changes into plans, budgets and schedules however a significant 15 % also reported they do not have a mechanism to do so. Cooper (2003) pointed to the fact that complex projects often involve unanticipated rework making them unsuitable for EVM. However, Song and Shalini(2009) pointed that clients implement EVM mostly in large, high-risk projects and cost-plus-incentive projects, and Anabri et al.(2003) also found that EVM is more applicable to large projects.

REV - Incorporate changes into plans, budgets & schedules

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Neutral	3	15.0	15.0	15.0
	To a Great Extent	9	45.0	45.0	60.0
	To a Very Great Extent	8	40.0	40.0	100.0
	Total	20	100.0	100.0	

Table 4.32: The response on whether megaprojects incorporate changes into plans, budgets and schedules

The reconcile budgets changes criterion requires the traceability of all changes currently being worked back to the original project baseline. Earned value baselines are constructed from bottom-up detail, and this requirement is satisfied by traceability down the lowest level of the project WBS. As shown in Table 4.33, 80% trace down to the budget and reconcile changes and 10% did not at all and the other 10% are not decisive about it.

REV - Reconcile budgets changes

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not to a Great Extent	2	10.0	10.0	10.0
	Neutral	2	10.0	10.0	20.0
	To a Great Extent	9	45.0	45.0	65.0
	To a Very Great Extent	7	35.0	35.0	100.0
	Total	20	100.0	100.0	

Table 4.33: The response on whether megaprojects reconcile budgets changes

The control retroactive changes criterion requires discipline from the performing organization. Project managers may be tempted to manipulate the report. This criterion prevents the indiscriminate altering of past period data without a documented justification, and includes both direct and indirect costs. Control retroactive changes to records pertaining to work performed that would change

previously reported amounts for actual costs, earned value, or budgets. As shown in Table 4.34, this is not clearly seen in 35 % respondents. Only 65% claimed that they control retroactive changes.

REV - Control retroactive changes

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not to a Great Extent	3	15.0	15.0	15.0
	Neutral	4	20.0	20.0	35.0
	To a Great Extent	7	35.0	35.0	70.0
	To a Very Great Extent	6	30.0	30.0	100.0
	Total	20	100.0	100.0	

Table 4.34: The response on whether megaprojects control retroactive changes

Revisions to the program budget must be controlled and any revisions must be prevented except for authorized changes. As shown in Table 4.35, 85% respondents said that their projects control revisions to the budget and 10% are indecisive.

REV - Control revisions to the program budget

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Neutral	2	10.0	10.5	10.5
	To a Great Extent	9	45.0	47.4	57.9
	To a Very Great Extent	8	40.0	42.1	100.0
	Total	19	95.0	100.0	
Missing	System	1	5.0		
Total		20	100.0		

Table 4.35: The response on whether megaprojects control revisions to the program budget

The fundamental aspect of earned value management is the maintenance of the approved project baseline. The criterion requires that the project have in place the necessary procedures to preclude unauthorized changes to the project baseline, and the all such changes be traceable back to the original baseline. As shown in Table 4.36, 75 % respondents said that they document changes to the PMB and 5% do not have any mechanism at all and the rest 20 % were not decisive at all.

In the revision criterion of earned value management, as shown in Table 4.37, most items have a mean score greater than 4 except the control retroactive changes item which has a mean score of 3.80.

The results showed that projects somehow provide due attention in incorporating and managing changes. Literatures cited several problems such as work done by the functions without approval of the project manager, slow incorporation of changes into the baseline, and poor or no estimates for scope changes. Forexample, Howes(2009) identified the difficulty in incorporating scope changes as one of the limitations in EVM implementations

REV - Document changes to the PMB

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not to a Great Extent	1	5.0	5.0	5.0
	Neutral	4	20.0	20.0	25.0
	To a Great Extent	8	40.0	40.0	65.0
	To a Very Great Extent	7	35.0	35.0	100.0
	Total	20	100.0	100.0	

Table 4.36: The response on whether megaprojects document changes to the performance measurement baseline

Revision

	N	Minimum	Maximum	Mean		Std. Deviation
	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic
REV - Incorporate changes into plans, budgets & schedules	20	3	5	4.25	.160	.716
REV - Reconcile budgets changes	20	2	5	4.05	.211	.945
REV - Control retroactive changes	20	2	5	3.80	.236	1.056
REV - Control revisions to the program budget	19	3	5	4.32	.154	.671
REV - Document changes to the PMB	20	2	5	4.05	.198	.887
Valid N (listwise)	19					

Table 4.37: The overall response on whether megaprojects meet revision criterion

4.3: The Assessment of the Challenges of EVMS Implementation in Ethiopian Selected Megaprojects

The challenges of implementing earned value management is based on Kim's et al. (2003) model for effective implementation. This includes factors related to EVM acceptance, factors related to EVM use, and factors related to EVM performance.

4.3.1: The Challenges of Implementing EVMS in Ethiopian Megaprojects: Factors Related to EVM Acceptance

Regarding factors related to EVM acceptance, one of the things asked was if shortfall to accept to new technique is among the challenges of implementing EVMS in Ethiopian Megaprojects. As shown in Table 4.38, only 35% respondents think that there is shortfall to accept new technique that hinders the implementation of earned value management. The majority of respondents said that this not a challenge.

CHA - ACP - Shortfall to accept new technique

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not to a Great Extent	1	5.0	5.3	5.3
	Neutral	11	55.0	57.9	63.2
	To a Great Extent	4	20.0	21.1	84.2
	To a Very Great Extent	3	15.0	15.8	100.0
	Total	19	95.0	100.0	
Missing	System	1	5.0		
Total		20	100.0		

Table 4.38: The response on whether shortfall to accept new technique is a challenge in implementing EVMS in Ethiopian megaprojects

As shown in Table 4.39, only 30% said that lack of management support contributes to the challenges but 60 % explicitly declare that lack of management support is not an issue. In the case study of EVM implementation on electrical system projects, Yrjölä (2017) stated that continuing top level management attention and facilitating support system(e.g. accounting , a project management office) are important factors to address that it is not enough to just introduce the methodology into an

organization, but instead it must be associated with over all organizational support. (Vargas, 2003; Valle, 2006; Netto, 2020) top management support as one of the critical factors for EVM use.

As shown in Table 4.40, only 15% think that cultural problems such as reluctance to report adverse information 'suppressing bad news' and excessive optimism for recoveries from cost overruns, have impact on implementing EVM.

CHA - ACP - Lack of management support

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not to a Very Great Extent	3	15.0	15.0	15.0
	Not to a Great Extent	9	45.0	45.0	60.0
	Neutral	2	10.0	10.0	70.0
	To a Great Extent	3	15.0	15.0	85.0
	To a Very Great Extent	3	15.0	15.0	100.0
	Total	20	100.0	100.0	

Table 4.39: The response on whether lack of management support is a challenge in implementing EVMS in Ethiopian megaprojects

This finding is quite different from the findings from other researchers that the objective of contractor or government project managers may be to protect the project and the careers of its managers in terms of suppressing the "bad news", rather than to determine the most accurate estimate(Beach, 1990; Fleming and Koppelman, 2010), and Christensen et al. (1992) claimed that the accuracy of estimate at completion(EAC) forecasting is of secondary importance compared with resolving 'abiding cultural problems'.

CHA - ACP - Cultural problems

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not to a Great Extent	7	35.0	35.0	35.0
	Neutral	10	50.0	50.0	85.0
	To a Great Extent	3	15.0	15.0	100.0
	Total	20	100.0	100.0	

Table 4.40: The response on whether cultural problems is a challenge in implementing EVMS in Ethiopian megaprojects

As shown in Table 4.41, only 30% think high cost, complicated and burdensome paper is one of the factors that impede EVM implementation. Kim et al. (2003) however identified high cost, complicated and burdensome paper work as one of the problems that may impede the implementation of EVM.

CHA - ACP - High cost, complicated and burdensome paper

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not to a Great Extent	8	40.0	40.0	40.0
	Neutral	6	30.0	30.0	70.0
	To a Great Extent	6	30.0	30.0	100.0
	Total	20	100.0	100.0	

Table 4.41: The response on whether high cost, complicated and burdensome paper is a challenge in implementing EVMS in Ethiopian megaprojects

As shown in Table 4.42, 30% confirmed that poor understanding of EVM is not an issue as challenges but 50% respondents said that poor understanding of EVM is major challenge. Various researchers have found knowledge and understanding to be a barrier to EVM implementation (Kim et al. 2003; Pillay et al.2013). Anbari et.al. (2003) affirmed that its wider acceptance and effectiveness may depend on better understanding of its capabilities. Simplification of EVM calculations, use of graphical tools to enhance understanding of performance trends, and successful application of EVM in industry are important factors for the growth and effective use of this valuable method in project management.

CHA - ACP - Poor understanding of EVM

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not to a Very Great Extent	2	10.0	10.0	10.0
	Not to a Great Extent	4	20.0	20.0	30.0
	Neutral	4	20.0	20.0	50.0
	To a Great Extent	6	30.0	30.0	80.0
	To a Very Great Extent	4	20.0	20.0	100.0
	Total	20	100.0	100.0	

Table 4.42: The response on whether poor understanding of EVM is a challenge in implementing EVMS in Ethiopian megaprojects

As indicated in the Table 4.43, the sufficiency of simple ways to control the projects is not the case that only 25% respondent said that it is among the reasons. The majority of respondents 65% are neutral about it.

CHA - ACP - The sufficiency of simple ways to control

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not to a Great Extent	1	5.0	5.3	5.3
	Neutral	13	65.0	68.4	73.7
	To a Great Extent	5	25.0	26.3	100.0
	Total	19	95.0	100.0	
Missing	System	1	5.0		
Total		20	100.0		

Table 4.43: The response on whether the sufficiency of simple ways to control is a challenge in implementing EVMS in Ethiopian megaprojects

As shown in Table 4.44, only 35 % think lack of EVM as a contractual requirement is an impediment to implementation of EVM. While EVM is not a pre-requisite for a project to be in control, if EVM is to have full impact on an infrastructure project (i.e., monitoring and directive control), it must be contractually specified in order to ensure a common understanding of project performance between the different role-players on the project (Nkiwane et.al. 2016). The lack of EVM as a contractual requirement diminished the directive use of EVM. The parties to a contract cannot have a common understanding of performance in terms of earned value metrics. Discussions in any official correspondence across project role-players/parties cannot be in terms of EV metrics (Nkiwane et.al. 2016).

CHA - ACP - Lack of EVM as a contractual requirements

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not to a Very Great Extent	1	5.0	5.0	5.0
	Not to a Great Extent	6	30.0	30.0	35.0
	Neutral	6	30.0	30.0	65.0
	To a Great Extent	2	10.0	10.0	75.0
	To a Very Great Extent	5	25.0	25.0	100.0
	Total	20	100.0	100.0	

Table 4.44: The response on whether lack of EVM as a contractual requirement is a challenge in implementing EVMS in Ethiopian megaprojects

As shown in Table 4.45, the same 35 % think that the type of contract is one of the factors in implementing EVM. Nkiwane et.al. (2016) found no relationship was between the contract type and the motivation to use EVM; there was a lingering uncertainty about the applicability of EVM to fixed price contracts. This is attributed to the understanding of EVM as merely a cost control tool rather than a powerful and integrated cost, time, and performance tool. However Song and Shalini (2009) indicated clients implement EVM mostly in large, high-risk projects and cost-plus-incentive projects, whereas contractors do not consider the contract type when deciding to implement EVM. On the other hand, earned value management is ignored and even discouraged for fixed-price contracts stated by Carol and Christensen (2010), since the customer has transferred the cost risk to the contractor and earned value is perceived to be less useful.

CHA - ACP - The type of contract

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not to a Very Great Extent	3	15.0	15.0	15.0
	Not to a Great Extent	3	15.0	15.0	30.0
	Neutral	6	30.0	30.0	60.0
	To a Great Extent	5	25.0	25.0	85.0
	To a Very Great Extent	3	15.0	15.0	100.0
	Total	20	100.0	100.0	

Table 4.45: The response on whether the type of contract is a challenge in implementing EVMS in Ethiopian megaprojects

As shown in Table 4.46, 40 % respondents think that forecasting and variance impact not an interest at all for their projects.

