

EXPLORING THE POSSIBILITY OF USING EARNED VALUE ANALYSIS DURING THE CONSTRUCTION PHASE OF A BUILDING PROJECT

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To deliver projects effectively is of paramount importance because most of the world population depends on services delivered by projects. Reports from various countries around the world, including Botswana, still indicate poor project delivery. Several causes may be advanced including ineffective project control. Devising means to alleviate the control problem is therefore, of great importance. Scholars and practitioners have suggested various techniques that monitor and keep track of projects. One of them is the earned value analysis (EVA) which touted by many as an efficient yet effective control system because of its ability to integrate scope, cost and time. Based on this premise, the study reported in this paper investigated possible use of EVA in building projects in Botswana. The investigation was two fold, firstly, through a questionnaire, quantity surveyors (Qs) were requested to indicate whether they have used EVA on any building project in Botswana. Results from this survey indicated that EVA is not used at all in Botswana. In fact, majority (63%) of the QS have not heard of the system before. The second phase of the study investigated its possible use, that is, if using EVA was more advantageous than the conventional control method (CCM). Results indicated EVA system provided quality information that was well structured, more objective, and easily accessible to all key stakeholders in a timely and understandable manner. However, to use the EVA system several challenges were also identified which included firstly, the need to train key players in the EVA technique; the need to change the project regime from arms-length to a cooperative one to allow transfer and sharing of information in the design and construction phases of a project; increasing the use of IT; completing the design before tendering even for other trades; and nominating sub-contractors as soon as the main contract is appointed.

Keywords: earned value management, construction project, project control, project monitoring, Botswana

1 INTRODUCTION

Construction projects are planned and implemented to deliver benefits to a targeted community. The successful delivery of a project is of paramount importance. Effective planning and implementation is the key to ensuring that a targeted community benefits from the project.

Studies from some parts of the world (e.g. [1]-[3]) have painted a bleak picture regarding project delivery. Projects are often delivered late, over the budget and below specified standards leading to dissatisfied clients and beneficiaries. The landscape has not been different in Botswana where various media reports and studies [4]-[6] have indicated unacceptable levels of project delivery. Mokotedi [7], for example, reported that at one time the situation became unpalatable that legislators questioned why a number of public projects encountered cost overruns of up to 71% above the original cost. Another empirical study indicated that of the total of public projects which were sampled,

92% were completed beyond both time and over cost [5].

Several models have been developed to explain the cause of poor delivery of projects. Pinto and Mantel [8], for example, suggested a four-factor model consisting of inappropriate decisions taken by clients (and their representatives), consultant incompetence, contractor deficiencies and environmental factors. Others, for example, Rwelamila and Hall [9] were of the view that three interrelated factors namely strategy/structure, technical and culture issues account for poor delivery of a number of projects. The technical component, for example, relates to weaknesses in project organisational skills, practises, tools and methods used throughout the project delivery chain. As part of understanding the technical component of project delivery process, this paper focuses on project control; a process that ensures that a project is in line with its planned performance, in particular at the construction phase.

An effective control system follows adequately developed processes of planning, monitoring and control. Its role is to provide timely and adequate information about the project status in order for the project team to make informed decisions [10]. The control system must be at each reporting period, be able to answer key questions, for example: how much work has been completed against how much should have been completed (scope/schedule)?; how much resources in monetary value have been spent against what should have been spent (cost/schedule)?; when will the project be completed and at what further cost (forecasting)?

Project teams can employ several techniques in controlling projects to avoid cost overruns and schedule slippages. According to Rozens [11] the techniques may be classified as one-dimensional or multi-dimensional. The former uses a single and often independent parameter to control a project. Such techniques include cost, time, leading parameter (e.g. volume of concrete), activity based costing and critical chain.

On the other hand multi-dimensional control systems, simultaneously and in an integrated manner, use more than one parameter to control a project. The most common system in this group includes the earned value analysis (EVA). A number of scholars and practitioners [12]-[14] have commented positively about the advantage of using EVA as a control technique. The assertions are based on EVA's ability to integrate scope, time and cost and its ability forecast time and cost for the remainder of the project at a specified period of review

The often reported prevalence of poor performance (as indicated by e.g. [5]) of construction projects in Botswana presented an opportunity to explore the use of EVA technique, particularly in construction phase of a building project. Studies (e.g. [6,15]) identified lack of project control as one of the major causes of poor performance in Botswana but never provided details of issues relating to project control. This paper therefore, presents findings of an exploratory investigation based on two research questions. The first being: *RQ₁: To what extent is the EVA technique used during the construction phase of a building project in Botswana?* The second question

is contingent on the first and was stated as: *RQ₂: If EVA is not used, is there a possibility of applying the technique during the construction phase of a building project in Botswana?*

Before discussing the research process used to investigate the two research questions, an overview of the conventional control method (CCM) and the EVA technique is provided.

2 OVERVIEW OF THE CONVENTIONAL CONTROL METHOD AND EVA SYSTEM

2.1 The Conventional Control Method

In a CCM, monitoring and control are achieved in four main ways, firstly by the use of a clerk of works (CoW), who on a daily basis, oversees the project activities with a view to providing a report to the lead consultant on any project activity anomaly. The CoW ensures that building materials are procured, brought to site and installed as specified. In addition, and the presence of CoW ensures quality of workmanship is of expected standard. The CoW may provide other oversight duties, for example, may support or refute any claim the contractor may allege for extension of time due to say, inclement weather.

