TECHNICAL RISK MANAGER

TRMANAGER

A thesis submitted in fulfilment of the requirements for the degree of
Doctor of Philosophy

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June 2008
Abstract

Successful projects may be defined by criteria set prior to a project being commenced. The project success criteria may include time, budget and performance. A description of a successful project is often one that has been achieved “on time”, “on budget” and “on performance”.

Project managers will utilise aids that enhance the possibility of achieving project success. A common aid used by project managers today is a project management tool. Project management tools typically provide a software environment that facilitates access to Gantt, network diagrams and PERT charts.

The research has focused on performance as a project success criterion and the aids available for project manager use to achieve performance success criteria. The research found that the project management tools available today provide time and budget management capability but were not able to provide performance management capability. Project managers rely on specialists to utilise other tools to manage performance aspects of a project. The research outcome is to provide a method to include performance management within project management tools through the development of a new model framework called TRManager. TRManager is similar in concept to Gantt, network diagrams and PERT charts and provides performance management capability. TRManager is complementary to Gantt, network diagrams and PERT and therefore can be incorporated into project management tools with minimum effort. TRManager is extensible and permits other activities, such as asset management to be integrated into or used in conjunction with the project management activity.

The research included consideration of how project managers were trained to manage a project that included a performance success criterion. The research found that with a new project management tool that included TRManager, project managers could be trained to carry out performance management.
Acknowledgements

I wish to thank Shona Mitchell for her belief that I would complete this thesis. I believe that this thesis is a result of Shona’s love and support for my efforts.

I appreciate the support of my supervisor Professor Henry Wu and to Professor Chris White who encouraged me to stick with it. I especially appreciated the support of Jo-Han Wong.

I would like to express my appreciation to AUSIndustry. Achieving the competitive COMET grant assisted with the development of the intellectual property based on the research outcome and subsequent patent application.

This work includes input from the survey interviewees, and to them I offer my appreciation for taking the time to contribute.

RMIT University has supported this research through time release and conference attendance. This has positively contributed to my research program.

Mark A Gregory
15 June 2008
Declaration

‘I certify that except where due acknowledgement has been made, the work is that of the author alone; the work has not been submitted previously, in whole or in part, to qualify for any other academic award; the content of this thesis is the result of work which has been carried out since the official commencement date of the approved research program; and, any editorial work, paid or unpaid carried out by a third party is acknowledged.’

Signed

Mark A Gregory
15 June 2008
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<th>Description</th>
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<tbody>
<tr>
<td>ABC</td>
<td>Activity Based Costing</td>
</tr>
<tr>
<td>AEE</td>
<td>Advanced Engineering Environment</td>
</tr>
<tr>
<td>C³</td>
<td>Command, Control and Communication system</td>
</tr>
<tr>
<td>CPM</td>
<td>Critical Path Method</td>
</tr>
<tr>
<td>Gantt</td>
<td>Gantt chart – project scheduling technique</td>
</tr>
<tr>
<td>IMS</td>
<td>Information Management Systems</td>
</tr>
<tr>
<td>LCA</td>
<td>Life Cycle Assessment</td>
</tr>
<tr>
<td>LCC</td>
<td>Life Cycle Costing</td>
</tr>
<tr>
<td>LCCA</td>
<td>Life Cycle Costing Analysis</td>
</tr>
<tr>
<td>MOP</td>
<td>Microsoft Office® Project</td>
</tr>
<tr>
<td>PERT</td>
<td>Program Evaluation and Review chart – project scheduling technique</td>
</tr>
<tr>
<td>PM</td>
<td>Project Management</td>
</tr>
<tr>
<td>PMBOK</td>
<td>Project Management Body of Knowledge Guide</td>
</tr>
<tr>
<td>PMI</td>
<td>Project Management Institute</td>
</tr>
<tr>
<td>PMT</td>
<td>Project Management Tool</td>
</tr>
<tr>
<td>SAV</td>
<td>System Analysis View window</td>
</tr>
<tr>
<td>SET</td>
<td>Systems Engineering Tool</td>
</tr>
<tr>
<td>TR</td>
<td>Technical Risk</td>
</tr>
<tr>
<td>TRM</td>
<td>Technical Risk Management</td>
</tr>
<tr>
<td>WLCC</td>
<td>Whole Life-cycle Costing</td>
</tr>
</tbody>
</table>
1 Introduction

1.1 Introduction

Robert Deemer, Chairman of the Committee on Advanced Engineering Environments (AEE) for the National Academies of the Aeronautics and Space Engineering Board, USA, called for the implementation of AEEs which would:

‘Use advanced computational, communications, and networking facilities and tools to create integrated virtual and distributed computer-based environments linking researchers, technologists, designers, manufacturers, suppliers and customers’, and

‘An ideal AEE would encompass concept definition, design, manufacturing, production, and analyses of reliability and cost over the entire life cycle of a product or mission in a seamless blend of disciplinary functions and activities.’ (Deemer 2000)

Both individuals and organisations provide their customers with products (including services), which from initial concept to final withdrawal and disposal may enter managed life-cycles. Product life-cycles may vary in their duration, phasing and complexity, and the methods organisations adopt to manage them is similarly variable. These management methods may include simple adhoc approaches, standard methods used by other organisations and specially tailored (bespoke) approaches unique to an organization.

Though products are typically thought of as physical in nature, physical items may only comprise one facet of a product. For example, a car may not only include the basic vehicle but also a range of ancillary products and services, such as, safety systems, navigation systems, warranties, servicing and spare parts, initial insurance and breakdown services. Likewise, the basic vehicle itself may comprise a combination of other products, such as, the shell, power train, interior, braking system and tyres. As such, no distinction is drawn here between products and services, and, a product is considered from a broader family "system" perspective to be a set of related items, services and processes.
Over a product's life-cycle an organisation may undertake numerous activities related to the broader system that is the product or service. In fact, a product or system life-cycle may be viewed as a series of projects and the various activities are commonly implemented as such. The management framework for projects is known as project management and the evaluation of both project management performance and a project's success is usually related to time, budget and performance criteria, with successful project managers being those that deliver projects “on time”, “on budget” and “on performance”. Project management is a key ingredient in successful project outcomes and this thesis deals with technical risk management and a number of other important aspects of project management, with the aim of translating Deemer's ideal AEE from idea to concrete reality.

To gain a proper perspective of the importance of this work, this chapter begins by considering the importance of project management both internationally and within Australia. This is followed by examination of the meaning and importance of technical risk management, the element at the core of this thesis. An overview is then given of the research and development that has been undertaken and outlines key elements of TRManger. Finally, having established a context for this work, an outline of the subsequent material is given and the chapter concludes with a brief summary.

1.2 The importance of project management

Though projects pervade all aspects of economic activity, there are few if any statistical measures which directly measure the importance of project management in economic terms. However, large scale projects, which tend to occur in industry sectors, such as, mining, essential services (water/electricity/gas), construction, transportation, education, health, and, government administration and defence, are by their very nature highly visible and expenditure in such areas provides an indirect measure of the importance and value of project management. Furthermore, because of the open budgetary processes in Western parliamentary systems, expenditure in the Government administration and defence sector is perhaps best documented and as such becomes the focus of attention.

Internationally, the importance of project management is illustrated by government expenditure for the world’s leading economy, the United States. The most recently published expenditure figures are given in the Consolidated Federal Funds Report
(CFFR) for fiscal year 2005. The CFFR breakdown of U.S. Federal Government expenditures or obligations by category is shown in Table 1-1.

<table>
<thead>
<tr>
<th>Category</th>
<th>$USD (billion)</th>
<th>$USD (billion)</th>
<th>%</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Retirement and disability</td>
<td>703</td>
<td>21.05</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other direct payments</td>
<td>500</td>
<td>14.97</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grants</td>
<td>470</td>
<td>14.08</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Procurement contracts</td>
<td>381</td>
<td>11.41</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Salaries and wages</td>
<td>232</td>
<td>6.95</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Direct expenditure or obligation</td>
<td></td>
<td>2,286</td>
<td>68.46</td>
<td></td>
</tr>
<tr>
<td>categories</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Direct loans</td>
<td>29</td>
<td>0.87</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Guaranteed or insured loans</td>
<td>165</td>
<td>4.94</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Insurance</td>
<td>859</td>
<td>25.73</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other Federal Assistance</td>
<td></td>
<td>1,053</td>
<td>31.54</td>
<td></td>
</tr>
</tbody>
</table>

Total                                     | 3,339          | 100.00         | 100.00|     |

Dollar amounts reported under these categories can represent either actual expenditures or obligations.

**Table 1-1 Consolidated Federal Funds Report for Fiscal Year 2005 (USCB 2007a)**

As shown in Table 1-1, total U.S. Federal Government expenditures or obligations in 2005 amounted to approximately $USD 2.3 trillion in direct expenditure or obligations and $USD 1.1 trillion of other Federal Government assistance. Of the categories shown, project expenses and obligations are most likely to be recorded under the category of "Procurement contracts" and Table 1-2 details the CFFR breakdown of this category by U.S. Federal Government Agency.

<table>
<thead>
<tr>
<th>Defense Agencies</th>
<th>$USD (000)</th>
<th>$USD (000)</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Army</td>
<td>78,450,018</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Navy</td>
<td>64,796,209</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Air Force</td>
<td>53,479,275</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other Defense</td>
<td>48,746,005</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Department of Defense</td>
<td></td>
<td>245,471,507</td>
<td>64.43</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Nondefense Agencies</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Agriculture</td>
<td>4,065,500</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Commerce</td>
<td>1,993,969</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Copyright Mark A Gregory 2008 20
Table 1-2 Federal Government Expenditure for Procurement Contracts, by Agency, by State and Outlying Area (USCB 2007b)

Not surprisingly, given that large projects are a feature of Defense agencies, Table 1-2 shows that U.S Federal Government Defense Agencies dominate this category, with 64.43% of the total expenditure and obligations. That is, expenditure by defense agencies represents approximately 11% of U.S. Federal Government direct expenditure or obligation categories.

Using the ‘Procurement contracts’ category in Table 1-1 as a proxy for project management together with the 'Salaries and wages' figure of 6.95% of total U.S. Federal Government expenditures and obligations produces an estimate of the direct annual cost of project management to the U.S. Federal Government of some $USD 26 billion (0.0695 x $USD 381 billion). Even though such an estimate is crude in nature, clearly the cost/value of project management is substantial.
A similar picture to the U.S. situation also emerges in an Australian perspective, with the notable exception of the difference in scale between the two economies. Figure 1-1 gives estimates of Australian Commonwealth government expenditures for the year 2007-08 of $AUD 235.6 billion.

In the case of Australian Defence expenditures, indicative expenditure estimates for major capital equipment procurement programs were published in "The 2006-16 Defence Capability Plan: Public Version (DCP 2006-16)" (DCP 2006). Figure 1-1 summarizes these estimates and shows that Australian Defence expenditures are expected to be in the order of $AUD 5 billion per annum. This represents approximately 2.1% of total Australian Commonwealth government expenditures.

Likewise, applying the U.S. rate of 6.95% for 'Salaries and wages', produces a proxy estimate of the direct annual cost of project management to the Australian Commonwealth Government in the area of Defence projects of approximately $AUD 348 million.

Clearly projects and project management constitute important components of Government outlays. The pervasive nature of projects across all sectors of economic activity suggests that the importance of projects and project management is likely to be far greater than the indication given by such direct proxy estimates. Moreover, it...
could reasonably be argued that the direct 'Salaries and wages' estimate understates the importance of project management and that a more accurate estimate may be the project value/cost itself. The reason for this is that the project value/cost is also representative of the loss associated with a completed project failing. Fortunately, most large projects do not completely fail, but reports of shortfalls in expected project outcomes abound. Such shortfalls arise in many forms and as Moon et al. (2005) note: 'Cost overruns, schedule slippages and capability (performance) shortfalls have become a major concern for many Defence organisations'. With this in view, the focus here now shifts to the likelihood of such shortfalls and the associated issue of risk.

1.3 Risk

There are many definitions of risk and Hansson (2007) in an entry for The Stanford Encyclopedia of Philosophy, gives four:

1. risk = an unwanted event which may or may not occur.
2. risk = the cause of an unwanted event which may or may not occur.
3. risk = the probability of an unwanted event which may or may not occur.
4. risk = the statistical expectation value of an unwanted event which may or may not occur.'

where:

'The expectation value of a possible negative event is the product of its probability and some measure of its severity.'

Of these definitions, he types the first two as being qualitative and the last two as quantitative. Furthermore, Hansson notes that:

'Although expectation values have been calculated since the 17th century, the use of the term “risk” in this sense is relatively new. It was introduced into risk analysis in the influential Reactor Safety Study, WASH-1400, (Rasmussen et al., 1975). Today it is the standard technical meaning of the term “risk” in many disciplines. It is regarded by some risk analysts as the only correct usage of the term.'
A common feature of Hansson's definitions of risk is the use of the qualifying term 'unwanted'. Negative terms such as unwanted event and hazard are widely used in this context. For example, the Gene Technology Regulator (2007) defined them in the following manner:

'A hazard (source of potential harm) may be an event, substance or organism. A risk is identified when a hazard is considered to have some chance of causing harm. Those events that do not lead to an adverse outcome, or could not reasonably occur, do not advance in the risk assessment process.'

Likewise, such negative connotations are also in evidence in the definition provided by Stoneburner et al. (2002) in the Risk Management Guide for Information Technology Systems - Recommendations of the National Institute of Standards and Technology, in which risk is defined as:

'Risk is the net negative impact of the exercise of a vulnerability, considering both the probability and the impact of occurrence.'

To further complicate matters, variations occur in the definition of risk between standards organizations. Variations also occur in the nature of standards as illustrated by the list of standards presented to the Technical Panel, Myriad Multiplying Risk Management Standards, INCOSE, 2006 and reproduced here as Table 1-3.

<table>
<thead>
<tr>
<th>Standard</th>
<th>Description</th>
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<tbody>
<tr>
<td>ISO 17666</td>
<td>Space systems – Risk management</td>
</tr>
<tr>
<td>MIL-STD-882D</td>
<td>DoD Standard Practice for System Safety</td>
</tr>
<tr>
<td>ISO 14971</td>
<td>Medical devices – Application of risk management to medical devices</td>
</tr>
<tr>
<td>AAMI TIR 32</td>
<td>Medical device software risk management</td>
</tr>
<tr>
<td>IEC 61508</td>
<td>Functional safety of electrical/electronic/programmable safety-related systems</td>
</tr>
<tr>
<td>ISO/IEC 16085</td>
<td>Information technology – Software life cycle processes – Risk management</td>
</tr>
<tr>
<td>Carnegie Mellon SEI</td>
<td>CMMI Risk Management (RSKM) process area</td>
</tr>
<tr>
<td>AIRMIC/ALARM/IRM</td>
<td>A Risk Management Standard</td>
</tr>
<tr>
<td>PMI</td>
<td>Book of Knowledge (Risk Management subject area)</td>
</tr>
<tr>
<td>IEC 60812</td>
<td>Analysis technique for system reliability – Failure mode and effect analysis</td>
</tr>
<tr>
<td>IEC 60300-3-9</td>
<td>Dependability mgmt application – Risk Analysis of technological systems</td>
</tr>
</tbody>
</table>
In contrast, to the negative connotations usually associated with risk, the AIRMIC/ALARM/IRM ‘A Risk Management Standard’ notes:

"In all types of undertaking, there is the potential for events and consequences that constitute opportunities for benefit (upside) or threats to success (downside)." and that 'Risk Management is increasingly recognised as being concerned with both positive and negative aspects of risk. Therefore this standard considers risk from both perspectives.'

Several points arise from the viewpoint expressed in this risk management standard. The first is to note that this dual view of risk provides a closer fit to the conventional statistical treatment of risk, in which expected values may be positive or negative, as is the case in the classical "newsboy model". The second point to note is that this view of risk is quantitative in nature and matches Hansson's fourth definition. The final point is that such a risk perspective carries the implication that risk management is dual in nature and involves considerably more than simply minimizing failures.

This last perspective is the one which underpins the approach taken in this thesis. While acknowledging that many risks may only be described and represented in a qualitative form, a quantitative view of risk lies at the heart of TRManager. However, while the approach is quantitative in nature, risk management and technical risk management involve far more than a series of expected value calculations and focus now shifts to this issue.

### 1.4 Risk management and technical risk management

In practice, there is little difference that can be discerned between risk management and technical risk management, but a number of points of distinction can be made. One obvious point of difference is that technical risk management is primarily concerned with risks that have technical or technological causes as is evidenced in the definition given by Moon et al. (2005):
“Technical risk may be defined as ‘the risk that a system will not reach its performance goals, development will not be within the specified time frame and/or it will cost more than estimated owing to difficulties experience with technical aspects’.”

A second point of distinction between the two terms appears to arise because the knowledge base and the practitioners associated with such technical aspects reside in the Engineering discipline. An example of this is given by Alingcastre (2004) who notes that in relation to asset management, risk management

"shares the exact same core principle to Reliability Centred Maintenance (RCM). The objective of any effective maintenance strategy, developed using RCM, is to maximise the effectiveness of an asset while minimising the effects and/or the likelihood of failure. One cannot effectively apply the risk management methodology to manage assets without also using RCM methodology, in some form. From an asset management context, RCM is risk management."

A further point of distinction is that the term technical is often used as an indicator of the level and degree of sophistication used in an analysis. In such cases, the use of the term technical is essentially decorative, as is indicated in the following quotation concerning Finance, Risk Management and Quantitative Methods.

"The relationship of Technical and Quantitative analysis can be likened to the relationship between Astrology and Astronomy. One is seen as superstition while the other as a science. Astrology came about due to the lack of sophisticated tools and theories. The same with Technical Analysis -- people relied on charts because it was easier to analyze than numbers. But in the advent of faster and more powerful computers, large amounts of numbers can be analyzed with ease."

In general, the aim of drawing such distinctions between risk management and technical risk management appears to be an attempt to establish a view of risk management as a highly quantitative, sophisticated, physical systems oriented undertaking. However, the opinion expressed here is that attempting to restrict the scope of risk management in this way is at best unhelpful. In reality, it is extremely
difficult to quarantine elements of risk management in this way and doing so may introduce additional risks. Such thorny issues were addressed by Brauner (2004) in an article examining the risk landscape of the future. In that article he raises numerous scenarios, such as the halting of the Gulf Stream and note:

"It would be wrong not to examine such scenarios on the simple assumption that past experience suggests that they are “improbable”. In fact, predictions about the likelihood of multi-causal losses actually depend either on sound understanding of cause-and-effect relationships or on a detailed loss history, and the risks of the future have neither of the two."

In addition to multi-causal losses, he also cites numerous examples of the impact of such losses, such as: "The 2001 power failures in California caused productivity losses of USD 21.8 billion, loss of income among private households to the tune of USD 4.5 billion, and the loss of about 135,000 jobs."

Invariably the nature of most projects is that they contain such 'risks of the future' and given the complex nature of the modern environment losses are most likely to be multi-casual. As such, the approach taken in this thesis makes no distinction between the terms risk management and technical risk management and considers the meaning of both terms to be interchangeable. Notwithstanding this statement, the term technical risk management is retained because of the direct association many people make between it and quantitative analysis and the engineering discipline.

1.5 An emerging picture of technical risk management

What begins to emerge from the discussion of technical risk management is an extremely complex, but somewhat fractured picture of what is involved. In the opening reference concerning an ideal AEE, Deemer identified the need for integrated tools that bring together the models and techniques used whilst carrying out life cycle activities and providing access to all of the system stakeholders. Clearly, in expressing such an opinion Deemer is arguing that integrated management and analysis tools that make information available to all stakeholders will enhance the likelihood of project or system life-cycle success, while acknowledging the fact that such integrated tools do not exist at present.
The second major element to emerge is that criteria for assessing both a project and a project's management are usually specified in terms of time, budget and capability. Closely associated with this is the observation by Moon et al. (2005) that shortfalls in relation to each of these three categories are common and ‘have become a major concern for many Defence organisations’. This view is also supported by the work of Black (2001), who reports that “Increasingly, Government customers and Industry contractors seek better methods to identify and manage technical, schedule and cost risk.” In the survey conducted by Black of participants at an Aerospace conference in 1998, 39 per cent of respondents expected engineers to play the major role in risk management, whereas 33 per cent placed that responsibility on the cost estimators, and 14 per cent placed it elsewhere.

Black’s survey results also give rise to additional elements. Firstly, they highlight the variability in understanding of and approaches to risk management and the lack of a consistent approach because existing methods and Information Management Systems (IMS) are unsatisfactory. Secondly Black's results confirm the view earlier that risk management is commonly considered to be a highly quantitative, sophisticated and physical systems oriented undertaking. This latter point gives rise to a series of related issues concerning current practices in project management, the common methods and tools used by project managers and the professional training and skills development of project managers.

The points to emerge concern the nature of risk and risk management. In this regard, the first point to emerge was the possibility of ambiguity arising from the lack of a single risk definition or risk standard. Table 1-3 not only reveals this variability but also that risks have specific contexts. A quick examination of Table 1-3 rapidly brings the reader to the (perhaps obvious) realisation that space risks may fundamentally differ from risks associated with medical devices, because different standards have been released for each by the International Standards Organisation. Closely allied is the additional point that future losses are likely to be multi-causal and that future projects are likely to to encompass future risks, for which there are no precedents.

1.6 An Overview of TRManager

Taking the first point to emerge in Section 1.5, TRManager represents a major step towards realising Deemer's concept of an ideal AEE. In Deemer's terms, TRManager
is an AEE which provides an integrated management framework, encompassing the tools and techniques used for project management, which allows effective management across the entire life cycle of a product or mission in a seamless manner.

In making such a statement two initial points need to be made. The first point concerns the fact that all projects will encompass future unknown risks. In this regard, TRManager is not a black-box panacea that will address or mitigate such unforeseen risks. The second point concerns the reality that the range of possible risks is vast, risks are context specific and TRManager provides a framework for effective management across the entire life cycle of a product. From a practical standpoint, it is impossible to consider all the possible sources of and responses to all types of risk. As such, the focus of the work presented in this thesis is more mundane and limited to considering the seamless integration of a model that includes life cycle costing and aspects of performance management and the standard tools and techniques used for project management. The reason for concentrating attention on one model is purely a practical consideration and based on the view that effective management and evaluation of projects can not be made if some costs remain hidden and effective management and evaluation depends on all of the costs across the entire life cycle being brought to account and a demonstration of how performance management would integrate as part of an analysis model.

Typically, project and system management activities are implemented using project management tools. The most commonly used project management tools, such as Microsoft Office Project, encapsulate three Management Science techniques developed or refined in the 1950s and 1960s namely: Gantt charts, Program Evaluation and Review Techniques (PERT), and, Critical Path Methods (CPM). All of these are essentially graphical techniques, with PERT and CPM being quantitative in nature. Life cycle costing and performance management techniques are quantitative in nature and not a typical feature of standard project management tools. TRManager achieves the seamless integration of these elements by exploiting the underlying commonalities which exist between the elements, the use of a single information or data element repository and data element re-use between techniques. In addition, TRManager is extensible and permits other activities, such as asset management, to be integrated into or used in conjunction with the project management activity.
Modern information management systems provide information collection, computational capability and information presentation capabilities. TRManager is no exception in this regard and provides such capabilities specifically tailored to a project management setting, allowing ready access to critical operational and performance management data by project teams and other stakeholders over the total project or system life-cycle. To achieve this, TRManager drew on the knowledge gained from a survey of Australian project managers’ performance management and presentational requirements. Figure 1-2 shows the relationship and interaction between the data elements or information, algorithms and TRManager's management activity information presentation capability. The data elements may be associated with parameters, for example in Figure 1-2 a parameter associated with resources indicates the resource type: material, work or cost.

![Figure 1-2 Interaction between information, algorithms and management activities](image)

Ultimately, any tool is only as good as the person who uses it and while good tools can aid good project management practice, they cannot replace it. In this regard the development of TRManager not only concentrated on achieving seamlessness at the technical level of the framework, but also considered the requirements for seamlessness at the user level. In relation to this, a key goal in the development of TRManager has been to achieve an environment that is familiar to, and easy to use by, practising project managers. As such, TRManager is capable of deployment in a number of forms, one of which is completely compatible with Microsoft Office Project. Furthermore, careful consideration has also been given to demystifying the
complexities of life cycle costing and raising skill levels of project managers and the work presented here provides empirical outcomes in this regard.

Finally, in keeping with the engineering connotations that were assigned to the term technical project management, engineering techniques were applied to create a solution that would permit the testing, analysis and refinement of the new TRManager framework. Similarly, engineering methods have been employed in testing the integration of TRManager with a widely used project management tool. By its very nature, TRManager spans a large number of areas and represents a primary aid for effective project management control, and with this in view attention now shifts to outlining the subsequent material.

1.7 An outline of subsequent material

The work concentrates on seamlessly integrating a hybrid model that includes life cycle costing and performance management with the standard tools and techniques used for project management and Chapter 2 reviews these areas. Following this, Chapter 3 examines indicators of current practice and needs of Australian project managers. This is presented as an analysis of a survey of project managers to capture their knowledge of performance management, their use of performance management and associated techniques within their organisation and their integrated performance management needs.

The core of the thesis is then presented as an overview of the TRManager framework in Chapter 4 and a detailed exposition of the TRManager framework in Chapter 5. This is supported by an examination of TRManager's performance using a CASA case study in Chapter 6, which is followed by a concluding chapter. Though the material is presented in the form of discrete chapters and focuses primarily on the integration of the hybrid model’s methods, it is important to keep in mind the much broader design principles that underpin the TRManager framework.

1.8 Published, submitted papers and grants

The research has been peer reviewed with refereed papers published in Project Management Institute – Australia (http://www.pmi.org.au/) conferences in 2004 (Gregory 2004) and 2005 (Gregory 2005). A peer reviewed accepted paper will be
presented at the upcoming 12th World Multi-Conference on Systematics, Cybernetics and Informatics (Gregory 2008a).

The research prototype and Intellectual Property development were supported by a competitive Australian Government AUSIndustry research and development grant (COMET 2004). A patent application, PCT/AU2005/000054 has been submitted in 2004 to protect the Intellectual Property developed during this research, Appendix A.

In addition, a paper has been submitted for review and publishing in the IEEE Transactions on Engineering Management (Gregory 2008b). Refereed papers published and submitted for publication are provided in Appendix G.

1.9 Summary

This chapter provided a brief overview of the research and development that has been undertaken into an AEE in keeping with Deemer’s vision and outlined key features of the TRManager framework. The area of application is the sphere of project risk management and to place a proper perspective on the importance of this work the importance of project management was considered both internationally and in Australia.

Project risk management is a complex issue to both design and explore. As such, this chapter examined in detail the meaning of the terms risk and technical risk management. In doing so, the chapter exposed the dual nature of risk and emphasized that the approach taken with TRManager is essentially quantitative.

At the heart of the thesis lies the seamless integration of tools and techniques used for project management, which allows effective management across the entire life cycle of a product. TRManager is an integrated framework which has been developed to achieve such seamless integration and an outline of key features of this framework was presented.

Having established the context in which the work is intended to be set and defined the limits to its scope, the chapter concluded by outlining the structure of the material which is presented in later chapters.
2 Background

2.1 Introduction

The research aim was to develop Deemer’s AEE by promoting performance management as a core function that should be integrated with other management activities. The goal was to show that by focusing on performance management and project management an outcome can be achieved that brings together many of the management activities. The research focused on project management because it is utilised by all organisations as a core function of the teams carrying out other management activities. An example may be where an organisation carries out asset management as a series of projects.

Examination of existing approaches revealed that models and techniques developed to support management activities were often linked or developed as hybrids, because of the key outcomes that organisations require from the models and techniques. Research revealed that the technique known as life cycle costing, usually carried out as part of the life cycle management activity, may be coupled with performance calculations in a hybrid model (CASA 2008) (ACEIT 2008) (EDCAS 2008). Moreover, life cycle management may be carried out as one or more projects, thus requiring teams to implement project management.

TRManager, the research outcome, facilitates integration of related management activities. To demonstrate TRManager the research focused on an implementation of TRManager integrated with project management. TRManager is a model framework that permits models and techniques to be incorporated into a common environment. For the purpose of demonstrating how this would be achieved a prototype TRManager implementation was created using a hybrid life cycle costing and performance management model called Cost Analysis Strategy Assessment (CASA 2008) (Gregory 2006).

One advantage of the model framework is that TRManager provides project managers with greater understanding of specialist activities carried out as part of major projects and is a tool that may be used to enhance training of project teams in the use of an AEE (Gregory 2004). A second advantage is that TRManager allows organisations to adopt new processes and training practices to ensure that project managers have...
greater knowledge and understanding of key specialist activities and what the impacts are on project outcomes (Gregory 2005).

**Figure 2-1 Literature review concentration**

As indicated, the work concentrates on seamlessly integrating a hybrid model that includes life cycle costing and performance management with the standard tools and techniques used for project management, as shown in Figure 2-1. As such the review of existing approaches focuses on three distinct but related management activities and the TRManager implementation created to demonstrate the research. The three management activities are (1) performance management, (2) project management and (3) life cycle management and each of these is now considered in further detail.

### 2.2 Performance management

The first management activity is performance management. This is a key management activity related to ensuring that outcomes are achieved in the manner assumed or described. Performance management may be applied to human resources or the pursuit of achieving *system* (products and services) outcomes described in technical documentation.

Here the concentration is on the performance management of *systems*. Achieving *system* performance requirements involves risk minimisation during the *system* life cycle and technical risk management is the risk minimisation activity that is associated with *system* performance management.
2.2.1 Risk management

A number of international definitions of risk and risk management were provided in Chapter 1, which show variance in the use and application of risk and risk management. In an Australian context, the Australian Risk Management Standard (ARMS) (2004) provides the following definitions:

‘risk: the chance of something happening that will have an impact on objectives’ and

‘risk management: the culture, processes and structures that are directed towards realizing potential opportunities whilst managing adverse effects’.

Moreover, ARMS designates the risk management process is shown in Figure 2-2, the main elements of which are:

“(a) Communicate and consult

Communicate and consult with internal and external stakeholders as appropriate at each stage of the risk management process and concerning the process as a whole.

(b) Establish the context

Establish the external, internal and risk management context in which the rest of the process will take place. Criteria against which risk will be evaluated should be established and the structure of the analysis defined.

(c) Identify risks

Identify where, when, why and how events could prevent, degrade, delay or enhance the achievement of the objectives.

(d) Analyse risks

Identify and evaluate existing controls. Determine consequences and likelihood and hence the level of risk. This analysis should consider the range of potential consequences and how these could occur.
(e) Evaluate risks

Compare estimated levels of risk against the pre-established criteria and consider the balance between potential benefits and adverse outcomes. The enables decisions to be made about the extent and nature of treatments required and about priorities.