CHA - ACP - Forecasting and variance impact not an interest at all

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not to a Great Extent	6	30.0	30.0	30.0
	Neutral	6	30.0	30.0	60.0
	To a Great Extent	7	35.0	35.0	95.0
	To a Very Great Extent	1	5.0	5.0	100.0
	Total	20	100.0	100.0	

Table 4.46: The response on whether forecasting and variance impact not an interest at all is a challenge in implementing EVMS in Ethiopian megaprojects

As shown in Table 4.47, only 35% think changes in work scope creates impediment in implementing EVM. 30% of respondents do not think at all and the other 30% are neutral. Devanshu et al.(2018) and Suresh et. al. (2015) stated that EVM is very sensitive to scope change.

CHA - ACP - Changes in work scope

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not to a Great Extent	6	30.0	31.6	31.6
	Neutral	6	30.0	31.6	63.2
	To a Great Extent	4	20.0	21.1	84.2
	To a Very Great Extent	3	15.0	15.8	100.0
	Total	19	95.0	100.0	
Missing	System	1	5.0		
Total		20	100.0		

Table 4.47: The response on whether changes in work scope is a challenge in implementing EVMS in Ethiopian megaprojects

As shown in Table 4.48, 40% think technical factors such as design changes, weak control, inaccurate evaluation of project time, nonperformance of subcontractors and nominated suppliers, lack of appropriate software are challenges of implementing EVM in Ethiopian megaprojects etc.

CHA - ACP - Technical factors

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not to a Very Great Extent	4	20.0	20.0	20.0
	Not to a Great Extent	5	25.0	25.0	45.0
	Neutral	3	15.0	15.0	60.0
	To a Great Extent	7	35.0	35.0	95.0
	To a Very Great Extent	1	5.0	5.0	100.0
	Total	20	100.0	100.0	

Table 4.48: The response on whether technical factors is a challenge in implementing EVMS in Ethiopian megaprojects

As shown in Table 4.49, 90% think that financial factors such as inflation of prices, dependency on imported materials, financing and payment of completed work, risks and uncertainty associated with projects have impact on implementing earned value management system. For long-term projects, it

may be appropriate to consider incorporating the time value of money and time-discounted cash flows into EVM (Anbari et.al. 2003). Inflation can be explicitly considered in EVM, and the inflation variance (IV) can be calculated (Farid & Karshenas, 1988). However, these considerations add complexity to the method and may be justifiable only for very long-term projects or in very high inflation periods or economies. Gransber and Jeong (2015) on their case study analysis of two complex megaprojects in Michigan illustrated the use of a framework for five-dimensional project management beyond the three-dimensional life cycle approach where the project manager seeks to optimize the dimensions of cost-schedule-technical (quality or design); this frame work elevated the recognition that project's social/political context and the financial arrangements create complexity adding two new dimensions.

CHA - ACP - Financial factors

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not to a Great Extent	2	10.0	10.0	10.0
	To a Great Extent	11	55.0	55.0	65.0
	To a Very Great Extent	7	35.0	35.0	100.0
	Total	20	100.0	100.0	

Table 4.49: The response on whether financial factors is a challenge in implementing EVMS in Ethiopian megaprojects

As shown in Table 4.50, 45% respondents claimed that contractual factors such as contract and specification, interpretation, and disagreement, conflict between project parties have impact on implementing earned value management system. EVM can be used for progress payments to contractors based on the EV of contracted or outsourced work(Anbari, 2003). Because such contractual arrangements create legal and financial obligations, it is important to consider the method specified for evaluating progress(Anbari, 2003). The determination of percent complete should be carefully considered and negotiated to achieve a fair and equitable environment that encourages successful accomplishment of contracted or outsourced project items (Anbari, 2003).

As shown in Table 4.51, only 30% respondents think unstable government policies might have impact on implementing EVMS but 45% did think that is not the case.

CHA - ACP - Contractual factors

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not to a Great Extent	6	30.0	30.0	30.0
	Neutral	5	25.0	25.0	55.0
	To a Great Extent	8	40.0	40.0	95.0
	To a Very Great Extent	1	5.0	5.0	100.0
	Total	20	100.0	100.0	

Table 4.50: The response on whether contractual factors is a challenge in implementing EVMS in Ethiopian megaprojects

CHA - ACP - Unstable government policies

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not to a Very Great Extent	2	10.0	10.0	10.0
	Not to a Great Extent	7	35.0	35.0	45.0
	Neutral	5	25.0	25.0	70.0
	To a Great Extent	3	15.0	15.0	85.0
	To a Very Great Extent	3	15.0	15.0	100.0
	Total	20	100.0	100.0	

Table 4.51: The response on whether unstable government policies is a challenge in implementing EVMS in Ethiopian megaprojects

As shown in Table 4.52, 40% respondents said that unpredictable weather conditions is one of the factor impede EVM implementation.

CHA - ACP - Unpredictable weather conditions

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not to a Very Great Extent	2	10.0	10.0	10.0
	Not to a Great Extent	9	45.0	45.0	55.0
	Neutral	2	10.0	10.0	65.0
	To a Great Extent	6	30.0	30.0	95.0
	To a Very Great Extent	1	5.0	5.0	100.0
	Total	20	100.0	100.0	

Table 4.52: The response on whether unpredictable weather conditions is a challenge in implementing EVMS in Ethiopian megaprojects

In dealing with factors related to acceptance, as shown in Table 4.53, the statistical mean score is very low that which is quite positive that Ethiopian megaprojects have a number of impediments in implementing EVMS.

Implementation Challenges – Acceptance

	N	Minimum	Maximum	Mean		Std. Deviation
	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic
CHA - ACP - Shortfall to accept new technique	19	2	5	3.47	.193	.841
CHA - ACP - Lack of management support	20	1	5	2.70	.300	1.342
CHA - ACP - Cultural problems	20	2	4	2.80	.156	.696
CHA - ACP - High cost, complicated and burdensome paper	20	2	4	2.90	.191	.852
CHA - ACP - Poor understanding of EVM	20	1	5	3.30	.291	1.302
CHA - ACP - The sufficiency of simple ways to control	19	2	4	3.21	.123	.535
CHA - ACP - Lack of EVM as a contractual requirements	20	1	5	3.20	.287	1.281
CHA - ACP - The type of contract	20	1	5	3.10	.289	1.294
CHA - ACP - Forecasting and variance impact not an interest at all	20	2	5	3.15	.209	.933
CHA - ACP - Changes in work scope	19	2	5	3.21	.249	1.084
CHA - ACP - Technical factors	20	1	5	2.80	.287	1.281
CHA - ACP - Financial factors	20	2	5	4.15	.196	.875
CHA - ACP - Contractual factors	20	2	5	3.20	.213	.951
CHA - ACP - Unstable government policies	20	1	5	2.90	.280	1.252
CHA - ACP - Unpredictable weather conditions	20	1	5	2.75	.260	1.164
Valid N (listwise)	17					

Table 4.53: The overall response on the challenges of implementing EVMS in Ethiopian megaprojects with factors related to EVM Acceptance

4.3.2: The Challenges of Implementing EVMS in Ethiopian Megaprojects: Factors Related to EVM Use

In factors related to use, as shown in Table 4.54, 40% respondents said that poor cost collection and estimation system is one impedes EVM implementation.

CHA - USE - Poor cost collection and estimation system

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not to a Very Great Extent	2	10.0	10.0	10.0
	Not to a Great Extent	10	50.0	50.0	60.0
	To a Great Extent	6	30.0	30.0	90.0
	To a Very Great Extent	2	10.0	10.0	100.0
	Total	20	100.0	100.0	

Table 4.54: The response on whether poor cost collection and estimation system is a challenge in implementing EVMS in Ethiopian megaprojects

As shown in Table 4.55, only 30% respondents think that lack of use of appropriate software system is one of the factors that impede EVM implementation. Subramani et al. (2014) indicated that EVA has significant value and presents unique features that can benefit clients, consultants and industries and showed that if projects were analyzed using software like MS Projects, Primavera P6, based on earned value analysis method, and if schedule variances respect to time (SV) is incorporated in MSP & Primavera P6, final results gives almost 100% accuracy. Devanshu et al. (2018) found from their literature review that Microsoft project is the active and useful program for following up the project performance especially in large construction projects using EVM. Mohammad et al.(2018) indicated that Microsoft Project is the active and useful program for following up the project performance especially in infrastructure project using earned value management and Subramani et al. (2014) indicated that both Microsoft Projects and Primavera P6 help achieve results that give almost 100% accuracy.

As shown in Table 4.56, 50% respondents said the non-availability of EVM analyst or specialists in projects have impact on implementing EVM. According to Fleming and Koppelman (2020) EVM

techniques are difficult to be applied to dynamic construction projects and do not add much value to project execution, especially when there is no EVM analyst or specialist within the project team.

CHA - USE - Lack of use of appropriate software system

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not to a Very Great Extent	1	5.0	5.0	5.0
	Not to a Great Extent	7	35.0	35.0	40.0
	Neutral	7	35.0	35.0	75.0
	To a Great Extent	4	20.0	20.0	95.0
	To a Very Great Extent	1	5.0	5.0	100.0
	Total	20	100.0	100.0	

Table 4.55: The response on whether lack of use of appropriate software system is a challenge in implementing EVMS in Ethiopian megaprojects

CHA - USE - No EVM analyst or specialist

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not to a Great Extent	5	25.0	26.3	26.3
	Neutral	4	20.0	21.1	47.4
	To a Great Extent	9	45.0	47.4	94.7
	To a Very Great Extent	1	5.0	5.3	100.0
	Total	19	95.0	100.0	
Missing	System	1	5.0		
Total		20	100.0		

Table 4.56: The response on whether the unavailability of EVM analyst or specialist is a challenge in implementing EVMS in Ethiopian megaprojects

As shown in Table 4.57, the pressure to report only good news does not have any impact at all that only 15% respondent's think that it was case. This is contrary to what Kim at al. (2003) found that pressure to report only good news is among the problems that impede EVM implementation.

As shown in Table 4.58, the 60% respondents think that the recurring cost and schedule changes have impact on implementing on EVM.

The lack of well-defined WBS at its most appropriate level is not an issue in implementing EVM that project has well-defined WBS. As shown in Table 4.59, only 35 % think that lack of well-defined WBS is one of the challenging factors in implementing EVM.

CHA - USE - Pressure to report only good news

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not to a Very Great Extent	4	20.0	20.0	20.0
	Not to a Great Extent	6	30.0	30.0	50.0
	Neutral	7	35.0	35.0	85.0
	To a Great Extent	3	15.0	15.0	100.0
	Total	20	100.0	100.0	

Table 4.57: The response on whether the pressure to report only good news is a challenge in implementing EVMS in Ethiopian megaprojects

CHA - USE - Cost and Schedule Changes

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not to a Very Great Extent	3	15.0	15.0	15.0
	Not to a Great Extent	1	5.0	5.0	20.0
	Neutral	4	20.0	20.0	40.0
	To a Great Extent	11	55.0	55.0	95.0
	To a Very Great Extent	1	5.0	5.0	100.0
	Total	20	100.0	100.0	

Table 4.58: The response on whether the cost and schedule changes is a challenge in implementing EVMS in Ethiopian megaprojects

CHA - USE - Lack of well-defined WBS at its most appropriate level

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not to a Very Great Extent	4	20.0	20.0	20.0
	Not to a Great Extent	8	40.0	40.0	60.0
	Neutral	1	5.0	5.0	65.0
	To a Great Extent	4	20.0	20.0	85.0
	To a Very Great Extent	3	15.0	15.0	100.0
	Total	20	100.0	100.0	

Table 4.59: The response on whether lack of well-defined work breakdown structure at its most appropriate level is a challenge in implementing EVMS in Ethiopian megaprojects

As shown in Table 4.60, only 20% think that inappropriate performance baselines is an impeding factor in implementing EVM in Ethiopian megaprojects.

CHA - USE - Inappropriate performance baselines

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not to a Great Extent	11	55.0	57.9	57.9
	Neutral	4	20.0	21.1	78.9
	To a Great Extent	4	20.0	21.1	100.0
	Total	19	95.0	100.0	
Missing	System	1	5.0		
Total		20	100.0		

Table 4.60: The response on whether inappropriate performance baselines is a challenge in implementing EVMS in Ethiopian megaprojects

The level of awareness on monitoring and evaluation of EVM metrics or indices may have an impact on the implementation of EVM, and this is ascertained here (Table 4.61) with 65 % respondents think that it created an impediments.

