CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter provides an insight in to the literature of construction procurement system. It discusses evolution of construction procurement as a project delivery method and studies its different types. It reviews the importance of time and cost parameters for the performance appraisal of construction projects and studies their effects on different procurement systems. The traditional time and cost monitoring techniques with their limitations are also included in this chapter. In addition, this chapter reviewed Earned Value Management method and discusses its theory, fundamentals, enablers and barriers for its implementation.

2.2 Construction Procurement Methods

In construction industry, the project delivery method is defined as a procurement process that is adopted by the clients or owners for the provision of civil works, infrastructure and facilities by signing an agreement with the private contractors. The International Commission on Building (CIB W92) defines the procurement process as;

“A strategy to satisfy client’s development and/or operational needs with respect to the provision of constructed facilities for a discrete life cycle”.

The notion of procurement in construction projects is unique as compared to other disciplines. This is mainly due to the intricate nature of relationship between the client's needs and expectations versus contractor's priorities. As, both of them are continually in a state of *tug of war* during the project life cycle in order to compete and safeguard their organizational interests.

Before describing the different types of procurement systems, it is appropriate to have a look into the chronological phases of modern procurement system. In past, researchers have linked up the progression of construction procurement system with the phases of world economic growth after the World War II [17]. Usually these phases are classified in to following periods;

- 1945 –1972: Post-World War II Economic Expansion Period
- 1973 – 1980: World Economic Recession Period due to Oil & Energy Crisis
- 1981 – 1990: Post Recession Period
- 1990 – 2010: Contemporary Period

Each of the above phases has their own effects and control on the construction industry. For example during the first phase (1945 – 1972), conventional method of procurement was widely been considered for construction projects. During that period, it was adopted in UK to mitigate the project execution risk in case of poor contractor performance [18]. The second phase of procurement system evolved during the recession period (1973 – 1980). Within this period, the use of non-conventional techniques got some attention of the construction practioners but their applications were quite limited. New procurement approaches were introduced during the third phase of post recession period (1981 – 1990) which mainly include design and build and management centered system of procurement. The modern era of procurement system (1991 – 2010) emphasised more on the partnerships and alliances techniques which usually come out from design and build arrangements.

Nowadays, various forms of procurements are being used in construction industry. A basic classification of procurement system is shown in Figure 2.1. Each of these types is further split into different sub-systems and is explained in the next sections.

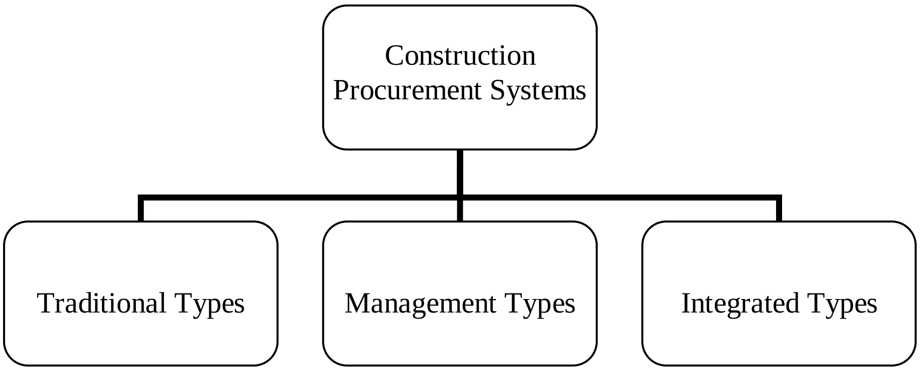

Figure 2.1: Types of Construction Procurement System [17].

2.2.1 Traditional Procurement System

Traditional procurement system is also known as conventional mode of building procurement. It has been in use for the past 200 years by the clients of construction industry. The distinguishing aspect of this type is mainly due to the assigning of design and construction jobs to different entities, namely; the consultants and the contractors [17].

2.2.1.1 Types

Traditional procurement systems can be further breakdown into two procurement packages based on the nature of bidding procedures as adopted by client for the selection of its prospective contractor. These types are as follows;

a) Single Stage Procurement

b) Two Stage Procurement

2.2.2 Management-Oriented Procurement System

This category of construction procurement system bridges the management gap between the design and construction phases of a project. As in case of conventional procurement system, the contractors were kept in isolation with the fundamental engineering and design process. Nevertheless, in management oriented systems the contractors are also get involved as associates with the client's consultants from the start of the project.

In this procurement system, a management contractor or a construction manager is appointed before the start of the construction works at the site. This team is then allowed to work in coordination with the client's designers or consultants. Now the whole team is responsible for managing and integrating the project phases. This includes design, procurement, selection of sub-contractors, construction activities etc [19].

2.2.2.1 Types

This procurement method can be classified into three types which are discussed below;

a) Construction Management

b) Management Contracting

c) Design and Manage Contracting

2.2.3 Integrated Procurement System (IPS)

The procurement systems describe in the previous sections spilt-up the responsibility of design and construction tasks between two independent entities. However, IPS provides an opportunity to a single organization or a consortium having sufficient expertise to take up the overall design as well as construction tasks as a unified project. The client may hire the services of a consultant as an internal advisor, however, the overall management and supervision of total design and construction is the contractual responsibility of contractor. The design and build contractor possess a team of architects, designers, engineers, surveyors and site workers for the execution of the contractual work or may engaged sub contractors for sub-letting the proportion of work [20]. In the last three decades, IPS and its variants have gained much popularity and considered as an innovative approach for public sector procurements. After the 1997 Asian financial crisis (which squeezed the Malaysian construction sector by 23%), the Malaysian construction industry also adopted design and build procurement as a preferred mode of building procurement system for public and private sectors projects [21].