(f) Treat risks

Develop and implement specific cost-effective strategies and action plans for increasing potential benefits and reducing potential costs.

(g) Monitor and review

It is necessary to monitor the effectiveness of all steps of the risk management process. This is important for continuous improvement.

Risks and the effectiveness of treatment measures need to be monitored to ensure changing circumstances do not alter priorities.”

Figure 2-2 Risk management process – overview (ARMS 2004)
The generic nature of this process is indicative of the fact that risk management is an activity that may be applied within all areas of an organization. More importantly, in the context of this work, risk management may be applied to projects and is an important tool that aids in the decision making process and management of specific risk areas.

2.2.2 Technical risk management

In a similar manner to the dual nature of risk, two related yet different perspectives come from the use of the terms ‘technology’ and ‘technical’ when applied to risk management. There is a useful need to distinguish between the two terms, for example when referring to a technology risk rating as described by Kinnaird (2003) or a technical risk assessment.

Technology is used to refer to the underlying principles involved, e.g. science, engineering and manufacturing. Technology is linked to research and development and the outcomes of the application of science and engineering by Roussel et al. (1991). Technology risk may then be defined as ‘the risk that an underpinning technology, necessary for a capability, will not mature with the required time frame’ (Moon 2005).

Technical risk (TR) may be defined as “the risk that a system will not reach its performance goals, development will not be within the specified timeframe and / or it will cost more than estimated due to technical developmental and maturity risks” (Moon 2005). Technical Risk Management (TRM) is the act of planning and executing systematic identification and assessment of technical risks, and implementing means to avoid or mitigate the effects of risks if they reach an unacceptable level.

An example of a complex system that involves both technology and technical risk is the Australian Army Command, Control and Communication System (ACCCS) (Gregory 1989a; Gregory 1989b; Gregory 1990). The ACCCS was to be the start of an evolving system that would grow and expand over time. At the time of the project’s first conception there were questions as to the underlying technologies maturity at the time and as to whether it would be possible to build the system envisaged. A system of technical risk management was implemented so that the
system could be developed over time to meet the original system specification and to integrate new capability as technology matured. The ACCCS design principle was for the whole system to remain in service and for subsystems to be replaced as new capabilities were developed; therefore there were technology, technical and project management risks to be considered for the ACCCS (Gregory 1991).

2.2.3 Technical risk assessment process

Moon et al. (2005) in their report on Technology Readiness and Technical Risk Assessment for the Australian Defence Organisation described the technical risk assessment process for defence projects shown in Figure 2-3. As part of a technical risk assessment Moon et al., identify five prime questions that should be asked at all decision points in a system life cycle:

“1. Is it fit for purpose?
2. Is it likely to work?
3. Will it work as expected or advertised?
4. Can it deliver as prescribed?
5. To what degree, and how, will the risks identified adversely affect, or be affected by, other projects planned or currently underway?”

The technical risk assessment process developed by Moon et al. (2005) aims to bring together the process of ‘shifting focus from technology readiness to the technical risk associated with systems, their integration with other systems and their implementation in Australian military operations’.
2.3 Project management

The second management activity is project management and this section reviews both project management and how project management processes are implemented, while also providing a discussion of project management fundamentals.

Project Management (PM) is a key activity carried out within organisations. By applying project management processes in accordance with accepted best practices the organisation promotes project success and reduces risk of project failure (Davis 1974a; Davis 1974b; Ibbs 1997). According to Clarke (1993) project management in the 21st century is a fundamental activity relying upon a new breed of project managers who must be a natural salesperson who can establish harmonious customer relations and develop trusting relationships with stakeholders.

Typically, project management processes are implemented within organisations using different approaches, policies and procedures. The differences between organisations exist because each organisation has developed independently and with key individuals possessing different qualifications and life experiences.
The project manager has a leading role in the project and, in the electronic era, utilise electronic devices and applications to assist in the project management activity. The implementation process is usually assisted by the use of software applications, which provide an environment where input data can be manipulated by rules and displayed within information presentation windows. Software applications may be multi-user, where the data is stored in a central database, and the applications are used to create reports for the project team and key stakeholders.

One common approach employed by project managers is a systems approach to management. The literature on the systems approaches to management utilised by effective project managers is extensive. Some of the better known references are Boulding (1956), Churchman (1979), van Gigch (1978) and Sir Stafford Beer (1985).

Figure 2-4 Overview of Project Management Knowledge Areas and Project Management Processes (reproduced from PMBOK Guide, Third Edition, 2004).

In addition, the Project Management Institute (PMI) has brought together knowledge of the project management process into one reference work, A guide to the project
management body of knowledge, which is also known as the PMBOK guide (2004). Examination of which rapidly reveals that project management is a comprehensive area of knowledge and that effective project management requires learning and experience.

Specifically, the PMBOK guide identifies five basic process groups and nine knowledge areas that are found in most projects. The five basic process groups are: (1) Initiating, (2) Planning, (3) Executing, (4) Controlling and (5) Closing. The nine knowledge areas include 44 project management processes which are shown in Figure 2-4. The processes overlap and interact throughout a project or project phase. The processes are described using: (A) inputs, (B) tools and techniques and (C) outputs.

According to the guide, a project manager is ‘the person assigned by the performing organisation to achieve the project objectives’ (PMBOK Guide 2004). How they achieve this depends on the project, the organisation they belong to and other considerations. In practice, project managers come from every possible background and many have no formal PM qualifications. PM knowledge is often learnt through experience and by being part of project teams.

In contrast to the scope of project management defined in the PMBOK guide (2004), Hawthorn et al. (1998) argue that the PM knowledge areas are inadequate to describe the totality of effective project management practice. In particular, they propose three additional knowledge areas of (1) Finance, (2) Computer Systems, and, (3) Ethics and Business Practices and state (1998 p16) that the reasons for including three additional knowledge areas are:

‘… with regards to finance, projects may be viewed as a microcosm of the broader business and cash flow and profit form two of the primary goals … Consequently, the project manager must have a thorough knowledge and understanding of the standard accounting and finance methods that will be applied to reporting and consolidating the project outcomes.

… computer systems … the reasons for incorporating this are purely practical … Because of the constraints imposed by existing systems, the project manager needs a thorough knowledge of how they can be used and how they relate to the current project, in order to run the project as a business.

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… ethics and business practices … projects are a reflection of the larger business. In practice this will mean that the project manager will have to negotiate with both suppliers and customers. Projects are not completed in isolation …’

The extensions of the PMBOK knowledge areas by Hawthorn et al. (1998) are important because they explicitly focus attention on (a) performance management, (b) the software tools commonly used by project managers and the associated training and (c) the open nature of many projects. These are issues that are directly addressed by this work and the TRManager model framework.

In relation to software, project management software applications are normally made available to assist project managers with creating project plans and implementing the PM processes. Major advantages of utilising a software application are that it becomes possible (a) to standardise the project plan through development of a suitable template and (b) to provide guidelines on how to create the project plan using the software application. Moreover, training on how to use suitable project management software applications may enable project managers to gain greater knowledge of and practice in implementing the project management processes described in the *PMBOK guide* (2004).

Project management processes implemented adequately should reduce the risk of project failure. Both collectively and individually, the project team is responsible for ensuring allotted tasks are carried out successfully and for reporting progress to the project manager. The project team feedback is then used by the project manager to shape the project management plan.

However, while the successful implementation of project management processes may ensure that the project is completed on time and on budget, it will not guarantee that the project outcome is operationally viable. The product concept or design may be successful, but the engineering and science applied to the project may result in a product that, while functionally adequate, does not meet reliability requirements. This is one of the principle ideas and reasons for pursuing the TRManager research in keeping with Deemer’s vision for a modern AEE.
There are many activities and events which occur during a project that may negatively impact on the operational outcome. A project manager is only able to judge the progress of the project objectively, based upon the information collection and analysis and subjectively, through a “gut feeling” based upon experience. Typically, project managers rely on specialists to complete key project activities and as the size of a project grows so too does the number of these specialists and activities. More importantly, there is a growth in possible instances and events, which may negatively impact upon project outcomes.

This poses special challenges for project managers, because the role requires the management of specialists, who by their very nature possess expertise that the project manager normally would not possess. To complicate such issues, members of project teams and even the project managers themselves possess unique qualities and characteristics, and may be drawn from any background. To address many of the challenges that arise, project managers frequently utilise a range of standard software applications and tools to assist with the tasks of project planning and scheduling, and non-standard software applications to address specialist requirements. However, such responses generate technical challenges of their own for the project manager, such as, difficulties in keeping all software applications up to date and reconciling outputs from different packages, when a multitude of software applications and tools are used.

Several points emerge from this. The first is that for effective project management, project managers must endeavour to gain an understanding of all key project activities including specialist activities. It is only when project managers are armed with the appropriate knowledge and tools that they will be able to properly judge progress and whether the outputs from the activity will meet the project requirements.

The second point is that project managers typically implement project management processes to minimise the risks associated with activities and events that may negatively impact on the project’s outcomes. This involves a process of gathering and analysing information from various sources. Clearly, effective project management can only occur and risks can only be minimized by using systems that permit timely and pertinent knowledge of the project system state and technical risk factors.
TRManager reduces the technical challenge facing project managers by integrating specialist activities into standard PM software applications. By enabling specialist activities to be project managed utilising one software application, and, by simplifying the terminology and presentation of the specialist activity information, the project manager is able to gain a better assessment of project progress and reduce project technical risk.

2.3.1 Project defined

The Project Management Institute (PMI) (USA) was established in 1969 and now has over 90,000 members worldwide. The PMI has an objective to codify the areas of learning required for competent and effective project management. The result of this work is *A guide to the project management body of knowledge (PMBOK guide 2004)* which is meant to be used as the fundamental basis for education of project managers.

The PMI defines a project as:

‘A temporary endeavour undertaken to create a unique product or service’ (*PMBOK guide 2004*, p. 167).

A general definition of a project is that a ‘project is a specific, finite task to be accomplished’ (Meredith 2003).

2.3.2 Project management defined

The *PMBOK guide* (2004) describes project management as

‘the application of knowledge, skills, tools, and techniques to project activities to meet project requirements. Project management is accomplished through the application and integration of the project management processes of initiating, planning, executing, monitoring and controlling and closing. The project manager is the person responsible for accomplishing the project objectives.’

This definition is extended to encompass the life-cycle aspects of projects by Colleen Garton (2004), who describes project management by considering the role of the project manager specifically:
‘The most important role of a project manager is to manage the project through all six stages of the project Life Cycle. This will include ensuring that the project stays within budget and is delivered on time and with high quality.’

2.3.3 Project Life Cycle

The *PMBOK guide* (2004) describes the project life cycle ‘as phases that connect the beginning of a project to its end.’ The *PMBOK guide* does not provide a definitive project life cycle but states ‘there is no single best way to define an ideal project life cycle’. In contrast a general project life cycle presented by Colleen Garton (2004) which includes the phases of (1) Planning, (2) Design, (3) Development (4) Integration, (5) Deployment and (6) Post-Deployment.

A project manager may adopt a project life cycle for the project. The primary advantage of adopting such a project life cycle is that it provides guidance to the key stakeholders and project team as to how the project manager will break the project into phases and where milestones and reviews will be positioned in the project timeline.

Projects may be categorised as either major or minor or when using three levels as major, medium and small. Project categories may be based on cost, duration or effort and typically project managers will apply project management processes and allocate resources based on the project category and available funds.

The principle of applying project management processes as a means of risk reduction is diminished when the project is not large enough to justify the cost associated with implementing all or many of the project management processes. The project manager uses experience or guidance from the key stakeholders to decide on which PM processes will be implemented and the effort attributed to each. A misjudgement as to the importance of a project management process and therefore a particular task may significantly increase risks. Project managers take on a significant responsibility when deciding what project management processes are to be applied and which are not.

Many activities carried out during a project provide information as one of the outputs. If the information can be collected and organised then the project manager gains a powerful advantage in the effort to reduce risk. Typically, software applications are used to collate and manage such information and the project manager gains a
productivity benefit if the software applications used to support the project management activities, (a) have a wide range of features, (b) are easy to use, (c) permit team members to input and update information, (d) permit team members to view the current project plan, (e) rapidly reflect project plan changes and (f) permit stakeholders to monitor the state of project completion against plan.

2.3.4 Project objectives and outcomes

The *PMBOK*® Guide (2004) describes managing a project as having four key aspects, namely: (a) identifying requirements, (b) establishing clear and achievable objectives, (c) balancing the competing demands for quality, scope, time and cost, and, (d) adapting the specifications, plans, and approach to the different concerns and expectations of the various stakeholders. More recently a fifth project objective has received more prominence and may be considered a fundamental objective – customer satisfaction (Darnell 1997).

Project outcomes can be measured in numerous ways and there may not be a single method for determining project outcomes that will fit all projects. Project success may be considered from four different angles: project efficiency, impact on the customer, the business impact on the organisation and opening new opportunities for the future (Shenhar 1997).

2.3.5 Project scheduling

Common approaches to project scheduling are to use Gantt charts, the Program Evaluation and Review (PERT) technique and the Critical Path Method (CPM). PERT was developed by the U.S. Navy in cooperation with Booz-Allen Hamilton and the Lockheed Corporation for the Polaris submarine project in 1958. CPM was developed by DuPont, Inc., at about the same time. The Gantt chart was developed around 1917 by Henry L. Gantt, a pioneer in the field of management studies and further developed in the 1950s and 1960s.

PERT was primarily developed for R&D projects and it is commonly used during development rather than the research. CPM was designed for construction projects and has been utilised in many areas where just-in-time construction and manufacturing are employed. PERT and CPM both share a common underlying
framework and many software applications now display the results of both techniques using a single combined view.

Research by Davis (1974) showed that there was no significant difference in the technological performance of projects where PERT/CPM was used. However, Davis’s research did find that there was a much lower probability of cost and schedule overruns when PERT/CPM was used. Literature on both techniques is extensive, with some of the better known references being those of Dean (1985); Moder, Phillips and Davis (1983); Naik (1984); and Weist and Levy (1977).

The Gantt chart is used in many software applications because it provides a user friendly way to view a project and the interlinking of tasks. The Gantt chart shows planned and actual progress for tasks displayed against a horizontal time scale. More importantly, in terms of the work here, the Gantt chart is used in Microsoft Office® Project™ (MOP) as the principal view for users to see project information.

Features such as the PERT/CPM and Gantt charts have become a standard in most PM environments and project managers learn how to use these features at an early stage in their careers, most often during initial project management training.

### 2.3.6 Project scheduling inputs

Typically, project management software applications provide the project manager with five features, namely: (a) single or multi-user project plans, (b) Gantt chart, calendars and task sheets, (c) PERT chart, network diagram view, (d) Cross-Project Critical Path Method and (e) resource identification, cost and availability graphs.

In addition, the data for a generic project management environment software application, such as Microsoft Office® Project, includes four types of data inputs, namely: (1) time, (2) cost, (3) tasks and (4) resources. From the four data inputs a project management environment can provide a project manager with features that permit a project plan to be developed.

### 2.4 Life Cycle Management

The third management activity is life cycle management and as with other terms, life cycle management is neither formally defined nor standardised. However, the business cost associated with the product or service life cycle is termed life cycle
costing and life cycle costing has been standardised by many international organisations and countries. As such, the discussion which follows concentrates on life cycle costing and the implementation of life cycle costing models.

Life cycle management has developed into a business approach for managing systems (products and services) over their life cycle. Life cycle management provides a business framework that is used to analyse and implement a system life cycle, identify potential opportunities and risks at different stages of the life cycle and to establish a management system.

Life cycle management may be applied by an organisation to a system. The United Nations Environment Programme (UNEP 2008) is currently developing life cycle management guidelines for use to enhance understanding of sustainability and environmental considerations during a system life cycle.

The United States Patent and Trademark Office (USPTO 2001) describes life cycle management in terms of its primary objective, which applied to automated information systems it describes as:

“the primary objective of life cycle management is to deliver quality systems when promised and within cost estimates using an identifiable, measurable, and repeatable process”.

Business is concerned with the total cost of ownership over the life time of a product or service. The method used to calculate the the whole of life total cost of ownership is called life cycle costing. Life cycle costing (LCC) is often carried out to provide an organisation with key indicators that are used during the life cycle management activity. In this regard, this view of life cycle costing echoes the much broader business perspective advanced earlier by Hawthorn et al. (1998).

2.4.1 Life Cycle Costing

Life Cycle Costing (LCC) was originally developed in the early 1960s by the US Department of Defence to increase the effectiveness of government procurement (Shields and Young 1991; Epstein 1996) and over the following decades LCC was further developed by other researchers (Artto 1994; Booth 1994; Bennett and James 1998). LCC analysis was extended to include whole of life costs associated with the
design, manufacture and use of the system being studied. Today LCC is a requirement for medium and large procurements by US government organisations (Federal Acquisition Regulation 2001) and has been adopted by many other countries, including Australia.

LCC and Whole of Life Costing (WLC) are being applied today in many projects to various degrees. A review of the literature shows that calls are being made for LCC to become a more important activity carried out by project teams to enhance the opportunity for project technical and financial success.

Three fundamental requirements to successfully implement a LCC methodology were identified by Flanagan and Norman (1983) as:

‘A system by which the technologies can be used: a set of rules and procedures

Data for the proposed project under consideration: estimates of initial and running costs of elemental life-cycles, discount rates, inflation indices, periods of occupancy, energy consumption, cleaning and the like’.

In addition, Bennett & Ferry (1987) identify five possible sources that the data required to carry out WLCC analysis can be derived from, namely: (1) Direct estimation from known costs and components, (2) Historical data from typical applications, (3) Models based on expected performance, average, etc. (4) Best guesses of the future trends in technology, market application and (5) Professional skill and judgment.

LCC has been adopted by many nations’ defence departments for many years (Federal Acquisition Regulation 2001; United Kingdom, Ministry of Defence 1974; Purchasing Australia 1996) and is in principle a major requirement to be implemented as part of project management processes.

In the case of large military projects, responsibility for a system often moves between Defence and the specific branch (Army/Navy/Airforce) organisations during the system’s life time. The implication of this is that the active project manager may change as responsibility shifts, with the project management plan being managed by
the active project manager. Typically, other organisations involved in the project would have a representative nominated to be a part of the project team and this person may also maintain a project management plan concentrating on their organisation’s involvement in the project.

In 1998 the Australian National Audit Office (ANAO) (1998) audit on the use of LCC in the Department of Defence concluded that:

‘1. LCC is a technique widely recognised in other nations’ defence forces, and in some commercial organisations, as a valuable aid to making more-informed decisions on the management of assets. Based on such experiences, Defence should promote extended use of LCC to ensure major financial decisions are cost-effective.

2. There are many cases where Defence uses LCC to support decisions, mostly in relation to tender selection. However, LCC is not generally used at other stages in the acquisition life cycle, such as the early concept development stages, and the in-service and disposal stages. Defence policy has been set for LCC for some time, but there appears to be little top-level enforcement or encouragement at present for the use of LCC throughout the acquisition life-cycle. There are also few incentives for middle managers to adopt life-cycle costing principles by making investments now to save operating costs later. At the present time, there are some limitations to the conduct of LCC due to the lack of available data. However, these difficulties can be addressed by concerted efforts to extract suitable information from available data bases and ensuring that any redevelopment of data bases addresses the need for specific data to support LCC.’

The ANAO report highlights that whilst LCC is a requirement to be implemented within Defence, LCC is in fact only being utilised during the tender phase and this reflects the author’s experience whilst working on major projects for the Army during 1988-1992.

The UK Department of the Environment, Transport and the Regions (DETR) commissioned a report in 1998 (Clift & Bourke 1998) on the use of Whole Life-cycle
Costing (WLCC) in the construction industry. The report identified several factors that were a barrier to applying WLCC in the construction industry:

‘The lack of universal methods and standard formats for calculating whole life costs

The difficulty in integration of operating and maintenance strategies at the design phase

The scale of the data collection exercise, data inconsistency

The requirement for an independently maintained database on performance and cost of the building components’

In an analysis of the report Boussabaine and Kirkham (2004) argued

‘that the barriers might be directly related to the absence of adequate knowledge of WLCC processes and mechanisms

there may also be a lack of willingness from stakeholders to set up appropriate mechanisms to solve these problems’

Bird (1987) argued that annual running costs profiles should be submitted annually by building occupiers and thereby providing historical data that could be used to reduce LCC risk. This argument was supported by White (1991) who indicated the case for ‘performance profiles’ and the requirements for a universal construction data information system.

Both the ANAO and DETR reports highlight the need for information collection and utilisation within a common framework that will support development of better LCC models. The work by Newton (1991) on cost modelling procedures found there was a need for a ‘methodical and organised framework for such research activities’. Boussabaine and Kirkham (2004) argued that the sheer complexity of many models lends to little practical application and the lack of available good quality data for further development of the model.

The DETR report on the UK construction industry highlights similarities with the ANAO report on the Australian Defence Department. To achieve a suitable outcome
there needs to be a willingness by the participants and mechanisms put in place to achieve a satisfactory use of LCC.


‘The Commonwealth Procurement Guidelines state that the core principle governing Commonwealth procurement is value for money, a concept evaluated on a whole of life basis of the goods or services being procured. Officials buying goods and services need to be satisfied that the best possible outcome has been achieved taking into account all relevant costs and benefits over the whole of the procurement cycle.

The Commonwealth Policy Principles for the Use of Private Financing establish policy principles and processes for the use of private financing by Commonwealth agencies. They state that, in assessing a private financing proposal, value for money is to be assessed by means of a business case that analyses the proposal on a whole-of-government basis and takes into account whole-of-life costing.’

The ANAO guide provides Australian Public Servants with guidance on the use of LCC so that they can:

‘[I]dentify issues to consider when making decisions relating to the acquisition, operation and maintenance and disposal of major assets;

Understand the range of information available to assist them in making decisions; and

Use LCC analysis to improve decision-making.’

In May 2004 the South Australian Parliament Public Works Committee (PWC) recommended to the South Australian Government:
1. Life-cycle costing be applied to all public capital works’ (South Australia, Parliament, Public Works Committee 2004).

The South Australian PWC recommendation is an example of the shift in thinking towards the adoption of LCC as a mandatory requirement in public capital works programs and this attitude reflects growing identification of LCC as an important tool to ensure project technical and economic success.

The UK DETR report (Clift & Bourke 1998) on the use of WLCC in the UK construction industry highlights similar impediments to the application of WLCC to that found by ANAO and the South Australian PWC. There is a trend of reasoning and argument in the literature that there needs to be a means to collect information that can be used to assist in the development of better LCC models, a common framework whereby LCC models can be applied and a means to store the information needed to carry out LCCA.

In the construction industry research by Flanagan et al. (1987) identified two key factors for the reduction in the impact of LCC:

‘A suspicion that life-cycle cost estimates are in some sense inaccurate or based merely on guesswork

The absence of sufficient and appropriate cost and performance data’

Karl Voigt (2004) provides an important insight into the need for LCC today when he wrote:

‘The decisions we make today are the decisions our successors must shoulder and live with tomorrow. We combat this by trying to impose a “systems” and/or “life cycle” view and attempt to exercise informed disciplines of managing the “life cycle” of a system.’

LCC is a process used to determine the sum of all costs associated with a product or service over the life-time of the product or service and may be considered a technical and economic assessment process (Blanchard 1998; Eisner 2002; Emblemsvag 2003; Shields 1991). Finding that a search of the global online bookstores produced only
about a dozen books concerning LCC, prompted Jan Emblemsvag (2003) to comment:

‘How can it be that one of the few concepts that systematically tries to eliminate costs before they are incurred gets so little attention, while an enormous body of work concerns how to assess and cut costs after the costs are incurred? After all, what counts the most: being cost effective or knowing what prevented us from being cost effective in the past?’

Decision making based on LCC may involve a combination of quantitative and qualitative assessments. The quantitative assessment provides a reference for decision making in terms that are measurable. However, value judgements based on experience and other factors provide valuable input to the decision making process. LCC has most value when applied early in the project life cycle and maintained throughout the product or service life. However, LCC has not attracted the attention that it should and Emblemsvag offers a number of reasons for this:

‘I believe that one of the prime reasons for this lack of interest in LCC is that it has mainly been associated with engineering: life cycle costs are the costs of some technical ‘stuff’ sometime in the future that the engineers worry about. But who cares about a distant future when most decision-makers are either in a new position, retired, or even fired? In fact, according to The Economist, an average American CEO only has a position for 18 months before he or she is removed. Or equally common, who cares about the impact on other people’s budgets? Apparently, LCC concerns many issues that stretch beyond most organisational short-term needs, functional boundaries, and present issues.’

Project managers in the 21st century should embrace LCC as a tool to be used to assist with improving project outcomes through risk reduction over the product or service life. LCC is used to control costs before they occur, especially during the design and development phase. The US Institute for Defense Analyses (IDA) estimated that 70 percent of the costs incurred during a weapon systems lifetime are determined during the design and development phase (Winner 1988). LCC is important because the need to predict the life time costs is significant when it is considered that the costs of sustaining equipment is frequently 2 to 20 times the acquisition costs (Barringer
1996). Competition has forced organisations to consider LCC as a method of assisting project managers to achieve cost targets and minimise risk. It has been said that ‘LCC is an accounting methodology that became very popular in the 1980s, when increasing competitive pressure on most markets forced firms to improve their capability to control and reduce manufacturing costs’ (Maccarrone 1998).

The picture that emerges of LCC is that while necessity has caused LCC to become widely recognised as an important aspect of project management, experience in and the application and use of LCC could at best be described as mixed, with serious difficulties being experienced in the area of data collection. Moreover, repeating Emblemsvag’s words, LCC is viewed as “some technical ‘stuff’ sometime in the future that the engineers worry about”.

Several observations need to be made at this point. The first is that the the picture that emerges of LCC reflects and reinforces the earlier view of risk management that the topic is generally considered to be “a highly quantitative, sophisticated, physical systems oriented undertaking”. The second is to note that TRManager represents a significant contribution, not only because it provides a framework for the collection and manipulation of LCC information but also because it directly addresses the issue of demystifying the entire process for project managers who might otherwise be deterred by the prevailing view of risk management and LCC.

2.4.2 Life Cycle Costing defined

The Australian Standard, AS/NZS 4536:1999 Life cycle costing – an application guide (Standards Australia and Standards New Zealand 1999), defines Life Cycle Cost as:

‘the sum of Acquisition cost and Ownership cost of a product over its life cycle’.

and defines Life Cycle Costing as:

‘the process of assessing the cost of a product over its life cycle or portion thereof’.

Though the definitions provided by AS/NZS 4536:1999 provide concise statements which can be adapted to different systems, products and circumstances, the definitions
are limited because they consider only a product rather than systems, products and services.

Other definitions are:

(1) ‘The sum total of the direct, indirect, recurring, nonrecurring and other related costs incurred, or estimated to be incurred, in the design, development, production, operation, maintenance and support of a major system over its anticipated useful life span’ (OMB Circular No. A-109 1976).

(2) ‘The amortized annual cost of a product, including capital costs, installation costs, operating costs, maintenance costs, and disposal costs discounted over the lifetime of a product’ (Executive Order 12873 1993).

(3) ‘The total cost throughout its (an asset’s) life, including planning, design, acquisition and support costs, and any other costs directly attributable to owning or using the asset’ (New South Wales, Government Asset Management Committee 2001).

(4) ‘A technique which enables comparative cost assessments to be made over a specified period of time, taking into account all relevant economic factors both in terms of initial capital costs and future operational costs’ (ISO 156868 Part 1 – Service Life Planning which cites LCC – ISO 2000)

These definitions expand those of provided by AS/NZS 4536:1999 by including aspects of the systems life that may be included in LCC, though even these aspects may vary depending on the system, product or service being studied. Of these other definitions (1) and (2) describe LCC as for a product and may be from the product vendor’s perspective. In contrast, definitions (3) and (4) describe the application of LCC to assets from the perspective of the asset’s owner. The use of LCC when considering assets provides an example of the dual nature of LCC and how LCC may be adapted to different circumstances.

2.4.3 Life Cycle Costing objectives

AS/NZS 4536:1999 (Standards Australia and Standards New Zealand 1999) lists the objectives of LCC as:
1. ‘Calculate a dollar value representing the LCC of a product as an input to a decision making or evaluation process, together with other inputs. The cost is based on a defined need associated with the product.

2. Support management considerations affecting decisions during any life-cycle phase.

3. Identify the attributes of the product or service which significantly influence the LCC (cost drivers) of the product so that they can be properly managed.’

Figure 2-5 Use of Life Cycle Costing (reproduced from AS/NZS 4536:1999).

As shown in Figure 2-5, LCC has a central role in providing intelligent decision support to project managers, when used to facilitate forward planning that overcomes many of the shortcomings of traditional cost accounting methods. Figure 2-5 also illustrates the inputs and decision making process when LCC is being used. In addition, this representation shows the concept of using LCC to identify when funds and other inputs may be needed during the product or service life-time. The evaluation process may be carried out using a developed LCC model or may be a
custom model that has been developed for the particular system, product or service being studied.

2.4.4 Life Cycle Costing benefits

LCC provides a number of benefits and a mechanism for project managers to better understand and assess technical performance and whole of life costs. The information obtained is not only of value to all project team members but also to key stakeholders, such as the project proponents.

Blanchard and Fabrycky (1998) identify five major benefits of LCC as:

1. ‘Forces long-range planning versus the more traditional short-term thinking and decision-making processes. As a result, decisions can be based on more complete information with less risk involved.

2. Forces total cost visibility and the identification of the high-cost system elements, equipment, processes and so on. This aids in pinpointing the specific functional areas where resource consumption is high and modifications for improvements are desired.

3. Enables a better understanding of the interrelationships between different system elements and categories of cost. The interaction effects become more visible through a life-cycle cost sensitivity analysis.

4. Aids in early identification of potential high-risk areas, the quantification of such, and in the subsequent elimination of the possible causes of risk.

5. Allows for better overall resource management because of the long-term visibility that is provided.’

Blanchard and Fabrycky (1998) also state that the value of LCCA is in its application and availability to the project manager:

‘The results of such an analysis must be to the proper depth, must be timely, and must be responsive to the designer/manager involved in the decision-making process.’
In this, Blanchard and Fabrycky mirror the stated aim of TRManager to provide a framework for project managers that permits project management and life cycle management to be integrated so that information is available in a consistent and timely manner.

2.4.5 Life Cycle Costing Analysis calculations

LCCA includes the development of processes and models that are applicable to the system under study. An example is the US Defence Department Cost Analysis Strategy Assessment model (CASA 2008). CASA was developed by the US Department of Defense in the early 1980s and provides a hybrid life cycle costing and technical risk model that is suitable for many different types of Defence systems and in particular Defence materiel systems.