CHA - USE - M&E of EVM metrics or indices

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not to a Great Extent	3	15.0	15.0	15.0
	Neutral	4	20.0	20.0	35.0
	To a Great Extent	12	60.0	60.0	95.0
	To a Very Great Extent	1	5.0	5.0	100.0
	Total	20	100.0	100.0	

Table 4.61: The response on whether the level of awareness on monitoring and evaluation of EVM metrics or indices is a challenge in implementing EVMS in Ethiopian megaprojects

The general statistical mean score is summarized below (Table 4.62) which showed a lower score that is quite a positive result.

Implementation Challenges – Use

	N	Minimum	Maximum	Mean		Std. Deviation
	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic
CHA - USE - Poor cost collection and estimation system	20	1	5	2.80	.287	1.281
CHA - USE - Lack of use of appropriate software system	20	1	5	2.85	.221	.988
CHA - USE - No EVM analyst or specialist	19	2	5	3.32	.217	.946
CHA - USE - Pressure to report only good news	20	1	4	2.45	.223	.999
CHA - USE - Cost and Schedule Changes	20	1	5	3.30	.263	1.174
CHA - USE - Lack of well-defined WBS at its most appropriate level	20	1	5	2.70	.317	1.418
CHA - USE - Inappropriate performance baselines	19	2	4	2.63	.191	.831
CHA - USE - M&E of EVM metrics or indices	20	2	5	3.55	.185	.826
Valid N (listwise)	18					

Table 4.62: The overall response on the challenges of implementing EVMS in Ethiopian megaprojects with factors related to EVM Use

4.3.3: The Challenges of Implementing EVMS in Ethiopian Megaprojects: Factors Related to EVM Performance

As shown in Table 4.63, only 60% confirmed that EVM are good for successful project deliveries of past project and 30% are indecisive and 10% did not think EVM contributes for successful project

deliveries of past project. The reliability test for the performance factor related to the challenges of implementing earned value management is as follows.

CHA - PER - EVM for successful project deliveries of past project

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not to a Very Great Extent	1	5.0	5.0	5.0
	Not to a Great Extent	1	5.0	5.0	10.0
	Neutral	6	30.0	30.0	40.0
	To a Great Extent	8	40.0	40.0	80.0
	To a Very Great Extent	4	20.0	20.0	100.0
	Total	20	100.0	100.0	

Table 4.63: The response on the perception whether the EVM contributes for successful project deliveries is a challenge in implementing EVMS in Ethiopian megaprojects

On whether EVM was an interest to make it to be the basis to terminate projects, as shown in Table 4.64, 55% responded that EVM contributes to the termination projects. However, it is not possible to confirm on interview session. Abba (1997; 2000) provides background on the historical events leading to the EVM standard, and discusses A-12 program cancellation to underlie its capability to issue early alerts for a potential failure.

CHA - PER - EVM to terminate projects

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not to a Very Great Extent	2	10.0	10.5	10.5
	Not to a Great Extent	1	5.0	5.3	15.8
	Neutral	5	25.0	26.3	42.1
	To a Great Extent	10	50.0	52.6	94.7
	To a Very Great Extent	1	5.0	5.3	100.0
	Total	19	95.0	100.0	
Missing	System	1	5.0		
Total		20	100.0		

Table 4.64: The response on whether the EVM was an interest to make it to be the basis to terminate projects is a challenge in implementing EVMS in Ethiopian megaprojects

As shown in Table 4.65, only 30% said that no common understanding of EV metrics among project participants. 40% respondents are neutral.

CHA - PER - No common understanding of EV metrics

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not to a Great Extent	5	25.0	26.3	26.3
	Neutral	8	40.0	42.1	68.4
	To a Great Extent	6	30.0	31.6	100.0
	Total	19	95.0	100.0	
Missing	System	1	5.0		
Total		20	100.0		

Table 4.65: The response on whether no common understanding of EV metrics is a challenge in implementing EVMS in Ethiopian megaprojects

As shown in Table 4.66, only 30% said that there is no well-defined valuation of planned work, and 40% did think their projects have well-defined valuation of planned work.

CHA - PER - No well-defined valuation of planned work

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not to a Very Great Extent	1	5.0	5.0	5.0
	Not to a Great Extent	7	35.0	35.0	40.0
	Neutral	6	30.0	30.0	70.0
	To a Great Extent	6	30.0	30.0	100.0
	Total	20	100.0	100.0	

Table 4.66: The response on whether no well-defined valuation of planned work is a challenge in implementing EVMS in Ethiopian megaprojects

As shown in Table 4.67, only 25% respondents think that there is well-defined metrics for the accomplishment of work. As shown in Table 4.68, 50% respondents think that no well-defined indicators and forecasts of cost performance, and they claimed this as an implementation challenges. As shown in Table 4.69, the same 50% respondents think that no well-defined indicators and forecasts of schedule performance, and they claimed this as an implementation challenges.

CHA - PER - No well-defined metrics for the accomplishment of work

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not to a Very Great Extent	3	15.0	15.0	15.0
	Not to a Great Extent	2	10.0	10.0	25.0
	Neutral	8	40.0	40.0	65.0
	To a Great Extent	7	35.0	35.0	100.0
	Total	20	100.0	100.0	

Table 4.67: The response on whether no well-defined metrics for the accomplishment of work is a challenge in implementing EVMS in Ethiopian megaprojects

CHA - PER - No well-defined indicators and forecasts of cost performance

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not to a Very Great Extent	2	10.0	10.0	10.0
	Not to a Great Extent	3	15.0	15.0	25.0
	Neutral	5	25.0	25.0	50.0
	To a Great Extent	10	50.0	50.0	100.0
	Total	20	100.0	100.0	

Table 4.68: The response on whether no well-defined indicators and forecasts of cost performance is a challenge in implementing EVMS in Ethiopian megaprojects

CHA - PER - No well-defined indicators and forecasts of schedule performance

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not to a Very Great Extent	2	10.0	10.0	10.0
	Not to a Great Extent	4	20.0	20.0	30.0
	Neutral	4	20.0	20.0	50.0
	To a Great Extent	9	45.0	45.0	95.0
	To a Very Great Extent	1	5.0	5.0	100.0
	Total	20	100.0	100.0	

Table 4.69: The response on whether no well-defined indicators and forecasts of schedule performance is a challenge in implementing EVMS in Ethiopian megaprojects

As shown in Table 4.70, 60% of respondents said that there is poor understanding of EVM metrics and their relationships while 36.8% did not think there is poor understanding of EVM metrics and their relationships. EVM's wider acceptance and effectiveness may depend on better understanding of its capabilities (Anbari, 2003). Simplification of EVM calculations, use of graphical tools to enhance understanding of performance trends, and successful application of EVM in industry are important factors for the growth and effective use of this valuable method in project management.

CHA - PER - Poor understanding of EVM metrics and their relationships

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not to a Very Great Extent	1	5.0	5.3	5.3
	Not to a Great Extent	6	30.0	31.6	36.8
	Neutral	1	5.0	5.3	42.1
	To a Great Extent	10	50.0	52.6	94.7
	To a Very Great Extent	1	5.0	5.3	100.0
	Total	19	95.0	100.0	
Missing	System	1	5.0		
Total		20	100.0		

Table 4.70: The response on whether poor understanding of EVM metrics and their relationships is a challenge in implementing EVMS in Ethiopian megaprojects

As shown in Table 4.71, 50 % respondents did not think that EVM results are invalid because of inexperienced project planners, and they did not think that this is an implementation challenge.

As shown in Table 4.72, only 30 % respondents think that project managers don't know how to interpret EVM results, but 35% think otherwise, and 30% are neutral. Its wider acceptance and effectiveness may depend on better understanding of its capabilities (Anbari et.al. 2003). Simplification of EVM calculations, use of graphical tools to enhance understanding of performance trends, and successful application of EVM in industry are important factors for the growth and effective use of this valuable method in project management.

CHA - PER – EVM results are invalid because of inexperienced project planners

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not to a Very Great Extent	5	25.0	26.3	26.3
	Not to a Great Extent	5	25.0	26.3	52.6
	Neutral	3	15.0	15.8	68.4
	To a Great Extent	4	20.0	21.1	89.5
	To a Very Great Extent	2	10.0	10.5	100.0
	Total	19	95.0	100.0	
Missing	System	1	5.0		
Total		20	100.0		

Table 4.71: The response on whether EVM results are invalid because of inexperienced project planners is a challenge in implementing EVMS in Ethiopian megaprojects

CHA - PER - PMs don't know how to interpret EVM results

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not to a Very Great Extent	1	5.0	5.3	5.3
	Not to a Great Extent	6	30.0	31.6	36.8
	Neutral	6	30.0	31.6	68.4
	To a Great Extent	4	20.0	21.1	89.5
	To a Very Great Extent	2	10.0	10.5	100.0
	Total	19	95.0	100.0	
Missing	System	1	5.0		
Total		20	100.0		

Table 4.72: The response on whether project managers don’t know how to interpret EVM results is a challenge in implementing EVMS in Ethiopian megaprojects

The overall statistical mean score for EVM implementation challenges related to performance is shown below in Table 4.73. The respondents confirmed that no well-defined valuation of planned work and no well-defined metrics for the accomplishment of work is less of a challenge in EVM implementation. The notion that EVM results are invalid because of the inexperienced project managers is not bought by the respondents.

Implementation Challenges – Performance

	N	Minimum	Maximum	Mean		Std. Deviation
	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic
CHA - PER - EVM for successful project deliveries of past project	20	1	5	3.65	.233	1.040
CHA - PER - EVM to terminate projects	19	1	5	3.37	.244	1.065
CHA - PER - No common understanding of EV metrics	19	2	4	3.05	.179	.780
CHA - PER - No well-defined valuation of planned work	20	1	4	2.85	.209	.933
CHA - PER - No well-defined metrics for the accomplishment of work	20	1	4	2.95	.235	1.050
CHA - PER - No well-defined indicators and forecasts of cost performance	20	1	4	3.15	.233	1.040
CHA - PER - No well-defined indicators and forecasts of schedule performance	20	1	5	3.15	.254	1.137
CHA - PER - Poor understanding of EVM metrics and their relationships	19	1	5	3.21	.260	1.134
CHA - PER – EVMresults are invalid because of inexperienced project planners	19	1	5	2.63	.317	1.383
CHA - PER - PMs don't know how to interpret EVM results	19	1	5	3.00	.254	1.106
Valid N (listwise)	18					

Table 4.73: The overall response on the challenges of implementing EVMS in Ethiopian megaprojects with factors related to EVM Performance

4.4: The Assessment of the Benefits That Could Be Realized If Ethiopian Selected Megaprojects Implements EVMS.

A set of a number of questions related to the benefits that projects realized if they implement EVM had been asked to respondents. The reliability test for items related to the benefits of implementing EVM as follows.

As shown in Table 4.74, 80% of respondents think that EVM improve planning process. (Netto et. al,.2020) identified the definition of scope and schedule, team training, top management support, and the need of pre-defined procedures as observed critical factors in the use of EVM in construction companies. These observed critical factors are the essential elements in the planning process of project implementation. This is also identified by Marshal (2007), Kim et.al(2003), Vargas (2008), Valle and Soares (2006).

BEN - REA - Improve planning process

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not to a Very Great Extent	1	5.0	5.0	5.0
	Not to a Great Extent	2	10.0	10.0	15.0
	Neutral	1	5.0	5.0	20.0
	To a Great Extent	8	40.0	40.0	60.0
	To a Very Great Extent	8	40.0	40.0	100.0
	Total	20	100.0	100.0	

Table 4.74: The response on whether EVM improve planning process in Ethiopian megaprojects

As shown in Table 4.75, 75% respondents think that EVM help to have clear definition of work scope within the project. EVM assists in defining the scope (Marshal, 2007; Kim et.al, 2003; Vargas, 2008; Valle and Soares, 2006).