2.2.3.1 Types

Some of the important types of Integrated Procurement System are as follows [17];

a) *Design and Build*

b) *Develop and Construct*

c) *Package Deals*

d) *Turnkey Method*

2.3 Effect of Time and Cost on Different Procurement Systems

The effects of time and cost on the performance of different procurement systems are summarized in Table 2.1;

Table 2.1: Time and Cost Effect on the Different Procurement System [17]

Project Performance Parameters	**Traditional Procurement System**	**Management Procurement System**	**Integrated Procurement System**
Time	It is considered as the slowest project delivery approach. The procurement stages are sequential in nature. Pre-contract duration of this system is longer.	This method is generally considered when early completion of the project is important. This system leads to faster completion due to overlapping of design and construction phase. The simple bidding documents and as well as parallel development of detail design during construction allows for an early execution of activities.	It is called time efficient and fast tracking system. The processes execute in parallel and concurrently to each other. The design free pre-tendering allows for earlier start-up dates for construction works.
Cost	It has low tendering cost because the detailed designs have fully developed prior to tendering. It provides an effective cost control to clients due to less post-contract changes.	Due to the use of work package contractors, the cost of the overall project tends to be lowered than other procurement systems. The fragmented nature of project scope provides the clients a more control over cost and financial risk.	This system lowers the initial and final cost of the project due to integration of process and in-built buildability of design. The cost of the project is fixed at the tender stage, however, client requested changes may cause price variations between the initial figures and the final contract sum.

2.4 Project Time and Cost Monitoring

A project time is defined as the agreed duration of completion for the delivery of product or services by the contractor whereas the cost is the total expenditures that may consumed for providing the resources to produce that product physically. As discussed in the previous section, the term ‘procurement’ is considered as a project based job in construction industry. Therefore, during the project execution stage clients and contractors are always keen to observe the performance measurements indicators. These indicators represent financial and non-financial efficiency and progress of construction project activities. Among them, time, cost and quality are the clear indicators of project performance and assessed its success or failure [22]. These triple constraints of a project are considered as traditional performance indicators for UK construction industry [23]. However, apart from time and cost, quality is a subjective or qualitative expression of client’s satisfaction level. Due to this, these three parameters were classified as “objective” and “subjective” indicators of project performance measurement. In which time and cost being ‘objective’ and quality being marked as ‘subjective’ indicator [24]. Although both of these classes are important for a project success, but typically time and cost are the two widely used parameters for construction project evaluation. It is the prime responsibility of managers in construction projects to ensure cost control and every effort must be made to complete the project with in the approved time period [25].

2.5 Time and Cost Overruns

The life cycle of construction project comprises of different phases. This may include preparatory, procurement, contract award and contract management phases. During the preparatory phase, the project team of client develop the initial time and cost estimates for the overall project duration. Based on these estimates and other preliminary information tender are soughted from the bidders. After the tenders screening and appraisal process, the contract is awarded to the lowest or best evaluated offer. The contract document which is the binding agreement between the client and the contractor stipulates the contractual completion timelines for the scope of work with the approved cost. During the contract management phase, it has been observed that certain causes may lead to delays in construction activities. This will result in time and cost overruns in projects. Time overruns is defined as the extension in time required by the contractor in order to complete the project scope of work [26]. Similarly, the cost overrun is due to the spending of surplus capital as compared to the planned budgeted amount. This is also known as ‘cost escalation’, ‘cost increase’, or ‘budget overrun’ [27]. Time and cost overruns always remained foremost apprehension for the stakeholders. These parameters directly affect the financial viability of a client’s investment and negatively impact the profit margins for the contractors [28].

In Malaysia, the Ministry of Finance issued a circular in 2009 and directed Public Works Department (PWD) and other government agencies to identify the projects that are falling in the category of time overruns. In this perceptive, the Ministry has declared criteria for distinguishing the delayed projects in Malaysia. According to this criterion, any project whose completion had been delayed by more than 20 per cent or two months as compared to its planned schedule is considered as delayed project. In this perspective, a new terminology is being used for delayed projects and they are called as ‘sick’ projects. This circular has changed the existing criterion in which the projects are classified as ‘sick’ when the completion delay is 30 per cent or three months with respect to its planned completion schedule [29].

