Earned Value Performance Measurement:

An Alternative Approach to Measuring

Information Systems Project Progress

AUTHOR: M.Fleishman

Earned Value Performance Measurement: An Alternative Approach to Measuring Information Systems Project Progress

---

Mark Fleishman

A research report submitted to the Faculty of Commerce, University of Witwatersrand, Johannesburg, in partial fulfilment of the requirements of the degree of Master of Commerce.

Johannesburg 1998

Declaration

I declare that this research report is my own unaided work except to the extent indicated by the acknowledgements, text and references. It is being submitted in partial fulfilment of the requirements for the degree of Master of Commerce at the University of the Witwatersrand, Johannesburg.

It has not been submitted before for any degree or examination at any other university.

Mark Fleishman

24th day of June, 1998.

Abstract

Information Systems (IS) project management is fundamental to organizations who are involved in the development of information systems, yet IS projects can fail for any number of reasons, and in some cases can result in considerable financial losses for the organisations that undertake them. One pattern of failure is that the IS project takes on a life of its own, continuing to absorb valuable resources without reaching its objective. A significant number of these projects will ultimately fail, potentially weakening an organisation's competitive position while siphoning off resources that could be spent developing and implementing successful systems.

Earned value performance measurement (EVPM) is a management technique that relates resource planning to schedules and to technical performance requirements. It is formed on a platform of fundamental project management, but with earned value performance measurement, with its focus being the continuous measurement of actual achievement against a detailed performance plan, thus providing a basis for problem identification, corrective actions, and management replanning, whilst providing the information necessary to be able to predict the final costs and final schedule forecasts for the project.

The purpose of this study is to highlight the earned value performance measurement system, and propose it as an alternative approach that can be used for controlling the IS software development effort.

Acknowledgements

I would like to thank all those people who, directly and indirectly, assisted me with this project. It is not possible to mention everyone by name, however, a special word of thanks to:

My wife, Estelle, and daughter, Mandi	For all their love, patience and support
Andre van der Merwe	Who supervised the project, and for his deep insight, patience, guidance, and exceptionally quick turnaround of draft copies
Tom Addison	For his additional supervision and assistance
First National Bank's IT Division	For their financial contribution and their confidence in my capabilities in nominating me for the Masters of Commerce studies,

and all those who spared time from their busy schedules for the discussions and the invaluable input of their experience.

Contents

Abstract iv

Acknowledgements v

Contents vi

List of Figures viii

Chapter 1 : Introduction and Background 1
- 1.1 Introduction to the Research Topic 1
- 1.2 The Problem 3
- 1.3 Research Objectives - Towards an Alternative Approach 6
- 1.4 Limitations of the Research 8
- 1.5 Structure of the Report 9

Chapter 2 : Review of the Related Literature 10
- 2.1 Introduction 10
- 2.2 The Importance of Project Management to the Success of Organisations 10
- 2.3 Issues that have an impact on IS project progress measurement 11
  - 2.3.1 IS Project Planning 11
  - 2.3.2 IS Project Estimating 12
  - 2.3.3 Scope Creep 14
  - 2.3.4 IS Project Risk 15
  - 2.3.5 IS Project Cost 17
- 2.4 Earned Value Performance Measurement 18
- 2.5 Summary 20

Chapter 3 : Research Method 21

Chapter 4 : The IS Project Management Process 24
- 4.1 Introduction 24
- 4.2 Initiating Process 25
- 4.3 Project Planning 25
  - 4.3.1 The purpose of planning 25
  - 4.3.2 The Project Planning Process 27
- 4.3 Project Execution 28
- 4.4 Project Control 28
  - 4.4.1 Prerequisites of a control system 29
- 4.5 Project Closure 30
- 4.6 The Project Life Cycle 30
- 4.7 Summary 32

Chapter 5 : Earned Value Performance Measurement 33
- 5.1 Introduction 33
- 5.2 Historical Overview 36
- 5.3 The Earned Value Performance Measurement Technique 38

5.4 Elements of Earned Value 51
5.5 Points to Consider When Using Earned Value 58
5.6 Variance Analysis 61
5.7 Earned Value in action 62
5.7.1 Project 1 62
5.8 Summary 63

Chapter 6 : Contribution of this Dissertation and Implications to Researchers 64

Chapter 7: Conclusion 66

Appendix 1 68

References 74

List of Figures

Figure 1 : Range of Uncertainty 14

Figure 2 : Drive the Risk Down 16

Figure 3 : Project Control Cycle 16

Figure 4 : The Basic Feedback Loop of Control 27

Figure 5 : The Waterfall 2 Life Cycle 31

Figure 6 : The Re-engineered Earned Value Performance Measurement Process 39

Figure 7 : Elements of Earned Value 51

Figure 8 : Gantt Chart - Project 1 62

Chapter 1 : Introduction and Background

1.1 Introduction to the Research Topic

Information systems (IS) project management is a risky business (McLeod and Smith 1996), and IS projects can fail for any number of reasons, and in some cases, can result in financial losses for the organisations that undertake them (Conway 1996; Keil 1995). For many years, newspapers, journals and books have contained reports of projects that have overspent their budgets or overshot their completion dates (Abdel-Hamid and Madnick 1991; Brooks 1995; Conway 1996; Earl 1995; Gioia 1996; Kharbanda and Stallworthy 1983; Lederer and Prasad 1993 a; Sterman 1992; Wall 1988), with some even being abandoned (Ewusi-Mensah and Przasnyski 1994; Ewusi-Mensah and Przasnyski 1995).

Studies by the U.S. Government General Accounting Office of nine federal software projects valued at $6.8 million in 1985 indicated that only 2% were used as delivered (Cort 1989). Another study (Parkinson 1991) shows only 8% of systems were used without modification. Garner (1995) quotes an example of the California Department of Motor Vehicles spending 7 years and $21 million on a database redevelopment project before scrapping it. Another example is the Bank of America's MasterNet which was projected to cost $20 million in 1987, and expanded to cost $60 million before it was abandoned (Garner 1995).

It is not only total project failures that should be attracting management's attention. Many of the successfully implemented projects overrun their schedules and budgets before they are completed. A study of 8380 projects in government jurisdictions and the private sector in the United States indicated that 53% of those that are completed cost an average of 189% of their original estimates and average only 42% of the originally-proposed features and functions, and the lost opportunity costs from project delays and cancellations could not be measured, but could easily be in the trillions of dollars, with only 9% being completed on time and on budget (Seldon 1996; Treasury Board of Canada Secretariat 1996). Garner (1995) lists the City of Denver airport baggage-handling software as an example where delays cost the city about $33 million a month, and stretched for more than a year. This same project is referred to by Bate et al (1995) as being delayed by 25 months at a cost of $500000 a day.

These are large schedule and budget overruns, and while most IS organisations have smaller projects, the overruns are still significant. Lederer and Prasad (1993 a) found that three quarters of all major IS projects in companies costing more than $50 000, substantially missed their estimates. Keil (1995) states further:

> "While it is difficult to obtain statistics on the actual frequency of IT failures, various sources suggest that at least half of all IT projects are not as successful as we would like them to be."

Project overruns, in time and cost are customarily seen as a failure in project management. De Marco (1982) writes about such projects:

> "So many software projects fail in some way that we have had to redefine 'Success' to keep everyone from becoming despondent. Software projects are sometimes considered successful when the overruns are held to thirty percent or when the user only junks a quarter of the result. Software people are often willing to call such efforts successes, but members of our user community are less forgiving. They know failure when they see it."

1.2 The Problem

Evaluation of computer-based information systems, is an integral part of the management control process (Hamilton and Chervany, 1981), yet

> "The ongoing evaluation of information system projects, once the projects are initiated, is generally not carried out with sufficient frequency or attention to detail. In fact, in many instances, no ongoing evaluation is conducted at all." (Remenyi and Sherwood-Smith 1996)

The literature is full of reasons why projects fail, amongst others:

- Inadequate planning and incomplete requirements
- Poor containment of project scope
- Poor estimating practices
- Fixation on first estimates
- Unrealistic budgets
- Insufficient cost control
- Insufficient control of activities
- Control is not exhaustive or is intermittent
- Necessary activities overlooked
- Project plans making no allowance for contingencies
- Checkpoints not used to monitor progress
- Performance not adequately monitored

There are other factors, for example, politics, changing technology, environment and organisational issues, and the economic climate, which are largely outside of the span of control of the project manager and project team, but which can also play a significant part in the project overrun, but the management of the project remains the responsibility of the project manager. (Kharbanda and Stallworthy 1983; Meredith and Mantel 1989).

All projects share one common characteristic - the projection of ideas and activities into new endeavours (Lock 1988), and thus the steps and tasks leading to completion can never be described accurately in advance. Most application development organisations therefore, have difficulty in predicting the probable outcome of their ongoing projects, since their project managers have a limited visibility into the true project status (Conway 1996).

By definition, because each project is unique, its outcome can never be predicted with absolute confidence, and added to this, project managers often submit estimates that make an effort to meet management's inflexible budgets and deadlines, but which are hopelessly inaccurate. Management must realise that software development is not an exact science (Gibbons 1995), and that as an estimate is a prediction based on probabilistic assessment (De Marco 1982), and because software remains largely intangible during most of the development process (In't Veld 1996), it is difficult for project managers to assess real progress on a project.

In most project management systems, there is some ability to determine progress, the most common method being the "per cent complete" measure. This is analogous to driving a car by looking in your rear-view mirror. It shows you what has happened, or where you have been, but it doesn't inform you about the concerns that matter, namely, the condition of the project at time now, and its prognosis for meeting its due date.

Another method incorporates the "spend plan" approach, whereby actual expenditures are compared against planned expenditures. This form of accounting-orientated analysis is inadequate for the control of project work (Hatfield 1996), as it merely highlights whether you have spent more or less than you budgeted, rather than whether you are getting the work expected for the money spent. As Abdel-Hamid and Madnick (1991) state:

> "....because software is an intangible product, it is difficult to evaluate the status of the intermediate work, and thus often progress is measured by the rate of expenditure of resources rather than by some count of accomplishment."

This approach has no objective relationship to the work that was actually accomplished (Meredith and Mantel 1989), and to the extent that the perceived progress rate differs from the real progress rate, an error in perceived cumulative progress will gradually compound. Furthermore, bias, often in the form of over-optimism, and delays in gathering and processing control information additionally distorts the reported progress.

1.3 Research Objectives - Towards an Alternative Approach

> "It is crucial to continuously explore ways to increase the probability of successful project completion."
>
> (Globerson 1997)

While past history is dismal, without changes, future performance is likely to be just as bad. Added to this, increasing project complexity has led to the recognition that management control on projects needs to be improved (Abba 1997), and there is the additional need to find a method of measuring progress that is less subjective (Sparrius 1996: c).

As Earl (1995) states:

> "Some IS developments qualify as major projects. They are large in work content, substantial in impact and carry several risks. IT executives therefore frequently call for both better project managers and improved project management techniques."

Cost overruns and schedule delays can be avoided if comprehensive planning and control analyses are performed during the development of the IS application, but where deviations occur, it is not only critical that they are contained, but more important that they are signalled early (De Marco 1982).

The primary objective of this research, therefore, is to highlight the earned value project performance measurement concept within the Cost Schedule Control System Criteria (C/SCSC) and to propose it as an alternative method of measuring IS project progress. This technique has largely been restricted to the acquisition of major systems by the United States (US) government, the US Department of Defence, and the US aerospace industry. Private industry, has not completely embraced the concept.

The objectives of the research were:

- To conduct a literature review to determine what has already been documented in relation to earned value performance measurement and the cost / schedule control system criteria.

- To propose a theoretical approach for using earned value performance measurement, as a means of measuring IS project progress.

To address the problems encountered with IS project progress measurement, the following hypothesis was proposed:

> **The earned value performance measurement technique can be used to measure IS project progress.**

To discuss the hypothesis, secondary objectives need to be addressed, these secondary objectives being:

- To describe the IS project management process at a high level;
- To identify the issues that impact on IS project progress measurement;
- To describe the earned value performance measurement technique, including:
    - an introduction to earned value performance measurement
    - a sound foundation of all essential principles, features and benefits
    - the proposed steps required for utilising earned value performance measurement on IS projects

1.4 Limitations of the Research

This study deviated from the usual research undertaken during a dissertation in that it highlights a project management technique that is currently used mainly by the US Government and Department of Defence for major acquisition projects. As a result thereof, the earned value performance measurement technique and cost schedule control systems criteria (C/SCSC) are not widely documented. That which is documented, concerns itself with the basic theory and the fundamentals of its application, and therefore the author had to resort to much of the research taking place on the Internet, by way of world wide web page searches, and informal discussions using e-mail and discussion groups.

As a further result of the topic not being widely documented, the literature review also differs from the normal review expected in a thesis in that much of the available literature and references were used as substantiating documentation in the body of the thesis, as opposed to appearing in the literature review.

1.5 Structure of the Report

The report is structured as follows:

Chapter 1 introduces the research topic, describes the research objectives and declares the limitations of the research.

Chapter 2 presents a review of the background research and literature upon which this research report is based, and highlights the issues that impact on IS project progress measurement, and the earned value performance measurement technique.