Secondly, in the CCM, time is monitored by tracking progress of a project scope against the project schedule prepared by the contractor and reported weekly to the lead consultant by the CoW. However, the measurement of progress is normally a subjective assessment.

Thirdly, there are progress site meetings at the end of every month in which the main contractor and CoW, each presents progress reports. The other parties to the project namely the lead consultant, QS, engineers and client provide comments on the progress of the project and the reports submitted by the contractor and CoW.

Lastly and contractually, detailed project costs performance are prepared and presented by QS to the lead consultant and client every quarter of the year during the duration of the project. Detailed cost performance is not reported monthly at the progress meetings except payment to date and sometimes notification of submission of payment certificate.

2.2 The EVA system

To use EVA in a traditional procurement system (TPS), a contractor needs to 'download' information from the tender documents in order to develop a project schedule and budget. Literature is abound with descriptions of the EVA system [13]-[16]. However, a brief description of technique is provided to contextualise the research study. The major components of EVA are illustrated in Figure 1. The components include sub-processes for planning, monitoring, reporting, performance measurement, control and forecasting. Each is briefly described.

2.2.1 EVA Planning Infrastructure

The EVA planning infrastructure requires six steps (Component 1 of Figure 1). The first step defines all the major deliverables and associated work packages of a project using a work breakdown structure (WBS) (Step 1.1 in Figure 1). The WBS is then used for assigning responsibility for planning, executing and controlling project tasks among the project team members (Step 1.2). The third (Step 1.3) step identifies work package activities, establishes their logical sequence and their duration is estimated.

The critical path of the project also determined to obtain the schedule at completion (SAC) for the deliverable while the critical path for the project will provide the SAC for the project. The fourth step (Step 1.4) estimates the cost of each activity and aggregates the costs of activities to create a budget for each work packages, deliverable and finally the project budget or budget at completion (BAC). The fifth step is an most important one in EVA system, because it involves breaking down the cost into the planned progress of activities for the duration of the work package, deliverable and the project to create what is called planned value (PV) or budgeted cost of work scheduled (BCWS) per month. Lastly, it is necessary to develop cost codes using a breakdown structure (CBS) (Step 1.6) in order to collate costs once the execution of activities starts.

2.2.2 EVA Monitoring and Control Phase

During the implementation phase of the project (Component 2), six sub-processes are needed for monitoring and controlling the project. First, is the measurement of work done during the month i.e. the percentage completion (PC) at work package level (see rules in Step 2.1). The measurements may be

physical in nature, for example, the number of square metres of paving tiles laid or number of items installed. However, several methods may be employed to measure PC completed, if the nature of work is not easily ascertainable as described in [17].

Second, is the compilation of the actual costs (AC) incurred for work completed during a particular month (Step 2.2). This may be in form of the payments made in favour of the contractor at the end of every month. Using the PC, the monthly earned value (EV) is computed for each work-package (see Step 2.3). The profiles of PV, AC and EV are then plotted on a graph against time (Step 2.4) to provide a graphical illustration of the state of the project at the review date. It is important to highlight that in collecting data on PC and AC and computing EV, the deliverable or project is being tracked in an integrated manner combining progress on scope/schedule and cost/schedule. This is the strength of EVA.

The third process requires computing the necessary performance information (Step 2.5) to provide project control. Computation of variances (absolute or in percentage form) provides a quick way of knowing whether the project is on track or not. To improve control, tolerance limits or thresholds may be set for each variance to provide means of knowing whether a particular deviation (variance) is significant. As an example, schedule variance percentage tolerance limits may be set in accordance to available float on the activity as provided for in the project schedule. In such a case all critical activities will have a zero variance and a zero percent tolerance.

Performance efficiencies of the project at each reporting period, are determined by the computation of performance indices (PIs) (Step 2.5 of Figure 1). A performance index (CPI or SPI) of greater than one indicates better than planned performance (cost or schedule) while less than one indicates poor performance (i.e. a cost overrun or schedule slippage) and an index of one means that the project is on budget or schedule [12].

The information arising from the computation of the variances and efficiency indices is analysed and compiled into a report form (Step 2.6). The report is then used as a basis for making control decisions. These may involve changing or not changing some

aspect of the project e.g. changing resource levels (Component 3 in Figure 1).

2.2.3 Updating the Project Plan

One of the strong points about using EVA, is that it forces a project manager to continuously forecast (Step 4.1) project time and cost to completion. Empirical evidence from recent studies (e.g. [17]) have indicated that EVA can be used to predict final costs and total durations to an accuracy of within $\pm 10\%$ when a project is only 20% complete. One of the major reasons for forecasting performance is to update the baseline project plan (Step 4.2) since it forms the benchmark of the next review period for which actual performance is compared. Therefore, for results to remain accurate and meaningful throughout the entire duration of the project, EVA requires updating project plans after each forecast, in a timely manner, to incorporate any approved changes at each reporting period. Forecasting of performance is however, determined by the project team's understanding of the past and future project conditions in order to decide on a form of forecasting scenarios (see Step 4.1). The updating of project plans completes the control cycle (Component 5 of Figure 1, though may not actually require going back to Steps 1.1 but starting at Step 2.1)

3 RESEARCH PROCESS

The research process was divided into two phases. Phase one responded to the first research question (RQ₁) and investigated the extent to which EVA is used as a project control technique in Botswana. Contingent on the outcome of the first phase, phase two investigated the possible use of the technique (RQ₂) on building projects in Botswana.