The National Audit Department of Malaysia in its 2008 Auditor’s General report also highlights the time and cost overruns in public sector infrastructure projects. According to this report a total of 92,687 projects were implemented under Public Infrastructure Maintenance Programme, Basic Infrastructure Programme and Parliamentary Constituency Rural Development Projects. The audit report indicates that many programmes / projects were not delivered efficiently due to the following main causes [30];

- Delay in project completion
- Increased project cost
- Unsatisfactory project monitoring and supervision

- Deviation from original project scope
- Improper payment mechanism to the contractor

This report also mentioned the projects that were implemented during the period of 2005 – 08 under the different Federal Ministries/Departments and suffered time and cost overruns. Some of them are as follows;

1. Ministry of Agriculture and Agro-Based Industry

   Project Title: Construction of Tanjung Manis Integrated Deep Sea Fishing Port, Mukah, Sarawak

   Project Cost: RM 313.62 Million

2. Ministry of Works

   Project Title: Construction of the Federal Government Administrative Centre, Muadzam Shah, Kedah

   Project Cost: RM 243.53 Million

   Project Title: Construction of Sapulut – Kalabakan, Sabah

   Project Cost: RM 563.33 Million

3. Ministry of Transport

   Project Title: Construction of Electrified Double Track Project

   Project Cost: RM 5.77 Billion

4. Ministry of Education Malaysia

   Project Title: Maintenance of School Buildings

   Project Cost: RM 22.18 Million

   Project Title: Project to Supply Clean Water to Rural Schools in Sabah

   Project Cost: RM 174.32 Million

5. Ministry of Health Malaysia

   Project Title: Construction of Pekan Hospital, Pahang

   Project Cost: RM 96.45 Million

The audit report further revealed that delay in project completion of Electrified Double Track Project between Rawang and Ipoh resulted in a cost overrun of RM 1.43 billion. Hence, a delay in carrying out the project activities causes deviation from the approved time and cost baselines. The delays will affect the current prices of the input due to the inflation. Time delay and cost overruns are the underlying factors that principally affect the value of money to the governments.

2.6 Time and Cost Monitoring Techniques

The main objective of project time and cost monitoring is to ensure that activates are completed successfully within the approved time and budget. Time and cost monitoring is an ongoing process and its importance can not be undermined during the project life cycle. Time is a critical factor for a project manager to meet the schedule objectives. On the other hand, its associated cash flow is also a lifeline for the project capital requirements. Both of these parameters are monitored in a variety of ways. The present scope of study has discussed traditional method and as well as integrated time and cost management system for project monitoring.

2.6.1 Traditional Approach

The traditional approach of project monitoring starts with the site commencement and the clients are periodically updated by the contractor with the on-going and completed project activities. The progress reports are generally based on achieved time and cost objectives with their planned targets on every specified intervals. If this report is approved by the client then it also forms a basis of progress payments to the contractor [31]. The next sections will describe the traditional time and cost monitoring tools separately.

a) Time Monitoring Tools

The most commonly used planning and controlling techniques in Malaysian construction industry are shown in Table 2.1.

Table 2.2: Most Commonly used Planning and Controlling Techniques [32]

S.No.	Techniques
1	Bar charts
2	Milestone monitoring
3	Critical Path Method (CPM)
4	Progress Curve/S-curve

The brief descriptions of most commonly used techniques are as follows;

- **Bar Chart:** It is the simplest and easy form of project time controlling. A bar char schedule comprises of activities anticipated start and finish dates with their completion duration. Project team members use this tool for their progress update on daily, weekly or monthly basis depending upon their communication requirement [33].

- **Milestone Monitoring:** Milestones are the critical events whose delay affects the overall schedule performance. In construction projects, it is used for monitoring schedule progress. It is similar to bar chart schedule and controls the start and finish dates of important events only [10].

- **Critical Path Method (CPM) Scheduling:** It is a method to plan and control the projects. During CPM scheduling the duration or completion time of each activity is known. The CPM defines the critical path of planned activities which is the longest path in order to get a project completed. It distinguishes the critical and non critical activities and determines a priority among them. The length of the critical path determines the shortest possible time period for project completion. CPM assists project team members to control the timelines of the project as per original plan [34].

- **Progress Curve/S-curve:** It shows cumulative project progress over the entire duration. In construction industry, S-curve is used as a graphical tool for measuring project progress [35]. It is also used as a basis of comparison with the actual progress. It assists in forecasting future performance trends by plotting and developing a relation between the actual progress and baseline.

b) Cost Monitoring Tools

The bulk of the project budget is consumed during the construction process. Therefore, it is the prime responsibility of the project manager to control the costs associated with the work packages. A project cost includes compensation, land and construction costs, equipment, financing and all other expenditures necessary for the successful completion of the project. During the budgeting process, all these costs are summed up to develop a cost baseline. It is defined as a cumulative time-phased budget that will be used to measure and monitor the current and future project cost performance. It is graphically represented in the form of S-curve and it is an important cost monitoring tool [10]. It allows the user to see the project cash flows over the period of time and also make it possible to forecast the trends of future expenditures. S-curve is an important tool for managing the cash flows in construction projects. It defines the amount of construction expenditures according to the budget allocation [36]. It is also a convenient tool for cost management. It can generate different cost scenarios that will make possible for the manager to envisage the cost trends [37]. Figure 2.2 shows an example of S-curve that is based on accumulative values of cost estimates.