Chapter 3 details the methodology employed, the hypothesis, the objectives and the gathering of data.

Chapter 4 presents a high level description of the IS project management process.

Chapter 5 proposes the earned value performance measurement technique as an alternative approach to measuring IS project progress.

Chapter 6 discusses the contribution of this dissertation and implications to researchers

Chapter 7 discusses the conclusion.

Chapter 2 : Review of the Related Literature

2.1 Introduction

An extensive review of IS and project management literature was conducted to identify what empirical information was available regarding the issues pertinent to the area of IS project performance measurement, with the focus being placed on the importance of IS project management to the success of organisations, issues that have an impact on IS project progress measurement, and earned value performance measurement. This included an intensive perusal of primary, secondary and tertiary (Sharp and Howard 1996) sources, especially US government and defence publications, and online sources.

2.2 The Importance of Project Management to the Success of Organisations

> "Project management has become today one of the main organisational activities performed within modern organisations."
>
> Shenhar et al (1997)

Business is going through a major revolution (Hammer 1990; McFarlan 1990; Drucker 1992; Handy 1994; Remenyi 1995). Added to this, the rate of change in organisations is increasing, and projects are often the source of these changes. This in turn, has led to a growing appreciation of the need for a project management culture as business-critical IS projects have come increasingly under the spotlight.

During these times of change, projects are no longer only being used as a means of improving efficiencies in organisations, but rather as an enabler of critical business functionality (CSC Research and Advisory Services 1994). Added to this, the number of projects have also increased, as have the dependencies between systems, not only internal to the organisation, but across organisations.

The principal reason for the development of the project management concept, organisation, and specialised, often highly sophisticated techniques, is that the traditional forms of organisation structure and management techniques do not cope with project-type work effectively, as Dinsmore (1993) states:

> "Executives face the challenge of adopting new management practices to meet the demands placed on the business by the changing world. The new practices must include approaches that provide timely and cost-effective responses."

2.3 Issues that have an impact on IS project progress measurement

2.3.1 IS Project Planning

Information Systems (IS) project management is fundamental to organizations who are involved in the development of information systems, yet IS projects can fail for any number of reasons, and in some cases can result in considerable financial losses for the organisations that undertake them.

One pattern of failure is that the IS project takes on a life of its own, continuing to absorb valuable resources without reaching its objective. A significant number of these projects will ultimately fail, potentially weakening an organisation's competitive position while siphoning off resources that could be spent developing and implementing successful systems.

The planning of an IS project is fundamental to the success of a project (Black 1996), but in many cases, this is overlooked, not applied very well (Kliem 1996), or not enough time is allocated to the planning process as management "demand" a quicker turnaround or delivery in line with their management-imposed deadlines.

Inadequate planning increases the likelihood of project failure (Lister 1995). Furthermore, planning is not an easy task and there are many pitfalls along the way that make it difficult to achieve the project objective. Black (1996) lists some of these pitfalls:

- it is unlikely that the project planners will have a knowledge of all the activities and resources needed to effect successful project completion
- project planning being done with insufficient data
- project not adequately defined at the beginning
- lack of clearly defined project goals and objectives
- poor work definition

The project manager must therefore plan his way around the problems that arise and take remedial action so that the impact on project time-scales and budget is minimised (i.e. risk management with planned contingencies).

2.3.2 IS Project Estimating

According to Van Der Merwe (1997), the purpose of a project is to deliver beneficial change, by undertaking a unique scope of work using a project team made up of different personnel for each project.

The change only adds value if it achieves its quality criteria within its cost and time parameters, and to user satisfaction, whether it be in the form of increased efficiencies, gaining an edge over competitors, or complying with legislation, but because the work undertaken for each project is unique, it involves a level of risk. The risk is that the change brought about by the project can cost more than the potential damage cause by maintaining the status quo, and therefore, a project is only cost justified if it provides a more effective solution to eliminate a problem, than to live with.

Whatever the intended objective of the project, the organisation needs estimates of the cost and timescale for developing the system to assess its net benefit to the organisation, and thus efficient estimating is essential to the initial decision on whether to proceed with the project or not. If project costs are underestimated, the organisation can be locked into uneconomic investments, undertake the wrong project, or "run out" of funds, and when project costs are overestimated, these projects may be declined, with the associated loss of potential benefit to the organisation, yet

> "An estimate is the most optimistic prediction that has a non-zero probability of coming true."
>
> (De Marco 1982)

De Marco (1982) suggests that an estimate is a prediction that is based on probabilistic assessment, i.e. a predicted value and a range of uncertainty about that predicted value (Saker 1990). Chapman and Turner (1995) add to this by stating that estimates are a form of mid-range value, which can almost be guaranteed to be different from the estimate.

Saker (1990) adds further that:

> "... the estimating process is, itself, fraught with difficulties."

IS development is not an exact science (Paul 1995), and therefore a project that is completed according to its first estimate is the exception rather than the rule, because of many factors, not the least of which is the lack of information at the early stages of the project life cycle on which to base an accurate estimate (Turner and Remenyi 1995). Yet the IS project manager is expected to commit to a delivery date and cost at the beginning of the project, to get the project authorised, and these figures usually become the de facto cost and date (fixation on first estimate), usually resulting in unrealistic expectations, project cost overruns, missed deadlines and failed projects.

As IS projects are not mechanistic (Turner and Remenyi 1995), and until the design has been completed, only imprecise estimates of project costs can be made, and therefore th[illegible] be several estimates through the life of the project, each of which is subject t[illegible] of uncertainty which declines as the project progresses and more information becomes available (see Figure 1).

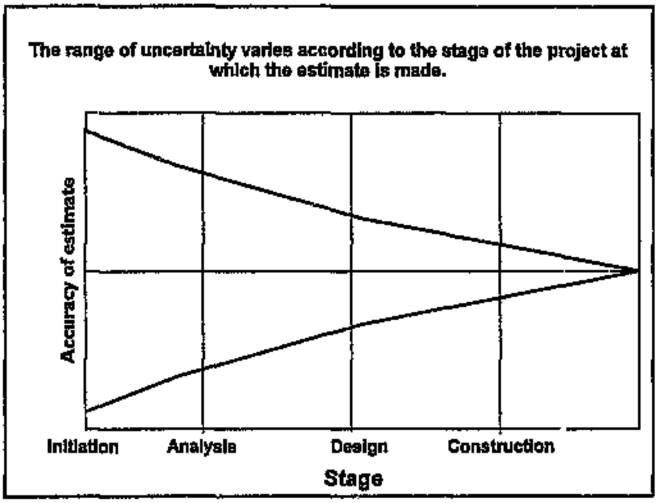

Figure 1 Range of Uncertainty (Saker 1990)

Estimating is also important throughout the life of the project to evaluate proposed changes, alternative methods of carrying out the work, and as a basis for effective cost control. Without a good estimate with which to construct the budget, there is no reliable baseline for evaluating performance. This is confirmed by Lederer and Prasad (1993 b) who allude to the estimate being used as a control standard in system development.

Software programming, unlike the construction business, is a creative effort, and without tangible evidence of progress, it is difficult to estimate how much effort is required to accomplish the entire task, and how much effort is required to complete what is left.

2.3.3 Scope Creep

As stated previously in this study, many projects are either late or never reach completion. One of the reasons for this is "scope creep", which results when significant application changes are made, after the systems requirements have been defined, and after development has started (LaPlante 1995). This has disastrous consequences to both the project budget and schedule, resulting in higher costs and late delivery (Gioia 1996). Kerzner (1989) warns that a minimal number of projects are completed within their original scope, that scope changes are inevitable, and that they have the potential to destroy not only morale, but the project itself, and therefore they must be kept to a minimum.

This often occurs as a result of "the users not knowing what they want until they've got it". McCracken and Jackson (1986) back this up by stating that system requirements can never be stated fully in advance, not even in principle. Rowen (1990) confirms this by stating that software requirements will always be incomplete when first received.

Project managers must guard against "scope creep", and where it is impossible for it to be eliminated, change and risk management techniques must be utilised to manage the impacts to the project budget and schedule.

2.3.4 IS Project Risk

> "Software risk management is a discipline whose objectives are to identify, address and eliminate software risk items before they become either threats to successful software operation or major sources of software rework."
>
> (Boehm 1987)

IS software development projects are plagued with unanticipated problems, which result in missed deadlines and budgets that are exceeded, and therefore risk management is an integral part of project activities (Kulik 1997). Often, these problems cannot be totally eliminated, but they can be controlled by using preventative actions, and risk management is the area of project management that deals with these threats before they occur.

Risk originates from the project life cycle and results in an increase to the project's duration, cost or both, and therefore the concept behind risk management is to avoid the impacts, or as a minimum, to ensure that contingencies have been identified to reduce the effects (Van der Merwe 1996)

> "Project risk management includes the processes concerned with identifying, analysing, and responding to project risk, with the intention of maximising the results of positive events and minimising the consequences of adverse events."
>
> (Project Management Institute Standards Committee 1996).

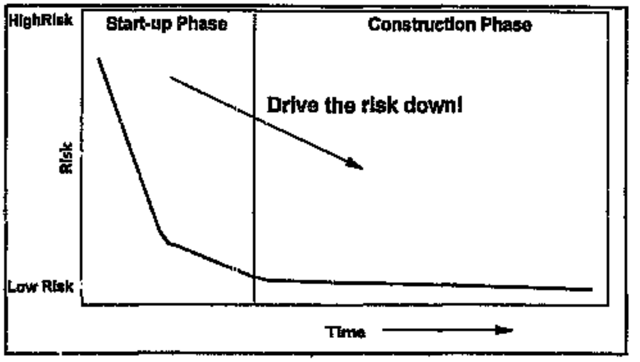

Figure 2 Drive the risk down (Buttrick 1997)

Looking at Figure 2, the start-up phase of the project is crucial, as the project should not continue until the risks have been eliminated or contingencies have been identified (Buttrick 1997), but since projects are never static, risk management should be performed on a regular basis throughout the project. As the project moves through the life cycle, and as more information comes to the fore, the probability of occurrence of the identified risks will change, new risks may be identified, predetermined risks may be eliminated, and the impacts to the project will also change. Project managers can minimise project risk by ensuring that the right level of project planning and control are carried out (See Figure 3).

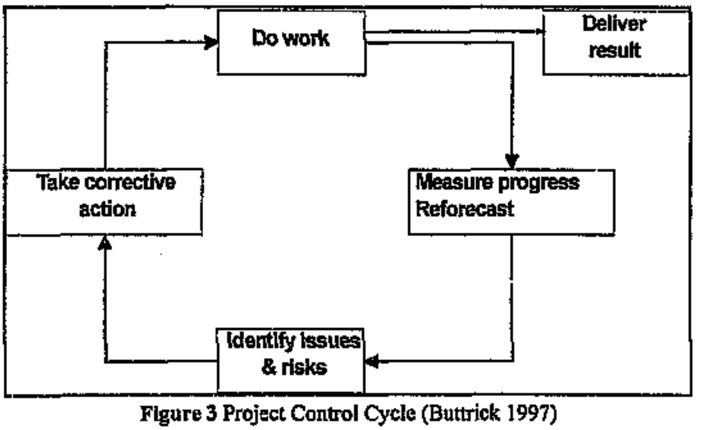

Figure 3 Project Control Cycle (Buttrick 1997)

Technical risks have been identified by the US Department of Defence (DOD) as one of the major causes of project failure as reported by Van Scoy (1992), whilst other studies suggest that projects fail managerially, not technologically (Boehm 1991; Phan et al 1988).

Failure to properly assess the risk of the project and identify contingencies, can lead to project failure, and therefore project risk analysis is an essential part of project planning. Hamburger (1990) describes contingency planning in terms of budget, schedule and technical contingencies, and states:

> "... the perfect plan is not possible, and [therefore] contingencies will be needed to account for the errors, omissions and uncertainties that affect the accuracy of the plan."

Willcocks and Margetts (1994) discuss the lack of an anticipatory mode of thinking about risks by IS personnel. Risk management must not be a "one-time affair", because as the project progresses through the life cycle, and because the project progresses in a dynamic environment, project risk management should continue throughout the project.

2.3.5 IS Project Cost

Failure to contain costs can lead to project failure (Black 1996). This usually occurs as a result of scope creep. The further the project is into the life cycle, the more the potential exists for cost overruns when changes to the scope are requested.

If a project is to be financially controlled with any degree of success, three factors must assume major significance in the considerations (Lock 1988). These are the budgets, the costs incurred, and the progress achieved in relation to these costs. A knowledge of the budgets and the costs by themselves will be of no use at all unless the corresponding progress can be gauged.

2.4 Earned Value Performance Measurement

> "The use of performance measures in business is hardly new. Companies have been measuring costs, quality, quantity, cycle time, productivity, etc., of products, services, and processes as long as ways to measure those things have existed."
>
> U.S. Department of Energy (1995)

Earned value performance measurement is the concept used to represent physical progress achieved in relation to cost and schedule performance by means of introducing the calculation of earned value (Association for Project Management 1997).

According to Humphreys and Associates (1996), the earned value concept has been an essential requirement applied to major projects since the 1960's by the U.S. Department of Defence, Energy, Transportation and the Treasury.