Hybrid models may be developed to assist with specialised system analysis or as a model that may be applied to a range of different systems. One aspect of hybrid models is the use of simulations to assist with the derivation of probabilistic outcomes, including reliability of equipment, system failure rates, availability of items such as personnel (who may become unavailable due to illness, etc.), test equipment, support items, and so on. CASA is a common hybrid model that is used in the CASA software application simulations (CASA 2008).

Typically, Monte Carlo simulations are used to model complex probabilistic systems. A Monte Carlo simulation randomly generates values for uncertain variables repeatedly and each outcome is used to simulate a model solution which may then be analysed. To help identify uncertainty and risk Monte Carlo simulations may be used (Evans 1998; Law 1990; Meredith 2002). Monte Carlo simulations are ‘the perfect tool of numerical theories and applications’ (Kaufmann 1983).

2.5 Summary

This chapter reviewed project management, how project management processes are implemented and provided a discussion of project management fundamentals. In particular, it focused on three distinct but related management activities, namely, performance management, project management and life cycle management. What emerged was a fractured picture of project management, a large number of important
issues and a number of recurring themes, the most important of which may be summarised by the following observations:

1. Common practice does not consider the three related management activities in an integrated manner.
2. Proper assessment and management of projects requires the adoption of a broad business view which considers the total cost of a project over its life span.
3. Many governments accept and mandate a ‘systems’ life cycle approach to major projects, but Life Cycle Costing (LCC) and Whole Life Cycle Costing (WLCC) are being applied in a piecemeal fashion.
4. The lack of an integrated project management framework or AEE is a major barrier to adopting a ‘systems’ life cycle approach.
5. Many project managers are deterred by issues such as LCC, which is seen as a highly quantitative, sophisticated, physical systems oriented undertaking of specialist engineers.
6. Effective project management can only occur and risks can only be minimized by using systems that permit timely and pertinent knowledge of the project system state and technical risk factors.

While these observations present a bleak outlook for the state of project management, this picture must be considered in the light of TRManager as a framework which permits models and techniques to be incorporated with the standard tools and techniques used for project management. Whether the view presented is overly pessimistic is debatable and so attention now shifts to examining indicators of the current practices and needs of Australian project managers.
3 Survey of Australian project managers

3.1 Introduction

As indicated, reviews of the state of project management reveal a lack of an integrated framework for implementing performance, project and life cycle management. However, reviews do not always fully reflect the realities confronting practitioners on the ground and so a voluntary survey was conducted to examine indicators of the current practices and needs of Australian project managers.

The voluntary survey took the form of a self-administered survey, administered to project managers over the internet or during the PMOz 2005 project management conference (2005). The advantages and disadvantages of adopting self-administered surveys were explored by Robson (2002, p. 233). Of the pros and cons, two advantages made the use of a self-administered survey particular attractive in the context of the current work, namely, (1) ‘They can be extremely efficient at providing large amounts of data, at relatively low cost, in a short period of time’, and, (2) ‘They allow anonymity, which can encourage frankness when sensitive areas are involved.’.

Of the two advantages cited, the second is of particular importance because the survey inevitably intruded into areas related to the competence of project managers. If the survey and results generated from it were to have any validity then honest responses were required. In this the chief prerequisites for success are the same as those outline for successful risk management by Brauner (2004) who noted:

‘The chief prerequisite for successful risk management is readiness to address questions, even if some are highly unsettling.’

At a broader level, the survey was tightly focused with the aim of becoming generally aware of the use and value of project management tools by project managers, their knowledge of specialist activities and the implementation of specialist activities within their organisation. Notwithstanding this, the survey was also intended to examine whether the issues raised in chapter two, such as the findings of the ANAO (1998) audit of the use of LCC in Defence, realistically reflect the situation confronting the broader community of project managers.
As such, the balance of this chapter documents aspects of and results derived from the survey. It begins with a section that discusses the background and approach which underpins the survey. This is followed by two sections that document ethics approval and the scope of the questions that were used. The results are then presented and this is followed by their analysis. The chapter then concludes with a brief summary.

### 3.2 Survey background and methodology

A conventional approach to organising and conducting a survey was used. An overview of the survey research methodology is shown in Figure 3-1.

![Figure 3-1: Overview of the survey research method](image)

The survey instrument was created after researching the conduct of self-administered surveys and processes identified by Bourque and Fielder (2003). The methodology employed exploratory applied research as defined by Neuman (2003) and a grounded theory approach similar to that utilised by James (2003). Grounded theory as described by James (2003) is:

‘A qualitative research analysis technique whereby theory is generated from the collected data (Punch 1998; Taylor and Bogdan 1998; Charmaz 2000; Ryan and Bernard 2000; Locke 2001). Inductive processes are used to collect and analyse the data (Punch 1998; Charmaz 2000), and theories, concepts, hypotheses and propositions are developed from the collected data and not from prior theories, assumptions or other research (Glaser and Strauss 1978; Taylor and Bogdan 1998; Locke 2001).’
Taylor and Bogden (1998) provided an overview of the grounded theory approach, which is reproduced here as Figure 3-2.

As illustrated, in Figure 3-2, a key feature of a grounded theory based qualitative survey is its iterative open ended nature. The process is iterative in that the initial data collection is followed by a data analysis to identify themes, which may be followed by the augmentation of the dataset through subsequent data collections. Put simply, the approach taken is one of progressive refinement, with the refinement being guided by the findings at each stage. This approach is particularly useful when initial exploratory research is being conducted, such as that being undertaken here into the situation facing the Australian project managers.

A grounded theory based qualitative survey research approach was selected to assist with background understanding by considering what was needed as the outcome from the preliminary research. A general understanding of the current situation was required and this could be obtained by using an approach that permitted predictive rather than explanatory analysis (Yin 2003a; 2003b).

Robson (2002, p. 233) provides a review on the advantages and disadvantages of questionnaire-based surveys. Two of the listed advantages for self-administered surveys were directly applicable to the research survey: ‘They can be extremely efficient at providing large amounts of data, at relatively low cost, in a short period of
As indicated, the intention was also to examine issues such as the findings of the ANAO (1998) audit of the use of LCC in Defence and to achieve this the survey included questions about two specialist activities, LCC and Activity Based Costing (ABC). There were two basic reasons for doing this. The first is that the inclusion of two specialist activities in the survey provides an opportunity to compare and contrast the responses about two different ‘specialist’ techniques. The second reason is that, though TRManager is considered in this thesis in the context of integrating LCC, TRManager is an AEE framework which permits not only LCC but also an entire range of models and techniques, to be incorporated with the standard tools and techniques used for project management.

The approach used was to prepare questions related to the use of project management tools and two specialist activities. The survey included questions about two specialist activities, LCC and Activity Based Costing (ABC). By having two specialist activities in the survey the opportunity to contrast responses would be possible.

Activity-based costing (ABC) was chosen as the second specialist activity because of its direct relationship and relevance to the three management activities of performance management, project management and life cycle management canvassed in chapter two. It is an accounting method identified by Cooper (1988a; 1988b; 1989; 1990b; 1990c; 1993), Cooper and Kaplan (1987; 1988), and Cooper et al (1992a; 1992b) in the 1980s and early 1990s, initially at the Harvard Business School, that allows businesses to identify operating costs. Costs are assigned to specific activities, such as planning, R&D, implementation or in-service support, and then the activities are associated with different products or services. The ABC method enables a business to analyse activities and identify where profit or loss is occurring.

Activity-based costing techniques have been promoted widely by some of the business mass media, consultants and business schools as a means of enhancing organisational efficiency, and addressing the limitations and pitfalls of traditional management accounting (Johnson 1992a; Johnson 1992b; Jones & Dugdale 2002).
3.3 Survey ethics approval

All surveys must be conducted with special care, particularly surveys that involve the disclosure of sensitive personal and commercial information, such as the current survey. In this regard, particular attention was paid to gaining the informed consent of survey participants and ensuring anonymity, so that no person or organization could be individually identified.

The survey instrument and methodology were submitted to the RMIT University Ethics Committee for approval during 2005. Approval was provided for the survey to be carried out and for the survey responses to be presented in this thesis provided responses were collated and respondent’s privacy was assured.

3.4 Scope of the survey questions


The survey was designed to gather information in six areas, namely, (1) Corporate Information, (2) General Project Management Information, (3) Personal Information, (4) Project Management Tools, (5) Life Cycle Costing (LCC) and (6) Activity Based Costing (ABC). The eight questions were designed to establish the project managers’ backgrounds, education levels, corporate knowledge and perception of their organisations spending on project management activities. The questions were a mix of yes/no answers, questions where the response required an estimate figure or open text. The survey instrument is provided in Appendix C.

3.5 Survey responses

The survey was administered to a group of active project managers during a PMOz 2005 conference session. Forty surveys were issued and 22 were returned completed, giving a response rate of 55%. The responses are listed here tabulated by the specific instrument question they correspond to.
Question 1.1  What industry sector(s) does this company operate in? Give a percentage ranking if more than one.

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Question 1.2  How would this company’s business structure be categorized?

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<tr>
<td>1.2.5</td>
<td>Joint venture (please specify whom)</td>
<td>1 Military</td>
</tr>
<tr>
<td>1.2.6</td>
<td>Other (please name)</td>
<td>1</td>
</tr>
</tbody>
</table>

Question 1.3  Is the company a subsidiary of an overseas company?

The responses indicated that all of the survey participants worked for Australian companies.

Question 1.4  What is the approximate turnover of the company?

The majority response was to indicate the survey participant was unsure of their organisation’s turnover. One response was a medium turnover and eight responses indicated their organisation’s turnover was large.

Question 1.5  How many people does the company employ in Australia?

The survey participants were from small to large organisations, with seven responses to indicating an organisation with less than 200 employees in Australia, six responses
indicating greater than 200 and less than 2000 employees in Australia and five responses indicating greater than 2000 employees in Australia.

**Question 1.6 Where does the company operate its non-office base processes? (Specify locations)**

The organisations non-office base processes are distributed, with five responses indicating the non-office base processes location as unknown, three indicating client premises and three as capital city. One response identified non-office base processes as regional, four as national and two as global.

**Question 2.1 Is there a written company project management guideline?**

<table>
<thead>
<tr>
<th>Item</th>
<th>Question</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.1.1</td>
<td>Does it include a mission statement?</td>
<td>8</td>
</tr>
<tr>
<td>2.1.2</td>
<td>Does it include objectives?</td>
<td>8</td>
</tr>
<tr>
<td>2.1.3</td>
<td>Does it include social, environmental or sustainable objectives?</td>
<td>4</td>
</tr>
<tr>
<td>2.1.4</td>
<td>Does it reference standards?</td>
<td>5</td>
</tr>
<tr>
<td>2.1.4.1</td>
<td>If so which ones?</td>
<td>StdS, PMI PM Stds</td>
</tr>
</tbody>
</table>

**Question 2.2 Who do project managers report to?**

<table>
<thead>
<tr>
<th>Item</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>CEO</td>
<td>3</td>
</tr>
<tr>
<td>CTO</td>
<td>1</td>
</tr>
<tr>
<td>CFO</td>
<td>0</td>
</tr>
<tr>
<td>CIO</td>
<td>1</td>
</tr>
</tbody>
</table>

  Director of Business Unit, PMO, Director, Business Manager, Consulting Manager,

| Other | 15 General Manager |

**Question 2.3 What project management methodology does your company use?**

The organisations use a range of project management methodologies. Four of the organisations use all of the methodologies and four use in house developed methodologies. The methodologies identified were Prince2 (three responses), PMI IT Management Methodology (two responses), Defence Procurement Management Methodology (three responses), and PMBOK (two responses).
**Question 3.1** *What is your highest tertiary qualification?*

The project managers surveyed have different educational backgrounds. One of the project managers did not have any qualification and three achieved a TAFE qualification. Six have achieved a Bachelors degree with a further eight achieving additional postgraduate qualifications. Three have achieved Graduate Diplomas and five have achieved Masters Degrees by coursework.

**Question 3.2** *What project management qualifications do you hold?*

Nearly half of the project managers did not have specialist qualifications in project management with nine responses indicating no project management qualification. Four responses indicated the project manager had achieved the PMP qualification and four responses for the RegPM qualification. One person indicated achieving a Diploma in project management.

**Question 3.3** *Are you a Company Director?*

Only one of the project managers responded positively to being a company director.

**Question 4.1** *What project planning and scheduling tool does your company use?*

<table>
<thead>
<tr>
<th>Item</th>
<th>Name</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.1.1</td>
<td>Microsoft Project</td>
<td>16</td>
</tr>
<tr>
<td>4.1.2</td>
<td>Open Plan</td>
<td>2</td>
</tr>
<tr>
<td>4.1.3</td>
<td>SureTrak</td>
<td>4</td>
</tr>
<tr>
<td>4.1.4</td>
<td>Other (please specify)</td>
<td></td>
</tr>
<tr>
<td>4.1.4.1</td>
<td>Primavera</td>
<td>2</td>
</tr>
<tr>
<td>4.1.4.2</td>
<td>Artemis</td>
<td>1</td>
</tr>
<tr>
<td>4.1.4.3</td>
<td>P3</td>
<td>2</td>
</tr>
</tbody>
</table>

**Question 4.2** *Please identify the tools and software applications that your company uses for the following activities?*

<table>
<thead>
<tr>
<th>Item</th>
<th>Analysis Type</th>
<th>Total</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.2.1</td>
<td>Life Cycle Costing</td>
<td>6</td>
<td>Microsoft Project, CASE, EDCAS</td>
</tr>
<tr>
<td>4.2.2</td>
<td>Life Cycle Analysis</td>
<td>3</td>
<td>Microsoft Project</td>
</tr>
<tr>
<td>4.2.3</td>
<td>Value Chain Analysis</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>4.2.4</td>
<td>Activity Based Costing</td>
<td>5</td>
<td>Expert Project</td>
</tr>
<tr>
<td>4.2.5</td>
<td>Environmental Impact Statement</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>4.2.6</td>
<td>Other project management activity</td>
<td>5</td>
<td>Internal, P3, ERP, Cognos</td>
</tr>
<tr>
<td>4.2.6</td>
<td>(Please specify)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
**Question 4.3** Identify the major weaknesses of the tools and software applications that your company uses (one or more)?

<table>
<thead>
<tr>
<th>Item</th>
<th>Name</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.3.1</td>
<td>Importing data</td>
<td>6</td>
</tr>
<tr>
<td>4.3.2</td>
<td>Exporting data</td>
<td>2</td>
</tr>
<tr>
<td>4.3.3</td>
<td>Communicating between tools</td>
<td>8</td>
</tr>
<tr>
<td>4.3.4</td>
<td>Communicating with team members</td>
<td>7</td>
</tr>
<tr>
<td>4.3.5</td>
<td>Compatibility of applications</td>
<td>6</td>
</tr>
<tr>
<td>4.3.6</td>
<td>Differences with standards?</td>
<td>3</td>
</tr>
<tr>
<td>4.3.7</td>
<td>Differences with local legislation, regulations or procedures?</td>
<td>2</td>
</tr>
<tr>
<td>4.3.8</td>
<td>Lack of features?</td>
<td>3</td>
</tr>
</tbody>
</table>

4.3.8.1 If so what features?

MSProject used and would like more features, currently different processes different portfolios, Resource Management

**Question 4.4** Does your project management tool permit you to import task and resource information from a data source?

Slightly less (yes – eight, no – ten) of the project management tools being used permit the user to import task and resource information from a data source.

**Question 4.5** Does your project management tool permit you to import task and resource information from a library?

Very few (yes – four, no – 14) of the project management tools permit the user to import task and resource information from a library.

**Question 5.1** Do you know what Life Cycle Costing is? If yes, please provide a definition of your understanding of what LCC is.
<table>
<thead>
<tr>
<th>Item</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>12</td>
</tr>
<tr>
<td>No</td>
<td>6</td>
</tr>
</tbody>
</table>

Resource costing at each stage of the project life cycle (or phase)
total cost of ownership from conception through to decomission
Cost of a deliverable over a period of time (life)

A relative cost of the cost or procuring, maintaining and disposing an item
Determination of total cost or a capability through all phases of
acquisition/sustainment/disposal
whole of life costs, NPV
Total cost over life of the project, Project + do your cost

The through life costs form acquisition, implementation, support + disposal of a
functionality, system, equipment, doing only costing relating to the provision of and
ongoing maintenance of the physical asset stores.
Total cost/ROI/depreciation
Total cost of purchase and operation over a common timeframe to enable comparison of
projects
True costing across full life cycle form creation to disposal

Question 5.2  Has a LCC been conducted and/or used in the company?
The project managers indicated (yes – five, no – 13) that a majority of companies had
not conducted a LCC study.

Question 5.3  Has What were the reasons for carrying out the LCC?
Most of the project managers did not answer, the two responses to the reasons for
carrying out the LCC were to find the ‘system life’ and ‘control required’.

Question 5.4  Is a LCC analysis carried out for every project?
None of the project managers indicated that LCCA is carried out for every project.

Question 5.5  Who does the LCC?
For the companies that do utilise LCC, two project managers indicated that internal
engineers or external consultants carry out the LCCA.

Question 5.6  What kind of benefits would the company see with using LCC?
None of the project managers provided a benefit to the company if LCC is used.

Question 5.7  What were the outcomes?
One of the project managers indicated that when using LCC the project outcome was successful.

**Question 5.8** What were the difficulties encountered?

There were no responses to the enquiry about difficulties encountered using LCC.

**Question 5.9** Were the results applied within the company?

Only one of the responses indicated that the LCC carried out was applied within the company during the project.

**Question 5.10** Were the results used as a component of another company’s LCC?

No answers.

**Question 5.11** Is the LCC being used now?

No answers.

**Question 5.12** Will it be used in the future?

One project manager indicated that the LCC would be used in the future.

**Question 5.13** Has the company been asked for LCC data?

No answers.

**Question 5.14** If no, what are the reasons for not applying it?

- Company has not been using any formal project management methodology
- Lack of knowledge
- Company not familiar with LCC concept (I'm ex Defence)
- Need to develop knowledge in LCC
- LCC is usually performed by a separate department. However, my particular section also requires this skill/tool for financial estimations and budgeting.
- BU only dealt with discrete maintenance project anwer by another BU setting requirements
- used on limited basis to assees major/significant projects
- too many comments, being worked perfect at present

**Question 6.1** Do you know what Activity Based Costing (ABC) is? If yes, please provide a definition of your understanding of what ABC is.
Question 6.2 Has Activity Based Costing (ABC) been applied in the company?

The majority of project managers (yes – seven, no – 11) indicated that ABC had not been applied in their company. The use of ABC was indicated as ‘project const tracking’ and ‘internal costing’.

Question 6.3 What kinds of benefits would the company see with using ABC?

Two project managers responded to a question on the kinds of benefits the company would see when using ABC. The benefits were:

‘Better tracking of cost of works for building purpose and future reference (historical comparisons); and

Better understanding of true costs of delivering services’

Question 6.4 If no, what are the reasons for not applying it?

Reasons provided for not applying ABC, were ‘the need for an engineer to gain experience with ABC’ and ‘better funds estimation, not sure’.

Question 7.1 Within your company what do you believe the costing priorities to be?

<table>
<thead>
<tr>
<th>Item</th>
<th>Name</th>
<th>Response Total /10</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.1.1</td>
<td>Management costs</td>
<td>106 5.89</td>
</tr>
<tr>
<td>7.1.2</td>
<td>Administration costs</td>
<td>105 5.83</td>
</tr>
<tr>
<td>7.1.3</td>
<td>External costs including permits, Government, etc.</td>
<td>85 4.72</td>
</tr>
<tr>
<td>7.1.4</td>
<td>Materiel costs</td>
<td>94 5.22</td>
</tr>
<tr>
<td>7.1.5</td>
<td>Personnel costs</td>
<td>117 6.50</td>
</tr>
<tr>
<td>7.1.6</td>
<td>Environmental costs</td>
<td>86 4.78</td>
</tr>
<tr>
<td>7.1.7</td>
<td>Whole of Life costs</td>
<td>92 5.11</td>
</tr>
</tbody>
</table>

Question 7.2 Can you name three items that currently do not exist in the company’s costing system that would be valuable to have?
3.6 Analysis of survey results

The survey results indicate that the survey respondents were from 10 of the 17 Industry areas identified. The largest group of project managers came from Government Administration and Defence (27.78%) and the next largest group came from Construction (18.06%) followed by Electricity, Gas and Water Supply (12.78%). Perhaps not surprisingly, these were the industry sectors identified in Chapter 1 as those in which large scale projects would occur and as such suggest that the survey group formed a representative sample.

Less than half the respondents indicated that their organisation possessed a written company PM guideline. Those that indicated that there was a guideline provided details of the wide range of competing standards, methodologies and approaches competing in the PM arena.

In the responses to Question 2.3, the spread of PM methodologies being used by respondents was roughly equal, with 22% of respondents indicating that their organisation used an in house methodology and 22% indicating that their organisation adopted all of the approaches. Of note here, is that the latter result is consistent with PM consultants who are often required to adopt the methodology of the organisation in which they are currently consulting.

The survey respondent’s academic qualifications were reasonably spread with the largest groups having a Bachelors Degree and a Masters Degree by coursework. One of the respondents had no formal qualification and several possessed either a TAFE Qualification or a Graduate Diploma. None of the survey respondents possessed a Masters Degree by research or a PhD. Overall the survey respondents academic qualifications indicated a group of people who had carried out academic programs where they may have been introduced to PM concepts and specialist activities such as LCC and ABC, though the specifics of the Academic program was not sought.
Half of the survey respondents indicated they possessed a PM qualification. Roughly equal numbers had either a PMP or a RegPM qualification. From this, it appears that the survey respondents contained a reasonable proportion that were trained in the project management processes and understood risk minimisation strategies.

In Question 4.1, about 88% of the survey respondents indicated that their organisation used Microsoft Office® Project (MOP). This was a significant figure and highlights the market penetration that has been achieved by MOP. It also strongly supports the choice of MOP as the standard PM software application to be used as the host application in conjunction with TRManager.

The range of software applications used for the nominated specialist activities highlighted the range of software applications available for specialist activities. Some of the respondents indicated that they used MOP in conjunction with other software applications. This result confirmed the use of multiple software applications for specialist activities and project management and supports the view expressed in chapter two that an integrated project management framework is not available currently. Clearly, the provision of such an integrated solution would reduce the number of software applications that project managers must utilise and master.

Respondents indicated in reply to Question 4.3 that the major weaknesses of the tools and software applications in use by the respondent’s organisations were evenly spread with about 45% indicating that they thought communicating between tools was a major weakness, about 40% indicated communicating with team members as a major weakness and about 30% indicated that compatibility of applications was a major weakness. These results once again emphasize the need for integration mechanisms and the current lack of availability of an integrated environment such as TRManager.

TRManager addresses such communication issues by identifying a mechanism to utilise the common information stores. Information may be kept in the PM information store and used by the specialist activity tool and the specialist activity tool information store may store additional information and also supplement the same type of information for resources, tasks and activities that are unique to the specialist activity analysis being undertaken.
About 30% of the respondents to Question 4.3 indicated that importing data was a major weakness with the tools and software applications being used. TRManager addresses this requirement by implementing a library capability that utilises a common information storage and transmission format, XML, and by being able to access XML files or XML streams of data from SQL tables.

More than 50% of the respondents to Question 4.3 indicated that they could not import task and resource information from a data source. In addition, 77% of respondents indicated that their PM tool would not permit them to import task and resource information from a library. Taken together, both results highlight the disjointed nature of the environment confronting project managers.

In relation to the specialist activities covered in Questions 5.1 and 6.1, about two thirds of the respondents indicated knowledge of LCC and ABC, though the descriptions were vague in some responses. The high response in this category is not surprising and matches the representation of the Government Administration and Defence sector in which it is mandated. However, the vague nature of many responses argues strongly for the need for more education and training for project managers in the specialist activities.

In Questions 5.2 and 6.2 less than one third of the respondents indicated that LCC and ABC had been used in their organisations. This response, taken together with that about knowledge levels, clearly highlights a divergence between knowledge and practice. Additionally, it would appear that allowing for the representation of Government Administration and Defence sector, LCC and ABC are rarely used. The implication of this is that at a broader level specialist tasks such as LCC are being applied in a piecemeal fashion.

In addition, the major reason given for non use of LCC and ABC in Questions 5.2 and 6.2 was that “someone”, typically identified as an engineer, needed to be trained. Two points emerge from this. The first is the response clearly suggests that activities such as LCC are clearly perceived as a highly quantitative, sophisticated, physical systems oriented undertaking of specialist engineers. The second subtler point is that the externalisation and separation of such specialist tasks, also implies that the three related management activities of performance management, project management and
life cycle management are not being considered and handled in an integrated manner. Moreover, if one considers the high knowledge levels of specialist activities covered in Questions 5.1 and 6.1, the results strongly suggest that project managers are deterred by and lack confidence in handling specialist activities. In this regard, while improved tools and integration may improve the situation, they will not provide a complete solution and there is a clear need to provide better education to project managers in the area of specialist activities.

Finally, respondents to Question 7.1 indicated costing priorities for their organisations were roughly equivalent at about 4-6/10 for each of the areas identified. This result shows that organisations were prepared to invest in different areas of activity.

Overall, the picture that emerges from the survey is remarkably consistent with the observations listed in the summary to chapter two. Put simply, (a) the three basic management activities are not considered in an integrated manner, (b) life cycle costing (LCC) is at best being applied in a piecemeal fashion, (c) numerous issues exist because multiple software platforms rather than an integrated framework are being used, (d) specialist activities are seen as a separate issue which is only capable of being addressed by engineers, and, (e) improved tools and integration may provide part of the solution, but there is a clear need to provide better education to project managers in the area of specialist activities.

### 3.7 Summary

Though, reviews of project management reveal a large number of issues, these issues may not be the most important issues confronting practitioners on a daily basis and so a voluntary survey was conducted to examine the current position and needs of Australian project managers.

This chapter documented the background and approach adopted for a self-administered survey, administered to project managers over the internet or during the PMOz 2005 project management conference (2005). The chapter also documented the ethics approval and the scope of the questions that were used. The results of the survey were then presented. The survey results highlighted that the respondents were a representative group of active project managers from a range of organisations.
The survey produced results that were consistent with the observations listed in the summary to chapter two and which suggested that the findings of the ANAO (1998) audit of the use of LCC in Defence may apply more generally. More importantly, these results appear to be completely at odds with the earlier observation that the proper assessment and management of projects requires the adoption of a broad business view which considers the total cost of a project over its life span. However, TRManager is a framework that is intended to directly address many of the issues raised and so attention turns to examining TRManager in detail in the following chapters.
4 TRManager

4.1 Introduction

TRManager is a framework, designed to be compatible with project management tools and systems that utilise Gantt, PERT and CPM, which provides an improved way to utilise techniques and calculations employed to perform specialist activities such as life cycle costing and technical risk management. At an aggregate level TRManager contains five major components and this chapter provides an overview of these.

A key feature of TRManager is its ability to not only directly integrate diverse hybrid models but also to interface directly with such models. The manner in which this is achieved is indicated throughout this chapter. In particular, the alternative treatments of the fundamental model data elements, which distinguish the various hybrid models, are also presented and discussed.

To help illustrate the various components, this chapter uses a prototype model which was constructed to implement the CASA (2008) hybrid life cycle costing and technical risk model.

The TRManager framework consists of three layers of functionality. The lowest layer includes the data element definitions and mechanisms to interact with data stores. Data stores that may be used for data elements include databases and disk files.

The intermediate layer includes the model framework functionality and features provided by models implemented within the framework. TRManager provides the facility for existing models to be implemented within the framework. An example of this is the implementation of the CASA (2008) hybrid life cycle costing and technical risk model within the TRManager model framework. The effect of this is that TRManager enhances the outputs from the CASA model and provides additional functionality currently not available in the CASA model. The TRManager features can be applied to any model implemented in the model framework and provide a mechanism to fit models into the TRManager framework.
The highest layer deals with user interaction and information display. TRManager provides information in a simplified way to ensure that non-technical users are able to gain maximum benefit from TRManager framework. The principle underpinning this TRManager layer is aimed at reducing complexity and a key feature of this is the use of colours and other aids that are readily identifiable by users.

4.2 Model framework

The TRManager model framework encapsulates several layers of functionality as illustrated in Figure 4-1. TRManager interacts with data storage for storage and retrieval of the data elements that for the system being studied. The user selected model manipulates the data elements and applies calculations to the data element parameters. The framework functions provide additional features that build upon the outputs of the user selected model and provide additional inputs to the way the model carries out data element manipulation and calculations. An example of this is the addition of rules and actions that add automation and intelligence within the framework. The TRManager model framework provides for information to be presented and interacted with through a user interface and reports. Other frameworks and tools may interact with TRManager through an interface or one or more frameworks or tools may be integrated within an information management system.

Figure 4-1 TRManager model framework diagram
TRManager may be implemented as a standalone system or alternatively implemented in conjunction with an existing information management system. An example of the latter and how TRManager can be integrated with a project management tool, such as Microsoft Project, is shown as a block diagram in Figure 4-2.

Figure 4-2 TRManager block diagram

TRManager may also be implemented as a separate entity or integrated at each layer with other frameworks and tools. Data elements may be stored either in a shared data
storage facility or in separate data storage facilities, as shown in Figure 4-2. The implementation of a calculations and data interface permits the data element manipulation and calculations to be shared between TRManager and other frameworks and tools.

The functionality features provided by TRManager include decision support tools and an automated intelligence capability. The addition of TRManager’s features enhances the opportunity for improved outcomes and decision making. The purpose of the TRManager decision support tools and automated intelligence capability is to enhance the way that TRManager manages the models implemented within TRManager. It may be possible, however, that the TRManager features could be implemented to interoperate with other frameworks and tools.

At an aggregate level, TRManager incorporates the following five major features:

1. Guide – a feature that assists the user interact with TRManager in a progressive manner.
2. ToDoList - an automated intelligence feature that assists the user through the provision of a guide that implements rules.
3. Template and Library – a feature that assists users manage data elements and information within TRManager.
4. System version control – a feature that provides revision control and management that may be used for system summation and comparison.
5. Information display and interaction – several features that provide enhanced user interface capability for representing model outcomes.

TRManager implementation may be done depending on the organisation and the information management system that is being enhanced by the addition of TRManager. An example of an alternative implementation to that given in Figure 4-2 is provided in Figure 4-3 and shows the use of a single data storage facility.