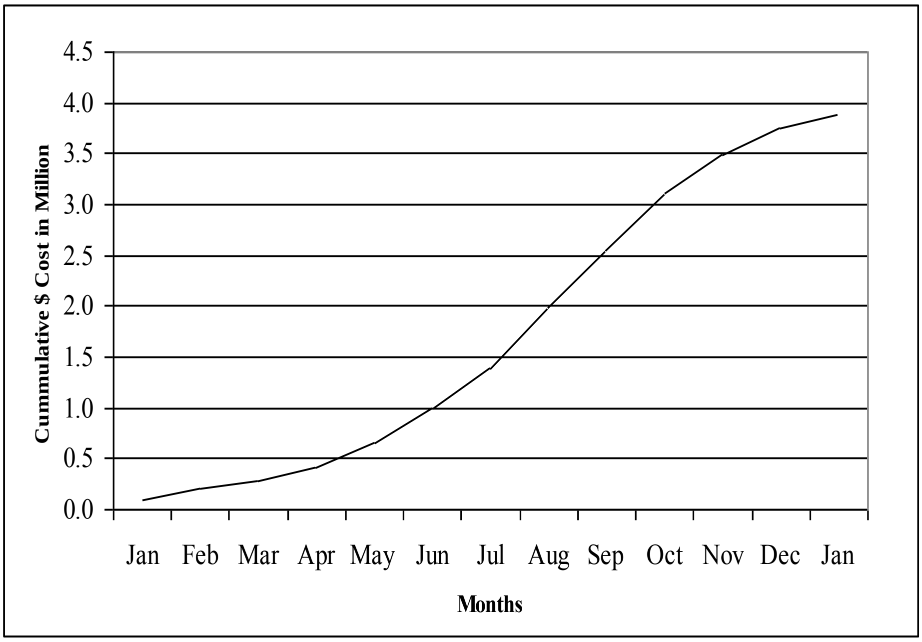

Figure 2.2: An Example of Project S-curve.

2.6.2 Limitations

The time and cost monitoring of an on going project as discussed section 2.5 (a) and 2.5 (b) can be monitored by using different tools like bar charts, milestone monitoring, critical path method (CPM), progress curves or S-curves. This may be reported in the form of day to day monitoring, monthly or weekly management reports, performance reviews, key performance indicators, project audit reports etc. In these customary approaches, usually separate and direct monitoring is used for time and cost analysis. In direct monitoring, there is split up between the time and cost performance indicators. Both of them are measured and reported in isolation with each other by comparing their planned and actual values at stipulated time frames. The direct monitoring does not indicate anything about what has actually been produced for the amount of money spent nor whether it is being produced at the rate, or according to the schedule, originally planned. In other words, it does not relate the time versus cost performance of the project [38].

An effective project performance control can not be achieved only by monitoring the actual physical progress with the planned progress and actual expenditures with the budgeted values. Nevertheless, this approach may be deceptive as it does not take into consideration the worth of the work which is completed during a particular period [39]. For instance, the physical progress graph as shown in Figure 2.3 illustrates that the project is going well and ahead of schedule but certainly there is a possibility that the project is consuming more resources than planned and causing a financial overburden to the organization. Similarly the cost performance graph as shown in Figure 2.4 merely indicates the actual cost against budget. It does not indicate any information that how much has been produced against the spent money. Usually the schedule variance and cost variance are measured by subtracting the actual values from the planned values without considering the value of the accomplished work. This aspect may limit the scope of traditional time and cost monitoring as it does not address the complete depiction of project current and as well as future progress trends in a true manner [40].

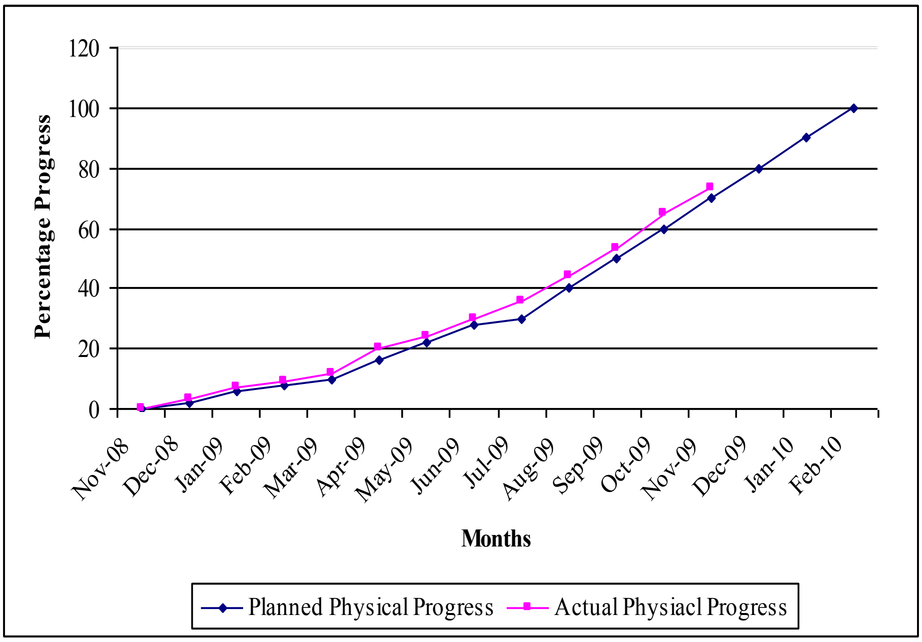

Figure 2.3: An Illustration of Traditional Project Progress Curves.