Moreover, as shown in Table 4.76, 70% respondents think that EVM promotes clear responsibility of work effort. EVM can be used for progress payments to contractors based on the EV of contracted or outsourced work (Anbari et.al. 2003). Because such contractual arrangements create legal and financial obligations, it is important to consider the method specified for evaluating progress.

However quiet significant number of respondents, as shown in Table 4.77, 85% respondents also confirmed that EVM provide early warning of potential problems. EVM provides project managers and the organization with triggers or early warning signals that allow them to take timely actions in

response to indicators of poor performance and enhance the opportunities for project success (Anbari, 2003). Such indicators have been found to be reliable as early as 15% into a project. Better planning and resource allocation associated with the early periods of a project might be the cause of this reliability (Fleming & Koppelman, 2000). EVMS can provide valid benefits like early warning signals through CPI and SPI(Salikuma and Johny, 2016).

BEN - REA - Clear definition of work scope

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not to a Great Extent	3	15.0	15.0	15.0
	Neutral	2	10.0	10.0	25.0
	To a Great Extent	9	45.0	45.0	70.0
	To a Very Great Extent	6	30.0	30.0	100.0
	Total	20	100.0	100.0	

Table 4.75: The response on whether EVM clear definition of work scope in Ethiopian megaprojects

BEN - REA - Clear responsibility for work effort

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not to a Great Extent	3	15.0	15.0	15.0
	Neutral	3	15.0	15.0	30.0
	To a Great Extent	7	35.0	35.0	65.0
	To a Very Great Extent	7	35.0	35.0	100.0
	Total	20	100.0	100.0	

Table 4.76: The response on whether EVM clear responsibility for work effort

BEN - REA - Early warning of potential problems

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not to a Great Extent	1	5.0	5.3	5.3
	Neutral	1	5.0	5.3	10.5
	To a Great Extent	7	35.0	36.8	47.4
	To a Very Great Extent	10	50.0	52.6	100.0
	Total	19	95.0	100.0	
Missing	System	1	5.0		
Total		20	100.0		

Table 4.77: The response on whether EVM promote early warning of potential problems

Similarly, as shown in Table 4.78, 85% respondents think that EVM support to identify problem areas for immediate and proactive management attention. EVM helps focus management's interest on projects that need most attention and may aid the prioritization and emphasis management gives projects within a portfolio, enhancing the enterprise's project portfolio management (Anbari, 2003). EVM was seen to have positively affected project performance (Nkiwane et.al. 2016). It was said to have given the project direction and allowed project management to focus on problem areas. EVM allows project problems to be anticipated(Marshal, 2007; Kim et.al, 2003).

BEN - REA - Identify problem areas for immediate and proactive management attention

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not to a Great Extent	1	5.0	5.0	5.0
	Neutral	2	10.0	10.0	15.0
	To a Great Extent	9	45.0	45.0	60.0
	To a Very Great Extent	8	40.0	40.0	100.0
	Total	20	100.0	100.0	

Table 4.78: The response on whether EVM help to identify problem areas for immediate and proactive management attention

As shown in Table 4.79, 80% respondents said that EVM enables more accurate reporting of cost and schedule impacts of known problems. For long-term projects, it may be appropriate to consider incorporating the time value of money and time-discounted cash flows into EVM (Anbari, 2003). Inflation can be explicitly considered in EVM, and the inflation variance (IV) can be calculated (Farid & Karshenas, 1988). However, these considerations add complexity to the method and may be justifiable only for very long-term projects or in very high inflation periods or economies.

As shown in Table 4.80, 85% of respondents think that EVM promotes consistent and clear communication of progress at all management levels. Netto et al (2020) identified project anticipating project and project communication and the definition of scope and schedule are among the observed benefits in the use of EVM in construction companies.

A relatively lower number of respondents, as shown in Table 4.81, 75% respondents confirmed that EVM improves project visibility and accountability. EVM produces valuable insight to organization (Salikuma and Johny, 2016).

BEN - REA - Enables more accurate reporting of cost and schedule impacts of known problems

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not to a Great Extent	2	10.0	10.0	10.0
	Neutral	2	10.0	10.0	20.0
	To a Great Extent	8	40.0	40.0	60.0
	To a Very Great Extent	8	40.0	40.0	100.0
	Total	20	100.0	100.0	

Table 4.79: The response on whether EVM enables more accurate reporting of cost and schedule impacts of known problems

BEN - REA - Consistent and clear communication of progress at all management levels

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not to a Great Extent	2	10.0	10.0	10.0
	Neutral	1	5.0	5.0	15.0
	To a Great Extent	9	45.0	45.0	60.0
	To a Very Great Extent	8	40.0	40.0	100.0
	Total	20	100.0	100.0	

Table 4.80: The response on whether EVM enables consistent and clear communication of progress at all management levels

BEN - REA - Improves project visibility and accountability

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Neutral	4	20.0	21.1	21.1
	To a Great Extent	6	30.0	31.6	52.6
	To a Very Great Extent	9	45.0	47.4	100.0
	Total	19	95.0	100.0	
Missing	System	1	5.0		
Total		20	100.0		

Table 4.81: The response on whether EVM improves project visibility and accountability

However, as shown in Table 4.82, 85% respondents think that EVM enables on time project delivery. Practicing EVM can help project stay on time and on budget (Salikuma and Johny, 2016).

BEN - REA - Enables on time project delivery

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Neutral	3	15.0	15.0	15.0
	To a Great Extent	7	35.0	35.0	50.0
	To a Very Great Extent	10	50.0	50.0	100.0
	Total	20	100.0	100.0	

Table 4.82: The response on whether EVM enables on time project delivery

Relatively higher respondents, as shown in Table 4.83, 90% respondents think that EVM enables within budget project delivery. Practicing EVM can help project stay on time and on budget (Salikuma and Johny, 2016). Netto et al (2020) identified achieving project cost as one of the observed benefits in the use of EVM.

BEN - REA - Enables within budget project delivery

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Neutral	2	10.0	10.0	10.0
	To a Great Extent	9	45.0	45.0	55.0
	To a Very Great Extent	9	45.0	45.0	100.0
	Total	20	100.0	100.0	

Table 4.83: The response on whether EVM enables within budget project delivery

Relatively lower number of respondents, as shown in Table 4.84, 75% of respondents think that EVM improves customer or client satisfaction.

BEN - REA - Improves customer or client satisfaction

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Neutral	5	25.0	25.0	25.0
	To a Great Extent	10	50.0	50.0	75.0
	To a Very Great Extent	5	25.0	25.0	100.0
	Total	20	100.0	100.0	

Table 4.84: The response on whether EVM improves customer or client satisfaction

As shown in Table 4.85, however 90% of respondents think that EVM improves project team collaboration and communication. Netto et al (2020) identified project communication as one of the critical success factor in the use of EVM in construction companies.

BEN - REA - Improves project team collaboration and communication

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Neutral	2	10.0	10.0	10.0
	To a Great Extent	11	55.0	55.0	65.0
	To a Very Great Extent	7	35.0	35.0	100.0
	Total	20	100.0	100.0	

Table 4.84: The response on whether EVM improves project team collaboration and communication

As shown in Table 4.85, the overall statistical mean score of greater than 4 points showed EVM has positive benefits and contribution to project success. A number of literature reviews (Abdul-Rahman and Norjumaah, 2010; Hunter, Fitzgerald and Barlow, 2014; Henderson, 2007; Candido, Heineck and Neto, 2014; Gershon,2013; Khamidi and Idrus,2011; Mofid,2011; Marshal,2007) support the positive contribution of EVM. Sham (2008) states that coupling with EVM problems in cost and schedule overruns can be eliminated. Besides, Mofid(2012) constructed a case study in the effectiveness of applying EVM and derived a report providing exact project information and the decisions in mitigating the risks. Furthermore, Hunter et al (2014) concluded that EVM provide clear understanding in project issue to the stakeholder and effective management decision. Apart from that, Marshall 2007) had also conducted research which suggested that EVM implementation result in great project success and moderate effect from contract. EVM was seen to have positively affected project performance (Nkiwane et al, 2016).

However, based on a review of available literature, Padalkar & Gopinath noted two facts (1) adoption levels of EVM remain low (Kim et al.2003; Besner Hobbs 2006, Rozenes et al.2006; Marshal et al. 2008; De Marko and Narbaev 2013; Singh et al.2014), and (2) the literature is ‘largely anecdotal’ in nature, with very few empirical studies on post-adoption experience (Kim et al. 2003; Marshall et al. 2008).

Opinions on Benefits Realized/Project Success as a Result of Implementing EVMS

	N	Minimum	Maximum	Mean		Std. Deviation
	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic
BEN - REA - Improve planning process	20	1	5	4.00	.262	1.170
BEN - REA - Clear definition of work scope	20	2	5	3.90	.228	1.021
BEN - REA - Clear responsibility for work effort	20	2	5	3.90	.240	1.071
BEN - REA - Early warning of potential problems	19	2	5	4.37	.191	.831
BEN - REA - Identify problem areas for immediate and proactive management attention	20	2	5	4.20	.186	.834
BEN - REA - Enables more accurate reporting of cost and schedule impacts of known problems	20	2	5	4.10	.216	.968
BEN - REA - Consistent and clear communication of progress at all management levels	20	2	5	4.15	.209	.933
BEN - REA - Improves project visibility and accountability	19	3	5	4.26	.185	.806
BEN - REA - Enables on time project delivery	20	3	5	4.35	.167	.745
BEN - REA - Enables within budget project delivery	20	3	5	4.35	.150	.671
BEN - REA - Improves customer or client satisfaction	20	3	5	4.00	.162	.725
BEN - REA - Improves project team collaboration and communication	20	3	5	4.25	.143	.639
Valid N (listwise)	18					

Table 4.85: The overall response on possible benefits of implementing EVM in Ethiopian megaprojects.

CHAPTER FIVE
SUMMARY, CONCLUSION AND RECOMMENDATION

5.1: Introduction

The research attempted to assess the practices and challenges of implementing EVMS in selected Ethiopian megaprojects such as road, railway and hydropower generation projects. It also attempts to discover the practices in Ethio telecom multibillion multi-site projects. In assessing the practices of EVMS in selected Ethiopian megaprojects, the research adopted the simplified version of the 32 EVMS criteria defined by ANSI. This research also attempted to assess the challenges of implementing EVMS in Ethiopian megaprojects. Other aspect of this research attempted to assess on the opinions of respondents on how projects benefits from implementing EVMS, i.e. the contribution of implementing EVMS on project success.

The research organized the assessment of the practices of EVMS in selected Ethiopia megaprojects around the five categories of the 32 EVMS criteria as defined by ANSI. The five categories are organization, planning, scheduling, and budgeting system, accounting, analysis, and revision.

In assessing the challenges of implementing EVMS in selected Ethiopian megaprojects, the research employed Kim's implementation model which involved factors related to EMV acceptance, use and performance. However, the author has used its own parameters or items for assessing each.

In also assessing on the opinions of project managers and consultants on benefits of implementing EVMS, this research used items identified as possible benefits in a variety of literatures cited in the literature review chapter of this thesis.

5.2: Summary

1. Assessment on the Practices of Implementing EVMS on Selected Ethiopian Megaprojects

The summary of this research finding is organized by the five categories: **organization**; **planning, scheduling and budgeting system**; **accounting**; **analysis**; and **revision**.

A. Organization

In meeting the organization criteria, Ethiopian megaprojects are yet to improve to a great extent. In aspects of the organization criteria, there should be improvement to be made with mean value of 3.81. Defining work elements and responsibilities are the basics of foundation for implementing EVMS. The organization should identify overheads and provide for performance management in a way an integrated system is established for accurate and timely cost and time measurement is done and scoped is defined and changed. The organization criteria is also the basis for planning, scheduling, and budgeting, but the improvements on the overall mean value from organization to planning criteria can be explained that project managers redefine and learn things overtime.

B. Planning, Scheduling and Budgeting System

Among the criteria to be met to ensure the EVMS is implemented appropriately and accurately is the planning, scheduling and budgeting. The planning, scheduling and budgeting criterion is the basis for the accuracy and reliability of the EVM results. Based on the response from 20 respondents, the Ethiopian megaprojects met this criterion with the overall mean value of 4.015. This tells us that Ethiopian megaprojects employed to a great extent a formal planning, scheduling, and budgeting system, and they, to a great extent, establish a project baselines which allows performance to be measured.