Hatfield (1996) calls it the most important of cost management tools, to the extent that he suggests that there is no cost management without earned value.

Earned value calculations provide visibility to the critical project areas that need further attention, and provide a clearer picture of the viability of the project than just looking at the budgets and actuals (Singletary 1996).

The earned value performance measurement technique method provides the project manager with an essential tool in organising, planning, and "statusing" the project in a disciplined, effective manner. Key benefits are visibility into the true progress of the project work against the baseline plan (Fleming 1995; Harroff 1995; Sparrius 1996: a), projections of expected project schedule and cost, and the ability to take timely corrective action when necessary (Hatfield 1996; Humphreys & Associates 1996; Project Management Institute Standards Committee 1996; Sparrius 1996: b).

Pinto (1997) goes so far as to state that all projects encounter problems, and that it is only the extent of the problem that is different. A sign of a good project manager, is how quickly he brings the project back on course. As early as fifteen percent through a project, the performance accomplishments achieved, and the actual cost performance efficiency factors can be used to predict the final project costs, and thus earned value provides the project manager with an "early warning signal" as early as 15 to 20 percent into the project (Fleming & Koppelman 1996), in time to take corrective actions whenever there is a deviation from the plan, thus creating the opportunity for the prevention of a forecasted unfavourable outcome, and therefore the benefits to project management of the earned value approach come from the disciplined planning conducted and the availability of metrics which show real variances from plan in order to generate necessary corrective actions.

Its use on commercial projects has also increased, as have the benefits, from using earned value in a performance-oriented approach to project management. According to Abba (1996), government and industry standards in Australia, Canada, Sweden and the United Kingdom incorporate the earned value performance measurement system. Non-defense agencies including NASA, Internal Revenue Service and the Federal Bureau of Investigation apply the same concepts. The Office of the Federal Procurement Policy has drafted guidelines that make earned value management mandatory for non-Defense information technology contracts, and in addition, U.S. and foreign industry increasingly use earned value for commercial project management in the absence of any government requirement.

As the final confirming "cherry on top", and as a statement of its acceptance as a valid and worthwhile project management technique, the earned value performance measurement technique has been incorporated in both the PMBOK (Project Management Body of Knowledge), and the British Guide to Project Management (BS 6079 : 1996).

2.5 Summary

Organisations are changing, and projects are being used as the means of implementing this change, in a timely and cost-effective manner. Yet there are many issues to consider when managing projects, and these issues must be successfully managed if the projects are to be implemented on time, and within the schedule and budget constraints.

The earned value performance measurement technique is a technique that the project manager can utilise to determine the status of the project as it progresses through its life cycle, and when there is a deviation from the plan, the project manager can take the necessary corrective actions, thus increasing the likelihood of attaining project success.

Chapter 3 : Research Method

Being employed as an IS project manager in a large financial institution, and having experienced many of the aforementioned problems associated with IS project management, it is the opinion of the author that well-researched and frequently-used project management techniques exist in the available literature to counteract said project management problems.

Whilst surveying the literature on project management in the military and aerospace industries, the author discovered material relevant to the earned value performance measurement technique, which in turn, became the basis for this research report.

Sharp and Howard (1996) define research as:

> "Seeking through methodical processes to add to one's own body of knowledge and, hopefully, to that of others, by the discovery of non-trivial facts and insights.... the purpose of which is to review existing knowledge, to describe some situation or problem, ... , or explanation."

The research methodology refers to a procedural framework within which research is conducted, and provides a guideline rather than a prescription as to how the research should be carried out (Remenyi and Williams 1995).

According to Bailey (1994), there are a variety of approaches in performing research, with each particular research study being unique in some ways because of the particular time and place in which it is conducted. Nevertheless, all research projects share a common goal of furthering our understanding, and thus share common basic stages, although there may be some variation in the specific details of these stages.

To achieve this study's objectives, the following activities were undertaken:

- Define the research problem
- Define research's purpose
  - To propose a theoretical approach for using earned value performance measurement, as a means of measuring IS project progress.
- Define research's specific objectives
  - To describe the IS project management process at a high level;
  - To identify the issues that impact on IS project progress measurement;
  - To describe the earned value performance measurement technique, including:
    - an introduction to earned value performance measurement
    - a sound foundation of all essential principles, features and benefits
    - the proposed steps required for utilising earned value performance measurement on IS projects
- Review relevant literature

  Literature related to the research was retrieved and reviewed to satisfy the objective of building up a comprehensive understanding of IS project management and its associated problem areas, earned value performance measurement and the cost/schedule control system criteria.

  In reviewing the relevant literature, several avenues were explored:

  - Academic literature searches were undertaken of several libraries.
  - Informal discussions were held with project managers from First National Bank, and other South African institutions.
  - Online literature searches were undertaken on the Internet, but focussed primarily on U.S. government and military sites, as they were deemed to be the prime users of the earned value performance measurement technique.
  - Informal discussions were held in the various project management forums and discussion groups on the Internet.

  This wide variety of information sources ensures that the review represents earned value's place in all the aspects of IS literature with the greatest possible degree of accuracy. In this field, journals are already being replaced by on-line 'electronic' journals and interactive discussion groups are pushing the frontiers of understanding, outward at a frightening rate. No review can hope to represent reality here in a complete form, but an interpretivist approach to the existing media can offer a starting point to all researchers looking for an understanding of earned value's contextual placement.

- Formulation of a theoretical approach (framework) for using earned value performance measurement, as a means of measuring IS project progress.

Remenyi and Williams (1995) state:

> "Some research studies stop at the stage of theoretical conjecture, perhaps having developed some hypotheses... It is argued that at this stage a contribution has already been made to knowledge and this may well be so."

Remenyi and Williams (1995) state further:

> ".... there is frequently scope for modelling.... [and] .. in this context, modelling refers to the creation of simplified abstractions of reality which capture the critical or key features of the situation. The use of models to consider various scenarios is a very powerful approach....."

In line with Remenyi and William's thinking, the structure of this report proposes a hypothesis, and concerns itself with the development of a theory, without attempting to prove it in practice. It does not seek to evaluate the merits of earned value performance measurement, but rather to formulate a theoretical framework or model with which to perform earned value performance measurement.

Chapter 4 : The IS Project Management Process

4.1 Introduction

Turner (1993) defines a project as:

> "An endeavour in which human, material and financial resources are organised in a novel way, to undertake a unique scope of work, of given specification, within the constraints of cost and time, so as to achieve beneficial change defined by quantitative and qualitative objectives."

The Project Management Institute Standards Committee (1996) defines project management as:

> "The application of knowledge, skills, tools, and techniques to project activities in order to meet or exceed stakeholder needs and expectations from a project."

Project management is a closed loop control process in which the plan forms the input to the process, the process is that which executes the plan and the output is the product of the project. To control the outputs, measurements must be taken, not just of schedule, but also of scope, cost and quality. Without a baseline, these measurements are meaningless. Only with the predetermined objectives established in the baseline, can the control process effectively identify deviations from the plan and initiate action to correct those deviations in order to keep the project on track.

The Project Management Institute Standards Committee (1996) describes the five processes used in project management, namely: Initiating, Planning, Executing, Controlling and Closure, with each process being decomposed into a number of functions which together make up the process.

4.2 Initiating Process

Initiating a project is the process of formally recognising the need for the project, implying that there must be a business need and justification for the project. Project evaluation and selection is the process of evaluating individual projects or groups of projects, and then choosing to implement a set of them so that the objectives of the organisation will be achieved. Selective numeric and non-numeric models are used by organisations when choosing between projects. Organisations use both at the same time, or a combination, and according to Meredith and Mantel (1989), the following models are in use:

Non-numeric models:

- the sacred cow - the project is suggested by a senior and powerful official in the organisation
- the operating necessity
- the competitive necessity
- the product line extension

Numeric models:

- payback period
- average rate of return
- discounted cash flow
- internal rate of return
- profitability index (also known as the cost-benefit ratio)

4.3 Project Planning

4.3.1 The purpose of planning

The plan is an estimate of reliable costs and expected completion dates for IS systems development activities require prediction right from the beginning of the project (Yeates 1986), and thus becomes the essential foundation for any effective project control function.

Duffy and Assad (1980) state that:

> "Planning is one of the basic functions of management. It complements another basic management function - control. The one cannot be effective without the other."

Kerzner (1989) defines the most important responsibilities of a project manager to be that of planning, integrating and executing plans, and describes planning in a project environment as establishing a predetermined course of action within a forecasted environment.

The planning process defines the actions and activities, the time and cost targets, and the performance milestones which will result in the successful achievement of project objectives. Without a detailed plan, there is no basis for comparison, no determination of deviation, and hence no satisfactory basis for corrective action or redirection. Furthermore, without substantial planning, it would be impossible to estimate the number of days of development effort that will be required to complete the project nor make any determination of the manpower, equally, it will be impossible to make any assessment of work schedules so as to predict a likely completion date, and thus planning needs to be organised, logical, efficient and thorough (Wall 1988), and all aspects of the project must be considered in sufficient detail to ensure that all potential and foreseeable problems are considered.

Looking at Figure 4, (the basic feedback loop of control), replanning is an inherent part of coping with the changes that occur during the lifecycle of a IS project, and the plan must reflect these continual changes (Yeates 1986), thus planning must be understood to be an activity that doesn't occur in isolation. It is an iterative process with the activities requiring constant refinement as the project progresses.

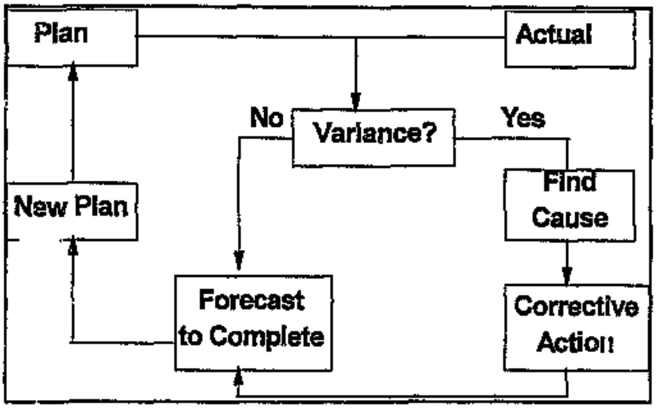

Figure 4 The basic feedback loop of control (Meredith & Mantel 1989)

4.3.2 The Project Planning Process

The critical starting point for any project is a unique, unambiguous statement of work (SOW) containing the prime goals the project is seeking to achieve, and the objective criteria for success (CSC Research and Advisory Services 1994). The SOW communicates the work scope requirements for a project, and should define the project requirements to the fullest extent practical as it is a basic element of control used in the processes of work assignment and the establishment of project schedules and budgets.

Starting with this statement of work, performance standard specifications and associated documentation, the project plan is achieved by:

- determining what is to be done and translating it into a work breakdown structure
- establishing a project team based on the major tasks
- coupling the tasks and resources
- creating key planning and control documentation, for subsequent derivation of schedule and cost criteria
- developing an event-logic network which is then translated into a schedule (and takes into consideration the resource constraints and other project priorities)
- establishing the manpower and facilities requirements by task - from these factors, task cost estimates are developed into a budget for project control

"The most successful project managers are those who take painstaking trouble to understand all aspects of the projects they control, plan their strategy meticulously, and follow through by carefully monitoring and controlling [all project activities]".

(Lashbrooke 1994)

4.3 Project Execution

Project execution entails executing the project plan by performing the activities included therein.

4.4 Project Control

Control provides the project manager with the tools for determining whether the project team is proceeding toward the planned project objective, and is the process of establishing targets and plans, doing the work, measuring actual performance, comparing actual performance against planned, and taking any necessary actions to correct the situation, i.e. the ability to initiate action which allows the plan to be adjusted in pursuit of the project objectives (Wall 1988). Often project managers pay lip service to control whilst carrying out a monitoring function, and even though monitoring techniques do raise red flags when used during project execution (Oosthuizen 1994), this is the difference between a dynamic forward-looking approach and a passive assessment of past history (Kharbanda & Stallworthy 1983).

Cost control is the work done to ensure optimal utilisation of funds and other resources available to the project, to ensure that the project is completed within the budgeted cost, and to ensure that the indicated end-of-job cost of the project is up to date at all times (Louw 1995).

Only current or future activities can be controlled, and thus deviations from plan must be identified as early as possible and corrective actions acted on immediately. The earlier these deviations can be forecasted in the development stages of the IS project, the more likely it is, that changes needed to facilitate a successful system can be made (Szajna and Scamell 1993).

4.4.1 Prerequisites of a control system

The requirements for an effective control system encompass:

- thorough planning
- good estimating
- a clear project scope
- a disciplined budget
- timely accounting
- periodic re-estimation and replanning
- frequent comparison of planned versus actual and projected outcomes

The sophistication of the control system depends on the complexity of the project and the ability of the participants to administer it, however, certain basic conditions must be met in order to have a workable control system (Cleland & King 1983):

- It must be understood by those who use it and obtain data from it.
- It must relate to the project organisation, since organisation and control are interdependent, neither can function properly without the other.
- It must anticipate and report deviations on a timely basis so that corrective action can be initiated before more serious deviations can occur.
- It must be economical, so as to be worth the additional maintenance expense.
- It should indicate the nature of the corrective action required to bring the project in line with the plan.
- It should reduce to a language (words, pictures, graphs) which permits a visual display that is easy to read and comprehensive in its communication.