3.1 Phase I- Extent of Use of EVA in Botswana

The investigation used a semi-structured questionnaire which was sent to quantity surveyors (QS). Due to the use of the TPS in Botswana (e.g. [18, 19]), QSs are involved in all construction building projects as cost managers. The population of QS was obtained from a list compiled by the Public Procurement and Asset Disposal Board (PPADB). PPADB deals with the procurement and disposal of all public assets. The list [20] indicated 25 QSs practiced in Botswana. Therefore, 25 questionnaires were mailed to the QSs on the list. A response rate

of 41.8% was achieved which was above the range (25-35%) that most scholars (e.g. [21]) expect from a postal questionnaire survey.

The results indicated that a significant number (88%) of QSs had over five years of experience practising in Botswana with some (68%) claiming experiences of 10 years and over. All (100%) respondents indicated that they had not used the EVA technique on any project in Botswana. Quite a significant number (63%) of QSs knew the technique through their professional studies or through own reading while a few (37%) had never heard of the technique before.

Responding QSs identified the CCM as the major project control technique (98%) used on projects. As to why EVA is not used, the answers varied and included responses like *'every one uses site meetings as means of project control where the clerk of works reports about quality, contractor/clerk of works report on schedule and sometimes the QS reports on cost'*. Others responded *'... if I do not know it how can I use it...'* and *'the procuring regime [TPS] currently used on almost all projects does not allow sharing of information in a manner expected of EVA'*. The result of the investigation led to the conclusion that EVA is not currently used on any project in Botswana.

3.2 Phase II- Possible Use of EVA on Building Project

The result of phase one indicated the lack of use of the technique in project control in Botswana and provided a basis to proceed to phase II of the study. The study was considered to be exploratory in nature since to the knowledge of the researchers, no empirical study has been conducted in Botswana relating to the use of EVA.

3.2.1 Choice of Research Strategy

To obtain an in-depth investigation into the application of EVA control technique on a project, the case study method was found to be the most suitable research strategy.