C. Accounting

In accounting criteria of EVMS, respondents in selected megaprojects of Ethiopia, projects identify unit/lot costs to a great extent. But the recording of direct costs, indirect costs and material costs, and providing summarized Work Breakdown Structure (WBS) and direct costs is yet to be improved.

D. Analysis

The analysis criteria require the measurement and analysis of actual performance against the authorized baseline and the forecasting of final results based on actual project performance.

Respondents said that in megaproject they have participated, projects identify and analyze schedule and cost variance to a great extent. They also responded that to a great extent projects develop revised estimates of cost at completion. The researcher was able to confirm

from the informal discussions with respondents that identification and analysis of schedule and cost variance not strictly follow EVM, but they rather do it in their own way of doing it that resemble EVM. Respondents confirm that projects they have participated provided a somewhat less emphasis to analyzing indirect costs, summarizing data for variance analysis and reporting, and take managerial decision-making based on this variance report. The interviewee from the Ethiotelecom with a number of experience in Ethiopian Ethiotelecom multibillion Birr projects at different sites said that " If EVM has any value to add to the current project management endeavor in Ethio telecom, it is a summary data elements and variances for reporting", he added " you see, some program and project managers are not supposed to be involved in the details of project activities, we just need and are entitled to get a summary data on the dashboard from EVMS , and take appropriate decision accordingly. But with the current system everyone involved in the details, however, we have a project management technique that consider elements of EVM, not exactly but if resembles it but that doesn't save us from involving in the details. But here in Ethio telecom we have a system that is adaptable and scalable that we can integrate EVMS easily than other project organizations, I could say, we can simply integrate EVMS as a module into our system."

E. Revision

Projects require the timely approval or rejection, and the incorporation of approved changes. In related to revision criteria, the overall response from Likert scaled questionnaire with the mean value of 4.09 pointed that projects have timely approval or rejection, and the incorporation of approved changes.

2. Challenges of Implementing EVMS on Selected Ethiopian Megaprojects

In assessing the challenges of implementing EVMS in selected Ethiopian megaprojects, the research employed Kim's implementation model which involved factors related to EMV acceptance, use and performance. The summary of this research's findings are based on these factors.

A. Factors Related to the Acceptance in Challenges of Implementing the EVMS on Selected Ethiopian Megaprojects.

The challenges of implementing EVMS on selected Ethiopian megaprojects with factors related the acceptance of EVM is still significant with the overall mean value of 3.12. It is only the financial items that stand out as the main challenge, with the overall mean of 4.15, for implementing EVMS. The respondents for other items have 'neutral' or 'no to a great extent' position that need to be addressed. For example, respondents are somehow neutral on to what extent poor understanding of EVM, to what extent the lack of EVM as a contractual requirements, to what extent the type of contract, whether or not forecasting and variance is an interest at all, and whether changes in work scope, the view that the shortfall to accept to accept new technique and the sufficiency of simple ways to control have an impact in accepting EVM. However, respondents did not think that lack of management support, cultural problems, high cost, complicated and burdensome paper, unstable government policies, and unpredictable conditions are serious issues or challenges in implementing EVMS in selected Ethiopian megaprojects.

B. Factors Related to the Use in Challenges of Implementing the EVMS on Selected Ethiopian Megaprojects.

The challenges of implementing EVMS on selected Ethiopian megaprojects with factors related to the use of EVMS are serious issues with the overall mean value of 2.90. Factors related to the use of EVMS related to the projects experiences in using EVM, the use of integrated project teams, the use of project management techniques and tools such as critical path method and Pert and others as the complementary scheduling tool and high levels of cross-organizational boundary communication. Based on this notion, this research sought to understand the level of detail and frequency in EVM use, the existence and use of EVM analyst or specialist, use of appropriate software system and other project management techniques and tools, response to cost and schedule changes in projects, whether WBS are appropriately defined, whether project managers and consultants have knowledge on monitoring and evaluation of EVM metrics or indices, better cost collection and estimation

system, use of integrated project teams, and other organizational level of communication among project teams and stakeholders(for example, pressure to report only good news).

Almost all measurement items showed there significant problems- in cost collections and estimation system (mean = 2.80), on the use of appropriate software (mean = 2.85), on the existence of EVM analyst (mean = 3.32), pressure to report only good news (mean = 2.45), on cost and schedule changes (mean = 3.30), and on the lack of well-defined WBS at appropriate levels (mean = 2.70).

C. Factors Related to the Performance in Challenges of Implementing the EVMS on Selected Ethiopian Megaprojects.

On factors related to performance in the challenges of implementing EVMS with factors related to the performance, respondents are somewhat neutral with the overall mean value of 3.04. More importantly however, respondents from selected Ethiopian megaprojects did think that megaprojects have features that promote the implementation of EVMS. Among them are well defined WBS, appropriate performance baseline, appropriate cost collection and estimation system, valuation of planned work and metrics for accomplishment of work etc.
Putz et al., (2007) describe a NASA case study pointing out problems in setting up baselines, lack of baseline validation, and weakness in cost estimates. Lukas (2007) lists ten pitfalls for EVM usage including incomplete requirements or their documentation, WBS-Schedule-Budget integration issues, inapplicability/resistance to WBS, ineffective change processes, and inadequate cost systems. DeMarco and Narbaev(2013) describe the stumbling blocks for EVM such as level of detail in plans/schedules and measurement reliability- especially assessment of work package completion.

3. The Contribution of Implementing EVM on selected EVMS for Project Success

The opinions' of respondents on benefits realized/project success as a result of implementing EVMS with the overall mean value of 4.17 pointed that implementing EVMS contributes to project success.

4. Responses on the open-ended questions:

A. What is your opinion on the current project management practices especially with regard to using Earned Value Management in Ethiopian megaprojects?

All respondents strongly agree that the use of EVM is an important practice that must be pursued. However, all respondents did not deny the challenges faced such as the difficulty to have all the expertise and professional at all levels to implement EVMS, the problems on the availability of real and reliable data for analysis, i.e., data could not be produced and produced data for analysis do not allow for EVMS to be practicable- for example, road projects are doomed to be delivered over budget and late.

Respondents also believed, in general, that training and the cost of customized software solutions need to be considered, and also think that a much more benefits could be captured if EVM could really track the quality of project works done. The limitation that EVM does not involve quality management is also indicated by Gedi et al (2015). A number of literatures however made an effort to incorporate quality in EVMS.

A particular respondent from ERA believed that as a nation, Ethiopia failed to manage projects properly. The same respondent think that Ethiopian projects lack appropriate development of WBS and OBS at the most appropriate level. As a consequence, projects fail and so many contractors and subcontractors were knocked out from the industry. Then, he added that if we had implemented the EVMS and intervened in several past projects in due time, a great number of projects could have been saved from suffering overrun and delay, and contractors could have been grown stronger today.

In the same vein, a particular respondent from EEP think that one of the reasons why almost all projects delayed in Ethiopia is lack of knowledge and skill in project management. The respondents added that managers in EEP projects use elements of EVMS due to a reason that they have been working with qualified international consultants with level of EVMS knowledge and expertise. However, it should be noted that EEP megaprojects do not implement and practice the EVMS as ‘hard fact’ to manage the megaprojects. But a somewhat better utilization of EVMS is noted however in Ethiopian railways megaprojects.

Based on a review of available literature, Padalkar & Gopinath noted two facts (1) adoption levels of EVM remain low (Kim et al.2003; Besner Hobbs, 2006, Rozenes et al.,2006; Marshal et al. 2008; De Marko and Narbaev 2013; Singh et al.2014), and (2) the literature is 'largely anecdotal' in nature, with very few empirical studies on post-adoption experience (Kim et al., 2003; Marshall et al., 2008).

B. What is your opinion on the challenges of implementing Earned Value Management in Ethiopian megaprojects?

Respondents identified the following as the challenges of implementing EVMS in Ethiopian megaprojects:

i. Lack of EVM knowledge, expertise, experience, and EVMS required competent professionals at all levels.
ii. Lack of revised work schedule and poor baseline work program by the contractors on road projects in particular.
iii. Most of the people involved in megaprojects do not know how to record, monitor, and measure the earned value.
iv. EVM as a tool is not a standalone tool, it requires of other tools such as critical path method(CPM), EVM requires timely and accurate data, time and budget, staff training, and does not have a mechanism to track the quality of works done etc.
v. A stable and predictable economic system is an impetus for EVMS implementation.
vi. Contractors' poor organizational and financial arrangements
vii. Poor systems in Ethiopia in order to collect cost data in due time.
viii. Cost and schedule changes due to resource availability and constraints, and timing of change orders.
ix. Lack of mandatory provision on part of government to enforce implementation of EVM in Ethiopian megaprojects. However, a particular respondent from ERA informed that EVM is used for evaluation of bidders on procurement of new road projects.

C. What is your opinion on the future direction of implementing EVMS in Ethiopian megaprojects?

Respondents reflected the following opinions:

i. EVMS should be adopted and implemented strictly and monitored properly on future megaprojects so as to assure the successful delivery of projects.
ii. EVMS promotes strong data management system in the future, however, should incorporate mechanism or feature that enable us to measure quality aspects of the project works.
iii. A stable and predictable economic system is an impetus for EVMS implementation. A better tool and mechanism to create stable and predictable economic system will surely have a great contribution in promoting the implementation of EVMS.
iv. The comprehensive competency on project management, not solely on EVMS, is an important element on the successful use of EVMS in Ethiopian megaprojects.
v. EVMS improves the current practice of project monitoring system in Ethiopian megaprojects. EVMS require proper and systematic implementation at all levels; once strong basis for EVMS is established, then could be moved to institutionalize it.
vi. Due to the increasing competition among contractors and the possibility that the Ethiopian government mandates, in the future, on the use of EVMS on projects, the application of the EVMS may increase.

D. What is your opinion on whether Ethiopian government should mandates the use of EVMS in Ethiopian megaprojects?

The respondents reflected the following points whether the Ethiopian government should mandate the use of EVMS in Ethiopian megaprojects.

i) The nature and complexity of the projects should be taken in to consideration for the government to mandate the use of EVMS on public projects.
ii) Respondents from railway projects did not think that government should mandate the use of EVMS (The researcher made a failed attempt to get the reason behind this opinion).

iii) The government should mandate the EVMS but a ground works have to be done on the part of the government such as comprehensive EVMS package that suits to Ethiopian megaprojects and its management practices must first be produced, for example, government rules and regulations, quality and risk and other project management and performance measurement features. This comprehensive EVMS packages need to be communicated and appropriate training should be provided. For this, government should give priority and attention, and appropriate budget and customized comprehensive software and network solutions need to be first in place.

iv) Other groups of respondents think that it is advisable to mandate the use of EVMS in Ethiopia once the practice is well established. EVMS is an increasingly popular tool that many developing nations are adopting; this will facilitate the adoption of EVMS by the international standard. Therefore the initiative to mandate EVMS in Ethiopian public megaprojects creates a foundation for that and an experience for change.

v) In particular, respondents emphasized that the government mandates the use of EVMS; this is because that public projects are constructed with the money out of poor's people pocket- so that tracking project schedule and budget every day of the project duration till its completion is a very important issue that need to be addressed. One effective system currently available that help us to do so is EVMS. The EVMS is especially an effective tool for program evaluation and performance monitoring; and for claim or dispute resolution purposes.

5. Responses on the interview with a senior program manager at Ethio telecom multi-site megaprojects:

A. Can you list megaprojects in Ethiopia that you are fully aware of that implemented earned value management?

They do not think there are any. However, every project might have more or less methods that help them address some elements of EVM. Every organization might have different interests to cost, time and scope of the project and it differs from one project type to the other. For example, in Ethio telecom, there might have multiple projects that costs up to

10 billion birr. In such multi-site projects, 98% the project costs are for material and professional services fees, the remaining costs is for labors and other stuff. In such projects, time is even more important than costs. We try to address cost, time and scope issues in different ways than it is put in EVM in hard facts. We have technical and financial index to follow up the progress of the project.

B. Do you think that EVMS is preplanned in megaprojects, completed or underway from the year 2000-2021, you have been involved? In what megaprojects?