> "You can't control what you can't measure."
>
> (De Marco 1982)

Kerzner (1989) discusses a three-step process to controlling the project:

- Measuring progress towards the objective.
- Evaluating what still needs to be done.
- Taking the necessary corrective action to achieve or exceed the project objectives.

4.5 Project Closure

This is the last stage of the project and is used to conclude the work on the project. The requirement definition is used to verify whether the user's requirements were met, lessons learnt are documented, and the success or failure of the project is discussed / debated, and thereafter the project team is disbanded.

4.6 The Project Life Cycle

All projects have a life cycle (Morris 1988). The project life cycle is the sequence of phases through which a project will pass from its conception to its completion (Association for Project Management 1997; McGettrick 1996), and is a term which describes the setting out in an ordered manner of the activities that combine to make up the project and also establishes the transition criteria to progress from one phase to the next (Turner 1993).

There are a number of life cycle models used in IS development, with each having unique characteristics which make it more or less suitable for a particular application, amongst others:

- Waterfall model
- Modified waterfall model
- Prototyping
- Boehm's spiral model
- Object-oriented analysis

Knight, Schroder and Walker (1992), McLeod and Smith (1996), and Turner (1993) provide descriptions of some of these models. Projects are often organized around the life cycle chosen and thus this is a contextual factor that must be taken into consideration when determining the project management practices used.

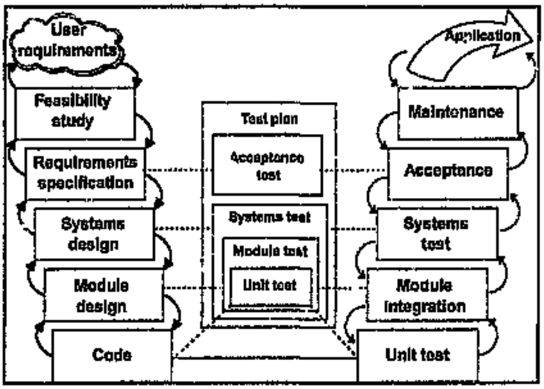

Figure 5 The Waterfall 2 Life Cycle (Turner 1993)

One of the life cycle models most commonly used in the IS industry is the waterfall model, or modifications thereof (as depicted in Figure 5), but generally the software development cycle can be divided into the following phases:

- Requirements analysis and specification
    - Feasibility study
    - Requirements analysis
    - Requirements definition
    - Requirements specification
- Design
- Code & unit test
- System testing
- Integration testing
- Acceptance testing
- Implementation
- Maintenance

Most software life cycles are phased processes with clearly identifiable goals, milestones, deliverables and tasks, with each task being given a duration and resource responsibility. The phases do not happen discretely, but often partially simultaneously, with overlaps between phases being a common occurrence.

In the early phases of the project life cycle, it is not unusual for the final costs and durations of the project to be underestimated by over 50% (McGettrick 1996), as a result of, amongst others, over-optimism (especially in the early stages of the project), a lack of information, incomplete design, or questionable estimating methods. The project life cycle thus becomes an integral part of project planning and control because it shows systematically what processes are needed to execute the project (Duffy and Assad 1980), and as the project progresses through the life cycle, the quality of the information improves in both detail and accuracy.

The ever-present goals of meeting performance, time and cost are the major consideration throughout the project's life cycle, and thus as the project life cycle progresses, the cost, time and performance parameters must be managed, and this involves the continuous replanning of the as yet undone work in light of the emerging data on what has actually been accomplished (Cleland & King 1983).

4.7 Summary

This chapter introduced the concept of a project and described the five processes used in project management, namely: Initiating, Planning, Executing, Controlling and Closure. In addition, it introduced the project life cycle concept, which is the sequence of phases through which a project will pass from its conception to its completion.

Chapter 5 : Earned Value Performance Measurement

5.1 Introduction

Earned value concepts embody the essential features of an effective performance measurement system based upon sound management principles (Humphreys & Associates 1996), and is an objective measure of how much work has been accomplished on a project (Harroff 1996), i.e. a measure of the value of work performed, and improves on the "normally used" spend plan concept (budget versus actual incurred cost) by requiring the work in progress to be quantified.

Earned value uses the original estimates and project progress to date to show whether the actual costs incurred are on budget (Microsoft Corporation 1995). All work is planned, budgeted, and scheduled in time-phased "planned value" increments, constituting a performance measurement baseline (Abba 1997). As work is performed, it is "earned" on the same basis it was planned, in rands or other quantifiable units such as labour hours. Planned value compared with earned value thus measures the rand volume of work performed versus the equivalent rand volume of work accomplished, and any difference is called a schedule variance. Earned value compared with the actual cost incurred for the work performed provides an objective measure of cost performance, and any difference is called a cost variance.

The essence of earned value management is that at some level of detail appropriate for the degree of technical, schedule, and cost risk or uncertainty associated with the project, a target value (i.e. budget) is established for each scheduled element of work. As these elements of work are completed, their target values are "earned". As such, work progress is quantified and the earned value becomes a metric against which to measure both what was spent to perform the work and what was scheduled to have been accomplished.

Schedule variances, which cannot be seen in a stand-alone budget versus actual cost tracking system, are isolated and quantified, and the cost variances are true cost variances that are not distorted by schedule performance. This provides for early identification of performance trends and variances from the management plan, and allows management decision making while there is adequate time to implement effective corrective actions. Without earned value, one can only compare planned expenditures with how much has been spent, which does not provide an objective indication of how much of the planned work was actually accomplished.

For the benefits of earned value to be fully realized, thorough planning, combined with the establishment and disciplined maintenance of a baseline for performance measurement are needed. The combination of advance planning, baseline maintenance, and earned value performance measurement yields earlier and better visibility into project performance than is provided by non-integrated methods of planning and control.

According to Muir (1996), uses of earned value data include:

- the ability to corroborate progress data from other performance indicators
- the ability to predict (by graphical or algebraic means) future performance or milestone achievement
- the provision to trigger claims for payments by contractors working on the project or to organisations performing outsourced software development
- the ability to substantiate claims for payment
- the provision of an indication of future cash flow requirements
- the provision of data that forms the base for the Estimate at Completion (EAC)

Wolfaard (1996) lists the following advantages in using earned value:

- it is a scientific technique to quantify the project's progress in terms of cost and time.
- it provides an overall view of the project's status; it relates current cost and schedule variances with each other and with a base plan.
- cost and schedule variances are both expressed in monetary terms, thus accommodating ease of interpretation.
- cost and schedule variances are based on the same data thus eliminating the duplication of data input and processing.
- it provides a basis for cost / time analysis (trade-offs).

Impediments to earned value performance measurement include:

- incomplete or data that is received late - ensure that all cost and manpower data is received timeously
- unreliable data - ensure that the data is correct, and that the old adage of "garbage in, garbage out" does not apply to the earned value performance measurement process
- inadequate schedule reports - good, consistent and integrated schedules confirm earned value performance measurement data, while the absence of schedules may indicate a lack of control or inadequate planning
- inconsistent data - reports should be consistent with both previous and subsequent reports, and with reports from other sources

5.2 Historical Overview

An important element in successful project management is the effective control of cost and schedule aspects of the project. In 1967, the US Department of Defence (DoD) embarked on a new course for contract performance management when it issued DoD Instruction 7000.2, Performance Measurement for Selected Acquisitions. This instruction prohibited imposing unique management control system requirements on contracts, and instead, it required contractors' management control systems on major contracts to meet certain minimum standards, called the Cost Schedule Control Systems Criteria (C/SCSC). The criteria embodied the earned value concept of performance measurement, a methodology for objectively measuring how much contract work had actually been accomplished as opposed to the budget versus actual (spend plan) technique commonly used at the time. At the same time, the Cost Performance Report (CPR) was developed to report the output from the criteria-compliant systems. These tools, the C/SCSC, earned value and the CPR, gave government managers the means to ensure consistent management of and visibility into cost and schedule performance on major contracts, and provided a means of keeping the ever escalating cost overruns on projects under control.

According to Abba (1996), the objectives of the C/SCSC policy were:

- to allow an organization to monitor the cost and schedule performance of work being done on its behalf
- for contractors to use effective internal cost and schedule management control systems
- for the US government to be able to rely on timely data produced by those systems for determining project status.

The C/SCSC consist of a set of 35 criteria (See Appendix 1) for measuring the adequacy of management control systems through, amongst other things, the application of earned value analysis concepts. These criteria define not how a project must be managed, but rather the minimum requirements of an integrated cost and schedule management control system (Abba 1997), and are organised in 5 parts:

- Organisation - definition of work, company organisations and the delegation of authority and responsibility (i.e. the integration of people and work)
- Planning and budgeting - scheduling of work, establishment of budgets and methods to measure achievement and the development of a baseline against which to measure project performance
- Accounting considerations - recording costs at the appropriate levels and the ability to summarise them by relevant category and element
- Analysis and management reports - performance measurement and the utilisation of this information within the company and in reports
- Revisions and data maintenance - maintaining the integrity of the baseline, and the timely incorporation of changes to the project

The criteria also introduced the earned value management technique to the DoD (Abba 1996); the C/SCSC require that actual work progress must be quantified through earned value, which is an objective measure of how much work has been accomplished on the project. Without earned value, one can only compare actual expenditure against planned expenditure with no objective indication of how much of the planned work was actually accomplished (Harroff 1995). The criteria require the contractor to plan, budget, and schedule work in time-phased, planned-value increments which constitute a performance measurement baseline (time-phased budget). Planned value, earned value, and actual cost data thus provide an objective measure of performance (Pelc 1996), enabling trend analyses and evaluation of estimates of cost at completions.

5.3 The Earned Value Performance Measurement Technique

In using the earned value performance measurement technique, the project manager has to provide, among other items, the following:

- A schedule of authorised work which describes the sequence of work and identifies the significant activity interdependencies required to meet the objectives of the project.
- Identification of physical deliverables, milestones, technical performance goals, or other indicators that will be used to measure output, i.e. tangible evidence of achievement (Parkin 1980).
- A time-phased budget baseline at the activity level against which project performance can be measured.
- Budgets for all authorised work with separate identification of cost elements (e.g. labour, materials, equipment, etc).
- An organisational breakdown structure.

Although the earned value performance management guidelines consist of 35 criteria (See Appendix 1), it is the opinion of the author that the formal process is too complex and time-consuming, and offers this as the reason why the earned value performance measurement technique has not been embraced by the private sector in measuring IS project progress. This is confirmed by Fleming and Koppelman (1996) who state:

> ".... It is our belief that earned value has been overlooked, sometimes even flatly rejected by project managers because the technique has been encased for the past three decades in countless non-value added regulations and esoteric interpretations of project requirements."

Using the 35 criteria as a guideline, the author thus proposes the following steps as a re-engineered earned value performance measurement process as an alternative approach to measuring progress on IS projects (See Figure 6):

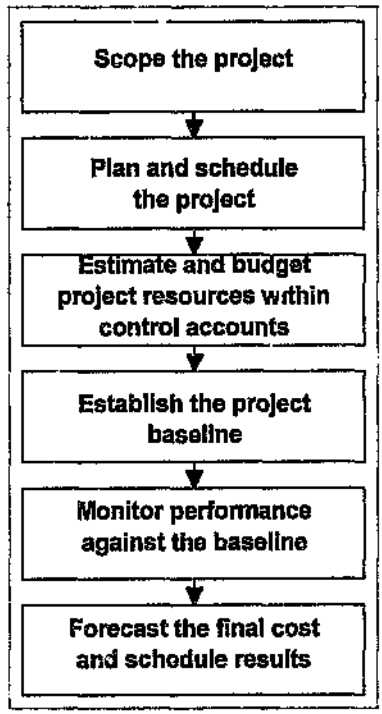

Figure 6 The re-engineered earned value performance measurement process

5.3.1 Define the scope of the project using a work breakdown structure - the requirement definition for the project should reflect all work to be accomplished.

5.3.1.1 Establish the work breakdown structure - the work breakdown structure (WBS) is the output that emanates from the scope definition, and defines the total scope of the project, with anything not included in the WBS being out of scope. Establishing the WBS provides the structure for the scheduling and budgeting process.

The underlying philosophy of the WBS is to break the project down into work packages which are assignable and for which accountability can be expected (Cleland & King 1983). The WBS divides the overall project into elements that represent assignable work units. These elements are further subdivided into tasks that are capable of being assigned and accomplished by an organisational unit or individual. The lowest level of the WBS becomes the unit around which project planning, organising and control can be carried out, thus making each work package a performance-control element.