The prototype developed during the research provides an example TRManager implementation where TRManager has been integrated within a tool as a separate view. The tool already included Gantt and PERT views.
The extensible approach taken with TRManager development permits new features to be added and existing features removed if this is appropriate for an organisation’s implementation strategy. As new models are added to TRManager the opportunity to develop and create new features also grows.

Figure 4-3 TRManager block diagram – example alternate implementation

4.3 Chart diagram

TRManager organises information to provide interaction and notification of events that are preset or nominated by the model within the TRManager framework. Hybrid
models within the TRManager framework are linked to a mechanism to highlight key indicator values.

Figure 4-4 shows the TRManager hierarchy view for a hybrid model that includes calculation of system availability. System availability is an indicator of reliability and provides an indication of system performance. In Figure 4-4 a system key indicator threshold for availability has been entered as 99.95%.

![Computer System diagram](image)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Availability</td>
<td>99.95%</td>
</tr>
</tbody>
</table>

Figure 4-4 TRManager chart hierarchy view – System key indicator parameter

To calculate availability the system data elements have associated parameters. For example, as shown in Figure 4-5, the parameters may include mean time between failure (MTBF) and mean time to repair (MTTR) which may be used to calculate system availability.
Figure 4-5 TRManager chart hierarchy view – System element parameters

Parameters for all data elements being used by a hybrid model within TRManager may be viewed or changed in the different view diagrams. In Figure 4-6 the parameters for the *Q1 07 Deployment* task are shown.

Figure 4-6 TRManager Chart Hierarchy View – Task parameters

The TRManager framework chart timeline view is shown in Figure 4-7. In the timeline view activities, tasks or resources are shown adjacent to a timeline.
information display includes linkages between activities, tasks and resources and associated parameters.

In Figure 4-7, for example, we are shown through the use of a linked box that appears when a task is highlighted that for the task called deployment with task ID 53 there will be a courier resource with resource ID 2486 used and ten systems are deployed during this task. The use of identifiers on the diagram may be used to indicate information is available. The small triangle on the left bottom corner of the task is used to indicate that activity, resource or system information is linked to this task.

![Figure 4-7 TRManager Chart Timeline View](image)

In Figure 4-5 the system data element parameters include **Cost**, **Start Date** and **End Date**. The parameters **Start Date** and **End Date** are used to indicate that a system data element was used in the system between the dates. The parameter **Cost** may be used to calculate the total cost of the system or individual activities or tasks.

To highlight how TRManager notifies hybrid model key indicator changes consider an example in which an alternative item is used within the system to reduce cost. A system data element, Figure 4-8, has been selected and included in the system to replace the item shown in Figure 4-5. The system and item entries in the TRManager hierarchy view are highlighted in red to indicate that a key indicator has fallen below the threshold value set, Figure 4-4. The system data element parameter **MTBF** value is also shown in red to highlight the possible cause of the key indicator falling below the threshold value.
In the TRManager timeline view a visual indicator and the use of colour is used to indicate that a key indicator has fallen below a threshold value. In Figure 4-9, the colour red is used to highlight when the change triggered the movement of a key indicator below its threshold value. A red circle has been added to the activity or task that corresponds to the time when the key indicator change occurred. When the red circle shown in Figure 4-9 is selected the system data element items identified as important to the change in key indicator value are shown.

The TRManager framework chart timeline view may show task, resource, activity and system data elements as the primary item linked to the timeline. The timeline view for...
A system data elements is shown in Figure 4-10. In Figure 4-10 a system item called *WidgetA* is a focus of a project action, in this instance we can see that this system item is linked to a task named *Development* that is occurring at this time. The visual indicator appears on the system item box to highlight that the system item MTBF changed during this time period and the flow on effect was an improvement in a key indicator the overall system availability from 67% to 99.96%.

![Diagram of TRManager timeline view showing system data elements linkages and events](image)

**Figure 4-10 TRManager timeline view showing system data elements linkages and events**

### 4.4 Model data elements

Central to how TRManager can integrate apparently diverse hybrid models is its treatment of fundamental model data elements. A study of model data elements shows that the number of data elements used by most hybrid models is limited and in many cases the hybrid models use the same data elements. The data elements may be referred to differently or have associated information arranged in different ways.

Consider the data elements used by Microsoft Office® Project and CASA (2008). Microsoft Office® Project utilises four data elements and associates parameters with each of these data elements. The four data elements used by Microsoft Office® Project are: (1) time, (2) cost, (3) tasks, and, (4) resources. An example of the parameters associated with the data elements is the classification of resources as either: (1) work, (2) cost, or, (3) material. Microsoft Office® Project data elements are further amplified by the addition of parameters and each of the parameters may be associated with sub-parameters. The data element structure used by Microsoft Office® Project is
hierarchical and permits linking of data element information between levels in the hierarchy.

In contrast, CASA (2008) utilises two core data elements: (1) system, and (2) activities. The CASA (2008) system data elements may also be known as parts, modules, components and are used to describe the system being studied in a hierarchical manner. The activities are actions associated with sections of the system or the whole system. Examples are transportation, research and development, repair, and operations.

There is an underlying similarity to the data elements used in Microsoft Office® Project and CASA (2008). The CASA system data elements may be identified as Microsoft Office® Project material resources. However on closer inspection it is found that whilst this may appear to be a logical association, in practice, it is not practical because the CASA system data elements are all used in the system being studied and Microsoft Office® Project does not provide a way to delineate between material resources that are part of the system being studied and other material resources being used in the project. An example would be where the system being studied is an aircraft and the project included the use of stationery as a material resource.

Possible methods of overcoming the different use of data elements are to describe the CASA (2008) system data element as a Microsoft Office® Project system resource or as a system material resource. In the first option it would mean adding to the list of resource parameters: (1) cost, (2) work, (3) material, and (4) system. The second option would require a sub-parameter being added to the material resource parameter: (1) system, or, (2) other.

Another option is to identify the system data element as a top level data element: (1) time, (2) cost, (3) tasks, (4) resources, and, (5) system. This option would permit the system data element to be identified separately and is a practical solution where the MIS does not provide for altering existing data elements or adding new parameters to existing data elements.

An examination of the CASA (2008) activities data element finds that these are groupings of tasks and resources. An example is the research and development activity which may be described as the tasks and resources utilised to carry out the activity.
research and development associated with the system over the duration of the project. This association provides an opportunity to describe the activities in more detail using an approach that is more common to Gantt, PERT and CPM.

4.5 Model calculations

The TRManager framework integrates the hybrid model calculations within a calculations layer, Figure 4-2. The calculations layer provides a facility for hybrid model calculations to be implemented with TRManager and for the calculation outputs to be used by other TRManager features and layers.

An example of the integration is the linkage between the system data element parameter values, the calculations layer and the TRManager chart diagrams. Where the hybrid model includes key indicators TRManager integrates the calculated key indicator values and relationship to threshold values with the TRManager chart diagrams and reports. TRManager provides flexibility when integrating hybrid models and calculation outputs may be highlighted using a range of approaches within the TRManager chart diagrams.

CASA (2008) is an example hybrid model that can be implemented within the TRManager framework. Examples of the calculations that may be implemented in the TRManager calculations layer for this hybrid model are presented in Appendix D.

4.6 System revisions

TRManager also provides a system revision feature. The purpose of the system revision feature is to permit the state of the system including all data elements currently being used to be frozen at a point on the timeline. The system revisions may not be changed so this will prevent inadvertent loss of the system status when a revision was made and also provides a record of the system that may be used for summative or comparative analysis with other system versions.

System revisions may be created at any time through a project life. It is anticipated that creating and comparing system revisions will be done at project milestones or when major changes occur to the project. The purpose of system revision comparison analysis is to highlight time, budget and performance changes.
4.7 Guide

The guide is a wizard that provides the steps necessary to enter data elements, system and parameter values and how to prepare reports. The guide is not a mandatory TRManager feature but is provided to ensure that sufficient information is entered into TRManager to permit reasonable outcomes.

The guide provides the user with a number of steps to complete and each step will involve user actions such as data input or other actions, for example calculations or report generation. A step may involve describing an action that is necessary with an external software application, such as checking to see that a data store has been loaded with data element details.

4.8 Reports, charts and summaries

The TRManager framework includes the capability for hybrid model outputs to be sent to reports, charts and summaries. The outputs may include comparative and summative analysis outputs from the model or the TRManager revisions feature. Examples of reports that may be included with TRManager using the CASA (2008) hybrid model are provided in Appendix B.

4.9 Library

The TRManager framework library feature provides the user with the capability to open, edit and delete library files of data elements; Activities, Resources, Tasks or System data elements. The library files may be XML files or SQL database tables containing the data elements.

The purpose of the TRManager framework library is to make the task of creating a solution easier, more efficient and less time consuming. The data elements used in one project may be used in other projects. The purpose of the library feature is to remove the need to use alternative tools to create, edit or delete data elements that are maintained in data stores such as XML files, SQL databases or other systems.

4.10 ToDo list

The TRManager framework ToDo List provides a list of outstanding actions to be completed. This action list is created by applying a set of rules to the data elements
and calculation outputs. An example of the ToDo List feature is where it can be used to provide alerts when data elements or their associated parameters are:

- Out of range
- Set to a default value
- Set to an initial state that must be changed

The severity of the actions in the ToDo List may be identified by the use of icons or colours and the affected data elements or associated activities, tasks and resources can be colored red in the TRManager framework hierarchy or timeline views. The use of a red exclamation mark in the ToDo List indicates an action that must be completed to ensure that the hybrid model within the TRManager framework is provided with enough information so that calculations will be valid and a green question mark is used to indicate a data element parameter should be updated.

4.11 Summary

This chapter provided an overview of the three levels of functionality and five major components that form the basis of the original contribution provided by TRManager. To help illustrate the various components, the chapter made use of a prototype to implement the CASA (2008) hybrid life cycle costing and technical risk model.

At a broad level, the levels of functionality and major components define TRManager’s key and original capabilities to directly integrate and interface with diverse hybrid models. The manner in which this is achieved was indicated throughout this chapter. In particular, the alternative treatments of the fundamental model data elements, which distinguish the various hybrid models, were also presented. Having outlined TRManager from this broad perspective, focus now shifts to a more detailed exposition of TRManager in the next chapter.
5 TRManager prototype framework

5.1 Introduction

This chapter contains a detailed exposition of TRManager using flow diagrams for a prototype of the CASA (2008) hybrid life cycle costing and technical risk model. As already noted, TRManager may be implemented either by enhancing existing applications or by creating a new information management system. To reduce the effort and time needed to create a TRManager prototype a decision to integrate TRManager into an existing application was made.

The TRManager prototype was developed using system engineering principles whereby the key outcomes were identified and implemented using a practical approach that was not fully able to represent all of the TRManager features due to time and effort limitations. Systems engineering is a holistic approach used to derive, evolve and verify a life cycle balanced system solution that satisfies customer expectations and meets public acceptability and accountability, (Blanchard and Fabrycky 1998). The key outcome here was to be able to demonstrate a TRManager prototype that may be used for further research and development and to verify the research approach.

To integrate TRManager into an information management system is a substantial activity even if the information management system was created from scratch. For this reason a project management activity environment was selected because project management is a narrower approach used to complete projects by scheduling tasks based on time and resources (PMBOK guide 2004) and this environment provides a significant overlap in data elements used by TRManager.

5.2 Selection of the prototype development environment

To facilitate prototype development it was necessary to identify a suitable prototype development environment that matched the author’s skillset. The author’s skillset included software architecture using the Microsoft development environments, languages and tools. It was therefore practical to utilise a Microsoft based environment for the prototype development.
The TRManager framework may be implemented within existing or new information management systems. Examples of applications that perform the project management activity, which is a core function of project and service management, are: (1) Microsoft Office® Project™, (2) Artemis®, (3) Deltek OpenPlan and (4) Primavera®. A benefit in adopting a Microsoft based development environment is that Microsoft Office® Project was identified by survey respondents as being the most common project management tool in use in their organisations.

5.3 TRManager prototype view

<table>
<thead>
<tr>
<th>Version 1</th>
<th>Version 2</th>
<th>Properties</th>
</tr>
</thead>
<tbody>
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<td></td>
<td>Item</td>
</tr>
<tr>
<td>Block diagram</td>
<td></td>
<td>Item</td>
</tr>
<tr>
<td>Flow diagram</td>
<td></td>
<td>Item</td>
</tr>
<tr>
<td>Message diagram</td>
<td></td>
<td>Deployment</td>
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<tr>
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<td></td>
<td>Training</td>
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<tr>
<td></td>
<td></td>
<td>Research and Development</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Etc</td>
</tr>
<tr>
<td>ToDo</td>
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<td>Tasks</td>
</tr>
<tr>
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<td></td>
<td>Resources</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Parts</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Versions</td>
</tr>
</tbody>
</table>

Figure 5-1 TRManager Prototype View

The TRManager prototype view (TPV) is shown in Figure 5-1. The TPV design aim was to be able to integrate many of the TRManager features in a functional layout that would highlight flexibility and ease of use. The key aspect of the TPV was to provide an implementation of the TRManager hierarchy view.

5.4 TRManager prototype hierarchy view

The TRManager framework prototype incorporated the CASA (2008) hybrid model. The TRManager hierarchy view includes the system in a tree structure and this permits the tree to be opened or collapsed as necessary to focus on sections of the system and better utilise available viewing space.
The TRManager framework hierarchy view includes the system, resources, tasks and activities that are used by the hybrid model. The data elements may be used in the Microsoft Office® Project network and Gantt views and are stored either in a separate data store or in the data store that is being used to store the Microsoft Office® Project data elements. The TRManager framework hierarchy provides features and capability to view, edit, delete or create data elements.

The data element parameters list provides the parameters for the currently selected data element. The parameter list provides the user with an explanation of each item and links to online help describing the item and more information on the type or property and values that may be assigned.

5.5 TRManager prototype drawings

As indicated, an instance of TRManager will now be described solely by way of a non-limiting example and with reference to the accompanying drawings in which:

- Figure 5-2 is a flow diagram showing the TRManager functional operations;
- Figure 5-3 to Figure 5-8 are flow diagrams of the creation and manipulation of data elements within the framework;
- Figure 5-9 is a flow diagram of the processing of the input data element information into output information;
- Figure 5-10 to Figure 5-15 are flow diagrams of the storing and traceability of different versions of the information model;
- Figure 5-16 and Figure 5-17 are flow diagrams showing the input data element information processing into output information where some information is drawn from the project management tool;
- Figure 5-18 to Figure 5-20 are flow diagrams of the use of templates to create and manipulate the input data element information and the output information;
• Figure 5-21 to Figure 5-27 are flow diagrams showing how the TRManager library feature may be used to create and manipulate information and data elements;

• Figure 5-28 to Figure 5-30 are flow diagrams showing how the TRManager ToDo List feature may be used to highlight actions needed to either complete or alter system information, data elements or output information;

• Figure 5-31 to Figure 5-34 are flow diagrams showing how the TRManager Guide feature may be used to create and manipulate system information or data elements;

The figures and flowcharts provide a visual description based on a general implementation of the integration method described. They provide a detailed description of the processes that were identified and implemented during the research. The processes were implemented in the prototype and refined as the prototype was tested.

The information flow design was created with a generic PM software application as the target for the integration methodology. In practice, the prototype was implemented to operate in conjunction with Microsoft Office® Project.

The flowcharts are a representation of the activities and information flow through the prototype application. Comments are added to the flowcharts to highlight the user interaction during the process described. The flowcharts are sufficient for a software developer to reproduce the research outcome in its entirety.

5.6 Detailed system description

Figure 4-2 showed TRManager integrated with a project management tool (PMT), as is the case here, where the PMT is a commercially available project management application, such as Microsoft Office® Project™, and TRManager is an add-in (or plug-in) to the PMT. Microsoft Office® Project™ is a common PMT in use today by a large number of users in all countries of the world. Microsoft Office® Project™ is a single or multi-user PMT that allows for collaboration through the storage of the
underlying application data objects in a relational database, such as Microsoft SQL Server™ or Oracle®. Microsoft Office® Project™ users can be assigned roles with authorisation to carry out certain PMT tasks associated with manipulating the underlying data; this is a collaboration feature.

The TRManager framework includes a Guide module, a reports/charts/summaries module, a ToDo List module, a template and library control module, a system version control module, a template and library module, a calculation and data interface and storage. The PMT includes a calculation and data interface and storage. The respective calculations and data interface modules of TRManager and the PMT map and bi-directionally synchronise data elements including system, activities, tasks, resources, time and costs to create an information model. Versions of the system information model are stored in the TRManager data storage where two data stores are used or the common data store where one data store is used, as shown in Figure 4-3. The respective functions of the TRManager modules are described below with reference to flow diagrams.

Figure 5-2 is a flow diagram illustrating a general method for integrating performance management and project management tools, consistent with an embodiment of TRManager. Although described serially, the flow points and method steps can be performed by separate elements in conjunction or in parallel, whether asynchronously or synchronously, in a pipelined manner, or otherwise. In the context of TRManager, there is no particular requirement that the steps or method operations must be performed in the same order in which this description lists flow points or method steps.

Referring to Figure 5-2, at the first step, 202, information relating to data elements, component parts and life cycle activities of a system are obtained using TRManager. An information model of the system is then created at the second step, 204, by selectively and individually linking data elements including system parts and activities from TRManager with tasks, resources, time and costs from the PMT. The information model is updated at step 206 by selectively and individually adding or modifying data elements including system parts, activities, tasks, resources, time, costs and links therebetween. At step 208, versions of the system information model are stored in the data storage storage of TRManager or the common data store. In
step 210, versions of the system information model are processed into output information by the calculation and data interface of TRManager to enable analysis of the system using the integrated hybrid models capabilities.

Figure 5-2 TRManager functional operations cycle

Figure 5-3 to Figure 5-8 illustrate the general flow of creating and manipulating a system information model using TRManager. Referring to Figure 5-3, a system can be designed, created or constructed using data elements including system component
parts, activities, tasks, and resources. Each of the system component parts, activities, tasks, and resources constitute something that consists of time, cost, materiel and other parameters associated with numerical values such that the system information model as a whole can be analysed using calculations and reports produced from TRManager. The system components can be added, deleted or changed.

Figure 5-3 System information model process
The TRManager view therefore provides an environment that simplifies the process of system design and analysis and works in conjunction with data element objects that may be provided through the PMT.

Figure 5-4 System information model process

As best seen in Figure 5-4 to Figure 5-8, the TRManager framework includes a system design capability using a structured approach that includes a hierarchical
structure for elements that can include sub-elements and also provides for a flat relationship for elements that do not include sub-elements.

Figure 5-5 System information model process
Figure 5-6 System information model process
Figure 5-7 System information model process
Figure 5-8 System information model process

For example, an element such as system deployment might contain sub-elements that are system deployment actions or, alternatively, an element such as system deployment might be an individual element that contains information about the system deployments for the life of the system, project or service and associated information such as the total number of systems deployed, how, cost, resources and other associated information.

Figure 5-9 illustrates the general flow of processing the system information model into output or end-user information to enable total-cycle analysis of the system. The system analysis capability provided by the calculations and data interface module and the reports/charts/summaries module of TRManager includes system analysis computations provided by the hybrid model that has been incorporated. The hybrid model may include calculations in the areas of performance management, systems engineering, risk management, life cycle costing, life cycle assessment and other areas under the general umbrella of performance or systems engineering or analysis including automated decision intelligence.
Figure 5-9 Deriving life cycle costing end-user information

Figure 5-10 to Figure 5-15 illustrate the general flow of manipulating and storing versions of the system information model within TRManager. The system version control module of TRManager provides for versions of the system information model to be frozen or active and copies of either frozen or active versions, known as sub-versions (or revisions). A version of a system information model includes all of the
information necessary to reconstitute the version if it was to be the active version. This includes all of the information necessary to alter the PMT to reflect the active version. This provides the user with the capability to compare versions of the system information model and to carry out “what-if” scenarios using TRManager or PMT. TRManager includes versions, calculations and rule sets needed to carry out automated decision making. In addition, TRManager identifies to the user information that is needed or actions that should be carried out by putting entries into a ToDo List. The ToDo List module of TRManager ties the ToDo List item to the information which the user needs to provide, such that if the user points to a ToDo List item TRManager will display the missing information and highlight it ready for user input. TRManager further includes intelligence such that the rule sets and calculations can identify areas of risk and highlight these in reports or in the hierarchy or timeline views. The rule sets and intelligence of TRManager will also predict outcomes based upon the hybrid model being used and key indicators and threshold values.
Start

Go to SET view

System brings up the SET view

Add new revision?

Y

SubVersion?

N

User select the Revision Node on the Revision Tree, right click, select Add SubVersion

System creates a new Revision

Remove revision?

Y

User select the Revision Node on the Revision Tree, right click, select Remove

System removes selected revision

N

Edit revision name?

Y

User select the Revision Node on the Revision Tree

System displays the revision details on the Properties Window

User edit the Revision Name

N

Hide/Close revision?

Y

User select the Revision Tab, right click and select Close

System close the Revision tab

N

Bring back hidden revision?

Y

User select the Revision Node on the Revision Tree

System brings up the hidden Revision tab

N

Synchronise?

Y

User select the inactive Revision Tab

User right click the Revision Tab, select Synchronise

System saves the revision as well as the Project details

System synchronising the selected revision and locking others

N

Finish?

End

Child version inherit information from the parent version

Figure 5-10 System version manipulation
Figure 5-11 System version manipulation
Figure 5-12 System version manipulation
Figure 5-13 System version manipulation
Figure 5-14 System version manipulation
Figure 5-15 System version manipulation
Figure 5-16 Deriving end-user information using information from the project management tool

Figure 5-16 and Figure 5-17 illustrate the general flow of accessing the PMT using the calculations and data interface module of TRManager to retrieve information from PMT data element objects needed for calculations, intelligence and reporting.
Figure 5-17 Deriving end-user information using information from the project management tool

Figure 5-18 to Figure 5-20 illustrate the general flow of using templates to create and manipulate the system information model and output end-user information. A template is a model including a collection of intelligence, rule sets, calculations, libraries (including rule sets, calculations, activities, component parts, resources and tasks) that can be loaded from a menu by the user. The template and library control module of TRManager provides a framework for templates to be created for most industries and services using standard hybrid models. The template and library module of TRManager provides the user with a number of the templates by default, including standard hybrid models that are related to performance management, systems engineering, risk management, life cycle costing, life cycle assessment and life cycle analysis, value engineering, activity based costing, environmental impact and other templates.
Figure 5-18 Templates
Figure 5-19 Templates
Figure 5-20 Templates
Figure 5-21 Libraries

Figure 5-21 to Figure 5-27 illustrate the general flow of using data element and other information libraries in TRManager. Libraries can be opened from templates or individually and include calculations, rule sets, activities, data elements, component parts, tasks, and resources. Libraries can be modified by the user and items in the library can be added, deleted or changed. In addition, libraries can also be merged or split. Further, libraries can be stored and accessed from file or from relational databases.
Figure 5-22 Libraries
Figure 5-23 Libraries
Figure 5-24 Libraries
Figure 5-25 Libraries
Figure 5-26 Libraries
Figure 5-27 Libraries
Figure 5-28 ToDo lists

Figure 5-28 to Figure 5-30 illustrate the general flow of processing ToDo Lists. The TRManager framework includes intelligence through the inclusion of the ToDo List module. This module includes rule sets and intelligence so that TRManager can publish items requiring the user’s attention, then when the user selects an item in the ToDo List, TRManager will display the data element parameter or property or other element or item that needs user input, usually in the form of new or changed values. The ToDo List is part of the intelligence capability of TRManager.
Figure 5-29 ToDo lists
Figure 5-30 ToDo lists
Figure 5-31 User guides
Figure 5-32 User guides

Figure 5-31 to Figure 5-34 illustrate the general flow of using a wizard or guide to assist the user with entering key information needed to successfully compile a system information model for analysis. The TRManager Guide improves the speed and accuracy with which a user will compile a system information model for analysis.
Figure 5-33 User guides
5.7 Summary

This chapter provided a detailed exposition of TRManager using flow diagrams for a prototype of the CASA (2008) hybrid life cycle costing and technical risk model. The TRManager design presented in this chapter is an original implementation.

Though the information flow design was targeted for use with generic PM software applications, the prototype was implemented to operate in conjunction with Microsoft Office® Project. While flow diagrams can document essential details, they cannot document project manager user aspects, such as seamless integration, which form an integral part of TRManager and attention now shifts to focus on such issues.
6 TRManager prototype implementation

6.1 Introduction

The previous chapter provided a detailed exposition of TRManager using flow diagrams for a prototype of the CASA (2008) hybrid life cycle costing and technical risk model. As noted though, flow diagrams can document essential details, such as seamless integration, which are essential aspects of TRManager from a project manager user perspective. Such issues are considered in this chapter, in which the practical use and performance of TRManager is presented through screen dumps and associated discussion.

Examining the performance of TRManager involved a process of testing and validation, which was achieved using a three stage process. The first stage was to create a TRManager prototype application incorporating the CASA (2008) hybrid model. The second stage was to use the TRManager prototype to carry out analysis of a sample system, which in this case is called Tenderer A Full Data and is a system provided with the CASA (2008) software application. The final stage was to compare the results obtained using TRManager to those achieved for the sample system using the CASA software application (CASA 2008).

6.2 TRManager prototype hierarchy view

The TRManager framework prototype incorporated the CASA (2008) hybrid model and a new system is presented in the TRManager hierarchy view shown as F3C in Figure 6-2. The TRManager hierarchy view includes the system in a tree structure and this permits the tree to be opened or collapsed as necessary to focus on sections of the system and better utilise available viewing space.

The TRManager framework hierarchy view includes the system, resources, tasks and activities that are used by the hybrid model. The data elements may be used in the Microsoft Office® Project network and Gantt views and are stored either in a separate data store or in the data store that is being used to store the Microsoft Office® Project data elements. Examples of the TRManager framework hierarchy may be seen in Figure 6-1 to Figure 6-6. The TRManager framework hierarchy provides features and capability to view, edit, delete or create data elements.
The data element parameters list provides the parameters for the currently selected data element. The parameter list provides the user with an explanation of each item and links to online help describing the item and more information on the type or property and values that may be assigned. Examples of the parameter list are shown as F3E and F4A in Figure 6-2. In Figure 6-6 the user has highlighted a system item called “Electronics Board”, F6E and the data element’s properties are shown in the properties window F6F.

6.3 TRManager prototype detailed implementation

Figure 6-1 to Figure 6-6 illustrate sample screen shots of TRManager prototype implemented as an add-in to Microsoft Office® Project™. Referring to Figure 6-1, TRManager includes menu, F1B, toolbar, F1C, and a wizard or guide, F1A, to assist a user to input information while being guided through a logical process to ensure that minimum required information is entered into TRManager. The wizard or guide, F2A, presents in a logical window questions and entry boxes for the user to enter information into TRManager when selected, F2B, as illustrated in Figure 6-1. The wizard or guide can be multi-page linked together as a number of steps.

As shown in Figure 6-2, TRManager provides a hierarchy or timeline view using a multi-window environment that permits the user to interact with the information in a logical way. TRManager provides for the user to customise the layout of the information windows and to opt to turn windows on or off as needed. When TRManager is active the toolbar F3A is active and may be displayed with any and all combinations of the following data entry and management windows: guide or wizard menu F3B; system hierarchical or timeline view window F3C; ToDo List window F3D; version, system, component, activity properties window F3E; and utility window F3F.
Figure 6-1 TRManager prototype menus and guide
Examining Figure 6-2, TRManager includes a template of data elements including activities, resources and tasks that can be dragged and dropped onto the system. The items in the template can be varied to reflect an industry or equipment or system type. The template items are included in the utility window F4B, and when a template item is selected the properties are displayed in the properties window F4A.
Figure 6-3 illustrates TRManager, when the template of tasks is selected in the utility window F5C, and a task from the hierarchy view list is highlighted, so that the properties or parameters for the task are displayed in the Properties window, F5B, and the task has been added to the system, F5A. TRManager includes automatic inclusion
of this task (or resource) in the PMT data element and user interface, F5D, as illustrated in Figure 6-3.

As illustrated in Figure 6-4 to Figure 6-6, TRManager includes a library that can be loaded into the utility window F6A using a library manager F6B, which provides for more than one data element and system information library to be open at any time.
from either a file or a SQL data source. The data elements are then displayed in the utility window F6C and can be dragged and dropped to form part of the system, activities, tasks or resources, F6D. Their parameters or properties can be viewed or modified, F6F using the Properties window when an item is selected, F6E, in the TRManager system hierarchy or timeline view window. The system information model is updated and changed as any component part is added or changed.

Figure 6-5 TRManager prototype library data elements
Figure 6-5 and Figure 6-6 illustrate the capability of TRManager to compare versions of the system information model in a logical and easy to use way through the system view. The system versions can be made active, frozen or copied and worked on as subversions of frozen or active versions providing the capability for “what if” scenario analysis. Figure 6-5 and Figure 6-6 illustrate two versions of a system information model of a computer system that includes a computer and different constituent parts of the computer, together with peripherals including a printer. To identify particular information about one of the items shown in the hierarchical tree the user can select the item and the properties are displayed in the Properties window F6E and F6F.
The TRManager prototype illustrated above includes a number of functional blocks or modules that carry out data processing and interfacing actions to achieve the operations that provide the user with the capability to perform operations in the areas of performance management and systems engineering, including but not limited to performance, risk management, life cycle costing, life cycle assessment.
environmental impact, and activity based analysis. The illustrated TRManager prototype allows TRManager to be tightly, yet seamlessly, coupled to the PMT so that the user who was not familiar with TRManager, when first using the PMT would not necessarily identify TRManager from its outward appearance because of TRManager’s implementation using the same look and feel as the PMT.

As shown in Figure 6-1 to Figure 6-6, the TRManager prototype is implemented as an add-in to Microsoft Office® Project™ which includes the use of hierarchy and timeline views (also known as groups of dockable windows within a window management framework), menus, toolbars, and wizards or guides. By tightly coupling the look and feel of TRManager to the PMT, the user is able to use TRManager in the same manner as for any functional part or process of the PMT.

In use, the user opens a project using the PMT. The user can open a project that is local to the user’s computer stored in a file or in a relational database or through an Internet browser. The user can also open a project that is made available to multiple users through a server system and relational database in a group co-operative approach where users are assigned roles and capabilities by an administrator.

If the project being opened is a new project or one that has not been opened by the TRManager previously, TRManager will create a corresponding information file or relational database store for the data element objects, as illustrated in Figure 4-2.