All respondents indicated that EVMS is not preplanned in megaprojects they involved. This is however from the point of 'hard facts'. For example, in the case Ethio telecom, the existing system promotes EVM implementation, i.e., our current information technology and software system can entertain the EVM software solution package as a module.

C. How far do you think the deviations identified through EVMS in megaprojects you have been involved, completed or underway from the year 2000-2021, are used for a management intervention?

This is again that Ethio telecom has not implemented EVMS, but has a different system that is more or less addresses the things considered by EVMS. We have ways to address deviations, crushing, parallel execution of project activities, implementing catch plans etc.

D. What challenges you have encountered in implementing EVM as a tool of monitoring and evaluation?

The general perspective is that organizations should have strong project management experience and maturity level before implementing EVM. Therefore, program and project managers, engineers and consultants need to be given very through and applicable EVM trainings. Organizations should also start to look EVM as a tool and implements it.

E. To what extent EVM is relevant and applicable to Ethiopian megaprojects?

EVM can be applicable to any projects of different size and complexity. It is a single system the address project cost, time, and scope and promotes the well-defined project organization, planning, scheduling, budgeting, analysis and change.

F. What do you suggest for implementing EVM in Ethiopian megaprojects?

Training is a major step to move forward to implementing EVM.

G. Do you think that EVM should be mandated for Ethiopian megaprojects?

EVMS might be on the table for all inclusive and participative dialogue and discussion that national and international experts are invited. Government mandate must come from project maturity level of organizations.

H. Do you think implementing EVM promotes project success in the case of Ethiopian project management endeavor?

Yes! But the questions such as 'Where do you apply it?" need to be addressed. How far do we know if there are project managers in Ethiopia well trained in EVM? They think there are not enough! But project managers could easily be trained for EVM.

I. Any closing remark?

EVM could easily be implemented in Ethiotelecom. The current software solution can simply take EVM software solution as a module. Ethiotelecom has all foundation to implement EVM. Ethiotelecom's organizational structure has Chief Executive Officer (CEO), Chief Technical Officer (CTO) or Program Director, Program Manager, and Project Manager, and all these need a concise and summary report on project progress. Our current system requires CEO, CTO, Program and project managers to see the details of all project activities and make decisions, and this is not appropriate and efficient way of doing things and engaging people. Thus, they think EVMS has all to provide these summary level indices that could help them make appropriate and timely decisions. This tool is welcomed for this.

5.3: Conclusion an Recommendation

5.3.1 Conclusion and recommendation on the assessment of the practices of EVMS in selected Ethiopian megaprojects

The assessment of the practices of EVMS in selected megaprojects in regard to the organization criteria found out that megaprojects somehow defined the entire project scope, an integrated project baseline(scope, schedule and cost) using a work breakdown structure(WBS), management control responsibilities using control account plans(CAPs) is established, and all CAPs are assigned to the functional organizations. But this however is not to the standards that are expected from megaprojects; therefore a great deal of improvement is required on this regard. Especially megaprojects have a relatively poor practice in managing overheads and identifying project responsibilities well.

The assessment of the practices of EVMS in selected megaprojects in regard to the planning, scheduling and budgeting criterion found that there are poor practices with regard to summarizing work packages to control purpose, in identifying and controlling the level of effort, and provide less emphasis to establishing overhead budgets and summarizing budgets to the target cost. However, megaprojects established a relatively better scheduling and budgeting of work, and provide for the planning of the performance measurement baseline. In addition, the finding from this research indicated that megaprojects are yet relatively far from establishing a formal scheduling system, in particular, a comprehensive project master schedule. This pointed that megaprojects yet exhibited gap in effectively implementing EVMS because EMVS requires that the projects' planned value is to be determined by compliance to this criterion.

The assessment of the practices of EVMS in selected megaprojects in regard to the accounting criterion found that given the relative simplicity of recording direct costs, there still gaps in megaprojects. Similar gaps were also found in megaprojects in summarizing direct cost into both WBS and OBS in which control accounts are used as basis for the accounting systems which can measure planned value, earned value and actual costs. Megaprojects in Ethiopia also experience poor practices on recording indirect costs and

material costs while exhibited better performance on identifying unit/lot cots. This is a paradox however that needs to be reexamined.

The assessment of the practices of EVMS in selected megaprojects in regard to the analysis criterion found that megaprojects in Ethiopia identify and analyze schedule variance and cost variance but respondents claimed that a relatively low performance in analyzing indirect costs. It was also found that megaprojects should establish better system for summarizing data elements and variance reporting by summarizing variances upward through WBS or horizontally by organizational units. This needs to be addressed because that is one of the key aspects of EVMS and help implement managerial actions. Moreover, however the majority of respondents claimed that they develop revised estimates of cost at completion, the accuracy of such estimates are yet in question provided the gap identified in other criterion.

The assessment of the practices of EVMS in selected megaprojects in regard to the revision criteria found that megaprojects in Ethiopia somehow give due attention in incorporating and managing changes. That is megaprojects in Ethiopia more or less incorporate changes into plans, budgets, and schedules; reconcile budget changes, control revisions to the budget; and document changes to the PMB but exhibited less control to retroactive changes.

5.3.2: Conclusion and recommendation on the assessment of the Challenges of Implementing EVMS in selected Ethiopian megaprojects

The challenges of implementing earned value management are assessed based on Kim's et al (2003) model for effective implementation. This includes factors related to EVM acceptance, factors related to EVM use, and factors related to EVM performance.

The Challenges of Implementing EVMS with Factors Related to Acceptance

The findings on the challenges of implementing EVMS with factors related to EVM acceptance include:

- Shortfall to accept new technique is not a key factor that hinders the implementation of EVM in Ethiopian megaprojects.
- Lack of management support does not really seriously hinder the implementation of EVM in Ethiopian megaprojects.
- Cultural problems have little impact in implementation of EVM in Ethiopian megaprojects.
- High cost, complicated and burdensome paper do not impede EVM implementation in Ethiopia megaprojects.
- Poor understanding of EVM is a major challenge in implementing EVM in Ethiopian megaprojects.
- Because of the size and scale of megaprojects, the view that the sufficiency of simple ways to control project is irrelevant.
- Lack of EVM as a contractual requirement is not a major impediment to implementation of EVM in Ethiopian megaprojects, and in the same vein, the type of contract of megaprojects is not really a major challenging factor.
- Provided that the case projects are megaprojects, a logical conclusion can be made that project forecasting and variances are an important aspect of megaproject management; the same conclusion was inferred from this research.
- There is a great tendency that changes in works cope in Ethiopian megaprojects create an impediment for EVM implementation.
- Technical factors are not seriously challenging factors in implementing EVM in Ethiopian megaprojects. Technical factors include design changes, weak control, inaccurate evaluation of project time, nonperformance of subcontractors and nominated suppliers and lack of appropriate software etc.
- Financial factors are a serious challenge in implementing EVM in Ethiopian megaprojects. Financial factors include inflation of prices, dependency on imported materials, financing and payment of completed work, and risks and uncertainty associated with project etc.

- There is a great tendency that contractual factors have an impact on EVM implementation in Ethiopian megaprojects. Contractual factors include contract and specification, interpretation and disagreement, and conflict between project parties etc.
- There is low tendency that unstable government policies have impact on EVM implementation on Ethiopia megaprojects.
- There is low tendency that unpredictable weather conditions have impact on EVM implementation on Ethiopian megaprojects.

The Challenges of Implementing EVMS with Factors Related to Use

The findings on the challenges of implementing EVMS with factors related to EVM use include:

- There is a tendency that poor cost collection and estimation system impedes EVM implementation in Ethiopian megaprojects.
- There is low tendency that lack of use of appropriate software system impedes EVM implementation in Ethiopian megaprojects.
- The non-availability of EVM analyst or specialist has a moderate but increasing impact on EVM implementation in Ethiopian megaprojects.
- There is very low tendency that 'pressure to report only good news' have an impact on EVM implementation in Ethiopian megaprojects.
- There is a great tendency that cost and schedule changes have impact on EVM implementation in Ethiopian megaprojects.
- Megaprojects claimed that they have well-defined WBS that the lack of well-defined WBS at its most appropriate level is not an issue in implementing EVM.
- There is very low tendency that inappropriate performance baselines are the reasons for not appropriately implementing EVM in Ethiopian megaprojects.
- The level of awareness on monitoring and evaluation of EVM metrics or indices has a major impact on EVM implementation in Ethiopian megaprojects.

The Challenges of Implementing EVMS with Factors Related to Performance

The findings on the challenges of implementing EVMS with factors related to performance include:

- Applying elements of EVM are good for successful project deliveries of past projects.
- EVM may contribute to the termination of projects however it was not possible to further confirm on this proposition.
- Ethiopian megaprojects have not established system for common understanding of EVM metrics and their relationships.
- Ethiopian megaprojects experienced gaps in having well-defined valuation of planned work and for the accomplishment of work.
- Ethiopian megaprojects do not have well-defined indicators and forecasts of cost performance, and similarly they do not have well-defined indicators and forecasts of schedule performance; and therefore are a challenge in EVM implementation.
- Inexperienced project planners are not the major causes of invalid EVM results hence are not implementation challenge. But there are still a significant number of project managers who don't know how to interpret EVM results.

5.3.3: Conclusion and recommendation on the assessment of the Benefits Realized As a Result of Implementing EVMS in selected Ethiopian megaprojects

The findings on the benefits realized as a result of implementing EVMS with factors related to performance include:

- EVM improve planning process in Ethiopian megaprojects.
- EVM helps to have clear definition of work scope within Ethiopian megaprojects.
- EVM promotes clear responsibilities of work effort in Ethiopian megaprojects
- EVM provides early warning of potential problems in Ethiopian megaprojects.
- EVM support to identify problem areas for immediate and proactive management attention in Ethiopian megaprojects.
- EVM enables more accurate reporting of cost and schedule impacts of known problems in Ethiopian megaprojects.

- EVM promotes consistent and clear communication of progress at all management levels in Ethiopian megaprojects.
- EVM improves project visibility and accountability in Ethiopian megaprojects.
- EVM enables on time project delivery in Ethiopian megaprojects.
- EVM enables within budget project delivery in Ethiopian megaprojects.
- EVM improves project team collaboration and communication
- The overall opinion on benefits realized as a result of EVM implementation in Ethiopian megaprojects is positive that EVM contributes to projects success.

5.3.4: Conclusion and recommendation on software available for EVMS implementation

The literature review evidence that the most widely used software solutions for EVMS implementation currently are Primavera from Oracle and Microsoft Project and Portfolio Management from Microsoft Inc. However different countries have different usage experiences.

The overall descriptive statistics is shown below (Table 5.1) to provide the comprehensive view on the results of the assessment.