Work packages are natural subdivisions (i.e. a low-level task or job assignment) of the project plan and constitute the basic building blocks used in planning, controlling, and measuring project performance. It describes the work managed by a specific performing organization and serves as a vehicle for monitoring and reporting work progress, and has the following characteristics:

- a work package represents units of work at the levels where the work is performed
- a work package is clearly distinct from all other work packages, and is assignable to a single organizational element (individual or workgroup)
- a work package has scheduled start and completion dates (with interim milestones, where applicable) which are representative of physical accomplishment
- a work package has a budget or assigned value expressed in terms of rand, labour hours, or other measurable units
- the duration of a work package is relatively short unless the work package is subdivided by discrete value milestones which allows for the objective measurement of work performed

5.3.1.2 Assign organizational responsibility - create the organizational breakdown structure (OBS) which reflects the way the project is functionally organized. When assigning work responsibility to appropriate organizational elements, the WBS and organizational structure must be interrelated with each other such that organizational responsibility can be established for identified units of work. The assignment of lower level work segments to responsible lower level managers provides a key control point for management purposes and cost collection. This is called the control account (CA).

5.3.2 Plan and schedule the work for the project to completion - the scheduling process defines the schedule hierarchy that must be established to ensure proper, effective planning and statusing of all effort on the project. Successful management requires the integration of the technical, schedule, and cost aspects of the project. Schedules that result from this integration show the planned time required to accomplish the technical scope of the project. When projects experience problems in technical performance, either schedule delays, cost problems, or both may follow. An adequate scheduling system will facilitate the depiction of the plan to accomplish the technical scope, the actual technical progress against that plan, and estimates of the time required to complete the remaining technical scope. The schedule baseline, progress, and estimated time to complete all should readily integrate with the financial depiction (budgets, earned value, and estimated cost to complete) of the technical scope.

The scheduling system should contain a master schedule and related subordinate schedules which provide a logical sequence from the detail to the summary level. The scheduling system must also provide for the identification of interdependencies between organizations and/or WBS elements at the level appropriate for efficient project management. Schedules and budgets should be established and approved for all authorized work at the level determined most appropriate by the project manager.

A schedule is the conversion of a project action plan into an operating timetable, and as such, serves as a fundamental basis for monitoring and controlling project activity, and is typically based on the previously determined WBS.

Various scheduling techniques are used, amongst others Gantt or bar charts, critical path method (CPM), programme evaluation and review technique (PERT), precedence networks, activity-on-arrow networks (Oosthuizen 1994; Project Management Institute Standards Committee 1996). These network plans represent projects in terms of the interrelationships among project elements. These pictorial displays graphically portray the sequential relations between the tasks in the project. Tasks that must precede or follow other tasks are then clearly identified, in time as well as function. Defining the network, identifying the dependencies, and estimating the activities all force a great deal of very specific planning very early in the project (Brooks 1995), and has the following benefits:

- it is a consistent framework for planning, scheduling, monitoring and controlling the project
- it illustrates the interdependence of all tasks, work packages and work units
- it aids in ensuring that the proper communications take place between departments and functions
- it determines an expected project completion date
- it identifies critical activities, which if delayed, will delay the project completion time
- it also identifies activities with slack that can be delayed for specified periods without penalty, or from which resources may be temporarily borrowed
- it determines the dates on which tasks must be started if the project is to stay on schedule
- it illustrates which tasks must be coordinated to avoid resource or timing conflicts
- it also illustrates which tasks may be run in parallel to achieve the predetermined project completion date

5.3.3 Estimate and budget project resources within control accounts - the project budget is a time-phased, detailed financial plan that is integrated with the project plan, and denotes the expenditure for each time period for each activity in the work breakdown structure. The project budget is not only one facet of the plan, but also a control mechanism for the project. It serves as a standard for comparison, a baseline from which to measure the difference between the actual and planned use of resources, and as the project manager directs the deployment of resources to accomplish the project work packages, resource usage should be monitored carefully. This allows deviations from planned usage to be checked against the progress of the project, and exception reports can be generated if resource expenditures are not consistent with accomplishments.

If budgets are not tied to achievements, the project manager may ignore situations where project funds are being spent in advance of accomplishment but are within budget when viewed by time period, and thus the project manager may misinterpret the true state of the project when the budget is overspent for a given period but outlays are appropriate for the level of task completion.

5.3.3.1 Define the control account and ensure management subsystems integration - the control account is the main action point for planning and control of effort. All aspects of the project come together at this point including budgets, schedules, work assignments, cost collection, progress assessment, problem identification, and corrective actions, and thus it is imperative that each control account contain, as a minimum:

(1) a discrete scope of work to be accomplished
(2) a time frame to complete these tasks (the schedule)
(3) the authorised resources (the budget)
(4) a designated responsible person to manage the account

5.3.3.2 Control account budgets - each control account contains resources necessary to complete the assigned effort and budgets reflecting these resources. Budgets established at the control account level must be planned by element of cost.

(1) Budgets may be stated either in rands, hours, or other measurable units.

(2) It is necessary to use rates that will provide a valid performance measurement baseline (PMB), and when there are significant changes in the anticipated labour, overhead, or other rates, internal replanning of remaining portions of the PMB must be done.

(3) In general, the budget process should provide for the following:

(a) Direct budgets allocated to organizations performing the planned work;

(b) Identification of any management reserves or undistributed budget.

5.3.3.3. Distribute the control account effort into work packages and planning packages - effort contained within a CA is distributed into either work packages or planning packages. "Work package" is the generic term used to identify discrete tasks which have definable results.

Work packages are single tasks assigned to a performing organization for completion. Work package descriptions must clearly distinguish one work package effort from another.

A key feature from the standpoint of evaluating accomplishment is the desirability of having discrete work packages that incorporate frequent, objective indicators of progress. Work packages should be natural subdivisions of project effort with each work package resulting in a definable end-product or event.

5.3.3.4 Establish and track management reserve (MR) - in IS projects, particularly planning and coding activities, there is considerable uncertainty regarding the timing or magnitude of future difficulties. The use of MR provides the project manager with a capability to adjust for these uncertainties. Adequate identification and control of MR is necessary, with the MR budget and its use being accounted for at the total project level. Management reserve is held for work scope growth, rate changes and other project unknowns, (i.e. for current and future project needs). It is a budget held in reserve as a source of funding for added work scope, and not a contingency which can be used to absorb the cost of project changes, and thus it cannot be used to offset accumulated over- or underruns that emanate from the variance analysis.

5.3.4 Establish the project baseline plan - all projects need to establish a baseline plan against which effort can be monitored during project execution, and the assignment of budgets to scheduled segments of work produces a plan against which actual performance can be compared. The baseline plan is a portfolio of documents which indicate how the project's progress and schedule objectives will be achieved, and is created during the planning phase of the project. It is the starting point for project control, as it quantifies what has to be executed, how the work will be carried out, and who will be responsible for the work. The establishment, maintenance, and use of the baseline plan are indispensable to effective performance measurement. The relationship of individual work tasks with the time-phased resources necessary to accomplish them is established at the control account level.

The baseline is needed to determine precisely how much of the planned work has been accomplished at any point in time, and to compare it to the work that was planned to be accomplished, as well as to compare the completed work with the actual cost of completing that work.

Without a baseline, without predetermined objectives, decisions will be made in response to other stimuli and may not serve the best interests of the project. Included in these decisions are those related to scope changes. All projects are susceptible to scope creep, and as the baseline also defines the scope of the project, the impact of scope changes can be effectively assessed in the context of a baseline, and thus the baseline also serves as a tool for managing and controlling scope.

Baselines in excess of project value - during the life of a project, situations may arise whereby available budgets for the remaining work are insufficient to ensure valid performance measurement. Under these circumstances, a requirement may exist for the total budget allocated to work to exceed the project budget. The project manager should perform a detailed estimate of all costs necessary to complete the remaining effort. If the difference between the estimated cost to complete and the remaining budget is significant, the project manager must notify management of the need to increase the remaining budgets, and should include a discussion regarding project cost, schedule, funding and technical implications expected as a result of increasing the budget.

The changes to baseline budgets must be fully documented and traceable, and when management are satisfied that the new baseline represents a reasonable plan for completing the project, the new baseline becomes the basis for future performance measurement.

5.3.4.1 Incorporate meaningful progress indicators - the scheduling system should cover all specified work and incorporate key deliverables and project milestones which can be used to assess progress, constraints and relationships. Milestones must be concrete, specific, unambiguous and measurable events (Brooks 1995).

The performance measurement indicators (milestones, earned standards, scheduled output, etc.) must be clearly identified and directly related to control accounts. They must be scheduled in a sequence which supports the achievement of project objectives. These indicators must clearly represent the accomplishment of an identifiable quantity of work within the project and be assigned a value reflecting the planned cost of that work. These values must summarize to or reconcile with the total budget for the project.

5.3.5 Monitor performance against the baseline - evaluate deviations from the plan - the scheduling system should provide current status and forecasts of completion dates for all authorized work. The summary and detailed schedules should enable a omparison of planned and actual status of project accomplishment based on ilestones or other indicators used for control purposes.

5.3.5.1 Managerial analysis - is the evaluation and feedback loop of the earned value management system. Management actions are determined, based on an analysis of problems, corrective actions are implemented, and their effect on cost and schedule performance are projected.

5.3.5.2 Analyse significant variances - analysis of deviations from planned activities provide management with visibility into needed actions to either return the project to plan or compensate for these deviations in cost, schedule or technical areas.

5.3.5.3 Schedule Variance (SV) - comparing the value of work completed to the value of work scheduled during a given period of time provides a valuable indication of schedule status in terms of rands worth of work accomplished. This variance may not, however, clearly indicate whether or not scheduled milestones are being met since some work may have been performed out of sequence or ahead of schedule. Schedule variance does not indicate whether a completed activity is a critical event or if delays in an activity's completion will affect the completion date of the contract. A formal time-phased scheduling system, therefore, must provide the means of determining the status of specific activities, milestones, and critical events.

5.3.5.4 Cost variance - comparisons of the cost of completed work with the value planned for that work provides a cost variance. Analysis of this differences reveals the factors contributing to the variances. Examples include poor initial estimates for the task, technical difficulties that required additional resources, the cost of labour being different from that that was planned, differences between planned and actual rates, and personnel efficiency different than planned.

5.3.5.5. Variance at completion - comparisons of the total budget with the EAC at the control account level provides a variance expected at the completion of the control account.

5.3.5.6 Required analysis - analysis of these variances is required at the control account level. Budgeting, measuring performance, and collecting costs by element of cost facilitates determining and reporting the reasons for significant variances.

5.3.5.7 Technical achievement - unfavourable cost or schedule conditions are usually caused by technical difficulties. Quantitative information as to technical status is desirable and should be supplemented by narrative reports. As work progresses, determine the adequacy and quality of the work performed by making inspections, tests, or other types of technical measurements. If the results are satisfactory and no corrective action is required, the work proceeds. If, on the other hand, deficiencies are found, consider alternatives for corrective action; for example, redesign, rework, etc. When considering these alternatives, the impact on cost and schedule must be weighed in addition to the technical considerations. After an alternative is selected, it may become necessary to plan the additional work in terms of new work packages or additions to existing unopened work packages and to change the schedules affected. In some cases the project manager may choose to provide additional budget to the responsible organization. Thus, there is a close relationship between technical achievement and its impact on cost and schedule.

5.3.6 Forecast the final cost and schedule results - generate periodic estimates at completion using all available information to arrive at the best possible estimate. This must include:

(a) evaluating the efficiency achieved by performing organizations for completed work and comparing it to remaining budgets;

(b) establishing a schedule forecast that reflects the expected time-frame for completing the remaining work;

(c) considering all remaining risk areas on the project versus cost avoidance possibilities;

(d) ensuring the most current direct and indirect rate structure is used to value the projected resources;

(e) applying this analysis to future efforts to derive the most accurate estimate.

Comparisons of this estimate to budgets for the associated effort must be made frequently enough for management to ensure project performance and resource availability will not be adversely impacted.

Take the necessary management action as a result of the forecast and analyses, ensuring that the data produced by the earned value management system is available to managers on a timely basis and is of sufficient quality to ensure that effective management decisions can be made as a result of its analysis.

From a reporting perspective, progress reports should be sent to the management or the project sponsor at the following intervals (Van Der Merwe 1997):

- If the project duration is in years, then report monthly
- If the project duration is in months, then report weekly
- If the project duration is in weeks, then report daily
- If the project duration is in days, then report hourly

5.4 Elements of Earned Value

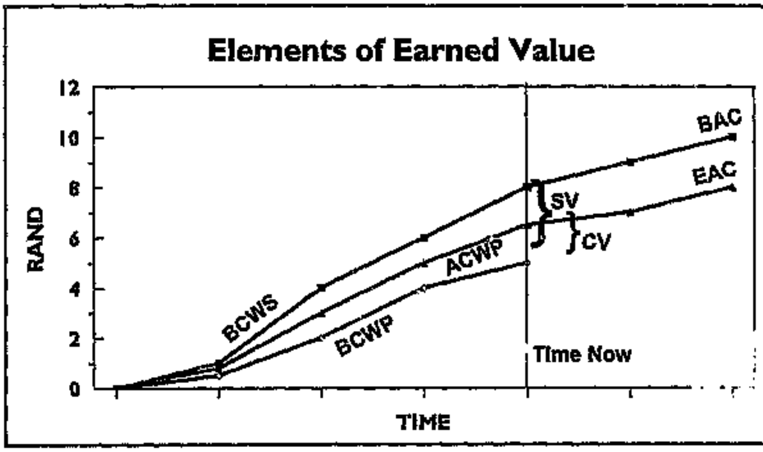

Figure 7 Elements of Earned Value

The earned value performance measurement system provides data and reports required for the effective analysis of variances (See Figure 7) which result from the comparison of budgeted cost of work scheduled (BCWS), budgeted cost of work performed (BCWP), actual cost of work performed (ACWP), Budget at Completion (BAC) and Estimate at Completion (EAC).