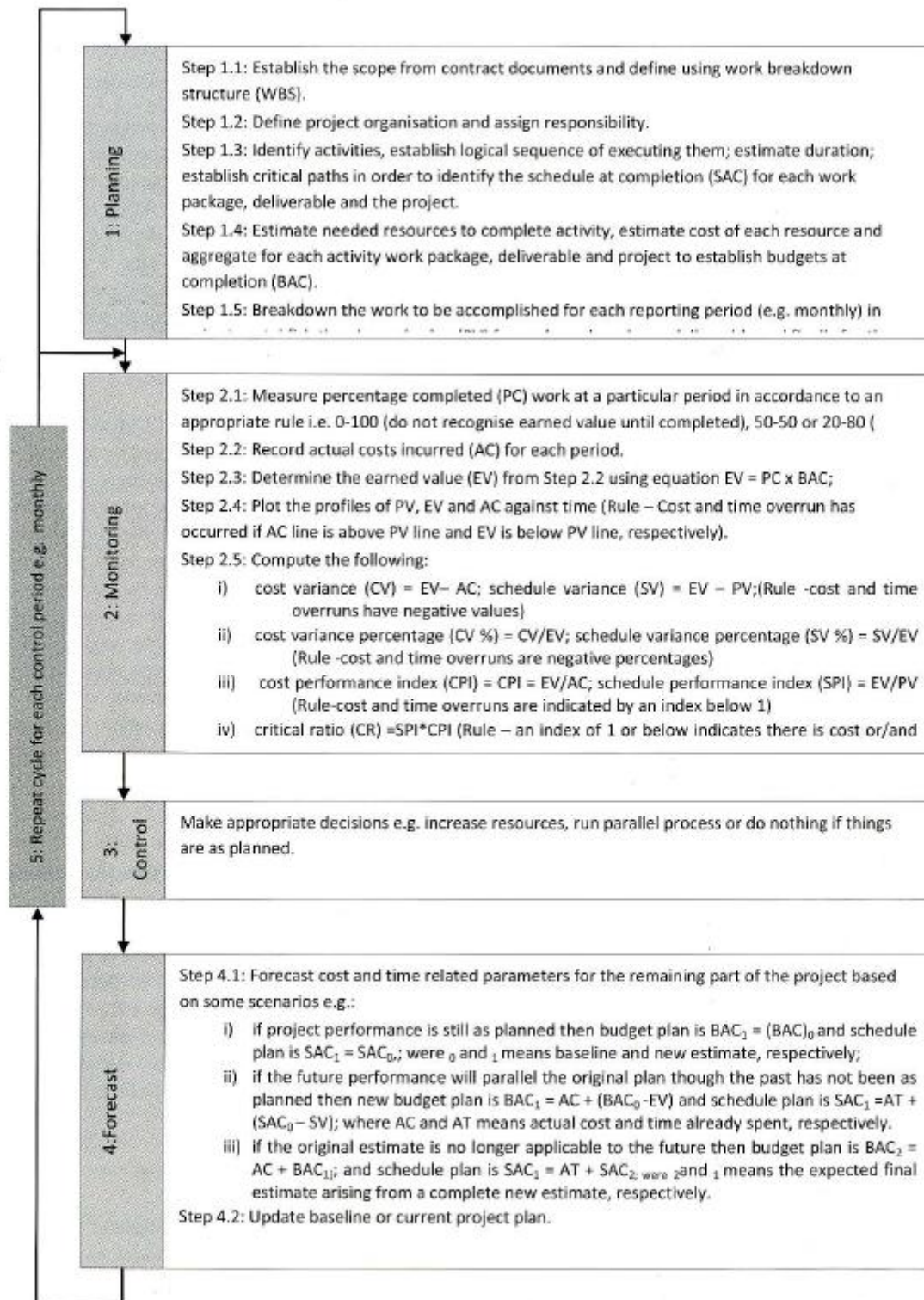


Figure 1: The components of the EVA Infrastructure

A single case was also considered the most suitable research design as opposed to multiple cases as the latter would be a logistical challenge in obtaining information from several project sites scattered in different locations of the country.

Yin [22] noted that a single case provides richer information than many cases, though the results are less generalisable as compared to multiple cases. The most suitable case was considered to be a building project where a contractor has just mobilised but not started any preliminary activities. This was important in order to fit the building project schedule in the research time framework. Secondly, there was a need to select a project where stakeholders were willing to participate in the study through the provision and sharing of information with the research team. Normally stakeholders are unwilling to share project data for a number of reasons. Firstly, cost data for an on-going project is considered very confidential for most parties to the project, especially contractors. Secondly, due to the bad publicity that the construction industry has received over the years in Botswana, to many a study investigating project cost and time would be very circumspect [6].

To identify a particular project case for the study, the assistance of the Department of Building and Engineering Services (DBES) was sought. DBES happens to oversee the design, construction and maintenance of all public buildings in Botswana. The Department assisted in identifying a project which fitted the two attributes described above.

A project located about 120 Km from the capital city, Gaborone was identified. The project was a police station with nine deliverables namely preliminary works; construction of a one-storey office block; horse stable; hazardous material store; external works; construction of a water pump house; and execution of all trades works (e.g. electrical, mechanical, landscaping, etc). The deliverables are shown in Figure 2. The estimated cost of the project was P17.8 million (1US\$ approx. P6.51). According to the contractor's programme, some of the project deliverables were to be constructed simultaneously and the duration of the project was estimated at 12 months by the contractor.

3.2.2 Revisiting the research question

The second research, question (RQ₂) required investigating the possibility of using EVA as a control system. For practitioners to be attracted to use the system, the advantages must outweigh the disadvantages when compared to the CCM.

The advantages may be in form attributes that a good control system should have. Scholars (e.g. [23]) have also noted that the attributes of a good control system must be similar to those of a good information system.

After all, control is about using quality information to make informed decisions. Based on this premise, a number of authors (e.g. [24, 25, 26,]) have noted that quality information must have at least two major themes, its nature/quality and its impact on the behavioural pattern of its users as indicated in Table 1.

The themes were then used to measure the advantage EVA would provide if used as control system relative to CCM.

In turn, this established any possibility of using EVA as an appropriate control system in building projects in the Botswana context.

Table 1: Themes and attributes of a good control system

<i>1 Nature/quality of information</i>	
i)	Timeliness - whether the information reaches the decision maker on time.
ii)	Accessible - whether information is available to the decision maker and other relevant stakeholders.
iii)	Ease to understand and use - whether the information is presented in the format that is easily understood by the decision maker and other relevant stakeholders.
iv)	Accurate - whether the information provides a factual state of the project's affairs necessary to make decisions.
v)	Comprehensive enough - whether the information is not lacking in the required detail but at the same time not overwhelming for decision maker
vi)	Relevant - whether the information can be provided for each level of responsibility.
vii)	Cost effective - whether the data is not too expensive to collect, process/analyse, interpret and disseminate.
<i>2 Behavioural aspects related to information</i>	
Whether the information does not lead to dysfunctional behaviour during data collection, interpreting, reporting, decision making and follow up action.	

Adapted from [26])

3.2.3 EVA Infrastructure plan

The EVA infrastructure plan was developed as according to the discussion in Section 2.2 (Component 1, Steps 1.1-1.5). It was developed at the time of mobilisation. However, it could not be put in actual practice since it was not the official control system. Its output though was informally shared with key project stakeholders, especially those who attended the monthly site meetings.

In preparing the EVA plan, a WBS was drawn up (see Figure 2) from which a schedule was prepared based on the logical sequence and activity duration provided by the contractor.

3.2.4 Data collection

At end of every month, two sets of data were collected for each of the nine deliverables. This was repeated for the nine months allotted to the data collection stage of the study. First, the work completed in each month was measured to obtain a percentage completion (PC) as indicated in Figure 1 (Step 2.1). Second, the amount of money paid to the contractor was obtained from the QS (Step 2.2 of Figure 1) and monthly values were added to those of the previous one to obtain cumulative totals to match PC which is measured in a cumulative mode. With help of a spreadsheet, data for PC and AC for the nine deliverables was aggregated to create a project status for each review period.

The planned value (PV) for the nine known deliverables (indicated on the second level of the WBS in Figure 2) and aggregated for the project was developed using the information obtained from the contractor's schedule and budget (Step 1.4) and entered into a spreadsheet similar to Table 2. Due to the need for brevity in the paper, only data for one deliverable (external works) is provided (see row 1 for the PV data for external works). The budget at completion (BAC) and schedule at completion (SAC) for the external works deliverable were estimated at P3, 688, 276 and 12 months, respectively. Row 2 and 3 of Table 2 shows the data

collected for PC and AC, respectively for the deliverable (external works) during the nine months.