The Overall Statistics of the Assessment

	N	Minimum	Maximum	Mean		Std. Deviation
	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic
ORG - Define authorized work elements(WBS elements)	20	1	5	3.95	.256	1.146
ORG - Identify organizational responsibilities	20	1	5	3.70	.263	1.174
ORG - Integrate system(cost, time, scope)	20	1	5	3.80	.277	1.240
ORG - Identify overhead management	20	1	5	3.70	.263	1.174
ORG - Provide for Performance Measurement	20	1	5	3.90	.289	1.294
PSB - Schedule the work	20	1	5	4.30	.219	.979
PSB - Identify products, milestones and indicators	20	1	5	4.20	.236	1.056
PSB - Plan the PMB	20	2	5	4.05	.256	1.146
PSB - Establish budgets for work	20	3	5	4.25	.176	.786

PSB - Identify work packages	20	3	5	4.30	.164	.733
PSB - Summarize work package budgets to control	20	2	5	3.85	.233	1.040
PSB - Identify and control LOE	20	2	5	3.85	.196	.875
PSB - Establish overhead budgets	20	2	5	3.80	.172	.768
PSB - Identify MR and UB	20	2	5	3.65	.196	.875
PSB - Summarize budgets to the target cost	20	2	5	3.90	.216	.968
ACC - Record direct costs	20	2	5	3.95	.235	1.050
ACC - Summarize WBS	20	2	5	3.90	.216	.968
ACC - Summarize direct costs	20	2	5	3.90	.228	1.021
ACC - Record indirect costs	20	2	5	3.60	.266	1.188
ACC - Identify unit/lot costs	20	2	5	4.05	.235	1.050
ACC - Record material costs	20	2	5	3.95	.235	1.050
ANA - Identify SV and CV	20	1	5	4.15	.233	1.040
ANA - Analyze SV and CV	20	3	5	4.30	.164	.733
ANA - Analyze indirect costs	20	2	5	3.75	.228	1.020
ANA - Summarize data elements and variances for reporting	20	2	5	3.90	.228	1.021
ANA - Implement managerial actions	20	3	5	3.95	.185	.826
ANA - Develop revised estimates of cost at completion	20	1	5	4.10	.250	1.119
REV - Incorporate changes into plans, budgets & schedules	20	3	5	4.25	.160	.716
REV - Reconcile budgets changes	20	2	5	4.05	.211	.945
REV - Control retroactive changes	20	2	5	3.80	.236	1.056
REV - Control revisions to the program budget	19	3	5	4.32	.154	.671

REV - Document changes to the PMB	20	2	5	4.05	.198	.887
CHA - ACP - Shortfall to accept new technique	19	2	5	3.47	.193	.841
CHA - ACP - Lack of management support	20	1	5	2.70	.300	1.342
CHA - ACP - Cultural problems	20	2	4	2.80	.156	.696
CHA - ACP - High cost, complicated and burdensome paper	20	2	4	2.90	.191	.852
CHA - ACP - Poor understanding of EVM	20	1	5	3.30	.291	1.302
CHA - ACP - The sufficiency of simple ways to control	19	2	4	3.21	.123	.535
CHA - ACP - Lack of EVM as a contractual requirements	20	1	5	3.20	.287	1.281
CHA - ACP - The type of contract	20	1	5	3.10	.289	1.294
CHA - ACP - Forecasting and variance impact not an interest at all	20	2	5	3.15	.209	.933
CHA - ACP - Changes in work scope	19	2	5	3.21	.249	1.084
CHA - ACP - Technical factors	20	1	5	2.80	.287	1.281
CHA - ACP - Financial factors	20	2	5	4.15	.196	.875
CHA - ACP - Contractual factors	20	2	5	3.20	.213	.951
CHA - ACP - Unstable government policies	20	1	5	2.90	.280	1.252
CHA - ACP - Unpredictable weather conditions	20	1	5	2.75	.260	1.164
CHA - USE - Poor cost collection and estimation system	20	1	5	2.80	.287	1.281

CHA - USE - Lack of use of appropriate software system	20	1	5	2.85	.221	.988
CHA - USE - No EVM analyst or specialist	19	2	5	3.32	.217	.946
CHA - USE - Pressure to report only good news	20	1	4	2.45	.223	.999
CHA - USE - Cost and Schedule Changes	20	1	5	3.30	.263	1.174
CHA - USE - Lack of well-defined WBS at its most appropriate level	20	1	5	2.70	.317	1.418
CHA - USE - Inappropriate performance baselines	19	2	4	2.63	.191	.831
CHA - USE - M&E of EVM metrics or indices	20	2	5	3.55	.185	.826
CHA - PER - EVM for successful project deliveries of past project	20	1	5	3.65	.233	1.040
CHA - PER - EVM to terminate projects	19	1	5	3.37	.244	1.065
CHA - PER - No common understanding of EV metrics	19	2	4	3.05	.179	.780
CHA - PER - No well-defined valuation of planned work	20	1	4	2.85	.209	.933
CHA - PER - No well-defined metrics for the accomplishment of work	20	1	4	2.95	.235	1.050
CHA - PER - No well-defined indicators and forecasts of cost performance	20	1	4	3.15	.233	1.040
CHA - PER - No well-defined indicators and forecasts of schedule performance	20	1	5	3.15	.254	1.137
CHA - PER - Poor understanding of EVM metrics and their relationships	19	1	5	3.21	.260	1.134

CHA - PER – EVMresults are invalid because of inexperienced project planners	19	1	5	2.63	.317	1.383
CHA - PER - PMs don't know how to interpret EVM results	19	1	5	3.00	.254	1.106
BEN - REA - Improve planning process	20	1	5	4.00	.262	1.170
BEN - REA - Clear definition of work scope	20	2	5	3.90	.228	1.021
BEN - REA - Clear responsibility for work effort	20	2	5	3.90	.240	1.071
BEN - REA - Early warning of potential problems	19	2	5	4.37	.191	.831
BEN - REA - Identify problem areas for immediate and proactive management attention	20	2	5	4.20	.186	.834
BEN - REA - Enables more accurate reporting of cost and schedule impacts of known problems	20	2	5	4.10	.216	.968
BEN - REA - Consistent and clear communication of progress at all management levels	20	2	5	4.15	.209	.933
BEN - REA - Improves project visibility and accountability	19	3	5	4.26	.185	.806
BEN - REA - Enables on time project delivery	20	3	5	4.35	.167	.745
BEN - REA - Enables within budget project delivery	20	3	5	4.35	.150	.671
BEN - REA - Improves customer or client satisfaction	20	3	5	4.00	.162	.725

BEN - REA - Improves project team collaboration and communication	20	3	5	4.25	.143	.639
Valid N (listwise)	15					

Table 5.1: The overall statistics of the assessment

Appendix- A: 12 'Megaprojects' Selected

Hydroelectric Power Generation Projects		
No.	Project Name	Description
1.	Fincha Amerti Neshe (FAN)	The Fincha Power Station is a hydroelectric power plant fed through Chomen Lake and discharging into the Fincha River in Ethiopia near the town of Fincha. It has a power generating capacity of 100 megawatts (130,000 hp) enough wattage to power over 66,900 homes.
2.	Gilgel Gibe I	The Gilgel Gibe I Dam is a rock-filled embankment dam on the Gilgel Gibe River in Ethiopia. It is located about 57 km (35 mi) northeast of Jimma in Oromia Region. The primary purpose of the dam is hydroelectric power production. The Gilgel Gibe I hydroelectric power plant has an installed capacity of 184 MW, enough to power over 123,200 households. The dam is 1,700 m (5,600 ft) long and 40 m (130 ft) tall. Construction on the dam began in 1988 but work was halted in 1994. In 1995 construction restarted with a new construction firm. The power station was commissioned in 2004. Water from the dam is diverted through a 9.2 km (5.7 mi) long tunnel to an underground power station downstream. The waters after power generation are discharged back into the Gilgel Gibe River to flow downstream northwards for roughly 2 km only to enter a 26 km (16 mi) long tunnel through a mountain ridge to an underground power station (Gilgel Gibe II Power Station) at the lower-lying Omo River.
3.	Gilgel Gibe II	The Gilgel Gibe II Power Station is a hydroelectric power station on the Omo River in Ethiopia. It is located about 80 km (50 mi) east of Jimma in Wolaita/Dawro Region. The power station receives water from a tunnel entrance 7°55'27"N 37°23'16"E on the Gilgel Gibe River. It has an installed capacity of 420 MW and was inaugurated on January 14, 2010. Almost two weeks after inauguration, a portion of the head race tunnel collapsed causing the station to shut down. Repairs were completed on December 26, 2010.
3.	Gilgel Gibe III	The Gilgel Gibe III Dam is a 250 m high roller-compacted concrete dam with an associated hydroelectric power plant on the Omo River in Ethiopia. It is located about 62 km (39 mi) west of Sodo in the Southern Nations, Nationalities, and Peoples' Region. Once fully commissioned, it will be the third largest hydroelectric plant in Africa with a power output of about 1870 Megawatt (MW), thus more than doubling total installed capacity in Ethiopia from its 2007 level of 814 MW. The Gibe III dam is part of the Gibe cascade, a series of dams including the existing Gibe I dam (184 MW) and Gibe II power station (420 MW) as well as the planned Gibe IV (1472 MW) and Gibe V (560 MW) dams. The existing dams are owned and operated by the state-owned Ethiopian Electric Power, which is also the client for the Gibe III Dam. The US$1.8 billion project began in 2006 and began to generate electricity in October 2015.The remaining generators would be operational by 2016. The project has seen serious delays; in May 2012, full commissioning had been scheduled for June 2013.
4.	Tana Beles	The Beles Hydroelectric Power Plant, sometimes referred to as Beles II or Tana Beles, is a run-of-the-river hydroelectric power plant in Ethiopia near Lake Tana. The power plant receives water from the lake through the Tana-Beles inter-basin transfer and after utilizing it to produce electricity; the water is then discharged into the Beles River. The plant has an installed capacity of 460 MW and it is the second largest power plant in the country. It is also expected to help provide water for the irrigation of 140,000 ha (350,000 acres). It was inaugurated in May 2010 and the last generator was operational in February 2012. Its construction was negatively perceived by downstream Egypt.
5.	Tekeze	Tekezé Dam is a double-curvature arch dam located between Amhara and Tigray region of Ethiopia. It is situated on the Tekezé River, a tributary of the Nile that flows through one of the deepest canyons in the world. CWGS was contracted to build the Tekezé Dam. The hydroelectric project was completed in February 2009. Its final cost was $360 million, which was $136 million over budget. The dam was Ethiopia's largest public works project. The dam helped to reduce power shortages as Ethiopia's power demand increases. At the time of its completion, the 188 metres (617 ft) Tekezé Dam was Africa's largest double-curvature arch dam.[3] The resulting reservoir is 105 km² large and it has a capacity of 9.3 billion m³ of water.
6.	GERD Hidase	The Grand Ethiopian Renaissance Dam (GERD), formerly known as the Millennium Dam and sometimes referred to as Hidase, is a gravity dam on the Blue Nile River in Ethiopia under construction since 2011. The dam is in the Benishangul-Gumuz Region of Ethiopia, about 45 km (28 mi) east of the border with Sudan. The primary purpose of the dam is electricity production to relieve Ethiopia's acute energy shortage and for electricity export to neighboring countries. With a planned installed capacity of 6.45 gigawatts, the dam will be the largest hydroelectric power plant in Africa when completed,as well as the seventh largest in the world. The Grand Ethiopian Renaissance Dam (GERD) is estimated to cost close to 5 billion US dollars, about 7% of the of the 2016 Ethiopian gross national product.
7.	Genale Dawa III	When completed, the GD3 Hydropower Project will have a total installed generating capacity of 254 MW. Three vertical Francis turbine generators, each having a generating capacity of 84.7 MW, are housed in an underground cavern with the main unit transformers housed in an adjacent cavern. A 500-m long cable tunnel leads to the 230kV/400kV switchyard located above ground. The concrete faced rock fill dam is 110m high with a crest length of 456m, creating a reservoir volume of 3.2 million m3. The spillway is an open chute type with an ogee weir crest and three radial spillway gates. The mid-level outlet is a 679m long tunnel with a radial gate and a maintenance gate. A 60-m high power intake structure with vertical sliding gate lies at the entrance to the 12.4-km long, 8.1-m diameter, headrace tunnel (10.5km excavated by TBM) which supplies water to the powerhouse through a 188-m deep vertical shaft, steel lined penstock and manifold tunnels. Water returns to the river through the 820m long tailrace tunnel and 480m