At the activity level, the project manager analyses the variances which result from the comparison of these five basic data elements. This data provides the current period and the cumulative to date performance status information for each activity and if a significant variance is identified, then this data provides an indication of the magnitude of the potential project impact in the future. Cost variances, schedule variances, and at completion variances are reviewed and reported to:

- Identify and isolate problems causing either favourable or unfavourable cost or schedule variances.
- Evaluate the impact of cost/schedule variances and recommend appropriate changes and work arounds.
- Evaluate the performance of the functional organizations by using the Cost Performance Index (CPI), Schedule Performance Index (SPI), and To Complete Performance Index (TCPI) indicators.

- P.oject favourable and unfavourable variance trends.
- Provide a valid Estimate at Completion (EAC), in terms of cost impact and schedule completion dates.

Trends show the direction the project is heading, and enable the forecasting of project cost and schedule and the projection of future funding needs. They may also indicate potential problems before they become major issues.

- Actual Cost of Work Performed (ACWP) - the ACWP is the actual amount spent on the work performed to date (including the work in progress).

- Budgeted Cost of Work Scheduled (BCWS) - the sum of the time-phased budgets established for all effort (including the work-in-progress) scheduled to be accomplished within a given time period, i.e. at any given time, it represents the budget for work that is planned to be accomplished by that time.

- Budgeted Cost of Work Performed (BCWP) - BCWP is the budgeted cost of the completed work and the work in progress at that time. BCWP is recorded as work is accomplished or earned, and is also known as "earned value".

- Budget at Completion (BAC) - BAC is the original cost estimate or budget indicating the funds required to complete all of the known work on the project.

- Schedule Variance (SV) - comparing the value of work performed with the value of work scheduled determines SV, and is an aggregate rand value of events ahead or behind schedule. Arithmetically, SV is expressed as:
  BCWP - BCWS → a positive value means that the project is ahead of schedule and a negative value means that the project is behind schedule.

- Cost Variance (CV) - comparing the value of work performed with the actual cost of work performed determines CV. CV is an objective indicator, and it is a rand value of what was accomplished for the resources expended. Arithmetically, this is expressed as:

  BCWP - ACWP ⇒ a positive value means that the project is under budget (work was accomplished for less resource expenditure) and a negative value means that the project is over budget (work accomplished cost more than planned resource value).

- %Over / Under

  $$\frac{ACWP - BCWP}{BCWP} \times 100$$

- Cost Performance Index (CPI)

  BCWP / ACWP ⇒ a value above one means that the project is under budget and a value below one means that the project is over budget.

- Estimate at Completion (EAC) - EAC is the projected completion cost and consists of the actual cost of the completed work plus the budget for the remaining work.

  The formula for the EAC is as follows:

  $$EAC = \frac{(BAC - BCWP)}{CPI} + ACWP$$

- Variance at Completion (VAC)

  VAC = BAC - EAC - comparing the variance between the budget at completion with the latest estimate at completion determines the variance at completion.

Performance indices show the percentage of variation, between planned and actual performance, for the current period, cumulative to data time span, and at the completion of the task.

The Schedule Performance Index (SPI) and Cost Performance Index (CPI) are calculated in order to provide an efficiency factor for work accomplished during the current period and for cumulative data. The To-Complete-Performance-Index (TCPI) calculates an efficiency factor which must be attained, if the remaining work scope is to be completed within the forecasted EAC.

Examples of SPI, CPI and TCPI are calculated using the following cumulative-to-date data:

BCWS	BCWP	ACWP	BAC	EAC
R 45 600	R 50 800	R 42 900	R 200 000	R 180 000

- Schedule Performance Index (SPI)

  The ratio of work accomplished versus work planned, for a specified period of time, defines the SPI. The SPI is an efficiency rating for work accomplishment. The SPI compares work accomplished to what should have been accomplished, with a value above one meaning that the project is ahead of schedule and a value below one meaning that the project is behind schedule.

  SPI = BCWP/BCWS = 50 800/45 600 = 1.11%

  The calculated SPI indicates that 1.11% of the work scheduled to be completed, has been completed through the current period. A favourable or ahead of schedule indication exists. A SPI of 100% indicates an on schedule condition. However, this performance indication may not necessarily provide the true status of the work accomplished, since some work may have been performed out of sequence or ahead of schedule. The project plan and project schedules must be used in conjunction with the SPI to provide valid Work In Process (WIP) status information.

- Cost Performance Index (CPI) - the CPI is defined as the ratio of work accomplished versus work cost incurred for a specified period of time. The CPI is an efficiency rating for work accomplished for resources expended.

  CPI = BCWP/ACWP = 50 800/42 900 = 1.18%

  The calculated CPI indicates that for each actual R1.00 of resource expended R1.18 in earned value was received. A cost underrun or higher than planned efficiency indication exists for the period analysed.

- Schedule Variance Percent (SV%)
  To arrive at a meaningful indication of schedule performance, the Schedule Variance (SV) must be related to the amount of work planned to have been accomplished. This is accomplished by converting the SV stated in rand into a Schedule Variance Percent (SV%) - if SV% = 0, then the project is on schedule.

  SV(%) = BCWP-BCWS / BCWP or SV(%) = SV/BCWP
  SV(%) = 50 800 - 45 600 / 50 800
  +.102 or +10.2%

  The example indicates that the plan is 10.2% ahead of schedule. This cumulative calculated index data provides results consistent with the cumulative calculated SPI.

- Cost Variance Percent (CV%)

  To arrive at a meaningful indication of cost performance the Cost Variance (CV) must be related to the amount of work accomplished. This can be accomplished by converting the CV stated in rand into a CV stated as a percentage; if cost variance% = 0, then the project is on budget.

  CV(%) = BCWP-ACWP / BCWP or CV(%) = CV/BCWP

  CV(%) = 50 800 - 42 900 / 50 800

  +.155 or +15.5%

  The example indicates that the cost is 15.5% under target cost. The cumulative CV calculated index data provides results consistent with the previous cumulative calculated CPI.

- Percent Complete

  The percent complete is the budget percent complete, and is the relationship of the amount of work performed to date to the amount of work scheduled for a specific element of the WBS. The base used to determine percent complete is the Budget at Completion (BAC).

  BCWP/BAC = 50 800/200 000 = .254 or 25%

- Work Scheduled for Completion

  BCWS/BAC = 45 600/200 000 = .228 or 23%

- Percent Spent (BAC)

  ACWP/BAC = 42 900/200 000 = .214 or 21%

- Percent Spent (EAC)

  ACWP/EAC = 42 900/180 000 = .238 or 24%

The percent of work complete should then be analysed by comparing it to the percent of work planned or scheduled to have been accomplished through the reporting period being analysed.

By comparing the value of the work completed (25%) to the value of the work schedule for completion (23%) the conclusion of this comparison should yield results compatible with the calculated SV% (+10.2). The results in this example indicate that the effort is 2% (25% - 23%) ahead of schedule at this time.

The percent spent can be calculated using two different approaches; (1) comparison of Actuals with BAC and (2) comparison of Actuals with EAC.

Analysis to determine realization of the EAC is performed by comparing the percent complete to percent spent. By using the data from the example provides an indication that the current EAC (180,000) may be understated and mathematically may be closer to R192,000 (25% of the work has been accomplished utilizing 21% of the budget instead of 24% of the budget as indicated by the EAC). This indicator points to the need for further review, of the remaining work scope value. This will help to determine the accuracy of the projected EAC.

- To Complete Performance Index (TCPI)

The analysis techniques discussed above are used for activities which have already taken place. The analysis data is based on past performance and the results cannot be changed; however, the information from these activities and events can be used to project future performance trends.

The To Complete Performance Index (TCPI), also known as the verification factor, is defined as the ratio of remaining work to remaining budget. The TCPI is calculated using cumulative-to-date information only.

TCPI=BAC-BCWP/ EAC - ACWP = 200 000 - 50 800 / 180 000 - 42 900 = 109%

The TCPI when compared to the cumulative-to-date CPI provides a meaningful data analysis tools which can be used to determine the accuracy of the remaining or - to complete - effort. A difference between the TCPI and cumulative-to-date CPI of more than 20% indicates that the EAC will probably not relate to the past performance. Using the cumulative-to-date CPI and TCPI calculations from the example:

Cumulative-to-date CPI = 118% and TCPI = 109%

The TCPI indicates that future performance on remaining work will be performed at a decreased efficiency. For each budget rand spent in the past, R1.18 in value was received. Based on the TCPI of 109%, for each budget rand of work remaining, R1.09 in value will be achieved. The efficiency for the remaining work scope is forecasted to decrease by 9%.

5.5 Points to Consider When Using Earned Value

5.5.1 It is essential that the earned value analysis extend down to the level where the root causes of variances can be determined and acted upon. Although the C/SCSC criteria refer to the control account level which is the level at which management responsibility for costs is allocated, it may be useful to extend the analysis down to the activity level (activity based earned value) thereby allowing the project manager to track BCWS, BCWP, ACWP and the resulting cost and schedule variances for each activity in the plan. This is essential to a proper analysis of the data and understanding of what is happening on the project.

5.5.2 If a work package has not yet started, its earned value by definition equals zero, or BCWP=0, but for work-in-process work packages, it is incorrect to assume that resource expenditure is proportional to work progress (i.e. there is no necessary relation between resources consumed and progress achieved).

For activities whose duration exceeds one reporting period, additional %complete values can be established. For example, an activity which spans 2 reporting periods could accept values of 0, 50 and 100 %complete. One which spans three periods could accept 0, 33, 67 and 100%. Such schemes would require a prorated accrual of costs since the accrual method used to develop BCWS must match the reporting method used to gather BCWP and ACWP if the data and variances are to be meaningful.

Another technique to overcome the subjectivity of reporting is to dispense with %complete entirely and report expected remaining duration. Generally software developers will be more realistic in estimating how much longer they will require to finish a job than they are at estimating their %complete. Most jobs progress rapidly to 80-90 %complete and then "stick there". This solution, however, is not perfect, but the use of an earned value management system and the consistent tracking and analysis of the data will demonstrate this problem very clearly and permit the Project Manager to address it.

The key to work-in-process estimation is to establish the actual physical tangible accomplishment which has been achieved, and then estimate the resources it was supposed to have consumed.

Alternate methods for work-in-process BCWP estimation include (most project management software tools permit a choice from at least three accrual methods namely, Start, Finish or prorated):

- 50/50 rule - 50% of the task is "earned" when the task starts, and 50% when it is completed - applicability - whenever start and completion dates fall within adjacent months, or closer (Sparrius 1996: c).

- 0/100 rule - this rule allows 0% when the task starts, and 100% when it is completed - applicability - suitable for activities whose planned duration is less than or equal to a reporting period. This is equivalent to accruing all costs at the end of an activity, and removes all subjectivity from the reporting process but also means that you do not get any interim status reports on the activity.

The work-in-process earned value estimates described above are only valid for discrete work packages (effort that can be scheduled in relation to clearly definable start and completion dates, and which contain objective milestones against which performance can be measured, e.g. a report) that are contained within the WBS. Two other types of tasks are contained in the WBS:

- level-of-effort - work which does not result in a final product, e.g. support / liaison activities. Level-of-effort activities usually occur at a uniform rate of resource expenditure, e.g. 10 person-hours per week spent on customer liaison.
- apportioned effort - work which can be directly related to another work package, e.g. 5% of the direct person hours on a coding task will be spent as direct labour on inspecting the code.

For apportioned effort work packages, the work-in-process BCWP depends on the work-in-process of the work package which is used as the apportionment base, and for level-of-effort work packages, the work-in-process BCWP automatically equals the BCWS. There is never a schedule variance (Sparrius 1996: c).

5.6 Variance Analysis

Variances will always exist, unless there is perfect execution of the project plan. Significant variances are those variances that break predetermined thresholds, require management attention, and corrective action. Significant variance may mean the original plan was inappropriate, or the actuals (ACWP) were incorrect. Significant variances inform management that something needs to be examined, analysed and proper corrective action instituted.