3.2.5 Data analysis

For each month, three sets of computations were carried out (in accordance to Figure 1, Steps 2.5). First, the monthly earned value (EV) was computed reflecting work done or earned (see Row 4 of Table 2). From this, respective variances (absolute and percentage) were computed (see Row 5-8 of Table 2). In addition, performance indices (Step 2.5) were also computed (see Row 9-11).

To estimate cost and time to completion, the contractor was requested to provide the most likely future performance scenario (Step 4.1 of Figure 1). The contractor's response provided means of forecasting time and cost to completion in order to obtain new estimates for the project's duration and cost. This information was then entered in the spreadsheet (Step 4.1 of Figure 1). Accordingly, the project plan was then updated in each month (Step 4.2). This is indicated in row 12-13 of Table 2.

3.2.6 Monthly reports

In order for EVA information to be shared with key stakeholders, a monthly report (Step 2.6 of Figure 1) was produced (containing narratives and graphical information). Each parameter (parameters 2-13) was reported in terms of its trend since the project started or in terms of the rules (see rules in Step 2.5 Figure 1) or both. To get an idea of what a monthly report entailed, the data for fourth month was chosen as the review period (see shaded data for Month-4 in Table 2).

The first part of the report indicated the profile of the work done or earned (EV) and its cost (AC) compared with the work which was planned (PV) in the first four months. This was plotted as an S-curve as indicated in Figure 3

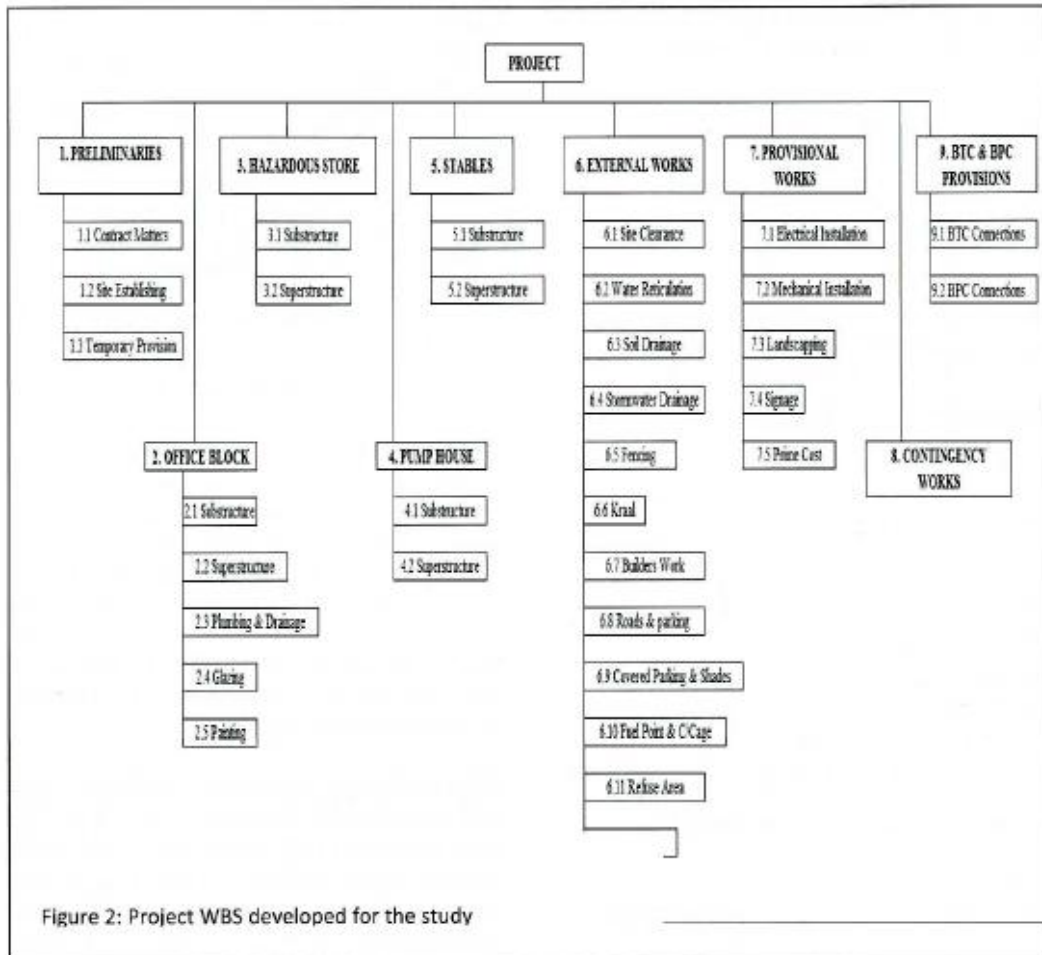


Figure 2: Project WBS developed for the study

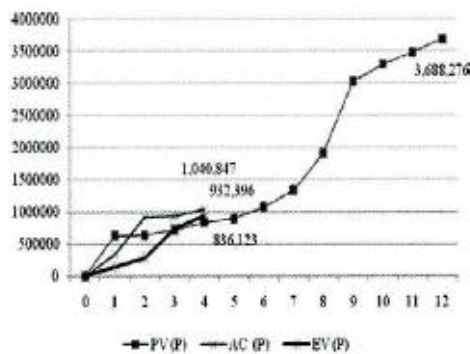


Figure 3: EVA profile of the external work deliverable as at end of Month-4

The information from the figure indicates there is a cost overrun as the AC line is on top of the PV line (see rule in Step 2.4 of Figure 1).