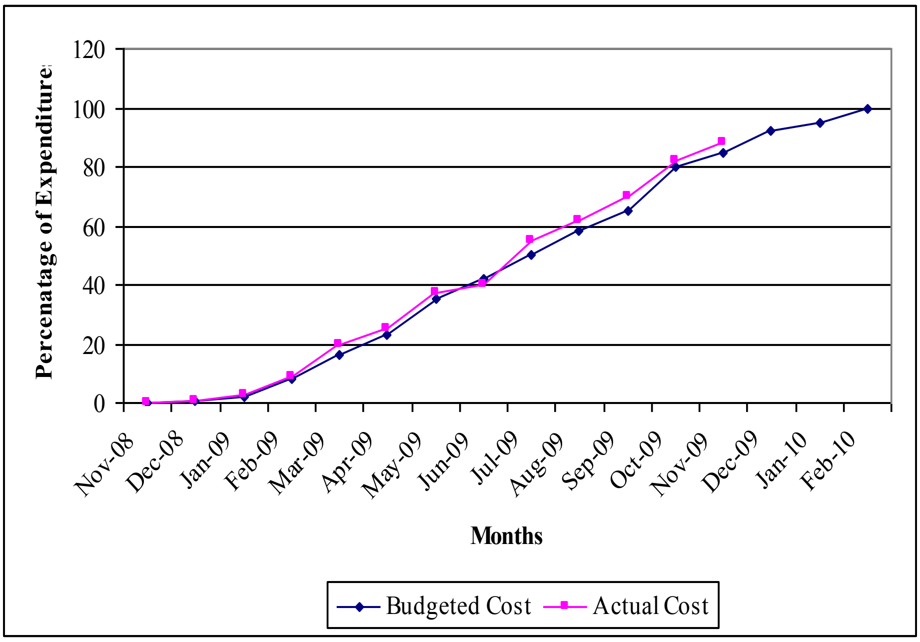

Figure 2.4: An Illustration of Budgeted *vs* Actual Costs Expenditures.

2.7 Earned Value Management Approach

As a remedy of these limitations in traditional monitoring practices, Earned Value Management (EVM) method integrates the cost, schedule and technical performance. It establishes the earned value of a completed work and compares it with the actual cost and planned cost to determine the objective project performance and forecast its future trends [41]. 'Earned Value' is described as an integrated, indirect or remote monitoring technique for the complex interaction of time and cost parameters in order to provide the performance measurement of a whole project [38]. EVM is an effective and useful project monitoring method that helps the client and as well as contractor to assess the project performance. As discussed in the previous section, the traditional approach of project performance measurement usually separates the time and cost parameters during the progress reporting. Nevertheless, EVM integrates time and cost functions and provides the project manager a clear insight of the project performance.

The concept of Earned Value was evolved in 1967 by US Department of Defense and subsequently developed a 35 criterion-based approach which was then called Cost/Schedule Control Systems Criteria (C/SCSC). Initially, it was considered that C/SCSC is a financial control tool which confined its usage in project and programme management. However, in 1989, Undersecretary of US Department for Acquisition adopted this criterion for programme management and procurement. In 1996, it was revised by the US industry and renamed it as Earned Value Management (EVM) [42]. Since then, it has been used as a widely accepted tool by many US government agencies like United States Department of Energy, NASA and US Defense Acquisition Department etc. In 2004, NASA has mandated the use of EVM on its strategic procurements with an estimated budget from 1 to 10 million USD. This is due to the strong features of EVM especially for curtailing the cost overheads and decreasing the schedule delays by indicating the early warnings [43]. It has attracted many other governments' procurement departments including industrial sectors like engineering, construction, oil and gas, infrastructure, information technology etc. In construction industry Earned Value Management (EVM) is also being used as a time and cost control method. It has an ability to bring together planning and management functions. During the last decade, many developed countries have implemented EVA technique in their public and private funded construction projects and achieved remarkable improvements in their practices. Ministry of Construction of Japan has emphasized the use of EVM method on its construction projects [44]. South Korean Congress in July 2000 passed a bill named 'The Effective Plan of the Public Construction Industry Bill' which mandated the construction firms to adopt Earned Value Management System (EVMS) in their project having worth more than 50 million dollars [45].

Earned Value Management (EVM) is a three dimensional approach and is based on following data sources:

- Planned Value (PV) of work scheduled
- Actual Value (AC) of work completed
- Earned Value (EV) of the physical work completed

EVM takes these three data sources and is able to compare the budgeted value of work scheduled (PV) with the Earned Value (EV) of physical work completed and the Actual Value (AV) of work completed. This analysis is more commonly known as Earned Value Analysis (EVA). Hence, performance data achieved by using EVA is an objective measure of actual work performed. Figure 2.5 is an illustrative example of EVA approach.