According to Sparrius (1997), variance analysis has as its objectives to:

- identify the existence of significant problems
- isolate the root cause of each problem
- determine which corrective action will eliminate both the problem and its cause
- provide a narrative report to the relevant managers of the problem and the corrective action which has been implemented

By definition, any variance is a variance from a baseline (the original budget and plan), and thus cannot be calculated if a planning baseline has not been defined and placed under strict change control. Furthermore, variance analysis only adds value to the extent that it acts as a precursor to the appropriate corrective action, and thus should also reveal the reasons for the problem, for example:

- initial cost and duration estimates are poor
- the schedule is not feasible
- technical difficulties have arisen which require additional resources

5.7 Earned Value in action

5.7.1 Project 1

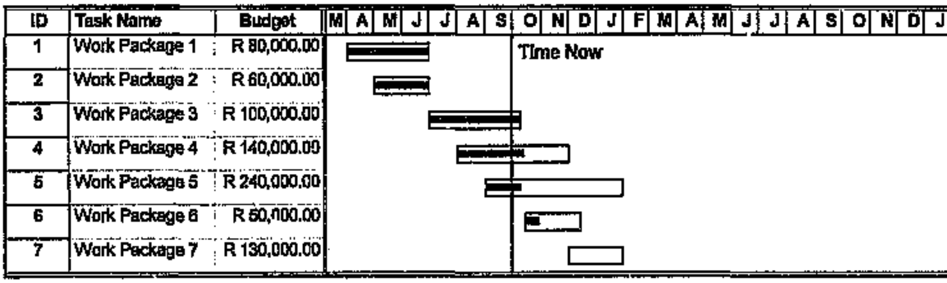

Figure 8 Gantt Chart - Project 1

Looking at Figure 8, consider a project consisting of seven work packages. Solid bars show the degree of completion of each work package. Using the 50-50 method to estimate work-in-process, at Time Now (end September):

BCWS = (80 000 + 60 000) + 0.5(100 000 + 140 000 + 240 000) + 0(50 000 + 130 000) = R380 000

BCWP = (80 000 + 60 000 + 100 000) + 0.5(140 000 + 240 000 + 50 000) + 0(130 000) = R455 000

ACWP = R500 000 (There is no way of obtaining the ACWP from Figure 8, and thus the ACWP must be obtained from the project management tool being used on the project).

Schedule variance = BCWP - BCWS = R 455 000 - R 380 000 = R 75 000

Cost Variance = BCWP - ACWP = R 455 000 - R 500 000 = -R 45 000

The project is thus early, but overspent.

BAC = (80 000 + 60 000 + 100 000 + 140 000 + 240 000 + 50 000 + 130 000) = R 800 000

Cost Performance Index = BCWP / ACWP = 455 000 / 500 000 = 91%

Schedule Performance Index = BCWP / BCWS = 455 000 / 380 000 = 120%

Thus the project's earned value is 91% of the actual cost spent, and 120% of its planned value.

$$EAC = \frac{(BAC - BCWP)}{CPI} + ACWP = \frac{(800\,000 - 455\,000)}{0.91} + 500\,000 = R\ 879\ 129.88$$

The projected cost variance at completion = BAC - EAC = -R 79 129.88

5.8 Summary

The effective management of a project during its life cycle requires that a performance management system is utilised so that immediate feedback can be obtained whereby the up-to-date status of a project can be determined, such that corrective actions can immediately be taken if there is a deviation from the baseline plan, thus minimising the chance of project failure.

The re-engineered earned value performance measurement process described in this chapter provides such a technique as well as examples, as a means of describing the various steps that make up the process, and as a means of gaining an understanding thereof.

Chapter 6 : Contribution of this Dissertation and Implications to Researchers

This dissertation provides a theoretical analysis of a subject which could become the focus of academic as well as business interest, and provides direction to literary material on areas relating to earned value performance measurement for people wishing to learn more about the subject.

It also provides the basis for developing a comprehensive theoretical process from which hypotheses can be proposed for later testing, and thus offers several suggestions to researchers to build on its contribution:

- The investigation of IS project performance measurement represents a major opportunity. Whilst this research provides an insight into the earned value performance measurement process, researchers should study it to contribute significantly to practice.

- This research suggests that earned value performance measurement can be used on private and commercial IS projects, and thus researchers should survey IS organisations by investigating their IS project performance measurement techniques to assess the applicability and accuracy of the earned value performance management technique. A quantitative study can also be initiated to assess whether the earned value performance measurement technique brings real value and benefits during the management of an IS project.

- The earned value performance management guidelines consist of 35 criteria, which in the author's opinion is too complex and time-consuming, and thus the study proposes a 6-step framework as a potential alternative. In doing so, the author was hoping to simplify the technique for use on IS projects. Modern organisations cannot afford to have the same kind of structures, red tape and bureaucracy in place, like the military, which is where most of the information on the topic was found. In addition, project managers do not have the time to get "bogged down" in complex administration, hence the simplified format.

- The framework developed in this research to aid in measuring the performance of the project during its life cycle may require further validation and refinement. This could be accomplished by testing the framework against "real" IS projects.

- In doing research on its application in the "real world", a "failed" project can be selected, with the suggested earned value performance measurement framework being used to determine whether its use on this project would have made a difference.

- A study can be initiated to determine whether the earned value performance measurement technique is applicable to projects across different industries within a South African context, with a focus being placed on the differences and similarities among industries.

Chapter 7: Conclusion

Earned Value management is a proven process that provides strong benefits for project planning and control. It provides for integration of project scope, schedule, and cost objectives and establishment of a baseline plan for performance measurement during the execution of the project. Furthermore, it provides a sound basis for problem identification, corrective actions and management replanning as may be required.

The earned value performance measurement technique is used to compare the planned value of the approved working project plan against the earned value of the physical work accomplished, and to relate this against the actual costs spent to do the work, in order to precisely measure the true project performance.

Having introduced earned value project management, and some of the problems associated with determining the status of IS projects during their life cycle, this dissertation proposed the theory behind applying a re-engineered earned value performance measurement technique as a means of measuring IS project progress.

The basic steps of the re-engineered earned value performance measurement system are:

- Scope the project.
- Plan and schedule all the work for the project.
- Estimate and budget project resources within control accounts
- Establish the project baseline - integrate project work scope, schedule, and cost objectives into a baseline plan against which accomplishments may be measured.
- Monitor performance against the baseline - objectively assess accomplishments at the work performance level.
- Forecast the final cost and schedule results - analyze significant variances from the plan and forecast impacts.

The earned value performance measurement technique is not a panacea, as it will not prevent overruns and schedule overruns. While nothing can totally eliminate risk from large and complex IS projects, the use of the earned value performance measurement technique will significantly reduce project overruns, ensure project cancellations are rare, and when they do occur, they do so much sooner in the project life cycle when less money has been spent, i.e. the earned value performance measurement technique provides management with an early warning signal and thus enables the project manager to detect deviations from plan as soon as they occur and to take the appropriate corrective actions.

Appendix 1

Earned Value Performance Measurement Guidelines (Fleming & Koppelman 1996; Muir 1997).

This appendix highlights the mandatory procedures contained in DOD Regulation 5000.2 R, necessary to ensure the proper implementation of the earned value performance measurement technique.

1. Organization

a. Define all authorized work and related resources to meet the requirements of the contract, using the contract work breakdown structure (WBS).

b. Identify the internal organizational elements and the major subcontractors responsible for accomplishing the authorized work.

c. Provide for the integration of the contractor's planning, scheduling, budgeting, work authorization and cost accumulation systems with each other, the contract work breakdown structure and the organizational structure.

d. Identify the managerial positions responsible for controlling overhead (indirect costs).

e. Provide for integration of the contract work breakdown structure with the contractor's functional organizational structure in a manner that permits cost and schedule performance measurement for contract work breakdown structure and organizational elements.

2. Planning, Scheduling, and Budgeting

a. Schedule the authorized work in a manner which describes the sequence of work and identifies significant task interdependencies required to meet the development, production and delivery requirements of the contract.

b. Identify physical products, milestones, technical performance goals, or other indicators that will be used to measure progress.

c. Establish and maintain a time-phased budget baseline, at the control account level, against which contract performance can be measured. Initial budgets established for performance measurement will be based on the negotiated target cost. Any other amount used for performance measurement purposes must be formally recognized by both the contractor and the government.

d. Establish budgets for all authorized work with separate identification of cost elements (labor, material, etc.).

e. To the extent the authorized work can be identified in discrete, short work packages, establish budgets for this work in terms of dollars, hours, or other measurable units. Where the entire cost account cannot be subdivided into detailed work packages, identify the far term effort in larger planning packages for budget and scheduling purposes.

f. Provide that the sum of all work package budgets plus planning package budgets within a cost account equals the cost account budget.

g. Identify relationships of budgets or standards in work authorization systems to budgets for work packages.

h. Identify and control level-of-effort activity by time-phased budgets established for this purpose. Only that effort which cannot be identified as discrete, short-span work packages or as apportioned effort may be classed as level-of-effort.

i. Establish overhead budgets for the total costs of each significant organizational component whose expenses will become indirect costs. Reflect in the contract budgets, at the appropriate level, the amounts in overhead pools that are planned to be allocated to the contract as indirect costs.

j. Identify management reserves and undistributed budget.

k. Provide that the contract target cost plus the estimated cost of authorized but unpriced work is reconciled with the sum of all internal contract budgets and management reserves.

3. Accounting Considerations

a. Record direct costs on an applied or other acceptable basis in a manner consistent with the budgets in a formal system that is controlled by the general books of account.

b. Summarize direct costs from cost accounts into the work breakdown structure without allocation of a single cost account to two or more work breakdown structure elements.

c. Summarize direct costs from the cost accounts into the contractor's functional organizational elements without allocation of a single cost account to two or more organizational elements.

d. Record all indirect costs which will be allocated to the contract.

e. Identify the basis for allocating the cost of apportioned effort.

f. Identify unit costs, equivalent units costs, or lot costs as applicable.

g. The contractor's material accounting system will provide for:

(1) Accurate cost accumulation and assignment of costs to cost accounts in a manner consistent with the budgets using recognized, acceptable, costing techniques.

(2) Determination of price variances by comparing planned versus actual commitments.

(3) Cost performance measurement at the point in time most suitable for the category of material involved, but no earlier than the time of actual receipt of material.

(4) Determination of cost variances attributable to the excess usage of material.

(5) Determination of unit or lot costs when applicable.

(6) Full accountability for all material purchased for the contract including the residual inventory.

4. Analysis and Management Reports

a. Identify at the cost account level on a monthly basis, using data from or reconcilable with the accounting system:

(1) Comparison of the budgeted cost for work scheduled and the budgeted cost of work performed. This comparison provides the schedule variance.

(2) Comparison of the budgeted cost for work performed and the actual (applied where appropriate) direct costs for the same work. This comparison provides the cost variance.

(3) Variances resulting from the comparisons between the budgeted cost for work scheduled and the budgeted costs for work performed and between the budgeted cost for work performed and actual or applied direct costs, classified in terms of labour, material or other appropriate elements together with the reasons for significant variances.

b. Identify, on a monthly basis, in the detail needed by management for effective control, budgeted indirect costs, actual indirect costs, and cost variances with the reasons for significant variances.

c. Summarize the data elements and associated variances listed in subparagraphs a. (1) and (2), directly above, through the contractor organization and work breakdown structure to the reporting level specified in the contract.

d. Identify significant differences on a monthly basis between planned and actual schedule accomplishment and the reasons.

e. Identify managerial actions taken as a result of criteria items in paragraphs a. through d., directly above.

f. Based on performance to date, on commitment values for material, and on estimates of future conditions, develop revised estimates of cost at completion for work breakdown structure elements identified in the contract and compare these with the contract budget base and the latest statement of funds requirements reported to the government.

5. Revisions and Data Maintenance

a. Incorporate contractual changes in a timely manner, recording the effects of such changes in budgets and schedules. In the directed effort prior to negotiation of a change, base such revisions on the amount estimated and budgeted to the functional organizations.

b. Reconcile original budgets for those elements of work breakdown structure identified as priced line items in the contract, and for those elements at the lowest level in the programme work breakdown structure, with current performance measurement budgets in terms of changes to the authorized work and internal replanning in the detail needed by management for effective control.

c. Prohibit retroactive changes to records pertaining to work performed that would change previously reported amounts for direct costs, indirect costs, or budgets, except for correction of errors and routine accounting adjustments.

d. Prevent revisions to the contract budget base except for authorized changes to contractual effort.

e. Document internally the changes to the performance measurement baseline and notify expeditiously the procuring activity through prescribed procedures.

f. Provide the contracting officer and the contracting officer's authorized representatives with access to the information and supporting documentation necessary to demonstrate compliance with the cost / schedule control systems criteria.

References

Abba W.F. (1996) *Earned Value Management Rediscovered*, [On-line].
Available:
http://www.acq.osd.mil/pm/newpolicy/misc/standown.html

Abba W.F. (1997) *Earned Value Management - Reconciling Government and Commercial Practices*, [On-line].
Available:
http://www.acq.osd.mil/pm/paperpres/abbapmmag.htm

Abdel-Hamid T.K., Madnick S.E. (1991) Software Project Dynamics - An Integrated Approach, *Prentice Hall, Inc.*, New Jersey.

Association for Project Management (1997), *The 40 Key Competencies*, [On-line].
Available:
http://www.apmgroup.co.uk/the40key.htm

Bailey K.D. (1994) Methods of Social Research (Fourth Edition), *The Free Press*, New York.