The report also described the critical ratio as the overall indicator of the performance of a deliverable (or project). In Figure 4, the critical ratio (CR) of 1.00 in month-4 indicated that the performance of the deliverable was in trouble (see rules in Figure 1 Step 2.5) even though the performance had been improving. However, it was not clear where the problem was and attention was turned to performance indices.

Figure 5 shows that SPI is above 1.00 (1.12) and hence the project is on schedule. However, the CPI is below 1.00 (0.9) indicating a cost overrun (see rules in Figure 1 Step 2.4). The extent to which the problem had occurred was not clear and further scrutiny was carried out based on variances.

Closer examination of the variances showed that the project had a cost overrun of 12% (see Figure 6)

amounting to P108,451 (see Figure 7) though it was still on schedule by 10% (i.e. 1.2 months)

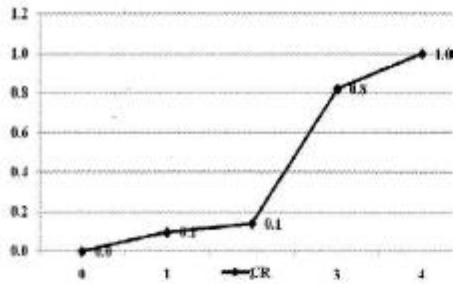


Figure 4: CR at end of Month-4

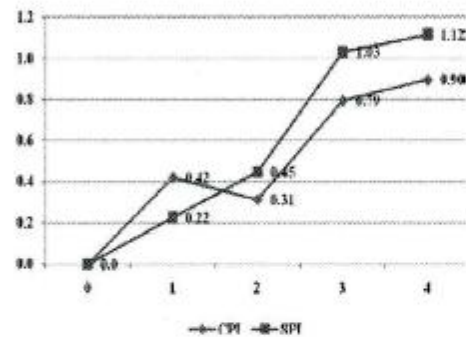


Figure 5: SPI and CPI at end of Month-4

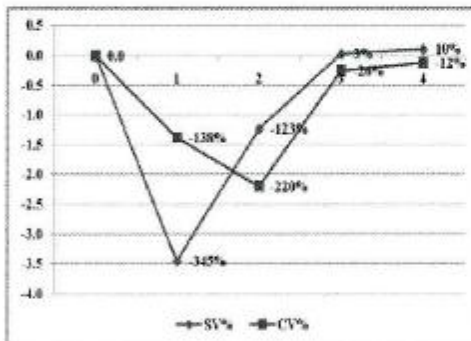


Figure 6: CV% and SP% at end of Month-4

However, EVA could not be used to spot the actual problem why there was a cost overrun. Could it have been that (i) the value of planned work was over estimated, (ii) there was an error in monthly measurement of the percentage completion (PC) (iii) the actual figure paid was wrong (AC), (iv) more work was completed than planned, or (v) the contractor bought materials which were included in AC yet EV is measured in actual work completed.

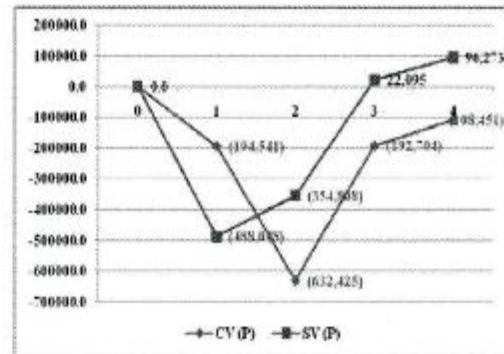


Figure 7: CV and SV at end Month-4

The information was shared with stakeholders and possible explanations for the cost overrun. The QS confirmed that the inclusion of materials (bought but not yet used) most likely caused what seemed like a cost overrun. Essentially, this meant that value of materials bought but not yet used should not have formed part of the data collected for AC – which makes sense because PC is measured in terms of work completed not in material form. EVA requires that this separation to be effected.

A last note on the information generated from the EVA system is that the system could not provide direct indication of any quality aspect. If it did, it would be indirect in form of a time overrun. This would be a situation where a contractor would have worked less than the planned amount because, more time is spent on reworking to rectify a defect. Therefore, the presence of a CoW or some form of quality assurance intervention is also essential in the EVA system.

4 FINDINGS AND DISCUSSION

Findings are discussed using three main headings namely the nature of information from the EVA system, behavioural issues surrounding its use and associated challenges.