		long open channel.(Source: https://www.stantec.com/en/projects/united-states-projects/g/genale-dawa-3-gd-3-hydropower-project)
8.	Genale Dawa IV	When completed, the GD3 Hydropower Project will have a total installed generating capacity of 270 MW.
9.	Koyesha	Koysha (2'160 MW, under construction) is the fourth hydropower plant of Omo/Gibe river cascade in Ethiopia, comprising Gilgel Gibe (200 MW), Gibe II (420 MW) and Gibe III (1'870 MW), all currently in operation.The layout includes an RCC gravity dam, approximately 180 m high, that creates a large reservoir of about 6'500 Mm3. (Source: https://www.pietrangeli.com/koysha-hydropower-plant-ethiopia-africa)
Railway Lines and Road Projects		
No.	Project Name	Description
10.	Addis Ababa–Djibouti Railway	The Addis Ababa–Djibouti Railway is a new standard gauge international railway that serves as the backbone of the new Ethiopian National Railway Network. The railway was inaugurated by Prime Minister HailemariamDesalegn on January 1, 2018. It provides landlocked Ethiopia with access to the sea, linking Ethiopia's capital of Addis Ababa with Djibouti and its Port of Doraleh. More than 95% of Ethiopia's trade passes through Djibouti, accounting for 70% of the activity at the Port of Djibouti. The total railway capacity is 24.9 million tonnes of freight annually, with 6 million tonnes annually expected in 2023.These plans are accompanied by construction works at the Port of Doraleh to expand the annual cargo handling capacity from 6 to 14 million tonnes, with the aim of reaching 10 million tonnes of cargo by 2022. In 2019 the railway transported 84 073 passengers and generated US$1.2 million in revenue from that service, less than in 2018. In 2019 the railway generated US$40 million in both passenger and cargo revenue, far below the operating cost of US$70 million. During the first half of 2020, the railway transported 0.7 million tonnes of freight.
11.	Addis Ababa–Adama Expressway	The Addis Ababa–Adama Expressway is a toll road that connects Addis Ababa to Adama. It is the first expressway in Ethiopia. The road was built between 2010 and 2014 by the China Communications Construction Company. The government opened the highway for traffic on September 14, 2014. The Government of Ethiopia covered 43 percent of the road's construction cost, while the remaining 57 percent was supplied by a loan from the Exim Bank of China. The highway, with six lanes on two sides for its 84.7-kilometre (52.6 mi) length, aims to abate the heavy traffic between its two endpoints. It reduces the time required to reach Adama from Addis Ababa to 45 minutes, a reduction of more than 50 percent over the time on previously available routes.
12.	Addis Ababa Light Rail	The Addis Ababa Light Railis a light rail system in Addis Ababa, Ethiopia. It is the first light rail and rapid transit in eastern and sub-Saharan Africa. A 17-kilometre (11 mi) line running from the city centre to industrial areas in the south of the city was opened on 20 September 2015 and inaugurated by Prime Minister Hailemariam Desalegn.Service began on 9 November 2015 for the second line (west-east).[7][8] The total length of both lines is 31.6 kilometres (19.6 mi), with 39 stations. Trains are expected to be able to reach maximum speeds of 70 km/h (43 mph). The railway was contracted by China Railway Group Limited. The Ethiopian Railways Corporation began construction of the double track electrified light rail transit project in December 2011 after securing funds from the Export-Import Bank of China. Trial operations were begun on 1 February 2015, with several months of testing following that. It is operated by the Shenzhen Metro Group.

Appendix - B: Questionnaire

SECTION A: RESPONDENT PROJECT EXPOSURE PROFILE

INSTRUCTION: Please write 'Yes' or leave it blank. For the ongoing 'mega projects' you are have been involved, please list the project names and concisely write about the project(it is optional to write the project description)

Hydroelectric Power Generation Projects		
No.	Project Name	Please write '**Yes**' if you have involved in this projects or leave it blank if you are not.
1.	Fincha Amerti Neshe (FAN)	
2.	Gilgel Gibe I	
3.	Gilgel Gibe II	
3.	Gilgel Gibe III	
4.	Tana Beles	
5.	Tekeze	
6.	GERD Hidase	
7.	Genale Dawa III	
8.	Genale Dawa IV	
9.	Koyesha	
Railway Lines and Road Projects		
No.	Project Name	
10.	Addis Ababa–Djibouti Railway	
11.	Addis Ababa–Adama Expressway	
12.	Addis Ababa Light Rail	
Any other ongoing megaprojects you have been involving		
No.	Project Name	Description
1.		
2.		
3.		

SECTION B: RESPONDENT PROFILE

INSTRUCTION: Please circle or highlight your choice

1. **Sex:**

   A. Male
   B. Female

2. **Education Level**

   A. Degree
   B. Master
   C. PhD
   D. Other

3. **Project Management Education Level**

   A. Degree
   B. Master
   C. PhD
   D. Other

4. **Professional Role**

   A. Project Manger
   B. Project Consultant
   C. Client (Government employee)
   D. Engineer/Architect
   E. I participated in projects with mix of roles identified above

5. **Knowledge level of Earned Value Management**

   A. Basic
   B. Working knowledge
   C. Expert
   D. Senior Expert/Professional
   E. None

6. **How do you track and monitor project progress currently?(You may select multiple answers?**

   A. Using Earned Value Management(EVM) method
   B. Critical Path Method(CPM)/Program Performance Evaluation Review(PERT) method
   C. A & B
   D. ____Other(Please specify)

7. Number of 'megaprojects you monitored since 2000?

A. 3
B. 5
C. 7
D. ____Other(Please specify)

8. Contract type of projects you observed(You may select multiple items if that applies)

A. Firm Fixed Price(FFP)[1]
B. Fixed Price Incentive Fee (FPIF)[2]
C. Cost Plus Incentive Fee (CPIF)[3]
D. Cost Plus Award Fee (CPAF)[4]
E. Cost Plus Fixed Fee (CPFF) [5]
F. Other. Please specify here:_____

INSTRUCTION: Please circle or highlight your choice below. Note that the list of choices are indicated on the questionnaire distributed to respondents but not indicated in each question here for the sake of limiting the number of pages of the thesis.

The lists of choices are:

A. Not to a Very Great Extent B. Not to a Great Extent
B. Neutral C. To a Great Extent E.To a Very Great Extent

SECTION C: EARNED VALUE MANAGEMENT IMPLEMENTATION PRACTICES IN ETHIOPIAN MEGAPROJECTS

SUBSECTION C-1: ORGANIZATION

Q1-1: Define authorized work (WBS elements)

[1] The contract stipulates a fixed amount of compensation regardless of the actual cost (i.e., regardless of whether the contractor has experienced a cost overrun or a cost underrun). This contract is the lowest risk instrument for the contracting entity.

[2] The contract stipulates a target cost, target fee, and a share ratio associated with any underrun or overrun to the target cost. The share ratio establishes percentages that project owner (client or government or organization) and the contractor will share in the underrun or overrun. The contract will define the maximum and minimum fee.

[3] The contract allows cost reimbursement for all in-scope effort. The fee determination is similar to FPIF contracts but there is no ceiling price. The incentive fee may be based on cost, technical performance, or both.

[4] The contract allows cost reimbursement for all in-scope effort. The award fee is used as an incentive to the contractor to perform to a predetermined set of criteria. An Award Fee Plan identifies the evaluation periods, the available award fee pool of dollars by period, and the award fee criteria to be used in evaluating the contractor's performance.

[5] The contract allows cost reimbursement for all in-scope effort. The contractor fee is fixed. The contractor is guaranteed that fee regardless of an underrun or overrun. This contract is the highest risk instrument for the contracting entity.

Q1-2: Identify organizational responsibilities

Q1-3: Integrate the system

Q1-4: Identify overhead management

Q1-5: Provide for performance measurement

SUBSECTION C-2: PLANNING, SCHEDULING AND BUDGETING

Q2-1: Schedule the work

Q2-2: Identify products, milestones and indicators

Q2-3: Plan the performance measurement baseline (PMB)

Q2-4: Establish budgets for work

Q2-5: Identify work packages

Q2-6: Summarize work package budgets to control accounts

Q2-7: Identify and control level of effort
Q2-8: Establish overhead budgets

Q2-9: Identify management reserves and undistrubuted budget

Q2-10: Summarize budgets to the target cost

SUBSECTION C-3: ACCOUNTING

Q3-1: Record direct costs

Q3-2: Summarize direct cost to the work breakdown structure (WBS)

Q3-3: Summarize direct cost to the organization

Q3-4: Record indirect costs

Q3-5: Identify unit/lot costs

Q3-6: Record material costs

SUBSECTION C-4: ANALYSIS

Q4-1: Identify schedule and cost variances

Q4-2:Analyze schedule and cost variances

Q4-3: Analyze indirect costs

Q4-4: Summarize data elements and variances for reporting

Q4-5: Implement managerial actions

Q4-6: Develop revised estimates of cost at completion

SUBSECTION C-5: REVISIONS

Q5-1: Incorporate changes into plans, budgets and schedules

Q5-2: Reconcile budgets changes

Q5-3: Control retroactive changes

Q5-4: Control revisions to the program budget

Q5-5: Document changes to the Project Measurement Baseline (PMB)

SECTION D: EARNED VALUE MANAGEMENT IMPLEMENTATION CHALLENGES IN ETHIOPIAN MEGAPROJECTS

SUBSECTION D-1: ACCEPTANCE

Q6-1: Shortfall to accept new technique

Q6-2: Lack of management support

Q6-3: The cultural problems such as reluctance to report adverse information 'suppressing bad news' and excessive optimism for recoveries from cost overruns.

Q6-4: High cost, complicated and burdensome paper work

Q6-5: Poor understanding of EVM

Q6-6: Simple ways to control budget seem to be satisfactory enough for some practitioners

Q6-7: Lack of EVM as a contractual requirement

Q6-8: The type of contract

Q6-9: Impacts of variances are not usually forecasted and estimates at completion are not usually prepared (either are not required or not an interest at all)

Q6-10: Changes in work scope

Q6-11: Technical factors (design changes, weak control, inaccurate evaluation of project time, nonperformance of subcontractors and nominated suppliers, lack of appropriate software)

Q6-12: Financial factors (inflation of prices, dependency on imported materials, financing and payment of completed work, risks and uncertainty associated with projects)

Q6-13: Contractual factors (contract and specification, interpretation, and disagreement, conflict between project parties)

Q6-14: Unstable government policies

Q6-15: Unpredictable weather conditions

SUBSECTION D-2: USE

Q7-1:Lack of appropriate cost collection and accurate actual cost estimation system

Q7-2: Lack of use of appropriate software system

Q7-3: There is no EVM analyst or specialist within the project team

Q7-4: Pressure to report only good news

Q7-5: Cost and Schedule changes (due to resource availability and constraints, timing of change orders)

Q7-6: Lack of well-defined Work Breakdown Structure (WBS) at its most appropriate level

Q7-7: Inappropriate performance baselines

Q7-8: Monitoring and evaluation of earned value management metrics or indices

SUBSECTION D-3: PERFROMANCE

Q8-1: EVM positively influenced the successful deliveries of past projects

Q8-2: EVM is a strong basis to terminate underperforming project contractors. Please respond based on your experience.

Q8-3: No common understanding of performance in terms of earned value metrics.

Q8-4: No well-defined valuation of planned work

Q8-5: No well-defined metrics for the accomplishment of work

Q8-6: No well-defined indicators and forecasts of cost performance (over budget or under budget)

Q8-7: No well-defined indicators and forecasts of schedule performance (behind schedule or ahead of schedule).

Q8-8: Use of EVM without understanding how to monitor project costs and schedules (lack of understanding of the relationship among metrics (PV, EV, AC, CPI, SPI, EAT, ETC, and ES).

Q8-9: The results are invalid because of inexperienced project planners

Q8-10: Project managers do not know how to interpret EVM results

SECTION E: EARNED VALUE MANAGEMENT IMPLEMENTATION BENEFITS REALIZED IN ETHIOPIAN MEGAPROJECTS

SUBSECTION E-1: BENEFITS REALIZED/PROJECT SUCCESS

Q9-1: Improves the planning process

Q9-2: Fosters a clear definition of the work scope

Q9-3: Establishes clear responsibility for work effort

Q9-4: Provides early warning of potential problems

Q9-5: Identifies problem areas for immediate and proactive management attention

Q9-6: Enables more accurate reporting of cost and schedule impacts of known problems

Q9-7: Provides consistent and clear communication of progress at all management levels

Q9-8: Improves project visibility and accountability

Q9-9: Enables on time project delivery

Q9-10: Enables within budget project delivery

Q9-11: Improves customer or client satisfaction

Q9-12: Improves project team collaboration and communication

Appendix - C: Interview Guide

1. Can you list megaprojects in Ethiopia, that you are fully aware of that, implemented earned value management?
2. Do you think that EVMS is preplanned in mega projects, completed or underway from the year 2000-2021, you have been involved?
3. How far do you think the deviations identified through EVMS in megaprojects you have been involved, completed or underway from the year 2000-2021, are used for a management intervention?
4. What challenges you have encountered in implementing EVM as a tool of monitoring and evaluation?
5. To what extent EVM is relevant and applicable to Ethiopian megaprojects?
6. What do you suggest for implementing EVM in Ethiopian megaprojects?
7. Do you think that EVM is mandated for Ethiopian megaprojects?
8. Do you think implementing EVM promotes project success in the case of Ethiopian project management endeavor?
9. How far do know if there are project managers in Ethiopia well trained in EVM?
10. Any closing remark?

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