With an open project, the user can enter data through the PMT, TRManager hierarchy or timeline views or wizard or guide, as illustrated in Figure 6-1 to Figure 6-6. As discussed above, the purpose of the wizard or guide is to provide the user with a step by step guided approach to entering key data into TRManager and to being guided through the process of accessing library or templates and utilising the information, data element objects or calculations and reports associated with the templates, as documented earlier in Figure 5-9, Figure 5-16 and Figure 5-17, Figure 5-18 to Figure 5-20, and Figure 5-21 to Figure 5-27. TRManager also allows the user to select a template at any time whilst TRManager is active. The template will make available a library, calculations, reports and associated activities that are related to the template. The templates for reports and calculations to enable analysis of the system over the life cycle can, by way of non-limiting examples only, include performance
management, life cycle costing, comparison, summation, Monte Carlo analysis, sensitivity analysis and deployment, maintenance, costs including annual and total and segmented and support rationale including requirements for spare parts and repair personnel. It will be appreciated that the templates and associated reports and calculations can include any and all conventional data structures, reports and calculations used in systems engineering in any and all industries or organisations.

A major advantage of TRManager’s template capability is that it reduces the user's need to understand the complexities of performance management and systems engineering and associated activities under this umbrella. The user will be able to provide information or use the information provided through the library to construct the system information model, and will be able to calculate and report on performance management and systems engineering and associated activities under this umbrella. Such an approach improves productivity and provides an opportunity for non-technical project managers to gain an indication of risk factors that would normally only be achievable through the use of specialised assistance and separate software applications. The template capability also reduces the time taken by the user to assemble the data objects and system design that make up the system information model. The user can also select other libraries to use in conjunction to the template assigned libraries. The user may opt to not use a template, and may wish to select libraries, calculations and reports on an as needed basis. As illustrated in Figure 6-2 to Figure 6-6, more than one library can be opened at one time in the utility window. Using the utility window, the user can select between libraries such that one is active at a time.

TRManager carries out background computation as the user inputs information into TRManager or makes changes to the data elements or system information model through the PMT. For example, Figure 6-6 illustrates the total cost of the system to be calculated and displayed in a column called “cost” F7A, F7B. It will be appreciated that this is but one example of the many background computations occurring in real time to provide the user with feedback and to identify items that require the user’s attention by being placed in the ToDo list window F3D illustrated in Figure 6-2.

As illustrated in Figure 6-5, the user selects data elements, activities, resources or tasks from the libraries F6C and places them into the system F6D to build up the
system items and activities of the system information model. An activity is one or more tasks or resources that are either contiguous or non-contiguous in time. An example of an activity is system deployment. The system deployment activity might include all of the systems being deployed at one time, or it might provide for systems to be deployed over time in batches. In TRManager, each deployment action is a task. The activities provide a means to bring together similar tasks for the purpose of identification and calculation requirements.

Another example of an activity is transportation, where a single activity and subsequent resource added to the PMT or TRManager is used to reflect the use of transportation throughout the life of the system under study. This is necessary as there are many activities that are included in systems engineering analysis that are not broken down into the fine detail of individual tasks and resources as typically used in the PMT but instead are identified as a single entity over time often the system life. To use the transportation example to show this, there may be 30 transportation actions carried out by a third party organisation per year. For the user’s systems engineering analysis all that is needed is an activity identifying transportation and the properties such as who carries out the action, what is it, the total cost, cost variations and so on.

The user can create system component parts, activities, tasks and resources in the system window of TRManager or for tasks and resources in the PMT. The user can copy any new items created into the appropriate library and save the library if the user has the appropriate security permissions.

The user can select calculations to perform or end-user reports to generate. Information used in the calculations or reports can be collected from TRManager or PMT and can be information from the data objects or computed collation of data objects, system assemblies or other activities. The system can include system assemblies. A system assembly is an item that is a collection of system component parts, such that the assembly parameters or properties reflect the aggregation of the component part parameters or properties.

TRManager also includes the capability to open and save the data objects, templates and libraries to file or relational database. TRManager will attempt to save information to the same data source as that in use by the PMT. If the PMT data source
is not available due to access restrictions, capability or other reasons then TRManager will save the data to a local file or data store.

TRManager includes the logic to transform the input data into a form suitable for the calculations and reports for analysing the system over its life cycle. TRManager also includes a data interface that is able to identify the format of the data objects and to either transform the data object or to place an item in the ToDo list for the user’s attention. An example of this is date formats, language settings and time zones. Date formats may include transformation between short and long dates. In general, TRManager will use the date, time zone, language and currency settings found in the current project under study through the PMT or host settings.

The reporting, document creation, charting capability provided by TRManager are ultimately a means for the user to review current or future decision making in a number of areas, including performance management, system availability, environmental outcomes, financial and resource usage, and other key engineering and management decision areas.

It will be appreciated from the foregoing description that TRManager acts as an umbrella for performance management, risk management, system analysis and systems engineering techniques. Variants and prototypes have application across most industries and markets to reduce development time, identify performance risk and life cycle changes, and improve the probability of system, product or service success.

TRManager allows a top-down functional approach to system design which involves creating and exploiting a hierarchical tree view of system components and related activities. When used in conjunction with a PMT, a user can selectively implement a system design using a bottom-up functional approach or partial top-down and bottom up by alternating between the PMT and TRManager hierarchy and timeline views. TRManager provides an interface for detailed information gathered from the user, the PMT and a library or relational database of the system data element, activity, task and resource items. TRManager also provides performance management, system analysis, risk analysis, life cycle costing, reporting and library functionality to enhance a PMT.

It should also be noted that TRManager provides engineers and project managers with an architecture and approach for the seamless integration of a PMT, which
understands task, time, resource, and cost, with TRManager that understands a system, its component parts, integrates hybrid models and life cycle activities associated with the system. This integration is done in a way that ensures that the existing or legacy PMT or IMS is unaffected and will either operate standalone or in conjunction with the integrated TRManager framework. The actual integration of a PMT and TRManager using specialised software interfaces and techniques provides an enhanced and simplified environment for the user to achieve outcomes that encompass project management, performance management and systems engineering processes.

TRManager also provides a system component parts or data elements library by creating a standard template capability where the user can load, edit or add templates containing, data elements, system items, activities, resources, tasks, component parts or any of these as individual libraries. The provision of system version control and comparison in an easy to use manner enhances the user experience and provides a range of system comparison capability including differences between the system, activities, tasks, resources, time and cost and coalesced factors such as total cost, changes to critical path, performance management and systems engineering functions such as availability, reliability, net present value changes, risk management factors and other computations included under the umbrella of performance management, systems engineering and project management.

The functionality provided by TRManager is an amalgam of the activities that are normally carried out by project managers and engineers in the development and management of large, technically complex products, services and systems. These activities have become fundamental to the process of developing systems or products within many fields of endeavour. Attempts have been made to combine project management with other activities for the purpose of improving or simplifying the process of achieving the information necessary for a company to successfully achieve outcomes in a competitive world. The time to train project managers and engineers in a number of specialisations is expensive and the provision of more than one tool to carry out the functions adds to the complexity and cost of the task.

A further advantage or TRManager is that it removes or reduces the general limitations of conventional project management practices. Project management is an
activity process that may occur for a few hours for a small project through to many years or even decades for large projects. There are a number of phases applied to projects and different project management methodologies use different terminology for the phases and are not uniform in phase length. Project management information is often not static - for example, costs change over time and the length of time to achieve a task may change. Typically reasonable project management tools provide for variability with respect to time by using a technique known as net present value and time and cost variability. Project management must also provide traceability. The public whether as interested parties to a public organisation or as shareholders of a public company are becoming increasingly interested in open governance. Problems still arise, projects still fail and people want to know why. Project managers and engineers need a simple mechanism to continue altering the information in a project plan over time, yet be able to go back to particular points in the project and be able to identify key decisions and key factors affecting major change in the project outcomes.

Against this background, TRManager provides an easy to use integrated functional approach to implement performance management, system analysis, risk analysis and system engineering (including, in particular, performance management, LCC and LCA capability) with information provided by the user while using a PMT. The user may provide the information directly to TRManager, or into the PMT whereby TRManager will automatically update from the PMT.

TRManager also provides the means to implement top-down system analysis design or bottom-up system analysis design of the outcome of the project under study using the PMT. For example, the user may opt to use TRManager prior to using the PMT, thereby creating the system using a top-down approach. Alternatively, the user may opt to use the PMT prior to using TRManager, thereby creating the system using a bottom-up approach.

TRManager is specifically designed to provide an interface that is inherently part of the PMT so as to simplify the learning required by the user to use TRManager. For example, the system is displayed in a hierarchical tree or timeline view in one window. When the user clicks on an item in the tree, the details of the item are displayed in another window. The user is able to display the system component parts library in another window and to add, edit or delete system component parts from the
library. The user can drag the system component parts from the library window and drop them into the appropriate place in the system tree. TRManager will then automatically carry out background tasks so as to reflect the changes to the system in both TRManager and the PMT.

TRManager is also specifically designed to provide means to input system information from either the PMT, from any information source used by the PMT, or from a library, database or XML information source. TRManager provides access to system component information, activity information, computations and reports that provide project managers and engineers with information in the areas of system analysis, risk analysis and systems engineering (including, in particular, performance management, LCC and LCA). TRManager can either integrate into the PMT application in the form of an add-in (or plug-in), or would be able to be run at the same time as the PMT where it is able to access and manipulate the PMT applications data, or would be part of an integrated IMS. In some scenarios, TRManager could therefore be run on a different computer to the PMT application or the data source.

TRManager also removes one of the shortcomings found in many system engineering and project management tools by providing a means to freeze a copy of the system information model being project managed. TRManager provides for the user to continue to work with either the copy or the frozen version of the system information model and to do comparisons between versions. Multiple versions can be frozen over time, thus providing for the current status of the project to be identified at the end of phases or as milestones are achieved over the life cycle.

However, it should be noted that the TRManager characteristics described above are intended only to serve as examples, and that many others are possible with the spirit and the scope of the present research outcome. Likewise, it is important to recall the fact that TRManager is not a black-box panacea for all project management shortcomings. However, achieving the seamless integration of TRManager and a PMT, has provided an approach whereby other performance management or systems engineering activities may now be integrated with generic PMTs.
6.4 Using the TRManager prototype

The current TRManager prototype developed is a fully functional realization of the research outcomes and this section provides a closer look at its use in practice. The TRManager prototype was developed to provide a mechanism to verify and refine the research scope, method and outcomes.

6.4.1 Entering system details

Project information may be entered by clicking on the top node shown as PSA in the TRManager hierarchy view in Figure 6-7 and providing parameters values in the Properties window, Figure 6-7. The TRManager Guide may also be used to enter the Project information and parameter values, Figure 6-8.

The user may select the system icon in the TRManager hierarchy view as shown in Figure 6-9, and enter further details about the system in the Properties window. Also, the TRManager Guide will provide steps for information entry to ensure there is sufficient information for the hybrid model within the TRManager framework to perform calculations.

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6.4.2 Entering activities, tasks and resources

The user can enter task and resource information directly into the Microsoft Office® Project Tasks and Resources sheets including the network diagram and Gantt diagram and this information is ready to be used by TRManager. Figure 6-10 shows Microsoft Office® Project open at the Resources sheet ready for resource information to be entered or altered.
Figure 6-10 Enter a resource into Microsoft Office® Project

Figure 6-11 shows the user entering a Task into the Microsoft Office® Project Tasks sheet and when this is completed, the user is provided with an option to make this task available to TRManager. The user can opt to make all tasks available to TRManager by selecting the option to make this the default action. The user can exclude tasks and resources entered into the Microsoft Office® Project Tasks and Resources sheets from TRManager. This is useful when the user wants to control or limit the tasks and resources used in the system model being analysed using TRManager.

Figure 6-11 Adding a task to Microsoft Office® Project task sheet
6.4.3 Adding resources, tasks and component parts to the system

Resources

The user may create new resources in TRManager or Microsoft Office® Project or add pre-created resources from a library (file or relational database), Figure 6-12. The user can drag and drop library resources onto the current system or by right clicking on a library resource choose Add to System as shown in Figure 6-12.

![Figure 6-12 Adding a library resource to the system model](image)

After selecting the resource, you can enter details in the Property window. Some of the resources are collections of items. To add an item to the collection right click on the collection entry and select Add as shown in Figure 6-13.
After an item has been added to a resource collection, Tool & Testing Equipment as shown in Figure 6-14, the user may select the resource collection item, Production Equipment as shown in Figure 6-14 and enter details in the Properties window.

Figure 6-14 Entering the Production Equipment details

Figure 6-15 shows how a data element may manually added by right clicking on the item and selecting Add. In the example shown in Figure 6-15 a Resource item is being added within the TRManager hierarchy view.

Figure 6-15 Add resource item within the TRManager hierarchy view

Tasks

The user carries out similar steps to add tasks to the system as was carried out to add resources. The user may select the library task, right click and select Add to System or may drag and drop it to the tree node under Tasks as shown in Figure 6-16. The user
may then select the task item and enter details in the Properties window as shown in Figure 6-17.

Figure 6-16 Drag and drop pre-created task into the TRManager hierarchy view

Figure 6-17 Entering task item details using the Properties window

Figure 6-18 shows how a new task data element may be added to the system by selecting the Tasks icon, right clicking and choosing Add.
The user may add items or component parts to the system manually or through the data elements library from a file or a relational database. To activate the library, select Tools -> Library from the prototype toolbar, Figure 6-19. This will activate the library dialog box which allows you to select the library, Figure 6-20.
When a library is selected the library is added to the Parts tab in Figure 6-21. A user can open more than one library connection at a time and can select parts from any of the open libraries as shown in Figure 6-22.

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Figure 6-22 Select an open parts library from the library list

The user may manually add a new system data element to the system by right clicking on the System icon and choosing Add as shown in Figure 6-23. When a new item has been added to the System the user selects the item and changes parameters in the Properties window, Figure 6-24.

Figure 6-23 Add new parts
6.4.4 Study revisions

TRManager provides the user with the capability to make study revisions. A revision copy is created by selecting a system, right clicking and choosing New Revision, as shown in Figure 6-25.

A user may wish to make study revisions at key points in the project. To facilitate future comparison analysis between revisions, Figure 6-26, it is possible to make revisions read-only as shown in Figure 6-27. This is an important feature that provides the user with the ability to carry out what-if analysis between revisions and to identify differences between revisions using comparison and summation analysis. The user is then able to quickly and clearly see where changes have occurred and whether the changes have had a detrimental or positive effect on the hybrid model outcome.

The user may unlock a read-only study revision if there is a need to make changes to the study information.
The user is provided with an option to ensure that individual task properties are identical between the PMT and TRManager. If the user selects a study revision, right clicks and chooses *No Synchronize*, Figure 6-27, then the user may change a task’s properties in TRManager and the changes to the task’s properties will not be altered in the PMT data. This is an important feature that permits the user to carry out what-if analysis in TRManager without affecting the original task properties in the PMT. The
user can reset Task properties between the PMT and TRManager by selecting the study version, right clicking and choosing Full Synchronize as shown in Figure 6-27.

![Figure 6-27 Synchronizing versions within TRManager](image)

### 6.4.5 Example study information

Figure 6-28 to Figure 6-30 show an example study within the TRManager prototype. Figure 6-28 shows the Microsoft Office® Project Tasks sheet, which is a modified Gantt chart. Figure 6-29 shows the example study system in the TRManager hierarchy view window. Figure 6-30 shows the example study system, resources and tasks in the TRManager hierarchy view window.

![Figure 6-28 Microsoft Office® Project Task sheet](image)
Figure 6-29 TRManager prototype showing study system
Figure 6-30 Example of TRManager study system items

6.4.6 Generating reports

Users create TRManager prototype reports by selecting the report that they wish from the TRManager prototype toolbar report menu, Figure 6-31. Reports are generated as html and are viewed using an embedded html viewer. Reports may be viewed and closed or saved using PDF format as shown in Figure 6-32. Examples of the reports are provided in Appendix B.
The user is provided with a shortcut when a comparison report is required. The user may select two study revisions on the revision tree in the TRManager hierarchy view window, right clicking and choosing *Compare* on the context menu as shown in Figure 6-33. The comparison dialog box is raised, Figure 6-34, and the user may select the comparison options required and then obtain the comparison by choosing *OK*. 
6.5 TRManager performance

Examining the performance of TRManager involved a process of testing and validation, which was achieved using a three stage process. The first stage was to create the TRManager prototype application incorporating the CASA (2008) hybrid model. The second stage was to use the TRManager prototype to carry out analysis of a sample system, which in this case is a system provided with the CASA (2008) software application called Tenderer A Full Data. The final stage was to compare the results obtained using TRManager to those achieved for the sample system using the CASA software application (CASA 2008).

The example reports provided in Appendix B are from a test carried out with the TRManager prototype application using a sample data set, which is provided in Appendix F. The reports provide project managers with information that can be communicated to project stakeholders and the project team. The reports can be stored in html or PDF format.
The CASA (2008) total LCC summary is shown in Figure 6-35 and the TRManager prototype LCC summary is shown in the TRManager hierarchy view window in Figure 6-36. The total LCC costs shown are similar and the variation is less than 1%.
6.6 TRManager Outcomes

The implementation of the TRManager research prototype provides numerous outcomes, which may be summarized as follows:

1. A new technique that:

   - Permits obtaining data elements and system information;
   
   - Permits creating an information model of the *system* by selectively and individually linking data elements, including system items, activities with tasks, resources, time and costs associated with the *system*;
   
   - updating the system information model by selectively and individually adding or modifying *system* items, activities, tasks, resources, time, costs and links there between;
   
   - storing versions of the system information model;
   
   - processing versions of the system information model into end-user output information to enable analysis of the *system* including understanding of life-cycle and performance outcomes.

2. TRManager may be implemented as an add-in or plug-in to a PMT or as part of a complete IMS.
3. The PMT software application can be any of the common PMT software applications available today including Microsoft Office® Project™, Artemis®, Deltek OpenPlan and Primavera®.

4. Information sharing with the PMT software application or IMS.

5. The system information model includes at least one of system items, activities, tasks, resources, time, costs and phases relating to at least one of requirements, definition, design, development, manufacturing, testing, deployment, operating, support, environmental impact, sustainability and decommissioning of the system.

6. The system information model and the end-user output information are created and manipulated using libraries and templates.

7. The libraries and the templates are stored in files or a relational database.

8. The libraries include information relating to system data elements, activities, tasks, resources and other system information.

9. The templates are expressed in eXtensible Markup Language (XML) or a format suitable for storage in a file or relational database.

10. The step of processing versions of the system information model may include comparing different versions to provide traceability between iterations of the system over the life cycle.

11. The end-user information to enable analysis of the system over the life cycle includes information relating to at least one of performance management, systems engineering, project management, risk management, life cycle cost, life cycle assessment, environmental impact and system activities of the system project.

12. Computer software for integrating performance management, systems engineering and project management tools, the computer software residing on a computer-readable medium and including instructions for causing a computer to perform the following operations:
• obtain system items, activities, tasks, resources and other system information;

• create an information model of the system by selectively and individually linking system items, data elements, activities of the system with tasks, resources, time and costs associated with the system;

• update the system information model by selectively and individually adding or modifying system items, data elements, activities, tasks, resources, time, costs and links there between;

• store versions of the system information model;

• process versions of the system information model into end-user output information to enable analysis of the system.

13. The computer software may be an add-in or plug-in to a PMT software application or a standalone IMS.

14. Computer software may include common PMT software applications including Microsoft Office® Project™, Artemis®, Deltek OpenPlan and Primavera®.

15. Computer software wherein the system information model accesses tasks, resources, time and costs from the PMT software application.

16. Computer software wherein the system information model includes at least one of system items, activities, tasks, resources, time, costs and phases relating to at least one of requirements, definition, design, development, manufacturing, testing, deployment, operating, support, environmental impact, sustainability and decommissioning of the system.

17. Computer software wherein the system information model and the end-user information are created and manipulated using libraries and templates.

18. Computer software wherein the libraries and the templates are stored in files or a relational database.
19. Computer software wherein the libraries include information relating to system items, data elements, activities, tasks, resources and other system information.

20. Computer software wherein the templates are expressed in eXtensible Markup Language (XML) or a format suitable for storage in a file or relational database.

21. Computer software wherein the step of processing versions of the system information model includes comparing different versions to provide traceability between iterations of the system over the life cycle.

22. Computer software wherein the end-user information to enable analysis of the system over the life cycle includes information relating to at least one of performance management, systems engineering, project management, risk management, life cycle cost, life cycle assessment, environmental impact and system activities of the system project.

23. A method for integrating hybrid models that reflect analysis of a system in the areas of performance management, systems engineering, life cycle costing, life cycle assessment and PMT, substantially as hereinbefore described with reference to the accompanying drawings.

24. Computer software for integrating performance management, systems engineering and PMT, substantially as hereinbefore described with reference to the accompanying drawings.

6.7 Summary

This chapter considered the practical use and performance of TRManager, through the use of screen dumps and associated discussion. To examine the performance of TRManager a prototype incorporating the CASA (2008) hybrid model was created, which was subsequently used to implement the sample system, called Tenderer A Full Data, provided with the CASA (2008) software application. An analysis of the results given by the CASA (2008) model and those of TRManager showed little variation, with the total LCC costs varying by less than 1%.
The implementation of the sample system, illustrated the fact that TRManager is an integrated project management framework or AEE that can be used successfully to carry out an analysis using a hybrid (LCC) model incorporated into TRManager. Moreover, the seamless implementation showed TRManager’s capability to address (1) the practical needs of project managers and (2) the lack of an integrated project management framework, which has proved to be a major barrier to adopting a ‘systems’ life cycle approach.
7 Conclusion

7.1 Introduction

TRManager is a new technique that is the result of research supported by Deemer’s call for the implementation of Advanced Engineering Environments that brings together in a ‘seamless blend of disciplinary functions and activities’ (Deemer 2000) all aspects of the management of a product or service over the entire life cycle.

Management activities are a substantial component of total annual organisation expenditure. The total expenditure on organisation management activities justifies the effort to improve management activity outcomes through the development of better information management systems, processes and practices.

Gantt, PERT and CPM are management science techniques that have been integrated into project management and project information management systems. Gantt, PERT and CPM have proven to be fundamentally important to modern management practices and are essentially graphical techniques, with PERT and CPM being quantitative in nature. TRManager is a graphical technique that is quantitative in nature based on life cycle and performance management principles.

TRManager is a new technique that integrates with information management systems and provides solutions on how to present complex technical information and calculation results using relationships, charts and key indicators.

TRManager is a framework for hybrid models that provide life cycle and performance management outcomes. Life cycle and performance management outcomes are key ingredients in the information mix needed by managers working to achieve successful system oriented project outcomes. TRManager provides a contribution that enhances the opportunity to achieve successful project outcomes including “on time”, “on budget” and “on performance”.

7.2 Research contributions

The research has been completed with all of the objectives met successfully. The research provides a contribution by demonstrating how life cycle and performance management may be integrated with other management activities. A further
contribution is provided by identifying through a survey of project managers of the current understanding of life cycle and performance management activities and how they are applied and by whom there applied within projects and organisations.

TRManager provides a new technique that may be incorporated into information management systems or project management tools and the research outcome contributes by providing the capability to perform life cycle and performance management together with other management practices.

TRManager leverages the principals of Gantt, PERT and Critical Path Method. The underlying similarities in the data elements used within project management tools for Gantt, PERT and Critical Path Method provides the basis for the data elements needed by TRManager. With the addition of a system data element project management tools or other information management systems may incorporate TRManager and thereby provide users with life cycle and performance management capability.
8 Future work and outcomes

8.1 Introduction

The research has highlighted the opportunity to integrate activities carried out by specialists with those carried out by people with a more general background. Improvements in technology and training make it possible to simplify education and provide information management systems which are more suitable a wider range of project managers.

8.2 Specialist activities

The research outcomes provide an approach to integrate life cycle and performance management into information management systems. Other specialist activities may be incorporated into information management systems using an approach similar to that provided by TRManager.

Specialist activities including performance management may be represented by many models including hybrid life cycle models that represent different products and systems. Further development of the models and frameworks, including TRManager should occur to test the integration of models and information management systems.

8.3 Project management

Project management practices and processes are being continually reviewed and refined. Future work may include a review of project management effectiveness when project managers gain access to new information management systems that include TRManager and specialist activities. An opportunity exists to research how project risk and failure may be further reduced through improvements to information management systems.

Organisations may participate in research into the use of information management systems that incorporate TRManager and hybrid models. Research may provide more certainty for organisations on how to implement integrated systems that permit all stakeholders to provide information that is used to better manage projects.

Investigation into how companies implement project management practices, processes and tools and how this may be done with new information management systems
would provide a valuable insight and point to how to improve access and implementation. The impact of the cost of implementing project management practices, processes and tools may be a significant factor, and it may be possible to research the effect of reducing the cost through the introduction of a single integrated information management system.

8.4 Complexity versus simplicity

Further research may consider each of the specialist activities undertaken as part of the management of a major project and to identify the key outcomes that each specialist management activity produces. A review of these key outcomes using input from project managers, project teams and key stakeholders may identify trends as to which key outcomes are used more often and the priority affecting use. It may be possible during the development of modern information management systems to further develop the hybrid models used to represent the specialist activities.

An approach that may be researched is to consider the use of most modern calculators. There is still a need for calculators that carry out a few basic functions and may be converted to device making more functions available through extra feature buttons. Further research may identify what functions are needed for project managers to gain a reasonable or significant improvement in functionality provided by information management systems or project management tools.

To achieve a functional improvement whilst maintaining reasonable complexity and cost further research may consider ways to improve the acquisition of data from stakeholders and how to manipulate and store this information. Specialist activities may require a reasonably large amount of input data for analysis and outcomes to be achieved.

8.5 Training

Key personnel and project managers come from many different backgrounds and have different life experiences and education to draw upon. Training is an important learning activity for key personnel and project managers. Further research into training approaches and new courses utilising information management systems and project management tools incorporating TRManager may be carried out.
The TRManager prototype is now used at RMIT University in the postgraduate course AERO 2390 Systems Engineering Design Tools. The course, AERO 2390, ran for the first time in Semester 2 2005 and is scheduled to run annually. By undertaking AERO 2390 future project managers gain an understanding of life cycle and performance management using an integrated environment. Further research into the use of TRManager as a course aid is being carried out. The course guide for AERO 2390 is attached at Appendix E.
9 Bibliography


Australia, Department of Finance and Administration 2001a, Commonwealth policy principles for the use of private financing, Department of Finance and Administration, Canberra, paras. 25, 41.

Australia, Department of Finance and Administration 2001b, Commonwealth procurement guidelines and best practice guidance, Department of Finance and Administration, Canberra, pp. 5-6.

Australia, Department of Finance and Administration 2005a, Commonwealth procurement guidelines – January 2005, Department of Finance and Administration, Canberra. (ISBN 0-9752394-6-5)

Australia, Department of Finance and Administration 2005b, Guidance for complying with legislation and Government policy in procurement, Department of Finance and Administration, Canberra. (ISBN 0-9757365-0-7)


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Cooper, R 1990c, ‘Explicating the logic of ABC’, *Management Accounting (UK)*, November, pp. 58-60.


Davis, EW 1974a, ‘CPM use in top 400 construction firms’, *Journal of the Construction Division, American Society of Civil Engineers*.


Meredith, JR, Shafer, SM & Turban, E 2002, Quantitative business modeling, South-Western, Cincinnati.


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Appendix A Research outcomes

An application was submitted for an Australian Government Commercialising Emerging Technology (COMET) grant (COMET 2004) to support development of the prototype and intellectual property. A COMET grant was awarded in 2005. COMET is a competitive, merit based program that supports early-growth stage and spin off companies to successfully commercialise their innovations.

In 2004 a preliminary patent claim was lodged with the Australian Patent Office titled “METHOD AND COMPUTER SOFTWARE FOR INTEGRATING SYSTEMS ENGINEERING AND PROJECT MANAGEMENT TOOLS”. In April 2006 an International Report on Patentability – Chapter 2 (IPRP-2) was issued by the Australian Patent Office on International Patent Application Number PCT/AU2005/000054 that indicates the application is novel, inventive and has industrial applicability.
Appendix B  Reports

Appendix 2 contains examples of the LCCA reports produced using the prototype software application for an example data set. The reports included in the prototype software application were selected so as to provide a means to verify the LCCA by comparing against results created using other standard LCCA software applications. There is an opportunity in future work to refine the reports and to provide more integration with MOP reports.