4.1 Nature of EVA Information

In using the information from EVA, several advantages were observed. The most critical aspect was that EVA indicated the project progress (work and time) in relation to what it cost to achieve that progress and compared it to the project planned value. This information was available in a timely

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Table 2: Data collected and analysed for the external works deliverable

	0	1	2	3	4	5	6	7	8	9	10	11	12
Planned value of work													
1 PV (P)	0	629,309	642,494	720,724	836,123	895,768	1,080,894	1,334,534	1,911,949	3,024,278	3,299,456	3,483,567	3,688,276
Data collected end of each month													
2 PC	0	4%	8%	20%	25%	29%	40%	55%	66%	82%			
3 AC (P)	0	335,802	920,111	935,523	1,040,847	1,040,847	1,399,056	1,908,335	2,505,166	2,903,331			
Performance analysis													
4 EV (P) (=PC*BAC)	0	141,261	287,686	742,819	932,396	1,053,372	1,459,082	2,045,518	2,450,491	3,022,911			
5 CV (P) (=EV-AC)	0	(194,541)	(632,425)	(192,704)	(108,451)	12,525	60,026	137,183	(54,675)	119,580			
6 SV (P) (=EV-SV)	0	(488,048)	(354,808)	22,095	96,273	157,604	378,188	710,984	538,542	(1,367)			
7 SV% (=SV/EV)	0	-345%	-123%	3%	10%	15%	26%	35%	22%	0%			
8 CV% (CV/CV)	0	-158%	-220%	-26%	-12%	1%	4%	7%	-2%	4%			
9 CPI (=EV/AC)	0	0.42	0.31	0.79	0.90	1.01	1.04	1.07	0.98	1.04			
10 SPI (=EV/PV)	0	0.22	0.45	1.03	1.12	1.18	1.35	1.53	1.28	1.00			
11 CR (=SPI*CPI)	0	0.1	0.1	0.8	1.0	1.2	1.4	1.6	1.3	1.0			
Forecast and project plan update													
12 BACo/BAC ₁ (P)* = (BAC/CPI)		3,688,276	3,882,817	4,320,701	3,880,980	3,796,727	3,675,751	3,628,250	3,551,093	3,742,951	3,568,696		
13 SAC ₀ /SAC ₁ = (SAC/SPI)			53.5	26.8	11.6	10.8	10.2	8.9	7.8	9.4	12.0		

* and ** past performance assumed because it was getting better
 AC- Actual costs also referred to as actual cost work performed (ACWP)
 BAC₁ - budget at completion (baseline)
 BAC₀ - budget at completion (new estimate)
 CPI-Cost performance index
 CR - critical index
 CV - Cost Variance
 CV%- Cost variance percentage
 EV - Earned value also referred to as budgeted cost of work performed (BCWP)
 PC- percentage completion
 PV -Planned value also referred to as budgeted cost of work scheduled (BCWS)
 SAC₀ -Baseline schedule at completion (baseline)
 SAC₁ - schedule at completion (estimate)
 SPI%- Schedule variance percentage
 SPI- Schedule performance index
 SV -Schedule variance

manner and accessible at each site meeting at the end of each month. Moreover, progress could be objectively determined.

The integration of metrics in the EVA system contrasted with the CCM where progress was reported independent of the cost. While time was monitored by tracking progress of works on a weekly basis by the clerk of works, detailed cost performance was not reported. Normally what was reported were payments made against the contract sum and sometimes notification of submission of payment certificate. Contractually, detailed project cost performance were only prepared and presented to the lead consultant and client quarterly. In this particular project, the first cost performance was presented six months after commencement of the project.

Progress determination was done subjectively as exemplified by one incident in one site meeting. The contractor told the meeting that the project was 80% complete but the CoW felt the project was actually 70%. An argument ensued with each party trying to justify their estimation. At the end of the meeting the EVA information was shared and progress was given as 73%. EVA system gave a more accurate figure because it deals with deliverables first and then aggregates them. The contractor was basing his argument on the programme and a perusal of what had been completed, a very subjective approach.

Another aspect which was observed was that EVA information is provided to different levels of responsibility and hence with varied details. As an example, a particular team member assigned to a particular deliverable may be given information for that deliverable while the project manager is provided with information for the whole project as an aggregation of the deliverables. The information provided to the project team may also have varying details, for example, it may be indices or variances. The former simply indicates whether there is cost/time overrun or not, while the latter indicates the extent of the problem. The inclusion of graphics in the reports makes it easier and quick to understand and use EVA information for decision making.

It must be noted though, that without the use of an IT system, EVA is hardly possible. The advantages of an IT system namely speed of calculations, the ease

of updating and the ability to create a database for various aspects of project information and produce multiple copies of information for the various stakeholders (or availing it on-line), makes it a handy tool in the EVA system. Secondly, the use of IT allowed the systematic use of a coding system which in turn facilitated the tracking of cost of project elements. There was lack of a systematic and uniform coding system of project work elements and work packages in the CCM yet these provided an efficient way of tracking costs for elements in the EVA system.

4.2 Behavioural Issues

A number of issues that cropped during the project studied indicated a number of interrelated aspects that need to change in order to use EVA as a project control technique. These are discussed briefly.

4.2.1 Change in working relationship

There is need to change the working relationship among the parties on a project. The use of the EVA system requires a cooperative regime and thus a change of mindset among the key project players (consultants and contractors). During the implementation phase of the project, where control is effected, parties should reference the same information which should have been shared, recognised, discussed and agreed on as the most appropriate information to form the project baseline and subsequent plan.

4.2.2 Use of a common WBS

It was observed that the architect and other consultants used different WBS schemes to define the work to be done. It was noted, for example, that while the QS went as far as level five of the work breakdown structure (which is closer to Figure 2), yet the architect went down to level two. This had several consequences, first was the use of different codes for each down stream activity (BoQ and programme). Second it created a situation where there were missing items in the design.