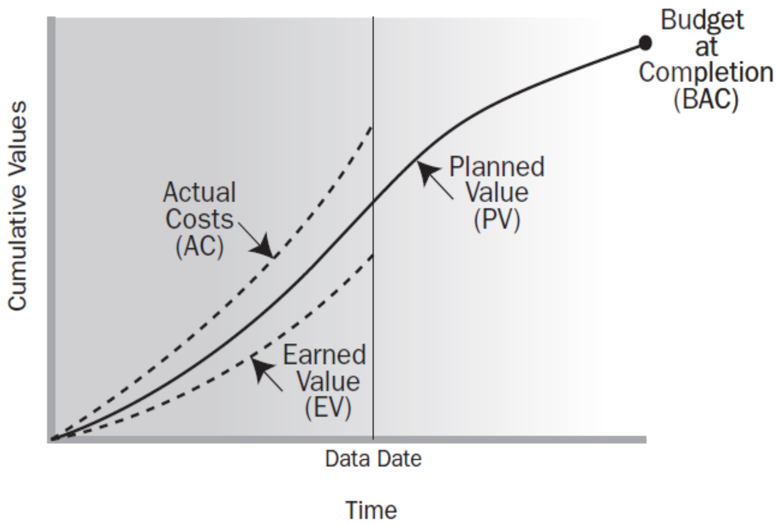

Figure 2.5: An Illustration of EV, PV and AC [10].

2.7.1 Earned Value Analysis

The last part of section 2.7 indicates that EVA relies on three key data points i.e. Planned Value (PV), Earned Value (EV) and Actual Cost (AC). PMI-PMBOK (2008) defined these key parameters as [10];

- **Planned Value (PV)** describes portion of the project budget planned to be spent at any given point in time. It is also known as the Budgeted Cost of Work Scheduled (BCWS). In Figure 2.5, the end point of PV curve is represented by Budget at Completion (BAC) which shows the total budgeted allocated for the entire life of the project.

- **Earned Value (EV)** is a description of work progress at a given point in time. It is also known as the Budgeted Cost of Work Performed (BCWP) and reflects the amount of work that has actually been accomplished at any particular time frame. EV is calculated by multiplying the allocated budget for an activity by the percent progress for that activity:

$$EV = (Allocated\ budget)\ x\ (\%age\ complete) \quad (2.1)$$

- **Actual Costs** (AC) is the amount of expenditures that are utilized for the completion of the work package activity. This is also known as the Actual Cost of Work Performed (ACWP).

After the terms PV, EV and AC are defined; the assessment of current and future time and cost performance can be done which will provide important information on the project progress.

2.7.1.1 Time Analysis and Forecasting

Schedule analysis and forecasting calculations helps the project manager to quantify the time-wise performance. The monitoring of Earned Value time variance, index and forecasting estimates indicate that how efficiently a project is progressing. These indicators are as follows;

- **Schedule Variance (SV):** It is the difference between what was planned to be completed and what has actually been completed as of the current date. It is calculated by subtracting the Earned Value (EV) from the Planned Value (PV). Mathematically it is defined as;

$$SV = EV - PV \quad (2.2)$$

A SV is a measure that whether the project activities are completed as per planned schedule or not. A positive value of SV indicates that the project is progressing well and ahead of schedule targets whereas a negative value shows that the progress is performing less than planned.

- **Schedule Performance Index (SPI):** It indicates the efficiency of time utilization in order to achieve the planned work. It is calculated as;

$$SPI = EV \div PV \quad (2.3)$$

The interpretation of SPI ratio is a useful feedback. A ratio which is less than 1.0 is an unfavourable scenario and it indicates that work is being completed at a slower rate. On the other hand, a SPI ratio which is equal to 1.0 or greater than 1.0 indicates that project team is accomplishing their job efficiently by utilizing their maximum working time in delivering positive yield.

- **Time Estimate at Completion (EAC_t):** It is a forecasting parameter that estimates the anticipated time duration required for completing the project. PMI Practice Standard for EVM (2005) defined a formula for calculating Time Estimate at Completion [46];

$$EACt = (BAC \div SPI) \div (BAC \div Original\ Duration) \qquad (2.4)$$

Where BAC is the budget at completion and it is equal to the total planned value of the project.

2.7.1.2 Cost Analysis and Forecasting

Project cost analysis and forecasting is an important concern of management and it requires for the cost-wise evaluation of project performance. A list of Earned Value Cost Performance indicators are as follows [46];

- **Cost Variance (CV):** It is the difference between the worth of the work that has been accomplished and to the amount of money that was spent to accomplish it. Mathematically it is represented as;

$$CV = EV - AC \qquad (2.5)$$

A positive value of CV shows that the project is spending less than the planned budget whereas the negative value shows that actual cost is exceeded than the budgeted amount. Whenever the later condition happens, it indicates an unfavourable scenario to the management and requires necessary corrective measures to control the negative variance within the approved limits.

- **Cost Performance Index (CPI):** It indicates the efficiency of resource utilization and measures the worth of the work that is achieved by spending every single unit dollar. Mathematically it is expressed as;

$$CPI = EV \div AC \qquad 2.6)$$

A ratio less than 1.0 is an unfavourable and indicates that the value of the work that has been accomplished is less than the amount of money spent. Similarly, vice-versa is the case for CPI ratio greater than 1.0.