Appendix B.1   Availability Report

<table>
<thead>
<tr>
<th>LRU Name</th>
<th>Unit Cost</th>
<th>QPS</th>
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<th>RTOK</th>
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**Summary**

- LRU Spares Cost per Location : $67,805.00
- System Logistic Availability : NaN
- System Inherent Availability : 0
- System Operational Availability : NaN
Appendix B.2  Life Cycle Cost

Study Name : XYZ Computer Labs [Revision1]

Starting Date : 1/01/2000

Duration : 120 months

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Appendix B.3  Support Rationale

Study Name : XYZ Computer Labs [Revision1]

Starting Date : 1/01/2000

Duration : 120 months

**General Input Information**

Average Monthly System Operating Hours  100
System Operator Required Portion                  1
System Operation Labor Rate ($/Hr)   20
Support Equipment And Spares Factor      0.8
Repair Time Portion Spent on RTOK Failures  0.05

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<th>Depot</th>
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<td>Modem Interface</td>
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<td>0.00</td>
</tr>
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</table>
### Item Name | Repair Level | Removal Level | RTOK | MCPR | NRTS | NRTS TAT | COND | COND TAT
---|---|---|---|---|---|---|---|---
Modem Cable | INTERMEDIATE | INTERMEDIATE | 0.00 | 5.00 | 0.00 | 0.00 | 0.40 | 1.00

### Item Name | Unit Cost | QPNHA | MTBF | Spares
---|---|---|---|---|---|---|---
Scheduled Computer Maintanence | 0.00 | 1 | 1,800 | 0 | 0 | 0 | 0
Computer System | 5,000.00 | 1 | 322 | 0 | 0 | 0 | 0
Computer | 1,200.00 | 1 | 3,840 | 0 | 1 | 0 | 0
Power Supply | 200.00 | 12 | 8,000 | 0 | 1 | 3 | 3
Electronics Board | 800.00 | 12 | 8,000 | 0 | 1 | 4 | 4
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<th>MTBF</th>
<th>Spares</th>
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Appendix B.4  Research, Development, Testing and Evaluation

Study Name : XYZ Computer Labs [Revision1]

Starting Date : 1/01/2000

Duration : 120 months

Research, Development, Testing and Evaluation Proportion

Research and Development 20%

Demonstration & Validation 30%

System/Project Management 5%

System Test & Evaluation 20%

Training 10%
Data 5%
Software Center 10%
Other 0%

Total Research, Development, Testing & Evaluation $3,000,000.00

Total RDT&E for Hardware Items $0.00

Total RDT&E Cost $3,000,000.00
Appendix B.5  Maintenance Man-Hours per Month and Maintenance Personnel per Location

Study Name : XYZ Computer Labs [ Revision1 ]

Starting Date : 1/01/2000

Duration : 120 months

Maintenance Man-Hours per Month per Location

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<th>2003</th>
<th>2004</th>
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<th>2006</th>
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<th>2008</th>
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## Maintenance Personnel per Location

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<th>2004</th>
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Appendix B.6 Deployment Data

Study Name: XYZ Computer Labs [Revision1]

Starting Date: 1/01/2000

Duration: 120 months

Number of Operating Systems

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### Number of Locations

*With Average Number of Systems*

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*With Maximum Number of Systems*

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<tr>
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### Operating Systems per Location

*With Average Number of Systems*

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<th>2006</th>
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<th>2008</th>
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<td>5.00</td>
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</table>

*With Maximum Number of Systems*

<table>
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<th>2002</th>
<th>2003</th>
<th>2004</th>
<th>2005</th>
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Appendix B.7  Annual Cost

Study Name : XYZ Computer Labs [Revision1]
Starting Date : 1/01/2000
Duration : 120 months

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Copyright Mark A Gregory 2008 204
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Copyright Mark A Gregory 2008 205
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| Misc. Acq. Costs | 5,000.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 5,000.00 | 0.00 | 5,000.00 | 0.00 |
| Warranty | 1,000.00 | 1,000.00 | 1,000.00 | 1,000.00 | 1,000.00 | 1,000.00 | 1,000.00 | 1,000.00 | 1,000.00 | 1,000.00 | 1,000.00 | 10,000.00 | 0.00 |
| Total Acq. Cost | 1,616,434.02 | 1,000.00 | 1,000.00 | 1,000.00 | 1,000.00 | 1,000.00 | 1,000.00 | 1,000.00 | 1,000.00 | 1,000.00 | 1,000.00 | 1,625,434.02 | 148,540.02 | 1,476,894.02 | 0.22 |
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Appendix B.8  Annual Cost Comparison

Base : XYZ Computer Labs [Revision1]

Started on 1/01/2000. Duration is 120 months

Alternative : XYZ Computer Labs[Revision1(1.1)]

Started on 1/01/2000. Duration is 120 months

Research, Development, Testing and Evaluation Costs

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#### Research, Development, Testing and Evaluation Costs

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**Summary**

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Copyright Mark A Gregory 2008 222
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## Appendix B.9 Summation (Constant Dollars)

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## Annual Costs

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Appendix B.10 Risk Analysis Sub-Model

Study Name : Tenderer A Full Data [ Revision1 ]

Starting Date : 1/01/2000

Duration : 300 months

LCC Monte Carlo Results

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Appendix B.11 Sensitivity Analysis

Study Name: Tenderer A Full Data [Revision1]
Starting Date: 1/01/2000
Duration: 300 months

Condemnation Rate

Sensitivity: $496,815.04

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<th>Acquisition</th>
<th>O&amp;S Cost</th>
<th>Total LCC</th>
<th>Operational Availability</th>
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Material Cost Per Repair

Sensitivity: $ 388,940.32

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Mean Time Between Failures

Sensitivity: $-3,640,387.35

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Mean Time to Repair

Sensitivity: $ 1,506,605.27

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Not Repair This Station

Sensitivity: $ 0.00

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ReTest OK

Sensitivity: $ 0.00

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### Spares Turnaround Time

**Sensitivity:** $239,719.38

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Unit Cost

Sensitivity: $ 798,435.21

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Sensitivity: $ -77,097.24

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### Maintenance Labor Rate

Sensitivity: $1,507,349.24

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## Maintenance Personnel Turnover Rate

Sensitivity: $ 66,024.00

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### Shipping Cost Per Pound

**Sensitivity:** $10,000.00

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### Spares Confidence Level

Sensitivity: $359,040.00

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Percent Labor for RTOK

Sensitivity: $ 0.00

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### Production Quantity Slope

Sensitivity: $0.00

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<th>Acquisition</th>
<th>O&amp;S Cost</th>
<th>Total LCC</th>
<th>Operational Availability</th>
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Production Rate Slope

Sensitivity: $0.00

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### System Operating Hours Per Month

Sensitivity: $3,451,862.24

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Appendix C  Survey Questions

This appendix contains the survey questions used to gain data for the research needs analysis. The survey was provided to project managers for completion during a session at the PMOz 2005 conference held in Brisbane Australia.

Your participation with this survey will provide information that will be used in doctoral research into the effectiveness of software applications for project management and associated activities. The survey includes questions about four activities carried out in the project life cycle. An important part of the survey is to gather your understanding of each activity. For this reason definitions for the activities are not provided.

The survey should take about 10 minutes to complete and is on both sides of this paper.

By participating in this survey you give your consent for the information you provide to be used in the research analysis and report. Individual responses will remain confidential, will not be published and may be retained for further analysis.

1. Corporate Information
   1.1 What industry sector(s) does this company operate in? Give a percentage ranking if more than one.
      1.1.1 Agriculture, Forestry and Fishing
      1.1.2 Mining
      1.1.3 Manufacturing
      1.1.4 Electricity, Gas and Water Supply
      1.1.5 Construction
      1.1.6 Wholesale Trade
      1.1.7 Retail Trade
      1.1.8 Accommodation, Cafes and Restaurants
      1.1.9 Transport and Storage
      1.1.10 Communication Services
      1.1.11 Finance and Insurance
      1.1.12 Property and Business Services
      1.1.13 Government Administration and Defence
      1.1.14 Education
      1.1.15 Health and Community Services
      1.1.16 Cultural and Recreational Services
      1.1.17 Personal and Other Services

   1.2 How would this company’s business structure be categorized?
      1.2.1 Publicly listed
      1.2.2 Public
      1.2.3 Private
      1.2.4 Wholly owned government
      1.2.5 Joint venture (please specify whom)
      1.2.6 Other (please name)

   1.3 Is the company a subsidiary of an overseas company?
      1.3.1 Yes/No (Please name companies)

   1.4 What is the approximate turnover of the company?

   1.5 How many people does the company employ in Australia?

   1.6 Where does the company operate its non-office base processes? (Specify locations)

2  General Project Management Information

   2.1 Is there a written company project management guideline?
      2.1.1 Does it include a mission statement?
      2.1.2 Does it include objectives?
      2.1.3 Does it include social, environmental or sustainable objectives?
      2.1.4 Does it reference standards?
      2.1.4.1 If so which ones?

   2.2 Who do project managers report to?
      2.2.1 CEO
      2.2.2 CTO
      2.2.3 CFO
      2.2.4 Other (Please specify)

   2.3 What project management methodology does your company use?
      2.3.1 Prince2
      2.3.2 PMI IT Management Methodology
      2.3.3 Defence Project Management Methodology
      2.3.4 Other (Please specify)

3  Personal Information

   3.1 What is your highest tertiary qualification?
      3.1.1 None
      3.1.2 TAFE Qualification
      3.1.3 Bachelors Degree
      3.1.4 Graduate Diploma
      3.1.5 Masters Degree by coursework
      3.1.6 Masters Degree by research
      3.1.7 PhD
      3.1.8 Other (Please specify)

   3.2 What project management qualifications do you hold?
      3.2.1 PMP
      3.2.2 PMReg
      3.2.3 Other (Please specify)

   3.3 Are you a Company Director?
      3.3.1 Yes/No
4 Project Management Tools
4.1 What project planning and scheduling tool does your company use?
4.1.1 Microsoft Project
4.1.2 Open Plan
4.1.3 SureTrak
4.1.4 Other (please specify)

4.2 Please identify the tools and software applications that your company uses for the following activities?
4.2.1 Life Cycle Costing
4.2.2 Life Cycle Analysis
4.2.3 Value Chain Analysis
4.2.4 Activity Based Costing
4.2.5 Environmental Impact Statement
4.2.6 Other project management activity (Please specify)

4.3 Identify the major weaknesses of the tools and software applications that your company uses (one or more)
4.3.1 Importing data
4.3.2 Exporting data
4.3.3 Communicating between tools
4.3.4 Communicating with team members
4.3.5 Compatibility of applications
4.3.6 Differences with standards?
4.3.7 Differences with local legislation, regulations or procedures?
4.3.8 Lack of features?
4.3.8.1 If so what features?

4.4 Does your project management tool permit you to import task and resource information from a data source?

4.5 Does your project management tool permit you to import task and resource information from a library?

5 Life Cycle Costing (LCC) Tools
5.1 Do you know what Life Cycle Costing is?
5.1.1 Yes/No
5.1.2 If yes, please provide a definition of your understanding of what LCC is.

5.2 Has a LCC been conducted and/or used in the company?
5.2.1 Yes/No (if No go to Q8.1)
5.2.2 If Yes on what and when?

5.3 What were the reasons for carrying out the LCC?

5.4 Is a LCC analysis carried out for every project?
5.4.1 Yes/No

5.5 Who does the LCC?
5.5.1 Project Manager
5.5.2 External Consultant
5.5.3 Internal Engineer
5.5.4 Other (Please specify)

5.6 What kind of benefits would the company see with using LCC?

5.7 What were the outcomes?

5.8 What were the difficulties encountered?

5.9 Were the results applied within the company?

5.10 Were the results used as a component of another company’s LCC?

5.11 Is the LCC being used now?

5.12 Will it be used in the future?

5.13 Has the company been asked for LCC data?
5.13.1 If yes, was the information supplied and in what form?

5.14 If no, what are the reasons for not applying it?

6 Activity Based Costing (ABC) Tools
6.1 Do you know what ABC is?
6.1.1 Yes/No
6.1.2 If yes, please provide a definition of your understanding of what ABC is.

6.2 Has Activity Based Costing (ABC) been applied in the company?
6.2.1 YES/NO (if No go to Q8.3)
6.2.2 If yes, on what and when?

6.3 What kinds of benefits would the company see with using ABC?
6.4 If no, what are the reasons for not applying it?

7 General Costing Philosophy
7.1 Within your company what do you believe the costing priorities to be? (please give a rank out of 1-10 with 10 high)
7.1.1 Management costs
7.1.2 Administration costs
7.1.3 External costs including permits, Government, etc.
7.1.4 Materiel costs
7.1.5 Personnel costs
7.1.6 Environmental costs
7.1.7 Whole of Life costs

7.2 Can you name three items that currently do not exist in the company’s costing system that would be valuable to have?

8 Thank you for your participation
8.1 Would you participate in a follow-up interview? (Yes / No)
8.2 If yes, Your Name

8.3 If yes, Your Email

The information provided in this survey will remain confidential and only compiled results from all of the survey participants will feature in the PHD thesis. If you wish to know more about the purpose of the research or to talk more about your answers to the questions please contact Mark Gregory mark.gregory@rmit.edu.au Mobile: 0418 999 089
Appendix D Life Cycle Costing Analysis Calculations

The LCCA model used in the prototype is based on the CASA 3.1 model. The key calculations included in the prototype from the CASA 3.1 model are shown in this appendix.

Table D-1 Research, development, test and evaluation cost calculations

<table>
<thead>
<tr>
<th>Item</th>
<th>Equation</th>
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<tbody>
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<td>1</td>
<td>RDT&amp;E Cost Equation</td>
</tr>
<tr>
<td></td>
<td>[ TRDTE = \sum_{i=1}^{LIFEYR} RDTECOST + \sum_{i=1}^{N} RDTEi ]</td>
</tr>
<tr>
<td></td>
<td>LIFEYR = The study life in years</td>
</tr>
<tr>
<td></td>
<td>= LIFE/12 (raised to the next higher integer, if fractional)</td>
</tr>
<tr>
<td></td>
<td>LIFE = The study life in months.</td>
</tr>
<tr>
<td></td>
<td>NI = Number of Hardware Items.</td>
</tr>
<tr>
<td></td>
<td>RDTECOSTi = The cost of RDT&amp;E in year i.</td>
</tr>
<tr>
<td></td>
<td>RDTEi = The RDT&amp;E cost for hardware item i.</td>
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</table>

| 2 | Acquisition Costs – Total |
|   | \[ TACQ = \sum_{y=INNER}^{ENDYR} \left[ TPTTEy + TPSUCy + TSAy + TSSSCy + TRPPy + TICy + TSECy + THSCy + \right. |
|   | \left. TSRCy + TTDCy + TITCy + TCTD + TCNFy + TIIMy + TISWDCy + TWTYy \right] \] |
|   | TACQ = Total Acquisition Cost. |
|   | INITYR = The initial year of the study. |
|   | ENDYR = The last year of the study. |
|   | = INITYR + LIFEYR - 1 |
|   | LIFEYR = The study life in years. |
|   | = LIFE/12 (raised to the next higher integer, if fractional) |
|   | LIFE = The study life in months. |
|   | TPTTEy = Cost of production tooling and test equipment in year y. |
|   | TPSUCy = Cost of production start-up in year y. |
|   | TSAy = Cost of system acquisition in year y. |
|   | TSSSCy = Cost of system shipping and storage containers in year y. |
|   | TECNRCy = Cost of pre-production engineering non-recurring in year y. |
|   | TRPPy = Cost of pre-production units refurbishment in year y. |
|   | TICy = Cost of installation in year y. |
|   | TSECy = Cost of support equipment in year y. |
|   | THSCy = Cost of hardware spares in year y. |
|   | TSRCy = Cost of spares reusable containers in year y. |
|   | TTDCy = Cost of technical data in year y. |
|   | TIIMy = Cost of initial item management in year y. |
|   | TISWDCy = Cost of initial software development in year y. |
|   | TMIACy = Cost of miscellaneous acquisition in year y. |
|   | TWTYy = Cost of warranty in year y. |
2.1 Acquisition Costs - Hardware Spares Cost Equation

\[ THS_C(y) = \sum_{k=1}^{NM} \sum_{i=1}^{NI} (\max[0, QSPR_{iky} - MAXSPR_{iky-1}]) (COST_i) (KZ) \]

- **QSPR_{iky}** = The total quantity of ith item spares required at all locations at the kth maintenance level in year y.
- **MAXSPR_{iky}**(y-1) = The maximum total quantity of ith item spares required at all locations at the kth maintenance level from year 1 to year y-1.
- **COST_i** = The unit cost of a spare for the ith item.
- **KZ** = The unit cost of a spare for the ith item.
- **NI** = The number of hardware items added to study.
- **NM** = The number of Maintenance Levels identified in study.

2.1.1 \[ QSPR_{iky} = (LOCSR_{iky})(MAXLOC_{ky}) \]

- **LOCSR_{iky}** = The quantity of ith item spares required at each location at the kth maintenance level in year y.
- **MAXLOC_{ky}** = The maximum number of locations at the kth maintenance level in year y.

2.1.2 \[ MAXLOC_{ky} = \frac{MAXSYS_{ky}}{NOPS_k} \]

- **MAXSYS** = The maximum number of operating systems is year y.
- **NOPS_k** = The maximum allowable number of operating systems supported by each location at the kth maintenance level.

2.1.3 \[ MAXSYS_{y} = \max_{m=1}^{12} \{TSYS_{my}\} \]

- **TSYS_{my}** = The total number of operating systems in month m of year y.

2.1.4 \[ TSYS_{my} = \sum_{z=1}^{N} \left[ T(y > YRDEP_z) \sum_{m=1}^{12} NSYS_{mz} + T(y = YRDEP_z) \sum_{m=1}^{12} NSYS_{mz}^2 \right] \]

- **YRDEP_z** = The year in which the deployment or removal of systems will take place for the zth set of deployment inputs.
- **NSYS_{mz}** = The number of systems to be deployed in month m for the zth set of deployment inputs.

2.1.5 \[ LOCSR_{iky} = FSPR\left[\left(\frac{SESF}{NLT_{iky}}\right), CL_k\right] \]

- **SESF** = Support equipment and spares factor used to adjust system operating hours for the calculation of support equipment and spares.
- **NLT_{iky}** = The expected number of demands on the ith item within the spares turnaround time at the kth maintenance level in year y. This is often referred to as N-Lambda-T.
- **CL_k** = The spares no-stockout confidence level at the kth maintenance level.

2.1.6 \[ FSPR\{d; c\} = \sum_{x=c}^{\infty} \left( e^{-d} \frac{d^x}{x!} \right) \geq c \]

- **FSPR\{d; c\}** = The Poisson distribution function used to determine required spares quantities with a demand rate of “d” and a confidence level of “c”. Time between demands for items is assumed to follow the exponential distribution. Thus, the quantity of demands within a certain time interval follows the Poisson distribution.
- **FSPR\{d; c\}** = The minimum value of s.
2.1.7

\[
\begin{align*}
NLT_{iky} &= (DPM_{iky}) \times \left( \frac{[0.9 - NRTS] \times \text{SPLAN}_{iky}}{\text{MAXFAC}_{iky}} \right) \\
NLT_{iky} &= (DPM_{iky}) \times \left( \text{NRTS} \times \text{SPLAN}_{iky} \right) \\
NLT_{iky} &= (DPM_{iky}) \times \left( \text{MAXFAC}_{iky} \times \text{SPLAN}_{iky} \right)
\end{align*}
\]

DPM\(_{iky}\) = The expected number of demands per month on the ith item per kth level location in year y.

MAXFAC\(_{iky}\) = The factor used to adjust variables at the kth maintenance level in year y so that the maximum number of systems is assumed instead of the average number of systems.

NRTS\(_i\) = The portion of failures of the ith item that is not repairable at the designated primary maintenance level.

SPLAN\(_{iky}\) = The average turnaround time in months for spares for the ith item at the kth maintenance level.

NRTSTAT\(_i\) = The average turnaround time in months for the ith items that are not repairable at the designated primary maintenance level.

CONDi = The portion of failures of the ith item expected to be condemned.

CONDTATi = The number of months required to replace spares of the ith item that were used to replace condemned items.

2.1.8

\[QSPR_{iky} = \max \left\{ QSPR_{iky} \right\} \]

QSPR\(_{iky}'\) = The total quantity of ith item spares required at all locations at the kth maintenance level in year y.

2.2

Acquisition Costs - Initial Item Management Cost Equation

\[YRIIM = \left[ T(YRIIM = y) \right] \times QTYNIP \times CSTPNI \]

YRIIM = The year in which the initial item management cost will be incurred.

QTYNIP = The total number of new parts or assembly types to be introduced into the inventory.

CSTPNI = The cost to introduce a new part/assembly type into the government inventory.

2.3

Acquisition Costs - Initial Software Development Equation

\[TISWDC = (TOTISWDC) \times SWPORTy \]

TOTISWDC = The total initial software development cost.

SWPORT\(_y\) = The portion of total initial software development cost incurred in year y.

2.3.1

\[TOTISWDC = (TEFFMM \times 160.0) \times SWLR \]

TEFFMM = Total initial software development effort in man-months.

160.0 = Man-hours per man-month.

SWLR = The average labor rate ($/hr) for the developers of the initial software.

2.3.2

\[TEFFMM = (4.0) \times (PEM) \times (EKDSI)^2 \]

PEM = Product of all effort multipliers for the appropriate software cost driver ratings.

EKDSI = Equivalent thousands of line of delivered source instructions.

2.3.3

\[PEM = \prod_{x=1}^{15} EM_{n,SWDRIVn} \]

EM\(_{n,SWDRIVn}\) = The effort multiplier for the nth software development cost driver with a rating of SWDRIV\(_Pn\).
2.3.4

\[ EKDSI = SWNEWL + (0.12)(SWRUL) + (0.017)(SWRELSWNEWL) \]

SWNEWL = The amount of new or modified software for the initial software
development effort in thousands of delivered lines of source
instructions (KDSI).

SWRUL = The amount of reused software for the initial software development
effort in thousands of delivered lines of source instructions.

SWRELSWNEWL = The amount of retained software for the initial software development
in thousands of delivered lines of source instructions.

0.12, 0.017 = Weighting constants.

2.3.5

\[ TDEV = 2.2(TEFFMM)^{0.32} \]

TDEV = Total initial software development schedule in months.

TEFFMM = Total initial software development effort in man-months.

2.3.6

\[ SWPORT_y = \frac{SWINPC_y}{\sum_{y=INTYR}^{ENDYR} SWINPC_y} \]

SWINPCy = The portion of total initial software development cost to take place in
year y (from the input file).

INTYR = The initial year of the study.

ENDYR = INTYR + LIFEYR - 1

2.3.7

\[ LIFEYR = \frac{LIFE}{12} \]

LIFE = The study life in months.

2.4

Acquisition Costs - Initial Training Cost Equation

\[ TITC = \sum_{n=1}^{N} \left[ T(\text{YRCRSE}_n = y) \right] (\text{CLSDEV}_n + \text{INCOS}_n + \text{TRCOS}_n) \]

YRCRSEn = The year in which the nth initial training course will be held.

CLSDEVn = The cost to develop the nth initial training course.

INCOSn = The cost for instructors for the nth initial training course.

TRCOSn = The cost for trainees for the nth initial training course.

2.4.1

\[ \text{CLSDEV}_n = (\text{CLSHRS}_n \times \text{CSTPH}_n) \]

CLSHRSn = The number of hours in the nth initial training course.

CSTPHn = The cost per class hour to develop the nth initial training course.

2.4.2

\[ \text{INCO}_n = (\text{CLSHRS}_n \times \text{TNOI}_n \times \text{TLR}I_n) \]

CLSHRSn = The number of hours in the nth initial training course.

TNOIn = The number of instructors required for the nth initial training course.

TLRIn = The hourly instructor labor rate for the nth initial training course
(including overhead, G&A, and profit).
2.4.3

\[ TRCOS_n = (MEN_n) \left[ (CLSHRS_n + 8TLR_n) + (NOD_n \times DIEM) + TRANS \right] \]

MENn = The total number of trainees attending the nth initial training course.
CLSHRSn = The number of hours in the nth initial training course.
8 = The number of hours allowed for travel to and from the course (round-trip).
TLRn = The average labor rate ($/hour) of trainees attending nth initial training course.
NODn = The number of days the nth initial training course runs (including weekends and holidays).
DIEM = The per diem allowance per day per trainee for initial training.
TRANS = The average round trip transportation cost per trainee sent for initial training.

2.5

**Acquisition Costs - Installation Cost Equation**

\[ TIC_y = \sum_{z=1}^{N} \left[ T(YRDEP_z = y) \right] \sum_{m=1}^{12} \left[ T(NSYS_m > 0) \right] (NSYS_m \times STALL) \]

YRDEPz = The year in which the deployment or removal of systems will take place for the zth set of deployment inputs.
NSYSmz = The number of systems to be deployed in month m for the zth set of deployment inputs.
STALL = The installation cost per system.

2.6

**Acquisition Costs - Miscellaneous Acquisition Cost Equation**

\[ TMAC_{y} = \sum_{z=1}^{NMAC_y} \sum_{z=1}^{NYMAC_z} \left[ T(YRMAC_{z} = y) \right] CSTMAC_{z} \]

NYMACn = The number of years that cost will be incurred for the nth miscellaneous acquisition cost category.
YRMACnz = The year in which the zth (z = 1, 2, ..., NYMACi) cost for the nth miscellaneous acquisition cost category will be incurred.
CSTMACnz = The cost in the zth year for the nth miscellaneous acquisition cost category.

2.7

**Acquisition Costs - New or Modified Facilities Cost Equation**

\[ TCNF_y = \sum_{n=1}^{N} \left[ T(YRFACIL_n = y) \right] (NSQFT_n \times CSTNSQFT_n) \]

YRFACILn = The year in which the cost of the nth new or modified facility will be incurred.
NSQFTn = The number of square feet in the nth new or modified facility.
CSTNSQFTn = The average cost per square foot for the nth new or modified facility.
T() = Truth function. Throughout the algorithm when the letter T is used with a statement in parentheses immediately afterwards it represents the truth function. If the statement within the parentheses is true, then \( T() \) is equal to one; if false, then \( T() \) equals zero. For example, \( T(3+2=5) = 1 \), while \( T(7+3=5) = 0 \).

2.8

**Acquisition Costs - Pre-Production Engineering Non-Recurring Cost Equation**

\[ TECNRC_y = \sum_{n=1}^{N} \left[ T(YRNR_n = y) \right] CSTNR_n \]

YRNRn = The year in which the nth pre-production engineering non-recurring cost is incurred.
CSTNRn = The total cost of the nth pre-production engineering non-recurring activity.
T() = Truth function. Throughout the algorithm when the letter T is used with a statement in parentheses immediately afterwards it represents the truth function. If the statement within the parentheses is true, then \( T() \) is equal to one; if false, then \( T() \) equals zero. For example, \( T(3+2=5) = 1 \), while \( T(7+3=5) = 0 \).
N = The number of Pre-Production Engineering Non-Recurring Costs added to system.
Acquisition Costs - Pre-Production Units Refurbishment Cost Equation

\[ TRPP_y = \left[ T(YRREF = y) \right] \left[ N \cdot CSTREF \right] \]

- **YRREF** = The year in which the pre-production units will be refurbished.
- **N** = The number of pre-production units to be refurbished.
- **CSTREF** = The average cost to refurbish each pre-production unit.

Acquisition Costs - Production Start-Up Cost Equation

\[ TPSUC_y = \left[ T(YRTPSU = y) \right] \left[ TPSU \right] \]

- **YRTPSU** = The year in which the production start-up cost is incurred.
- **TPSU** = Production start-up cost.

Acquisition Costs - Production Tooling and Test Equipment Cost Equation

\[ TPTTE_y = \sum_{n=1}^{N} \left[ T(YRTTE = y) \cdot CSTPTTEn \right] \]

- **YRTTE** = The year in which the nth production tooling or test equipment cost is incurred.
- **CSTPTTEn** = The cost of the nth production tooling or test equipment.
- **N** = The number of Production Tooling and Test Equipment items added to system.

Acquisition Costs - Spares Reusable Containers Cost Equation

\[ TSRC_y = \sum_{n=1}^{N} \left[ T(YRRSC = y) \cdot TCCTn \right] \]

- **YRRSCan** = The year in which the nth reusable container’s cost will be incurred.
- **TCCTn** = The total cost for the nth reusable containers.

Acquisition Costs - Support Equipment Cost Equation

\[ TSEC_y = \sum_{k=1}^{NM} \left[ \left( SEAC_{ky} \right) \cdot \left( 1.0 + SUPP_k \right) \right] \]

- **SEACky** = The support equipment acquisition cost at the kth maintenance level in year y.
- **SUPPk** = The initial cost of support equipment spare modules, piece parts, and material for repair of support equipment at the kth maintenance level, expressed as a decimal fraction of support equipment acquisition cost.
- **NM** = Number of maintenance levels.

2.13.1

\[ SEAC_{ky} = \sum_{j=1}^{NSE} \left( \max \{0; QSE_{jky} - MAXSE_{j(k(y-1))} \} \cdot SCST_j \right) \]

- **QSEjky** = The quantity of the jth item of support equipment required at all locations at the kth maintenance level in year y.
- **MAXSEj(k(y-1))** = The maximum total quantity of jth support equipment required at all locations at the kth maintenance level from year 1 to year y-1.
- **SCSTj** = The average unit cost of the jth item of support equipment.

2.13.2

\[ QSE_{jky} = \left( LOCSE_{jky} \right) \cdot \left( MAXLOC_{ky} \right) \]

- **LOCSEjky** = The quantity of the jth item of support equipment required at each location of the kth maintenance level in year y.
- **MAXLOCky** = The maximum number of locations at the kth maintenance level in year y.
2.13.3

\[ LOCSE_{ky} = \left( \frac{MAXFAC_{ky}}{ASE_{k}} \right) \left( SEUTIL_{jky} \right) \left( SESF \right) \left( UF_{k} \right) \]

MAXFAC\(_{ky}\) = The factor used to adjust variables at the kth maintenance level in year y so that the maximum number of systems is assumed instead of the average number of systems.

SEUTIL\(_{jky}\) = The average utilization in hours per month of the jth item of support equipment at the kth maintenance level in year y.

SESF = The support equipment and spares factor used to adjust average system operating hours to peak system operating hours.

ASE\(_{k}\) = The number of available hours per month for support equipment at the kth maintenance level.

UF\(_{k}\) = The estimated decimal fraction of ASE that support equipment at the kth maintenance level will be available.

2.13.4

\[ MAXFAC_{ky} = \frac{MAXOPS_{ky}}{AVGOPS_{ky}} \]

MAXOPS\(_{ky}\) = The number of operating systems supported by each location at the kth maintenance level when the maximum number of systems in year y is operating.

AVGOPS\(_{ky}\) = The number of operating systems supported by each location at the kth maintenance level assuming the average number of systems in year y is operating.

2.13.5

\[ MAXOPS_{ky} = \frac{MAXSYS_{y}}{MAXLOC_{ky}} \]

MAXSYS\(_{y}\) = The maximum number of operating systems in year y.

MAXLOC\(_{ky}\) = The maximum number of locations at the kth maintenance level in year y.

2.13.6

\[ AVGOPS_{ky} = \frac{AVGSYS_{y}}{AVGLOC_{ky}} \]

AVGSYS\(_{y}\) = The average total number of operating systems in year y.

AVGLOC\(_{ky}\) = The number of locations at the kth maintenance level assuming the average number of systems in year y is operating.

2.13.7

\[ AVGSYS_{y} = \frac{1}{NMON_{y}} \sum_{m=1}^{NMON_{y}} TSYS_{my} \]

NMON\(_{y}\) = The number of months in the study in year y.

= 12 if y is not equal to LIFELYR.

= LIFE - (LIFELYR-1)(12) if y equals LIFELYR.

LIFELYR = The number of years in the study.

= LIFE/12 (raised to the next higher integer, if fractional)

LIFE = The number of months in the study.

TSYS = The total number of operating systems in month m of year y.

2.13.8

\[ AVGLOC_{ky} = \frac{AVGSYS_{y}}{NOPS_{k}} \]

(Rounded up to the next higher integer, if fractional)

AVGSYS\(_{y}\) = The average total number of operating systems in year y.

NOPS\(_{k}\) = The maximum allowable number of operating systems supported by each location at the kth maintenance level.

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2.13.9

\[ SE_{\text{UTIL, } jky} = \sum_{i=1}^{\text{NI}} \left( MA_{\text{dy}} \right) \left( SETT_{\text{ijk}} \right) \left( EHR_{\text{k}} \right) \]

\( MA_{\text{dy}} \) = The average number of maintenance actions per month on the ith item at each location at the kth maintenance level in year y.

\( SETT_{\text{ijk}} \) = The average hours per maintenance action required on the jth item of support equipment for each maintenance action of the ith item at the kth maintenance level.

\( EHR_{\text{k}} \) = The earned hour ratio at the kth maintenance level.

\( \text{NI} \) = Number of hardware items.