4.2.3 Use of common coding

To reduce confusion downstream each party has to contribute to the development of the EVA infrastructure, for example, the architect and other

consultants should code their design in such way that the QS and the contractors can use the same codes for the down stream work. It was observed that the architect, the QS and contractor used different codes to refer to the same elements for the same project. The introduction of new codes wastes time and does not add value to the delivery process.

4.2.4 Missing items

Lack of use of the same scope definition scheme resulted in a number of items being omitted while some were not well defined from the architect's information. As an example, out of the 23 project work elements identified from the architect's drawings, only 17 were listed and coded in a legend depicting the overall project scope. The remaining six elements were not listed and hence not coded. In addition, even for the project elements defined, some details were left out by the architect only to be discovered during construction. Thus the lack of standardisation of information produced by respective parties made it difficult for the information to be comparable.

Furthermore, in producing the bill of quantities, the QS also left out some items whose design information at the time were not defined, especially project work relating to elements of, for example, mechanical, electrical and landscaping. Provisional sums were allotted to these elements to cater for their estimated costs and thus in developing the project budget, the QS could only estimate 54% of project elements resulting from the project elements that were defined. The incompleteness of the estimate was thus extended to the contractor, that is, the provisional sums were used to arrive at the tender sum.

4.2.5 Nominated contractors

The detailed costs for provisional works by nominated subcontractors were defined two to six months after signing of the contract with the main contractor. This indeed meant that a detailed project schedule could not be prepared at the time of tendering and instead it was prepared after construction works had started.

4.2.6 Programme accuracy

The provisional nature of the information provided meant that the contractor had to estimate the duration

of execution of provisional items in order to incorporate their schedules in the overall project programme. Due to the incomplete information at the time of tendering, the contractor had to revise the project schedule two times after commencement of the project, with the last revision being produced two months after commencement of work. These project schedules were considered working versions, different from the one submitted at tendering, though the duration of 12 months stated during tendering remained the same.

Also noted was the fact that at tender stage no format for schedule presentation was given to the contractor. Thus the project programme did not show critical items resulting from a critical path analysis. This finding was similar to what Hegazy [27] noted that in this kind situation it is possible to find a simple Gantt chart being used as a schedule on a big project where the critical path is not even defined. Without a critical path the project duration cannot be effectively established.

In view of all these aspects, missing information, lack of identifying the critical path and non-incorporation of the programmes of subcontractors in the main programme, it was inconceivable that the project would take 12 months to complete. In fact the project ended up with an extension of four months and perhaps this was the real duration.

Since the EVA system requires that almost all aspects of the project must be defined at the time of tendering. It clearly shows that nothing must remain provisional otherwise the concept of planned value is violated.

When the WBS was used in the EVA system it provided the basis for scope down loading and which in turn allowed adequate scheduling and pricing of all work prior to the construction stage. The use of a well defined schedule to derive planned value (PV) required a detailed examination of the tasks that make the work packages as defined in the work breakdown structure. In addition, a detailed cost definition allowed detection of work whose costs were not adequately defined. In the TCM system it was noted that mere following the BoQ did not provide a deeper understanding of the details of work to be executed and hence the system failed to provide the ascertainment of the project duration and cost.

5 CONCLUSION

Effective project delivery is of paramount importance because of the need to provide access to services to people. However, projects cannot be delivered on time and within budget and specified quality if there is no effective control. Reports from various countries around the world, including Botswana, indicate flaws in project delivery. While there could be several causes for this anomaly, project control has been cited as one of the key reasons for poor delivery. Devising means to alleviate the problem is therefore, of great importance.

Scholars and practitioners have suggested various techniques that can keep track of projects. One of them, most touted by authors, is the EVA system. They base their claim on the fact that EVA integrates scope, cost and time during monitoring and control. Based on this premise, the study investigated its possible use in building projects in Botswana.

Results from a survey of QS, who are used as cost managers, in all building construction projects, indicated that EVA is not used at all in Botswana. In fact, majority (63%) of the QS have not heard of the system before. Another finding from the second phase of the study was that EVA system provided quality information that could be used in effective project monitoring and control. The information could easily be accessible to all key stakeholders in a timely and understandable manner. In addition, the information could be structured in a manner that it is relevant to each level of responsibility for the various project team members. Another interesting finding was that project progress and associated cost is reported in a more objective manner.

However, to use the EVA system several challenges were also identified. These included firstly, the need to train key players on the project (e.g. QS, architect, CoW and contractors) in the EVA technique. This could be in form of a short course as part of continuous professional development (CPD) or life-long learning. Secondly, there is need to change the project regime from arms-length to a cooperative one to allow transfer of information from design to construction phase and hence be able share the information. Thirdly, the use of IT must be increased at all phases. Fourthly, the design information is fully completed at tendering for all trades. Fifthly, to

ensure that sub-contractors are nominated as soon as the main contract is awarded the project job so as to ensure that their programmes are incorporated in the main programme. Lastly, in using the EVA, the human intervention is not eliminated especially the need to monitor the quality of workmanship. EVA cannot be used to control the quality of building construction and therefore, the CoW is useful even if the system is used.

This being an exploratory study, a further investigation is worthwhile as to how EVA may be used in a design and build (D&B) environment. The D&B environment is a more cooperative regime than the TPS because of the fact that both phases (design and construction) are conducted by one entity.

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