- **To-Complete Performance Index (TCPI):** It indicates the efficiency which must be maintained by the project team in order to complete the remaining project activities with in the approved budget. It is expressed as;

$$TCPI = (BAC - EV) \div (BAC - AC) \qquad (2.7)$$

- **Cost Estimate at Completion (EAC_c):** It is a forecasting indicator and calculates the finishing cost of the project by assuming the current cost performance efficiency. It is calculated as;

$$EAC_c = BAC \div CPI \qquad (2.8)$$

- **Cost Variance at Completion (VAC_c):** It forecast the variation in cost expenditures and shows that how much the project will be under or over budget at the end. It is obtained by subtracting the original budget at completion from the new cost estimate at completion.

$$VAC_c = BAC - EAC \qquad (2.9)$$

- **Estimate to Complete (ETC):** It indicates the estimated remaining worth of the project work. It is calculated as;

$$ETC = (BAC - EV) \div CPI \qquad (2.10)$$

2.7.2 Advantages of EVM Method

The objective of using EVM method is to make certain the time and cost performance during the project is in control with respect to the original schedule and budget [47]. EVM performance indices are efficient and methodologically simple in order to calculate a number performance measures [14]. The applications of EVM method supports project practitioners with the early warning indicators that allow them to envisage future performance problems and implement corrective actions in a timely manner [48]. It is a useful communication tool and keeps the project team focus on achieving successful completion of projects [49]. Table 2.3 shows a summarized list of EVM benefits;

Table 2.3: Benefits of EVM [50]

S.No.	Description
1	A single management control system providing reliable data.
2	The integration of work, schedule, and cost using a Work Breakdown Structure.
3	A database of completed projects useful for comparative analysis.
4	The cumulative Cost Performance Index as an early warning signal.
5	The Schedule Performance Index as an early warning signal.
6	The Cost Performance Index as a predictor for the final cost of the project.
7	An index-based method to forecast the final cost of the project.
8	The To-complete performance index to evaluate the forecasted final cost.
9	The periodic (e.g., weekly or monthly) Cost Performance Index as a benchmark.
10	The management by exception principle can reduce information overload.

The use of EVM method is now highly accepted among project professionals due to its ability of forecasting time and cost impacts of problems. It helps them to mange their projects with a proactive approach. Table 2.4 presents rating of EVM utilities in the public and private sector as surveyed from the member of Project Management Institute (USA) and the former Performance Management Association (PMA). During this survey, it has been revealed that high positive ratings were achieved towards the advantages and acceptance of EVM method in the industry.

Table 2.4: Utilities of EVM* [51]

S.No.	**EVM Utilities**	**Mean Rating**	
		Public	**Private**
1	Estimate cost and time to complete	6.0	5.7
2	Identify cost and schedule impacts of known problems	5.9	5.5
3	Accurately portrays the cost status of a project	5.7	5.6
4	Can trace problems to their sources	5.3	5.1
5	Can portray the schedule status of a project	5.3	5.4
6	Can provide timely information on project	5.3	5.4
7	Identify problem areas not previously recognized	5.1	5.4

* Ratings: 1 – 3: Disagree, 4: No opinion, 5: Mildly Agree, 6: Agree, 7: Strongly Agree

In 2009, an exploratory study was conducted in the South African (SA) construction industry to find the usage of EVM method with respect to the project success. This survey was conducted from the members of Project Management Institute (South African Chapter) and the Cost Engineering Association of South Africa. The survey result found that there was a strong agreement among the respondents regarding the benefits of EVM performance indices for controlling the project scope, schedule, cost and change control process. Table 2.5 shows the preliminary results of this study.

Table 2.5: EVM Users Perception with respect to Advantages [52]

S. No.	EVM Advantages	Attributes						
		Strongly Disagree	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Strongly Agree
1	EVM performance indices contributed to controlling the contract schedule.	0	0	0	25%	0	25%	50%
2	EVM performance indices contributed to controlling the contract scope.	0	25%	0	0	25%	0	50%
3	EVM performance indices contributed to controlling the contract cost.	0	0	0	0	25%	25%	50%
4	EVM performance indices contributed to evaluating and processing change orders.	0	0	0	0	0	33%	67%

2.7.3 Barriers to EVM Implementation

In the past decade, researchers studied and collected information to ascertain the barriers of EVM implementation in project organizations. Generally, it has been established that the small and medium size organizations may not have adequate resources to adopt EVM System in their working environments. In these organizations, it is tedious and costly to implement EVM System [14]. Furthermore, the administrative efforts required for the implementation of EVM method is considerably higher which increases the cost to validate its acceptance and understanding in the organization [53]. Table 2.6 presents a number of EVM barriers that have been reported in the precedent literature. Their mean ratings are provided with respect to the respondents of public and private sectors.

Table 2.6: *Ratings of EVM Barriers [51]

S.No.	EVM Barriers	Mean Rating	
		Public	**Private**
1	Optimistic view of users in planning	3.4	3.2
2	Inaccurate assessment of EVM	3.3	3.2
3	Lack of understanding of EVM	3.2	3.3
4	Culture such as distrust	3.2	3.1
5	Poor image of EVM	3.0	2.9
6	Takes long time to train	2.9	3.0
7	Too much paper	3.0	2.8
8	Lots of jargon	2.8	2.8
9	Inaccuracy in high-tech projects	2.8	2.7
10	Too much rules	2.8	2.8
11	Lack of user participation in designing EVM	2.7	2.6
12	Projection based on historical data	2.6	2.6
13	Lots of costs	2.6	2.3
14	Inconsistency between WBS and Org.	2.6	2.6
15	Use of deterministic scheduling tech.	2.6	2.3
16	Need additional scheduling systems	2.6	2.3
17	Detailed WBS	2.2	2.1
18	EVM weakens management power	1.7	1.5

*Ratings: 1: Not a problem

2: Insignificant problem

3: A minor problem

4: Major problem

5: Extreme problem

The mean ratings of EVM barriers from Table 2.5 indicate its range between 3.4 and 1.6. It is also revealed that there is no considerable difference between the public and private sectors rating and ranking of EVM barriers. As both of them have similar understanding towards EVM problems.