2.13.10

\[ MA_{\text{dy}} = \left( DPM_{\text{iky}} \right) \left[ T(LRPR_{i} = k) \right] + NRTSMA_{\text{iky}} \]

\( DPM_{\text{iky}} \) = The expected number of demands per month on the ith item per kth level location in year y.

\( LRPR_{i} \) = The maintenance level where the ith item is primarily repaired.

\( NRTSMA_{\text{iky}} \) = The average number of maintenance actions on the ith item at the kth maintenance in year y resulting from a NRTS demand at a lower level.

2.13.11

\[ DPM_{\text{iky}} = \frac{\left( AVGOPS_{\text{iky}} \right) \left( SOH \right) \left( QPS_{i} \right)}{MTBMA_{\text{iky}}} \]

\( AVGOPS_{\text{iky}} \) = The number of operating systems supported by each location at the kth maintenance echelon assuming the average number of systems in year y is operating.

\( SOH \) = The average operating hours per month per system.

\( QPS_{i} \) = The quantity of ith items in each system.

\( MTBMA_{\text{iky}} \) = The mean time between maintenance actions for the ith item in year y.

2.13.12

\[ QPS_{i} = \left( QPNHA_{i} \right) \left[ T(NHA_{i} \neq 0) \right] \left( QPS_{\text{NHA}} \right) + T(NHA_{i} = 0) \]

\( QPNHA_{i} \) = The quantity of ith items in its next higher assembly.

\( NHA_{i} \) = The hardware item of the ith item's next higher assembly. If none exists, then NHA = 0.

2.13.13

\[ NRTSMA_{\text{iky}} = \left( DPM_{\text{iky}} \right) \left( NRTS_{i} \right) \left[ T(k = LNRTS_{i}) \right] \]

\( DPM_{\text{iky}} \) = The expected number of demands per month on the ith item per kth level location in year y.

\( NRTS_{i} \) = The portion of failures of the ith item that is not repairable at the designated primary maintenance level.

\( LNRTS_{i} \) = The maintenance level where NRTS repairs are performed.

2.14

**Acquisition Costs - System Acquisition Cost Equation**

\[ TSA_{y} = \sum_{n=1}^{Q_{Py}} SCOST_{xy} \]

\( Q_{Py} \) = The quantity of systems produced or purchased in year y.

\( SCOST_{xy} \) = The cost to produce or purchase the nth system in year y.
2.14.1

\[ QP_y = \sum_{n=1}^{N} \left[ T(\text{YRPTOD}_{z} = y) \right] \left( QTPRD_{z} \right) \]

- **YRPROD_{z}**: The year in which the production or purchasing of systems will take place for the zth set of production inputs.
- **QTYPRD_{z}**: The quantity of systems produced or purchased for the zth set of production inputs.

2.14.2

\[ SCOST_{ny} = \left[ (QP_y)^{RFAC_y} \right] \left( \frac{TOTQP_{ny}}{QFAC_y} \right) \left( UC \cdot KZ \cdot UCADJ_y \right) \]

- **QP_{y}**: The quantity of systems produced or purchased in year y.
- **RFAC_{y}**: The rate factor in year y used in system cost determination.
- **TOTQP_{ny}**: The cumulative total quantity of systems produced or purchased up to and including the nth system in year y.
- **QFAC_{y}**: The quantity factor in year y used in system cost determination.
- **UC**: The base unit cost of a system.
- **KZ**: The cost adjustment factor for all items and systems.
- **UCADJ_{y}**: The adjustment factor for base unit cost in year y.

2.14.3

\[ RFAC_y = \frac{\log_{10}(RSLOPE_{z'y})}{0.30103} \]

- **RSLOPE_{z'y}**: The rate slope for the zth set of production inputs. This value shows the effect of yearly build quantity on system cost.
- **z'y**: The set of production inputs to be used for year y.

2.14.4

\[ QFAC_y = \frac{\log_{10}(QSLOPE_{z'y})}{0.30103} \]

- **QSLOPE_{z'y}**: The quantity slope for the zth set of production inputs. This value shows the effect of total quantity built on system cost.
- **z'y**: The set of production inputs to be used for year y.

2.14.5

\[ z' = \max \left[ 1; \max \left\{ \left[ T(\text{YRPROD}_{z} \leq y) \right] (z) \right\} \right] \]

- **YRPROD_{z}**: The year in which the production or purchasing of systems will take place for the zth set of production inputs.
- **max[]**: Maximum function. In some equations, "max" or "min" terms are used, which signify "maximum value of" or "minimum value of". There are two forms of the equation using max or min. One shows max or min followed by a list of terms in brackets separated by semicolons. In this case, the highest or lowest value is selected.

2.14.6

\[ TOTQP_{y} = \sum_{y=\text{INITYR}}^{y-1} (\text{PREVQT} + QP_{y'} + n) \]

- **PREVQT**: The previous quantity of systems built before this study.
- **QP_{y}**: The quantity of systems produced or purchased in year y.
2.14.7

\[ UCADJ_{INITYR-1} = 1.0 \]

\[ UCADJ_y = \left( UCADJ_{y-1} \right)^{(TOTQP_y / QFAC_y) - QFAC_y} \]

TOTQP0\(y\) = The cumulative total quantity of systems produced or purchased before year \(y\).

QFAC\(y\) = The quantity factor in year \(y\) used in system cost determination.

2.15

**Acquisition Costs - System Shipping and Storage Containers Cost Equation**

\[ TSSC_y = \left[ T \left( YRSSC = y \right) \right] (N1)(UCC) \]

YRSSC = The year in which the shipping and storage containers cost will be incurred.

N1 = Number of system shipping and storage containers to be procured or produced.

UCC = The average unit cost of the shipping containers.

2.16

**Acquisition Costs - Technical Document Cost Equation**

\[ TTDC_y = \sum_{n=1}^{N} \left[ T \left( YRDOC_n = y \right) \right] \left( QTYPGS_n \right) \left( CSTPPG_n \right) + \left( PREPCST_n \right) \left( CPYS_n \right) \]

YRDOC\(n\) = The year in which the \(n\)th technical document cost will be incurred.

QTYPGS\(n\) = The total number of pages in the \(n\)th technical document.

CSTPPG\(n\) = The average cost per page to develop the \(n\)th technical document.

PREPCST\(n\) = The average cost per page to print, collate, bind, punch holes or otherwise prepare as a finished printed document, the \(n\)th technical document.

CPYS\(n\) = The total number of copies of the \(n\)th technical document to be printed and distributed.

2.17

**Acquisition Costs - Training Devices Cost Equation**

\[ TCTC_y = \sum_{n=1}^{N} \left[ T \left( YRTD_n = y \right) \right] \left( QTYTRD_n \right) \left( CSTTRD_n \right) \]

YRTD\(n\) = The year in which the \(n\)th training device cost will be incurred.

QTYTRD\(n\) = The quantity of the \(n\)th training device to be procured for training support.

CSTTRD\(n\) = The average unit cost of the \(n\)th training device.

2.18

**Acquisition Costs - Warranty Price Equation**

\[ TWTY_y = \sum_{z=1}^{NYWAR} \left[ T \left( YRWAR_z = y \right) \right] \left( PRCWAR_z \right) \]

NYWAR = The number of years the warranty price will be spread over.

YRWAR\(z\) = The \(z\)th year in which warranty price will be paid.

PRCWAR\(z\) = The warranty price to be paid in the \(z\)th year.

**Table D-2 Acquisition cost calculations**
3. O&S Costs – Total

\[
TOSL_{ky} = \sum_{y=INITYR}^{ENDYR} \left( \frac{TCOL_{ky} + TCRL_{ky} + TCSEMKy + TCRT_{ky}}{+ TCRPM_{ky} + TCRC_{ky} + TCCSR_{ky} + TCTDR_{ky}} \right) \\
\left( + TCTRAN_{ky} + TCRF_{ky} + TCRIM_{ky} + TCSWM_{ky} \right) \\
\left( + TCCS_{ky} + TCECP_{ky} + TCMOS_{ky} + TCRWTY_{ky} \right)
\]

INITYR = The initial year of the study.
ENDYR = The last year of the study.
LIFEYR = INITYR + LIFEYR - 1
LIFE = LIFE/12 (raised to the next higher integer, if fractional)
TCOL_{ky} = Operation labor cost (k=1, organizational level only) in year y.
TCRL_{ky} = Repair labor cost at the kth level in year y.
TCSEMKy = Support equipment maintenance cost at the kth level in year y.
TCRT_{ky} = Recurring training cost at the kth level in year y.
TCRPM_{ky} = Repair parts and materials cost at the kth level in year y.
TCRC_{ky} = Repair consumables cost at the kth level in year y.
TCCSR_{ky} = Condemnation spares replenishment cost at the kth level in year y.
TCTDR_{ky} = Technical data revisions cost at the kth level in year y.
TCTRAN_{ky} = Transportation cost at the kth level in year y.
TCSWM_{ky} = Software maintenance cost at the kth level in year y.
TCCS_{ky} = Contractor services cost at the kth level in year y.
TCEF_{ky} = Engineering changes cost (highest maintenance level only) in year y.
TCMOS_{ky} = Miscellaneous operation and support costs at the kth level in year y.
TCRWTY_{ky} = Recurring warranty cost at the kth level in year y.

3.1 O&S Costs - Operation Labor Cost Equation

\[
TCOL_{ky} = \left[ T(k = 1)(AVGSYS_{ky})(SOH)(OPR)(SOLR)(NMON_{ky}) \right]
\]

MA_{ky} = The average number of maintenance actions per month on the ith item at each location at the kth maintenance level in year y.
AVGLOC_{ky} = The number of locations at the kth maintenance level assuming the average number of systems in year y is operating.
MTTRi = The mean time to repair the ith item, in man-hours.
EHRk = The earned hour ratio at the kth maintenance level.
MLRk = The average hourly labor rate of the personnel at the kth maintenance level.
NMONy = The number of months in the study in year y.
= 12 if y is not equal to LIFEYR.
= LIFE - (LIFEYR-1)(12) if y equals LIFEYR.
LIFEYR = The number of years in the study.
LIFE = LIFE/12 (raised to the next higher integer, if fractional)
RTOKi = The portion of failures of the ith item, expected to retest okay, expressed as a decimal fraction of real failures.
PLRTOK = The portion of repair time expended on reported failures that actually retest okay, expressed as a decimal fraction of repair time spent on real failures.
3.2 O&S Costs - Repair Labor Cost Equation

\[
TCRL_{ky} = \sum_{i=1}^{N} \left( \frac{MA_{iky} \cdot AVGLOC_{ky} \cdot MTTR_{ki} \cdot EHR_{k} \cdot MLR_{k} \cdot NMON_{y}}{1.0 + RTOK_{i}} \right) \cdot \left[ 1.0 + \left( \frac{RTOK_{i}}{PLRTOK} \right) \right]
\]

- MA_{iky} = The average number of maintenance actions per month on the ith item at each location at the kth maintenance level in year y.
- AVGLOC_{ky} = The number of locations at the kth maintenance level assuming the average number of systems in year y is operating.
- MTTR_{ki} = The mean time to repair the ith item, in man-hours.
- EHR_{k} = The earned hour ratio at the kth maintenance level.
- MLR_{k} = The average hourly labor rate of the personnel at the kth maintenance level.
- NMON_{y} = The number of months in the study in year y.
  - = 12 if y is not equal to LIFEYR.
  - = LIFE - (LIFEYR-1)(12) if y equals LIFEYR.
- LIFEYR = The number of years in the study.
- LIFE = LIFE/12 (raised to the next higher integer, if fractional)
- RTOK_{i} = The portion of failures of the ith item, expected to retest okay, expressed as a decimal fraction of real failures.
- PLRTOK = The portion of repair time expended on reported failures that actually retest okay, expressed as a decimal fraction of repair time spent on real failures.

3.3 O&S Costs - Support Equipment Maintenance Cost

\[
TCSEM_{ky} = \sum_{j=1}^{NSE} \left( QSE_{jky} \cdot SCST_{j} \cdot SEMANT_{j} \cdot NMONOP_{y} \right)
\]

- QSE_{jky} = The quantity of the jth item of support equipment required at all locations at the kth maintenance level in year y.
- SCST_{j} = The average unit cost of the jth item of support equipment.
- SEMANT_{j} = The annual cost of maintenance on the jth item of support equipment, expressed as a decimal fraction of the cost of the support equipment.
- NMONOP_y = The number of months in year y in which systems are operating.

3.3.1

\[
NMONOP_{y} = \sum_{m=1}^{12} \left[ T \left( TSYS_{my} > 0 \right) \right]
\]

- TSYS_{my} = The total number of operating systems in month m of year y.

3.4 O&S Costs - Repair Parts and Materials Cost

\[
TCRPM_{ky} = \sum_{i=1}^{N} \left( \frac{MA_{iky} \cdot AVGLOC_{ky} \cdot (1.0 - CONDi) \cdot MCPR_{i} \cdot NMON_{y}}{1.0 + RTOK_{i}} \right)
\]

- MA_{iky} = The average number of maintenance actions per month on the ith item at each location at the kth maintenance level in year y.
- AVGLOC_{ky} = The number of locations at the kth maintenance level assuming the average number of systems in year y is operating.
- CONDi = The portion of failures of the ith item expected to be condemned.
- MCPR_{i} = The average material cost per repair of the ith item.
- NMON_{y} = The number of months in the study in year y.
  - = 12 if y is not equal to LIFEYR.
  - = LIFE - (LIFEYR-1)(12) if y equals LIFEYR.
- LIFEYR = The number of years in the study. (LIFE/12 (raised to the next higher integer, if fractional))
- LIFE = The number of months in the study.
- RTOK_{i} = The portion of failures of the ith item, expected to retest okay, expressed as a decimal fraction of real failures.
3.5 O&S Costs - Repair Consumables Cost

\[ TCRC_{k_y} = (CONSUM \cdot TCRPM_{k_y}) \]

- **CONSUM** = The portion of repair parts and materials cost that is expected to be required for consumables, such as alcohol, cleaners, swabs, solders, etc.
- **TCRPM_{k_y}** = The repair parts and materials cost at the kth maintenance level in year y.

3.6 O&S Costs - Recurring Training Cost

\[ TCRT_{k_y} = \left( NOM_{k_y} \cdot MAXLOC_{k_y} \cdot TOR_k \cdot TRHRS_k \cdot MLR_k \cdot \left( \frac{NMONOP_y}{12} \right) \right) \]

\[ + \left( TRHRS_k \cdot TCDCST_k \cdot TDCAST_k \cdot \sum_{k=1}^{NOM_{k_y}} \mathbf{1} \left( TRCT_{k,y-1} = 0 \right) \cdot \mathbf{1} \left( NOM_{k_y} > 0 \right) \right) \]

- **NOM_{k_y}** = The number of maintenance personnel required at each location at the kth maintenance level in year y.
- **MAXLOC_{k_y}** = The maximum number of locations at the kth maintenance level in year y.
- **TOR_k** = The annual turnover rate of maintenance personnel at the kth maintenance level.
- **TRHRS_k** = The number of hours required to train new personnel at the kth maintenance level.
- **MLR_k** = The average hourly labor rate of the maintenance personnel at the kth maintenance level.
- **NMONOP_y** = The number of months in year y in which systems are operating.
- **TCDCST_k** = The initial cost per class hour to develop the recurring training course at the kth maintenance level.
- **NMON_y** = The number of months in the study in year y.
  - = 12 if y is not equal to LIFEYR.
  - = LIFE - (LIFEYR-1)(12) if y equals LIFEYR.
- **LIFEYR** = The number of years in the study.
- **LIFE** = LIFE/12 (raised to the next higher integer, if fractional)
- **FROUND** = A rounding function that rounds down if the fractional part is less than or equal to 0.25 and rounds up if the fractional part is greater than 0.25. Thus, FROUND (2.1) = 2 and FROUND (2.3) = 3.

3.6.1

\[ NOM_{k_y} = FROUND \left( \frac{MAXMMH_{k_y}}{160} \right) \]

- **MAXMMH_{k_y}** = The maintenance man-hours per month per location at the kth maintenance level when the maximum number of systems in year y is operating.

3.6.2

\[ MAXMMH_{k_y} = \sum_{i=1}^{N} \left( MA_{i,k_y} \cdot MAXFAC_{i,k_y} \cdot MTTR_i \cdot EHR_k \right) \cdot \left[ 1 - RTOK_i \cdot PLRTOK \right] \]

- **MA_{i,k_y}** = The average number of maintenance actions per month on the ith item at each location at the kth maintenance level in year y.
- **MAXFAC_{i,k_y}** = The factor used to adjust variables at the kth maintenance level in year y so that the maximum number of systems is assumed instead of the average number of systems.
- **MTTR_i** = The mean time to repair the ith item, in man-hours.
- **EHR_k** = The earned hour ratio at the kth maintenance level.
- **RTOK_i** = The portion of failures of the ith item, expected to retest okay, expressed as a decimal fraction of real failures.
- **PLRTOK** = The portion of repair time expended on reported failures that actually retest okay, expressed as a decimal fraction of repair time spent on real failures.
3.7 **O&S Costs - Software Maintenance Cost**

\[ T_{C_{SWM}}_{ky} = (TEFFMM)(SWRCPC_{ky})(160)(SWRCLR_{k}) \]

- **TEFFMM** = Total initial software development effort in man-months.
- **SWRCPC_{ky}** = The amount of effort required for software maintenance and enhancements in year y at the kth maintenance level, expressed as a portion of the total initial software development effort.
- **SWRCLR_k** = The average hourly labor rate of the software maintenance personnel at the kth maintenance level.

3.8 **O&S Costs - Transportation Cost Equation**

\[ T_{C_{TRAN}}_{ky} = \sum_{i=1}^{N_{i}} \left[ (TRIPS_{iy}) (TPCOS_{iy}) + (TPNRTS_{iy}) (TPCOSN_{iy}) \right] \]

- **LRPR_{i}** = The maintenance level where repair of the ith item primarily takes place.
- **TRIPS_{iy}** = The total number of times the ith item will be transported between its removal level and its primary repair level.
- **TPCOS_{iy}** = The transportation cost for one trip of the ith item between its removal level and its primary repair level.
- **TPNRTS_{iy}** = The total number of times the ith item will be transported between its primary repair level and its NRTS repair level.
- **TPCOSN_{iy}** = The transportation cost for one trip of the ith item between its primary repair level and its NRTS repair level.

3.8.1

\[ TRIPS_{iy} = (2.0)(DPM_{iky})(AVGLOC_{ky})(NMON_{y}) \]

- **2.0** = Two trips per demand.
- **DPM_{iky}** = The expected number of demands per month on the ith item per kth level location in year y.
- **AVGLOC_{ky}** = The number of locations at the kth maintenance level assuming the average number of systems in year y is operating.
- **NMON_{y}** = The number of months in the study in year y.
  - **= 12 if y is not equal to LIFEYR.**
  - **= LIFE - (LIFEYR-1)(12) if y equals LIFEYR.**
- **LIFEYR** = The number of years in the study.
- **LIFE** = The number of months in the study.
- **NRTS_{iy}** = The portion of failures of the ith item not repairable at the designated primary maintenance level.

3.8.2

\[ TPNRTS_{iy} = (TRIPS_{iy})(NRTS_{iy}) \]

- **TRIPS_{iy}** = The number of locations at the kth maintenance level assuming the average number of systems in year y is operating.
- **NRTS_{iy}** = The portion of failures of the ith item not repairable at the designated primary maintenance level.

3.8.3

\[ TPCOS_{iy} = (WT_{i})(MLCPP_{LREM_{i}}LPPR_{i}) + \left[ T(WT_{i} > 0)\right] (TRANPW) \]

- **WT_{i}** = The shipping weight in pounds of the ith item.
- **LREM_{i}** = The maintenance level where removal and replacement of the ith item takes place.
- **LPRRI_{i}** = The maintenance level where repair of the ith item primarily takes place.
- **MLCPP** = The transportation cost per pound between the maintenance level where removal and repair of the ith item takes place.
- **TRANPW** = The cost allotted for paperwork and packaging when an item is transported.
3.8.4

\[ TPCOSN_i = (WT_i)^2 MLCPP_{LREM_i,LPFR_i}^{-1} + I{(WT_i > 0)} TRANPW \]

- \(WT_i\) = The shipping weight in pounds of the ith item.
- \(LREMi\) = The maintenance level where removal and replacement of the ith item takes place.
- \(LRPRi\) = The maintenance level where repair of the ith item primarily takes place.
- \(MLCPP\) = The transportation cost per pound between the Organizational and the Intermediate Level.
- \(TRANPW\) = The cost allotted for paperwork and packaging when an item is transported.

3.9 O&S Costs - Technical Documentation Revisions Cost

\[ TCTDR_{ky} = \frac{(QTYRPG_k)^2 (CSTRPG_k) (NMONOP_y)}{12} \]

- \(QTYRPGk\) = The average number of pages of technical documentation that will be revised each year at the kth maintenance level.
- \(CSTRPGk\) = The average cost per page to develop technical document revisions at the kth maintenance level.
- \(NMONOPy\) = The number of months in year y in which systems are operating.

3.10 O&S Costs - Condemnation Spares Replenishment Cost

\[ TCCSR_{ky} = \sum_{i=1}^{N}(MA_{iky})(AVGLOG_{iky})(COND_i)(COST_i)(KZ)(NMON_y) \]

- \(MA_{iky}\) = The average number of maintenance actions per month on the ith item at each location of the kth maintenance level in year y.
- \(AVGLOG_{iky}\) = The number of locations at the kth maintenance level assuming the average number of systems in year y is operating.
- \(COND_i\) = The portion of failures of the ith item expected to be condemned.
- \(COST_i\) = The unit cost of a spare for the ith item.
- \(KZ\) = The cost adjustment factor that is multiplied by the cost of each item.
- \(NMON_y\) = The number of months in the study in year y.
  - \(= 12\) if y is not equal to LIFEYR.
  - \(= LIFE - (LIFEYR-1)(12)\) if y equals LIFEYR.
- \(LIFE\) = The number of months in the study.
  - \(= LIFE/12\) (raised to the next higher integer, if fractional)
- \(LIFEYR\) = The number of years in the study.

3.11 O&S Costs - Contractor Services Cost Equation

\[ TCCS_{ky} = \sum_{z=1}^{NYCMM_k} [T(y = YRCMM_{kz} = 1)](CMM_{kz})(CSTCMM_{kz}) \]

- \(NYCMMk\) = The number of years that contractor support will be required at the kth maintenance level. This is the number added in the study.
- \(YRCMMkz\) = The year in which the zth contractor support cost will be incurred.
- \(CMMkz\) = The total number of support man-months to be provided by the contractor at the kth maintenance level for the zth contractor support year.
- \(CSTCMMkz\) = The average cost of contractor support per man-month for the zth contractor support year at the kth maintenance level.

3.12 O&S Costs - Engineering Changes Cost Equation

\[ TCECP_{ky} = [T(k = 3)] \sum_{z=1}^{NYECP} [T(y = YRECP_z)](EPCPCST_z) \]

- \(NYECP\) = The number of years in which engineering changes will take place.
- \(YRECPz\) = The year in which the zth engineering change cost will be incurred.
- \(EPCPCSTz\) = The estimated cost for engineering changes in the zth year.
3.13 O&S Costs - Recurring Facilities Cost Equation

\[
TCRF_{ky} = \frac{(SQFT_k \times CSTSQFT_k \times MAXLOC_{ky} \times NMONOP_y)}{12}
\]

- SQFTk = The total number of square feet in recurring facilities at each location at the kth maintenance level.
- CSTSQFTk = The annual cost per square foot for recurring facilities at the kth maintenance level.
- MAXLOCky = The maximum number of locations at the kth maintenance level in year y.
- NMONOPy = The number of months in year y in which systems are operating.

3.14 O&S Costs - Recurring Item Management Cost Equation

\[
TCRIM_{ky} = \frac{[QTYNP_k \times (RIMCST_k)] + (QTYS_k \times CSTSL_k) \times (MAXLOC_{ky} \times NMONOP_y)}{12}
\]

- QTYNPk = The quantity of new piece parts and assembly types to be introduced into the inventory system at the kth maintenance level.
- RIMCSTk = The recurring yearly inventory management cost to maintain a piece part or assembly in the inventory system at the kth maintenance level.
- QTYSk = The number of piece parts or assembly types stocked at the kth maintenance level.
- CSTSLk = The annual cost per stocked item type per inventory location at the kth maintenance level.
- MAXLOCky = The maximum number of locations at the kth maintenance level in year y.
- NMONOPy = The number of months in year y in which systems are operating.

3.15 O&S Costs - Recurring Warranty Cost Equation

\[
TCRWTY_{ny} = \left[ T(k = LVCSTW) \times (MA_{ik'y} \times CSTWMA) \times NMON_y \right]
\]

- k' = ITMWMA
- LVCSTW = The maintenance level where the warranty maintenance action cost will be incurred.
- MAiky = The average number of maintenance actions per month on the ith item at the kth maintenance level in year y.
- CSTWMA = The cost per maintenance action associated with the warranty.
- NMONy = The number of months in the study in year y.
- LIFEYR = The number of years in the study.
- LIFE = LIFE/12 (raised to the next higher integer, if fractional)
- ITMWMA = The item number of the item that is used for the warranty maintenance actions cost.
- LEVWMA = The maintenance level where the warranty maintenance action will occur.
- RATIOy = The warranty adjustment ratio.
- \( j \) = The warranty actions added to the system.

\[
RATIO_y = \frac{NumberCovered_y}{NumberDeployedy_y}
\]

- NumberCoveredy = Number of systems covered by warranty in year y. This is the total number of systems in service – the number of systems that the warranty has expired.
- NumberDeployedy = Total number of systems in service in year y.
3.16 O&S Costs - Miscellaneous Operation and Support Cost Equation

\[
TCMOS_{iy} = \sum_{x=1}^{n} \left[ f (k = LEVMOS_z) \right] \times \left[ \left( AVG SYS_{y} \right) \times SOH \left( MKOPHR_{x} \right) + \left( NMON_{y} \right) \times MKTIME_{x} + \left( MA_{x} \right) \times MKMA_{y} \times NMON_{y} \right] + \sum_{x=1}^{NYMOSC} \left[ f \left( y = YRMOSC_{zn} \right) \times CSTMOS_{yn} \right]
\]

- MKTIMEEn = The hardware item that is used for the maintenance action cost factor for the nth miscellaneous O&S cost category.
- MKLEn = The maintenance level that is used for the maintenance action cost factor for the nth miscellaneous O&S cost category.
- LEVMOSn = The maintenance level (1, 2, or 3) where the nth miscellaneous O&S cost category will be incurred.
- AVG SYSy = The average total number of operating systems in year y.
- SOH = The average operating hours per month per system.
- MKOPHRn = The miscellaneous system operating hour cost per hour for the nth O&S miscellaneous O&S cost category.
- NMONy = The number of months in the study in year y.
- LIFEDR = The number of years in the study.
- LIFE = The number of months in the study.
- MKTIMEEn = The monthly cost factor for the nth miscellaneous O&S cost category.
- MAiky = The average number of maintenance actions per month on the ith item at the kth maintenance level in year y.
- MKMA = The maintenance action cost factor for the nth miscellaneous O&S cost category.
- MKYR1n = The first year that costs will be incurred for the nth miscellaneous O&S cost category for the system operating hour, monthly, and/or maintenance action cost factors.
- MKYR2n = The last year that costs will be incurred for the nth miscellaneous O&S cost category for the system operating hour, monthly, and/or maintenance action cost factors.
- NYMOSCn = The number of years that costs will be incurred for the nth miscellaneous O&S cost category.
- YRMOSCnz = The year in which the zth cost for the nth miscellaneous O&S cost category will be incurred.
- CSTMOSnz = The cost in the zth year for the nth miscellaneous O&S cost category.

Table D-3 Operations and support cost calculations

### Operational Availability Analysis

\[
Ao = \frac{MTBMA_{(2)}}{MTBMA + METTR + MLDT}
\]

- MTBMA = Mean time between maintenance actions.
- METTR = Mean elapsed time to repair.
- MLDT = Mean logistics downtime.

4.1

\[
LA_i = \frac{MAXOPS_{iy}}{MAXOPS_{iy} + EBO_i}
\]

- LAi = The logistics availability of the ith item.
- MAXOPS1y' = The number of operating systems supported by each location at the organizational level when the maximum number of systems in year y' is operating.
- y' = The last year of deployment.
- EBOi = The expected number of back orders for the ith item at each organizational location in year y'.
4.2

\[ y' = \max_{z=1}^{N} \left[ T \left( \sum_{m=1}^{12} \left[ T(\text{NSYS}_{zm} > 0) \right] > 0 \right) \left( YRDEP_{z} \right) \right] \]

NSYSzm = The number of systems to be deployed in month m for the zth set of deployment inputs.
YRDEPz = The year in which the deployment or removal of systems will take place for the zth set of deployment inputs.

4.3

\[ EBO = \sum_{x=s+1}^{\infty} \left( e^{-d} \frac{(d^x)}{x!} \right) (x - s) \]

s = The number of spares.
d = The demand rate. The expected number of demands within the spares turnaround time.

4.4

\[ s = \text{LOCSPRi}_{1y'} \]

\[ d = \frac{(\text{MAXOPS}_{1y'})(\text{QPS})(\text{SOH})(\text{TAT}_i)}{\text{MTBMA}_{i1y'}} \]

LOCSPRi1y' = The quantity of ith item spares required at each location at the organizational level in year y'.
MAXOPS1y' = The number of operating systems supported by each location at the organizational level when the maximum number of systems operate in year y'.
QPS = The quantity of ith items in each system.
SOH = The average operating hours per month per system.
TATi = The average spares turnaround time in months for all types of demands on the ith item at the organizational level.
MTBMAi1y' = The mean time between maintenance actions for the ith item in year y'.