Bate R., Kuhn D.,Wells C., Armitage J., Clark G., Cusick K., Garcia S., Hanna M., Jones R., Malpass P., Minnich I., Pierson H., Powell T., Reichner A., (1995) A Systems Engineering Capability Maturity Model, Version 1.1, CMU/SEI-95-MM-003, Maturity Model, *Software Engineering Institute*, Carnegie Mellon University, Pittsburgh.

Black K. (1996) Causes of Project Failure, *PM Network*, PMI Publications Division, North Carolina, November.

Boehm B.W. (1987) Improving Software Productivity, *IEEE-CS Computer*, Volume 20, September.

Boehm B.W. (1991) Software Risk Management: Principles and Practices, *IEEE Software*, Institute of Electrical and Electronics Engineers, Inc.

British Guide to Project Management - BS 6079 (1996) *Management Systems Sector Board*.

Brooks Jr. F.P. (1995) *The Mythical Man-month - Anniversary Edition*, Addison-Wesley Publishing Company, Inc., Massachusetts.

Buttrick R. (1997) *The Project Workout*, Pitman Publishing, London.

Chapman C., Turner J.R. (1995) *Risk Analysis*, in, The Commercial Project Manager, Turner J.R., McGraw-Hill Book Company, England.

Cleland D.I., King W.R. (1983) *Systems Analysis and Project Management* (Third Edition), McGraw-Hill, Inc., New York.

Conway B. (1996) Best Practices in AD Project Management, Part 1, *Gartner Group, Inc.*, Note Number SPA-650-1292, 20 March.

Cort G. (1989) A Software Configuration Management Survival Kit, *Course Notes*, NOTES-CA-SCM-025, Version 2.1.

CSC Research and Advisory Services (1994) Project Management in the 1990s - PEP Paper 26, *CSC Index*, United Kingdom.

De Marco T. (1982) Controlling Software Projects, Yourdon Press, Inc., New York.

Dinsmore P.C. Ed. (1993) *The AMA Handbook of Project Management*, AMACOM, New York.

Drucker P.F. (1992) *Managing for the Future*, Butterworth-Heinemann Ltd., Oxford.

Duffy N.M., Assad M.G. (1980) *Information Management - An Executive Approach*, Oxford University Press, Cape Town.

Earl M.J. (1995) Putting Information technology in its Place: a Polemic for the Nineties, Galliers R., Baker B. (1995) *Strategic Information Management - Challenges and strategies in managing information systems*, Butterworth-Heinemann, Oxford.

Ewusi-Mensah K., Przasnyski Z.H. (1994) Factors Contributing to the Abandonment of Information Systems Development Projects, *Journal of Information Technology*, Volume 9, Number 3, Chapman & Hall, London, September.

Ewusi-Mensah K., Przasnyski Z.H. (1995) Learning from Abandoned Information Systems Development Projects, *Journal of Information Technology*, Volume 10, Number 1, Chapman & Hall, London, March.

Fleming Q.W. (1995) Reengineering the Earned Value Process, The Forum, *Project Management Institute*, Phoenix Chapter, Arizona, November.

Fleming Q.W., Koppelman J.M. (1996) Earned Value Project Management, *Project Management Institute*, Pennsylvania.

Garner R. (1995) *Management Meltdown*, Open Computing, McGraw-Hill, January.

Gioia J. (1996) Twelve Reasons Why Programs Fail, *PM Network*, PMI Publications Division, North Carolina, November.

Gibbons P. (1995) Rising Above the Guessing Game, *Computer Select*, Ziff-Davis Publishing Company.

Globerson S. (1997) Discrepancies between Customer Expectations and Product Configuration, *International Journal of Project Management*, Elsevier Science Ltd., Volume 15, Number 4, Great Britain.

Hamburger D. (1990) The Project Manager: Risk Taker and Contingency Planner - Part 2, *Project Management Journal*, Project Management Institute, Volume XXI, Number 4, Boston, December.

Hamel J. (Ed.) (1992) The Case Study Method in Sociology, *Current Sociology*, Spring.

Hamilton S., Chervany N.L (1981)., *Evaluating Information System Effectiveness - Part 1: Comparing Evaluation Approaches*, MIS Quarterly, September.

Hammer M. (1990) *Re-engineering Work. Don't Automate, Obliterate*, Harvard Business Review, July/August.

Handy C. (1994) The Empty Raincoat, *Hutchinson*, London.

Harroff N.N. (1995) *Earned Value Defined*, [On-line].
Available:
http://www.nnh.com/ev/what2.html

Harroff N.N. (1996) *Earned Value FAQS*, [On-line].
Available:
http://www.nnh.com/ev/faqs.html

Hatfield M.A. (1996) The Case for Earned Value, *PM Network*, PMI Publications Division, North Carolina, December.

Humphreys and Associates (1996) *Managing Projects and Programs with Earned Value*, [On-line].
Available:
http://www.ultranet.com/projectworld/proooo4.htm

In't Veld C. (1996) Providing Hope for the Hopeless, *Computerweek*, Systems Publishers, Johannesburg, April.

Kharbanda O.P., Stallworthy E.A. (1983) *How to learn from Project Disasters*, Gower Publishing Company Limited, England.

Keil M. (1995) Pulling the Plug: Software Project Management and the Problem of Project Escalation, *MIS Quarterly*, December.

Kerzner H.K. (1989) Project Management - A Systems Approach to Planning, Scheduling and Controlling (Third Edition)., *Van Nostrand Reinhold*, New York.

Kliem R.L. (1996) Project Management Keeps Reengineering on the Right Path, *PM Network*, PMI Publications Division, North Carolina, August.

Knight J., Shroder G. and Walker A. (1992) *Software Quality and SABS ISO 9000: Implementation*, Software Engineering Applications Laboratory, Revision 0.1, University of the Witwatersrand, Johannesburg.

Kulik P. (1997) Software Project Success Factors, *Kulik & Lazarus Consulting, Inc.*, Online: http://www.klci.com/accelerate, February.

LaPlante A. (1995) Scope Grope, *Computerworld*, Volume 29, Number 12.

Lashbrooke G. (1994) *A Project Manager's Handbook*, Kogan Page Ltd., London.

Lederer A.L., Prasad J. (1993 a) Systems Development and Cost Estimating, *Information Systems Management*, Vol. 10, No. 4, Fall.

Lederer A.L., Prasad J. (1993 b) Information Systems Software Cost Estimating: A Current Assessment, *Journal of Information Technology*, Volume 8, Number 1, Chapman and Hall, London, March.

Lister G. (1995) How to Manage Projects in the New South Africa, *ProjectPro Magazine*, Project Publishing cc., Pretoria, November.

Lock D. (1988) Project Management (Fourth Edition), *Gower Publishing Company Limited*, England.

Louw W. (1995) The Basics of Project Cost Control, *ProjectPro Magazine*, Project Publishing cc., Pretoria, May.

McCracken D., Jackson M. (1986) cited in Globerson S. (1997) Discrepancies between Customer Expectations and Product Configuration, *International Journal of Project Management*, Elsevier Science Ltd., Volume 15, Number 4, Great Britain.

McFarlan G.W. (1990) *The 1990s: The Information Decade - IT will be everyone's business*, Business Quarterly, Vol. 5, No. 1.

McGettrick S. (1996) The Project Life Cycle - Impacts, *Project Magazine*, Association of Project Management, Volume 9, Number 3, July.

McLeod G., Smith D. (1996) Managing Information Technology Projects, *Boyd and Fraser Publishing Company*, Massachusetts.

Meredith J.R., Mantel Jr. S.J. (1989) Project Management - A Managerial Approach, *John Wiley & Sons*, New York.

Microsoft Corporation (1995) *User's Guide to Microsoft Project*, Microsoft Corporation.

Morris P.W.G. (1988) Managing Project Interfaces - Key Points for Project Success, cited in Project Manager's Handbook 2nd Ed., *Van Nostrand Rheinhold*, New York.

Muir J. (1996) *Earned Value Study Report: Report on the Use of Earned Value Data in the Australian Acquisition and Logistics Program*, [On-line].
Available:
http://www.acq.osd.mil/pm/paperpres/evatrep.html

Muir J. (1997) *Comparison of Old 35 DOD Criteria with New 32 Industry Criteria*, [On-line].
Available:
http://www.acq.osd.mil/pm/currentpolicy/critcomp.htm

Oosthuizen P. (1994) The Silent Revolution - How to Make Business Work - The Project Management Approach, *PM Publishers*, Arcadia.

Paul L.G. (1995) Rising Above the Guessing Game, *PC Week*, Ziff-Davis Publications, Volume 12, Number 42, October 23.

Pa. ᵏin A. (1980) *Systems Management*, Edward Arnold Publishers Ltd., London.

Parkinsoı. ᴶ. (1991) *Making CASE Work*, Hobbs Printers, Oxford.

Pelc C. (1996) *E. rned Value: Exploding Some Myths*, [On-line].
Available:
http://www.hq.af.mil/. AFAQ/acq_ref/news/July_Newsletter/feature_3.htm

Phan D., Vogel D., Nunamaker J. (1988) The Search for Perfect Project Management, *Computerworld.*

Pinto J.K. (1997) Twelve Ways to Get the Least from Yourself and Your Project, *PM Network*, PMI Publications Division, North Carolina, May.

Project Management Institute Standards Committee (1996) *A Guide to the Project Management Body of Knowledge*, Project Management Institute, Upper Darby, USA.

Remenyi D. (1995) *What will Organisations Look Like in Future*, Course Notes in Mcom course, University of the Witwatersrand, Johannesburg.

Remenyi D., Sherwood-Smith M. (1996), *A New Look at Evaluation for Information Systems - The Formative Approach, Henley Working Paper* Series, Henley Management College.

Remenyi D., Williams B. (1995) Some Aspects of Methodology for Research in Information Systems, *Journal of Information Technology*, Chapman and Hall, London.

Rowen R. (1990) cited in Globerson S. (1997) Discrepancies between Customer Expectations and Product Configuration, *International Journal of Project Management*, Elsevier Science Ltd., Volume 15, Number 4, Great Britain.

Saker N. (1990) Project Estimating, *Butler Cox plc.*, PEP Paper 16, London, Octoper.

Seldon A. (1996) Get the Process Right, *Computerweek*, Systems Publishers, Johannesburg, April.

Sharp J.A., Howard K. (1996) The Management of a Student Research Project (Second Edition), *Gower 'ublishing Limited*, England.

Shenhar A.J., Levy O., Dvir D. (1997) Mapping the Dimensions of Project Success, *Project Management Journal*, Project Management Institute, Boston, June.

Singletary N. (1996) What's the Value of Earned Value?, *PM Network*, PMI Publications Division, North Carolina, December.

Sparrius A. (1996: a), *Chicken Shl& Squared*, ProjectPro Magazine, Project Publishing cc., May, Pretoria.

Sparrius A. (1996: b), *The Principles of Earned Value*, ProjectPro Magazine, Project Publishing cc., Vol. 6 No. 4, July, Pretoria.

Sparrius A. (1996: c), *How to Earn Earned Value*, ProjectPro Magazine, Project Publishing cc., Vol. 6 No. 5, September, Pretoria.

Sparrius A. (1997), *Variance Analysis*, ProjectPro Magazine, Project Publishing cc., Vol. 7 No. 2, March, Pretoria.

Sterman J.D. (1992) *System Dynamics Modeling for Project Management*, [On-line].
Available:
http://web.mit.edu/jsterman/www/SDG/project.html.

Szajna B., Scamell R.W. (1993) *The Effects of Information System User Expectations on their Performance and Perceptions*, MIS Quarterly, December.

Treasury Board of Canada Secretariat (1996) *An Enhanced Framework for the Management of Information Technology Projects*, Project Management Office, Financial and Information Management Branch, Canada.

Turner J.R. (1993) *The Handbook of Project-Based Management*, McGraw-Hill International Limited, United Kingdom.

Turner J.R., Remenyi D. (1995) *Estimating Costs and Revenues*, in, The Commercial Project Manager, Turner J.R., McGraw-Hill Book Company, England.

U.S. Department of Energy (1995) *How to Measure Performance - A Handbook of Techniques and Tools*, [On-line].
Available:
http://www.lint.gov/PBM/handbook

Van der Merwe A.P. (1996) *Another Shot at Understanding Project Risk*, Course Notes in Mcom course, University of the Witwatersrand, Johannesburg.

Van der Merwe A.P. (1997) *A Procedure Manual for Project Management*, Course Notes in Mcom course, University of the Witwatersrand, Johannesburg.

Van Scoy R.L. (1992) Software Development Risk; Opportunity, Not Problem, Technical Report CMU/SEI-92-TR-30, *Software Engineering Institute*, Carnegie Mellon University, Pittsburgh.

Wall A.J. (1988) *Project Planning and Control Using Micros*, National Computing Centre Limited, Manchester, England.

Willcocks L., Margetts H. (1994) Risk Assessment and Information Systems, *European Journal of Information Systems*, Stockton Press, United Kingdom.

Wolfaard H. (1996) Integrated Cost / Schedule Control, *ProjectPro Magazine*, Project Publishing cc., February, Pretoria.

Yeates D. (Ed) (1986) *Systems Project Management*, Pitman Publishing Ltd., London.