2.8 Earned Value Management (EVM) Standards

This section briefly reviews the EVM Standards which are being used in industry from the past one decade.

a) ANSI/Electronic Industries Alliance EVM Standard – 1998

In May 1998, American National Standards Institute (ANSI) set forth 32 steps criteria, named as ANSI/Electronic Industries Alliance 748-A-98 for EVM.

According to this Standard [54]:

"Earned Value Management System (EVMS) for program management will effectively integrate the work scope of a program with the schedule and cost elements for optimum program planning and control. The primary purpose of the system is to support program management. The system is owned by the organization and is governed by the organization's policies and procedures."

This Standard describes five processes to implement EVM in managing projects at programme level. These processes are further elaborated by using 32 guiding steps which provides an overall structure for an integrated performance measurement system.

b) PMI Practice Standard for Earned Value Management – 2005

According to this Standard [46]:

"It has been developed as supplement to A Guide to the Project Management Body of Knowledge (PMBOK® Guide). The Practice Standard for EVM is designed to provide readers who are familiar with the PMBOK® Guide with a fundamental understanding of the principal of EVM and its role in facilitating effective project management."

The standard describes the basic elements of EVM i.e. Planned Value (PV), Earned Value (EV), and Actual Cost (AC) and examines their derivation and relationships in detail. It discusses the EVM performance analysis and forecasting. This Standard outlines the structure of EVM processes which consists of 10 criteria and organized into two high level categories.

c) Australian Standards for EVM – 2006

According to this Standard [55]:

"It establishes requirements and gives guidance for the measurement and reporting of cost and schedule performance of projects and programmes using the EVPM method".

It describes the fundamental notions and actions that are required for the EV performance measurement. It can be applied to any single or multidisciplinary array of projects (i.e. programme). The EVM processes are listed in 11 steps with stipulated requirements for each step.

2.8.1 Comparison of Processes of EVM Standards

As discussed in the previous section, all EVM Standards (i.e. ANSI/EIA-748-A-1998, PMI Practice Standard EVM – 2005 and AS4817-2006) provide different levels of detail and approach in order to implement an EVM System. These standards establish procedures and guidelines to facilitate effective planning and control of projects and programmes. These standards satisfy the users with their stated objectives. Table 2.7 presents a comparison of EVM processes as described by these three standards.

Table 2.7: Comparison of Earned Value Standards [56]

	ANSI/EIA-748-A-1998	**Practice Standard EVM – 2005**	**AS 4816 – 2006**
EVM Processes	The 5 basic processes are listed as; 1. Organization 2. Planning, scheduling and Budgeting 3. Accounting considerations 4. Analysis and management reports 5. Revisions and data maintenance	The 10 fundamentals steps are as follows; 1. Decompose the work to a manageable level 2. Assign unambiguous management responsibility 3. Develop time-phased budget for each work task 4. Select EV measurement techniques for all task 5. Maintain the integrity of PMB throughout the project 6. Record the resource usage during the project execution 7. Objectively measure the physical progress 8. Credit earned value according to EV technique 9. Analyze and forecast cost/schedule performance 10. Report performance problems and/or take actions	The 11 basic processes are as follows; 1. Decompose the project scope 2. Assign responsibility 3. Schedule the work 4. Develop time-phased budget 5. Assign objective measures of the work 6. Set the performance measurement baseline 7. Authorise and perform the work 8. Accumulate and report performance data 9. Analyse project performance data 10. Take management action 11. Maintain the baseline

2.9 Summary

Construction projects evolved as a result of procurement. Different types of procurement systems are discussed in the previous sections. Each of them has its own procedures and limitations. These systems provide multiple options to the clients to conceive a project. After the approval of project scope and its associated cost by the clients, the execution stage follows. This stage requires an effective project management under demanding conditions of time, cost and quality. However, time and cost monitoring of construction projects are the critical elements. Any overruns in these parameters during the project cycle make it difficult for the project team to recover and achieved the baseline targets. Traditional time and cost monitoring practices simply compares actual performance against estimated which generally provide a limited control and insight in to the project progress. Further more, these techniques are not so much efficient to provide the early warning indicators and forecast future performance trends. Hence, the use of an appropriate and standard technique is the primary objective during the construction process in order to ensure the completion of project with in the approved time and budget. The increasing use of Earned Value Management method integrates time, cost and technical performance of projects. Earned Value calculations for the assessment of current performance and future predictions provide an explicit view of the project progress in a three dimensional direction. It provides early warning signs about any divergence from the project baseline and triggers the implementation of contingency strategies by the project team to ensure the successful completion of project.