4.5

\[ \text{TAT}_i = \left[ T(\text{LRPR}_i = 1) \left( \frac{\text{SPLAN}_{i1y'}}{1.0 - \text{NRTS}_{i}} \right) + \left( \text{NRTS}_{i} \right) \left( \text{NRTSTAT}_{i} \right) + \left( \text{COND}_{i} \right) \left( \text{CONDTAT}_{i} \right) \right] + \left[ T(\text{LRPR}_i \neq 1) \left( \text{SPLAN}_{i} \right) \right] \]

\[ + \left[ T(\text{SPLAN}_{i} = 0) \right]\left( \text{METTR}_{k'} \right) / 730 \]

LRPRi = The maintenance level where the ith item is primarily repaired.
SPLANi1 = The average turnaround time in months for spares for the ith item at the organizational level.
NRTSi = The portion of failures of the ith item that is not repairable at the designated primary maintenance level.
NRTSTATi = The average turnaround time in months for the ith items that are not repairable at the designated primary maintenance level.
CONDI = The portion of failures of the ith item expected to be condemned.
CONDTATi = The number of months required to replace spares of the ith item used to replace condemned items.
METTRRk' = The mean elapsed time (in hours) to remove and replace an LRU spare from a system when the spare is obtained from the k'th maintenance level.
k' = The lowest maintenance level where the ith item is either spared or repaired given that no spares are desired at the organizational level (SPLANi1=0).
\[ \text{TEBO} = \sum_{i=1}^{N} \left[ n \left(T\left( \text{ITYPE}_i = 2 \right) \right) \right] \left( EBO_i \right) \]

- **TEBO** = The total expected back orders for all LRUs at the organizational level.
- **ITYPEi** = The assembly type of the ith item.
- **EBOi** = The expected number of back orders for the ith item at the organizational level.

\[ \text{SYSTAT} = \left[ T\left( \text{LPPR, } = 1 \right) \right] \left( \frac{\text{SPLANi'}/\left(1.0 - \text{NRTSi'}/\alpha \right)}{\text{NRTSTATi'}} \right) + \left[ T\left( \text{LPPR, } = 1 \right) \right] \text{SPLANi'}/\alpha \frac{\left( \text{MTBMAi'} \right)}{\left( \text{MAXOPS1y'} \right)} \frac{\text{SOH}}{} \]

- **I** = Lowest maintenance level entered in system.
- **SYSTAT** = The average spares turnaround time in months for all demands on the system at the organizational level.
- **i'** = The system level hardware item.
- **LRPRi'** = The maintenance level where the system is primarily repaired.
- **SPLANi'1** = The average turnaround time in months for spares for the system at the organizational level.
- **NRTSi'** = The portion of failures of the system that is not repairable at the designated primary maintenance level.
- **NRTSTATi'** = The average turnaround time in months for the systems that are not repairable at the designated primary maintenance level.
- **CONDi'** = The portion of failures of the system expected to be condemned.
- **CONDTATi'** = The number of months required to replace spares of the system which were used to replace condemned systems.
- **MTBMAi'y'** = The mean time between maintenance actions for the system in year \( y' \).
- **TEBO** = The total expected back orders for all LRUs at the organizational level.
- **MAXOPS1y'** = The number of operating systems supported by each location at the organizational level when the maximum number of systems in year \( y' \) is operating.
- **SOH** = The average operating hours per month per system.

\[ \text{SYSIA} = \frac{\text{MTBMAi'y'}}{\text{MTBMAi'y'}} + \left( \frac{\text{METTRR1}/\left( \text{SOH}/730. \right)}{\text{SOH}} \right) \]

- **SYSIA** = The system inherent availability.
- **MTBMAi'y'** = The mean time between maintenance actions for the system in year \( y' \).
- **METTRR1** = The mean elapsed time (in hours) to remove and replace an LRU spare from a system at the organizational level.
- **SOH** = The average operating hours per month per system.

\[ \text{SYSOA} = \left( \frac{\text{SYSLA}}{1 - \left( 1 - \text{SYSIA} \right) \left( 1 - \text{SYSLA} \right)} \right) \]

- **SYSOA** = The system operational availability.
- **SYSIA** = The system inherent availability.
- **SYSLA** = The system logistics availability.

\[ \text{SYSLA} = \sum_{i=1}^{N} \left[ n \left(T\left( \text{ITYPE}_i = 2 \right) \right) \right] \left( \text{OPTSPRi} \right) \left( \text{COSTi} \right) \left( \text{KZ} \right) \leq \text{MAXCOST} \]

- **SYSLA** = The system logistics availability.
- **ITYPEi** = The assembly type of the ith item.
- **OPTSPRi** = The optimized number of spares at each organizational level location.
- **COSTi** = The unit cost of a spare for the ith item.
- **KZ** = The cost adjustment factor that is multiplied by the cost of each item.
- **MAXCOST** = The maximum LRU spares cost per organizational level location.
\[ MAXCOST = \sum_{i=1}^{N_l} [T(I\text{TYPE}_{i} = 2)](LOCSPR_{i;y}) \cdot (COST_{i} \cdot KZ) \]

\text{LOCSPR}_{i;y} = \text{The quantity of ith item spares required at each location at the organizational level in year y}. 

Table D-4 Operational availability analysis calculations
Appendix E  AERO 2390 System Engineering Design Tools

This appendix includes a copy of the RMIT University AERO 2390 System Engineering Design Tools Course Guide Part A. The prototype software application developed during this research has been incorporated into this course to provide an integrated environment for students to learn project management and life cycle costing. The course ran for the first time in Semester 2 2005 as part of the Master of Engineering (Integrated Logistic Systems) and Master of Engineering (Systems Engineering) programs.

The practical use of the research outcome is a demonstration of the research value to society.

Appendix E.1  Part A - Course Identification

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| Course Description: | This course provides an introduction to performing project management and system engineering activities using system design tools. Participants are shown how traditional project management practices are now changing to include systems engineering and logistics concepts such as Life Cycle Costing. The course includes an introduction to project management using Microsoft Office Project and life cycle costing using a Microsoft Office Project Add-in called Pipercove System Analysis. The course commences with an introduction to Microsoft Office Project and project management concepts. Project management principles and the evaluation and optimisation of project alternatives are considered. Systems engineering and logistics in the context of life cycle costing are then introduced. The relevant reliability engineering, finance and risk management concepts are then introduced. The course then addresses the concepts and methods of life cycle costing. The concepts and methods are introduced using a hands-on approach, |

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using Pipercove System Analysis and Microsoft Office Project, so that participants, upon completion of the course, may immediately apply these tools to their projects.

Life cycle costing is a key methodology widely used during many phases of a project to assist in selection between project alternatives. The outcome of a Pipercove System Analysis / Microsoft Office Project life cycle analysis is valuable data on whole of life costs of project alternatives, on a net present value (NPV) basis. In some cases, life cycle cost will be the sole discriminator between these alternatives.

Pipercove System Analysis is used to apply key concerns of project management (tasks, resources, time and money) to a life cycle costing analysis of the project alternatives defined in the Microsoft Office Project environment. The tool is used to perform a Monte Carlo life cycle cost risk analysis, provide detailed risk reports, and carry out baseline comparisons of Microsoft Office Project models. This is a breakthrough approach to the conduct and use of life cycle costing.

A strongly workshop-based, hands-on approach throughout the course provides course participants with the opportunity to learn by doing. Two case studies play a major role in the course. The case studies include all normal aspects of a project, including task and resource allocations, time and money considerations. A life cycle cost analysis is carried out on each of the two projects, and baseline comparisons are made. Course participants are then taught how to create reports which reflect the predicted outcomes of each project, including life cycle cost and risk analysis.

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<th>Objectives / Learning Outcomes / Capability Development:</th>
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<td>Failure Management</td>
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<td>Whole of Life Analysis</td>
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<td>management and system analysis using Pipercove System Analysis. Hands on creation of a project solution using Pipercove System Analysis and Microsoft Office Project.</td>
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<td>Refining the Process</td>
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<td>The workshop includes decision</td>
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<td>and risk analysis of design alternatives and features, to demonstrate the process of selecting, dismissing or refining the outcome over the conceptual, preliminary and detailed design</td>
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stages.

- Information, roles and responsibilities.
- The workshop includes evaluation of the roles and responsibilities of key staff in the information gathering and dissemination process. The selection of information to include in the life cycle costing process is a key driver of successful outcomes. What should and should not be included in the information gathering process will be discussed. Having attained the information necessary to conduct a complete life cycle costing analysis, attention turns to the information reporting capabilities of Pipercove System Analysis and Microsoft Office Project. The applications are used to prepare an information package suitable for Board or Executive level analysis, as well as for lower levels in an enterprise.

| Overview of Learning Activities: | Student learning occurs through the following experiences and evaluation processes:

- Lectures: Technical material will be addressed in lectures. Specific reading will be assigned each week for preparation for the following week. Attendance at lectures is not compulsory, but it is strongly recommended since the material presented in lectures provides much of the information required for assignments and examinations.
- Assignment: Designed to allow the student to explore aspects of the subject in depth. The assignment is assessed to determine a grade.
- Supervised Laboratories: Technical skills and understanding will be addressed in two supervised laboratories. Students should review lecture material and assigned reading in preparation for laboratories. Attendance at these laboratory sessions is compulsory. Laboratory reports are assessed to determine a grade.
- Unsupervised Laboratories: Provide the opportunity to develop and reinforce the understanding and skills the student is attempting to acquire.
- On-call Consultation: To assist understanding and provide opportunity for two-way feedback.
- Problem Sheets: To assist students in testing their understanding. Problem sheets are not assessed.
- Examination: Summative assessment designed primarily to determine a grade.


Prescribed Texts & References

1. Microsoft Office Project Professional
2. Pipercove System Analysis from Pipercove Software
   http://www.pipercove.com/

Recommended Resources

We recommend you also purchase (if you don’t already have them) the following references as they form the underlying text for the Certificate,
### Post Graduate and Masters of Systems Engineering:

- **EIA 632 Processes for Engineering A system, Version 1.0 28 April 1998.** This can be purchased from Global Engineering Documents (Address: 15 Inverness Way East, Englewood, CO 80112-5704 USA or call USA and Canada 1-800-854-7179) URL – [http://www.global.his.com](http://www.global.his.com)
- **INCOSE Systems Engineering Handbook, Version 2A**
- For students undertaking this course online, additional system engineering textbooks can be purchased from online sellers like Amazon (highly recommended). URL – [http://www.amazon.com](http://www.amazon.com)
- **RMIT University Library supports students by providing ONLINE RESOURCES.**
  - access to online data bases
  - library catalogue searching
  - document delivery service
  - online question and answer service
  - guides and tutorials for information literacy including referencing
  - full text books and journals
- For more information visit the RMIT web sites:

### Overview of Assessment:

### Assessment Tasks consist of:

- **Assignment 1** can be completed during the three-day workshop which usually happens around the 5th week. Assignments handed in late will be penalised 10% per week. Assignments will normally be returned in Week 10. Details of the Assignment are available online on the course website. 30% maximum contribution to the final grade.
- **Assignment 2**. This should be completed three weeks after the workshop (or around week 10 if you are unable to attend the workshop). Laboratory reports handed in late will be penalised 10% per week. Laboratory reports will normally be returned in Week 12 of the Semester. Details of the Laboratories are available online on the course website. 60% maximum contribution to the final grade.
- **Contribution and participation in the Threaded Discussions.** 10% maximum contribution to the final grade, based on the frequency and quality of the contributions.

### Course Coordinator Details:

- Associate Professor Louis Doukas, PhD, MSc, FRMIT, P.E
- Mark Gregory, M.Eng(Comms), B.Eng(Elec)(Hons), MIEEE, MAIPM
Appendix F  Example Tenderer A Full Data

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Appendix G  Refereed Papers

This appendix contains published and accepted refereed international conference papers and a journal paper submitted in December 2006.


Whole of Life Project Management

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Abstract

Many engineers in project management roles utilize methodologies and tools that need to evolve to be more in tune with the outcomes that society wants. Society is growing more environmentally and sustainability aware, and over time will demand that project managers lead the way by changing existing project management practices. Existing project management practices include consideration of tasks and resources with the goal of minimising the time and cost of a project. Sustainability requires new approaches to systems analysis; analysing the system and selecting approaches and materials that reduce the overall cost to the environment, upon the available resources and the long term impact on society. Engineering leadership in project management in the 21st century will be measured by the rate of change of the old practices to new more socially acceptable, sustainable and environmentally friendly project management practices. The research identifies that the change process will not be immediate and considers what may prevent change from occurring at a reasonable rate.

1. Introduction

Engineering leadership in the 21st century will be measured by the rate of change from the 20th century project management guidelines and practices to those which must be adopted for the 21st century. Project management must take into account more socially acceptable, sustainable and environmentally friendly project management practices.

Project management is the process of applying tasks, resources and timelines to achieving an outcome. The process of project management should include social, sustainable and environmental factors so that these can be identified and measured.

Life Cycle Costing (LCC) has been applied to projects for many years, however, often only for a sub-set of projects and only as part of the tendering and pre-contract phases.

The research presented identifies that the change process will not be immediate and considers what may prevent change from occurring at a reasonable rate.

2. Systems Analysis

The term Systems Analysis has many meanings and usage. For the purpose of this paper a suitable definition is [1]:

“analysis of all aspects of a project along with ways to collect information about the operation of its parts.”

A more detailed description and definition is provided by Blanchard and Fabrycky [2], however, the purpose of the research is to consider systems analysis more broadly than to limit it within the engineering domain.

2.1. Life Cycle Costing

Systems analysis has been used for many years in large projects to consider system parameter development including LCC and other factors, though not as a core component of the project management process. LCC, which is the determination of the cost of acquisition and ownership for the whole of life, is in most cases used during the tendering and pre-contract phases as part of the process to find the right vendor for the job.

What is interesting about systems analysis and LCC techniques being applied to a project is that potentially through the correct application at the outset the costs, risk outcomes and performance success criteria of a project should be known. Therefore, correct application of systems analysis and LCC principles should be a critical part of any project.

Systems analysis and LCC are Whole of Life (WOL) techniques that are traditionally used by engineers and project managers. They are overlapping to some degree in that both techniques are used to analyse a system from different perspectives and to achieve an understanding of the projects potential outcomes.

More recently LCC has been expanded to include sustainability and environmental factors. The traditional use of LCC on hardware or software system outcomes is being changed as the nature of solutions change and as a new generation of engineers and project managers see the potential for LCC principals being applied in new ways.

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2.2. Life Cycle Assessment

Life Cycle Assessment or Life Cycle Analysis (LCA) is an attempt to broaden the traditional use of systems analysis and LCC techniques and find an approach that is more suitable for the Life Cycle Initiative and Life Cycle Economy sponsored by UNEP/SETAC [3]. UNEP has contributed to the development of LCA since 1995.

LCA is described by UNEP / SETAC [4] as:

"Life Cycle Assessment (LCA) is a tool for the systematic evaluation of the environmental aspects of a product or service system through all stages of its life cycle. LCA provides an adequate instrument for environmental decision support. Life cycle assessment has proven to be a valuable tool to document the environmental considerations that need to be part of decision-making towards sustainability. A reliable LCA performance is crucial to achieve a life-cycle economy. The International Organisation for Standardisation (ISO), a worldwide federation of national standards bodies, has standardised this framework within the ISO 14040 series on LCA."

LCA may be considered as a next step in the evolution of WOL techniques, though there are opponents to its mandated use [5]. The problems identified by detractors of LCA as proposed by UNEP / SETAC may be those of a methodology that is not yet mature, or could it be that LCA is one step closer to a 21st century project management tool?

4. Many Approaches One Outcome?

Let us consider a top down approach to project management. What are the objectives of project management? Three are proposed for consideration:

- Satisfy stakeholders
- Achieve a working solution
- Achieve social, sustainable and environment goals

Are these three objectives mutually inclusive? How do we measure whether each of these objectives has been met?

21st century projects should satisfy these three objectives, however, it is important to add some reality. Bringing project and WOL management together is not necessarily always going to occur, even under the best conditions.

4.1. Stakeholders

The research has identified several stakeholders of interest and these are:

- Legislative and regulatory bodies
- Investors
- Consumers
- The environment including flora and fauna
- Project managers and engineers

There are other stakeholders that can be readily identified, however, it is sufficient for this research to focus on this list.

It may be seen that of the members of this list only the last group, project managers and engineers, are in most situations sufficiently technically aware and capable of ensuring that the three objectives of project management are achieved.

The research has identified that project managers and engineers do not necessarily all work for a common purpose.

Consider this scenario. The military is purchasing a new range of aircraft. As part of the tender process a LCC analysis is completed by each of the vendors. This would be anticipated as a reasonable requirement for a large project as required by most Government Acquisition Regulations, for example Section 7.103 of the US Federal Acquisition Regulations [6] indicates that

"The agency head or a designee shall prescribe procedures for—

(i) Establishing criteria and thresholds at which design-to-cost and life-cycle-cost techniques will be used."

A preferred vendor is selected to move to contract negotiation. During the contract negotiation phase the vendor project manager indicates that a new source of paint has been identified since the LCC was complete and that this paint is more readily available, cheaper, and has “much the same characteristics as the original paint”. The LCC analysis is often seen as a two edged sword. If the project ultimately fails, then the LCC may be used in court as part of a dispute resolution process as proof that a vendor supplied system did not meet requirements and operational performance. Therefore it may be seen to be important for a vendor to ensure that the LCC analysis provided at the tender phase is tainted prior to contract signing. This process can only be achieved by the vendor’s project managers and engineers failing to maintain a reasonable ethical behaviour.

4.2. Achieve a Working Solution
The project management objective that is most easily identified is for the project manager to achieve a working solution.

What is a working solution and how does it measured and communicated?

Consider this scenario. The military is purchasing a new fleet of submarines. This is a large project. The process continues to the point that the first submarine commences commissioning trials. During the commissioning trial it quickly becomes evident that the submarine makes more noise than a whale and the fire control systems are not optimal.

This is an example of a worst case scenario for a large project. The reason for highlighting this example is what is found during the process of rectifying these problems.

A new fire control system is to be installed and it is to be provided by the nation’s closes ally. However, it is then found that the torpedoes to be used with this fire control system cannot be used in the submarine without major structural alterations to the submarine. The overall cost for project rectification grows significantly.

It is possible to have a cascade of problems occur when project management plans change to achieve “a working solution”. Therefore, project management should include a capability to carry out what-if scenarios.

4.3. Social, Sustainable and Environment Goals

The newest project management objectives are the social, sustainable and environment goals. It may be said that these objectives have always been there, but not specified.

This work has identified these project management objectives as having probably the greatest effect in the longer term.

For example, if the former Soviet Union had not gone broke there would not be fleets of nuclear powered naval vessels rusting away in northern ports. Anticipated optimal WOL project management for these nuclear powered vessels would have included disposal.

The solution to this problem is for society to think more broadly, and for other more prosperous nations to take over the WOL project management process and to assist with disposal. Such as statement is provocative and not the purpose of the research, however, it re-enforces one aspect of the work.

Another example is an inappropriate development in an environmentally important location. The outcome of such a development may be the loss of a species of flora or fauna.

21st century society demands WOL project management of those systems that have potential detrimental social, sustainable and environmental impacts.

5. Project Management Processes

This research has identified problems or limitations that need to be considered and rectified if project management processes are to be able to achieve the three project management objectives identified earlier. The three areas where problems or limitations were identified are:

- Education
- Tools
- Legislation and regulation

5.1. Education

Typical project management courses completed as part of undergraduate engineering programs cover project management basics. There is not sufficient time for students to cover all of the detail that one would expect a graduate who had completed an undergraduate project management degree. In fact there are actually very few specialised undergraduate project management programs in the world today.

How do project managers learn what to do? In most organisations the process is one of on the job training. Larger organisations provide sponsored access to training courses or postgraduate programs. Unfortunately this means that there are a large number of project managers in smaller organisations that do not get access to suitable external training programs.

Efforts are being made for engineers and project managers to be professionally accredited. Investigation has shown that there is a need for accreditation to be finer grained. A certified practicing engineer or project manager is a good first step.

Is a project manager qualified on LCA or LCC? What are the implications of using a consultant project manager when the project manager has not specialised in the project area?

Several companies now provide accreditation courses that are fine grained. For example, Microsoft, Novell and Cisco [7][8][9] offer accreditation that adequately reflects the area of expertise achieved on successful course completion.

5.2. Tools

A review of project management, LCC and LCA tools shows that there are issues of interoperability, transfer of information and access.
5.3. Legislation and Regulations

There are many aspects of legislation and regulations that may be considered. The aspects that the research has concentrated on are the need to re-enforce the need for education and improved tools.

Improved legislation and regulation is needed to guide the accreditation and training of project managers. In many industries and work categories this has already occurred. For example, in Australia it is now mandated that accredited tradesmen are required for electrical, plumbing, cabling, and other specialisations.

It is necessary for project management to be seen to be a leadership role and as such accreditation is necessary to ensure project managers are qualified for the roles they undertake.

Further regulation is needed to ensure that suppliers of components, modules or systems provide specifications in a common format. This information specification should include sufficient data items to permit systems analysis, LCC and LCA to be carried out in a uniform way so that measurable outcomes are achieved.

Another aspect of legislation that needs to be considered is to broaden the idea of project registration, approval and monitoring. Currently many projects require approval from some form of government organisation, especially building and construction projects. This approval process includes all levels of government.

The research has identified the notion of projects that are important to society for social, sustainable and environmental reasons. Projects that include these factors may need to be registered and project documentation collected at intervals to ensure that project management processes are continuing in an acceptable way. This is not a new concept; corporations are required to report on many aspects of their operation annually, and to undergo financial audits.

An example of this situation is hazardous materials. Some aspects of hazardous materials have been covered through legislation and regulation. The handling and storage of hazardous materials has been specified.

There are aspects that have not been specified. For example how much of a particular material is held and to whom it is sold. Recently in Australia there were calls to tighten regulations regarding the sale of some fertiliser products. Government at all levels was reluctant to move on this even though some fertiliser products are a base ingredient in terrorist bombs.

A problem with any information collection process is the cost of undertaking the information collection and what information should be collected. The issue of what information should be collected has been identified by the research as a topic that needs broad debate and a completely new view of what project management means to society.

In the 21st century the availability of electronic means to collect and submit information will provide a mechanism to overcome previous information collection limitations.

An example was the recent MIS Innovation Awards winner in the customer service category [10]. The Western Australian Water Corporation introduced “a web-based system that has cut customer waiting times from days to minutes and slashed the administration costs” and “The system called BuilderNet, was developed by the State’s Water Corporation, and allows builders to electronically submit plan approval and water connection requests, which are then automatically checked and returned. The approval process, which used to take up to three days, can now usually be completed within five minutes. Human intervention is only required if the system determines proposed plans might interfere with existing water infrastructure.”

6. The Future

Project management in the 21st century will be based on better education, tools and government legislation and regulation. When these basics are in place there will be a need for project management specialists to raise the standards for practice to a new level.

This paper has identified an aspect of current project management practices that need to be altered to achieve the 21st century project management objectives highlighted in this paper. Currently systems analysis, LCC and LCA are only carried out in a majority of projects in the tender and pre-contract phases. To facilitate this all practicing project managers need to have achieved a minimum level of accreditation in these areas.
The example of a change in aircraft paint may to many engineers be of no consequence when first considered. However, when this information is entered into a project management tool that incorporates LCC capability it would quickly become evident that changes to the paints weight, friction co-efficient and other factors such as availability in the supply chain would have significant consequences.

If a change to a system was necessary at some time during the systems service it would be good engineering practice to see how the original systems analysis and LCC or LCA is affected by this change. In many situations the original systems analysis, LCC or LCA have been filed away, lost or in many instances created using an earlier software tool that is no longer available.

This need for a review is equally true for all aspects of the project to see if the proposed change would affect the project such that one or more of the project management objectives is no longer met.

7. Conclusion

The research has concentrated on a sub-set of the issues confronting project managers achieving 21st century project management objectives. The sub-set includes those aspects that provide guidelines and a framework that should assist with a gradual improvement in achieving satisfactory project management outcomes.

The research has identified that project managers need further education, better tools and more defined guidance. It will only be through a combination of these improvements that project managers will achieve outcomes that 21st century society desires.

The newest project management objectives include social, sustainable and environment goals. The project management process must be reworked to ensure that these goals are now specified in all aspects of project management.

8. References


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Integrating Project Management and Systems Analysis

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Abstract

Project management is a process that provides structure, direction and control to achieve a successful project outcome. There is now a large body of knowledge applied to the understanding, implementation and review of project management principles and guidelines. Project managers are now offered training and accreditation by a range of organisations that support similar goals; improving the application of project management in our endeavours. Project management still suffers from limitations, and many projects are not successful for various reasons. One of these reasons is insufficient understanding and attention to system analysis principles and techniques. Project management is now ready to evolve to the next level through the integration of system analysis techniques into the fundamental project management principles and process. The paper highlights an approach to integrate project management and system analysis that facilitates training, knowledge of the principles and a simplified methodology.

1. Introduction

Project managers in the 21st century are becoming more specialised than their 20th century counterparts. The project management body of knowledge continues to expand and project managers now seek to attain accreditation to reflect their professionalism and mastery of the discipline.

Are project managers now ready to take the next step; that is, to investigate systems analysis techniques and principles that to date have largely been the domain of specialist engineers with postgraduate degrees in systems engineering or logistics?

Why should systems analysis be the next field of endeavour to be integrated into a project manager’s role? This question is a complex one and may be answered by considering the similarities between project management and systems analysis.

Project management relies upon four ingredients: time; cost; resources; and tasks. Systems analysis relies on five ingredients: time; cost; resources; tasks; and component parts.

A thorough understanding of the system that results from a project will in most circumstances lead to an improved project outcome. This improvement may be measured in terms of the time taken, the bottom-line cost for the current project, the whole of life cost for the system created, or by other means, such as environmental units which measure the impact of the project outcome on the environment.

Does the addition of one more ingredient, the consideration of component parts, so change the knowledge base and skill set required of practitioners as to place systems analysis out of the reach of project managers? The author believes it does not, provided a simple and effective way can be presented for project managers to learn and apply systems analysis principles and practices.

The research presented identifies a solution to the two needs identified. The first is how to provide project managers with effective, clear and concise systems analysis training and the second is how to provide project managers with a suitable environment that can be used to conduct project management and systems analysis concurrently.

The paper provides a brief description of systems analysis and the chosen systems analysis technique, Life Cycle Costing, which is integrated into a project management software application. The
The paper focuses on the integration methodology and proposes the addition of a “Systems Analysis View” (SAV) to all project management software applications. The results of the research are provided.

2. Systems Analysis

The term Systems Analysis has more than one usage. For the purpose of this paper a suitable definition is [1]:

“analysis of all aspects of a project along with ways to collect information about the operation of its parts.”

A more detailed description and definition is provided by Blanchard and Fabrycky [2], however, the purpose of this research is to consider systems analysis broadly. Systems analysis may be considered in other domains, such as from a business perspective [3], or as a general process for problem solving. James Robertson and Suzanne Robertson [4] use systems analysis to analyse “the complex requirements of a television station’s airtime programming department”.

Systems analysis may involve modelling, activity based costing, life cycle costing, levelling, life cycle assessment, data models, object oriented modelling, event modelling, systems engineering, risk management, probabilistic modelling, financial analysis, design and other well known techniques that may be used stand-alone to consider a system from a specific viewpoint. A major result of this research was to show that each of these techniques conceptually could be incorporated with base project management data through the addition of specific additional data and thereby be incorporated as a template to project management software applications.


Systems Analysis (SA) and Life Cycle Costing (LCC) are Whole of Life techniques that have been used for many years in large scale projects. They are overlapping to some degree in that both techniques are used to analyse a system from different perspectives and to achieve an understanding of the project’s potential outcomes. LCC, which is the determination of the cost of acquisition and ownership for the whole of life of a product or project, is in most cases used during the tendering and pre-contract phases as part of the process to find the right vendor for the job. Traditionally, SA and LCC have been used to consider system parameter development and not as a core component of the project management process.

What is interesting about SA and LCC techniques is that when applied correctly to a project at the outset, they have the potential to reveal costs, risk outcomes and performance success criteria of a project. Therefore, correct application of systems analysis and LCC principles should be a critical part of any project.

More recently LCC has been expanded to include sustainability and environmental factors. The traditional use of LCC on hardware or software system outcomes is being changed as the nature of solutions change and as a new generation of engineers and project managers see the potential for LCC principles being applied in new ways.

2.2. Basic Ingredients

The basic ingredients for project management are time, cost, resources and tasks. Several software applications considered during the research used these basic ingredients as the inputs through which project management was facilitated in the software application.

Resources may be considered as human or material, single or multiple use, and may be applied in whole or part to one or more tasks. Tasks may be individual or a group often formed into a task and sub-tasks. Groups of tasks may be contiguous or time displaced. Cost may be represented as net present, inflated or discounted. Time provides a boundary for tasks.

A project can also be considered as an entity. It is possible the project as a whole to be considered as a system. For example, the effect on a panorama when a new multi-story building is constructed is an outcome that is not directly part of the building project. Another example is the environmental impact of a project, which may not become apparent until the project is completed.

Project management is, of course, more than just the acquisition and manipulation of four basic ingredients. Teamwork, inter-personal relations, goal setting, and other very important aspects to project management are often an intangible part of human endeavour. What makes a good team? How
are these factors applied to project management planning when sitting looking at a project management software application on a computer screen?

Each of these activities may be implemented as tasks to be carried out at certain points in the project. For example, each week the project manager allocates one hour to the consideration of current team work and to consider impediments and possible improvements. Other tasks could then be assigned as a result of this analysis.

Life Cycle Costing as with other systems analysis templates include system components as a basic ingredient. System components may be combined to form a system which will be the outcome of the project. A system may be a single entity or multiple entities, such as a project to build a suburb with five house variations, streets, power, water, sewage, etc.

For LCC system components have attributes that include Mean Time Between Failure (MTBF), Mean Time To Repair (MTTR), and other reliability and maintainability factors. The purpose of a LCC analysis is to attain a whole of life cost and calculate associated information including such logistic information as number of spare parts, repair levels, and the number of repair personnel required at each level.

For the purpose of this reader a more detailed discussion of LCC is provided by [6] or other international standards.

3. Integrating Project Management and Life Cycle Costing

The purpose of the research was the integration of systems analysis with existing project management software applications and to identify what is required to achieve this outcome. It is therefore logical that new software applications developed from scratch would incorporate the systems analysis aspects into the design minimising duplication where ever possible.

To achieve interoperability with an existing software application it is necessary to create a separate storage object for the additional data items, Figure 1. This may be either a separate file or a separate database table depending on the project information source. The purpose of the separate storage object was primarily to store the system hierarchy of system components and associated attributes and also extra attributes needed for the other inputs; time, cost, tasks and resources.
Having designed the storage object to complement the existing data storage object the next step was to add a new unique System Analysis View, Figure 2, to the standard views, for example Gantt and Pert. As with the renowned Gantt and Pert charts the SAV may become a mainstay of future project management applications.

The SAV was divided to provide four functional areas. The first was the system hierarchy window, the second is an attribute (property) window, the third is the library window and the last is the ToDo window.

The system hierarchy window provides a location where system components, resources or tasks can be dragged and dropped from the library window or added as new items by the user. The items in the system hierarchy window can be selected individually and their attributes (properties) changed in the property window. Value and range checking is applied to ensure meaningful information is entered into the attributes.

The system hierarchy window provides a visual design environment for implementing the system and associating specific LCC resources and tasks with the system for the purpose of ensuring sufficient information is available to ensure the LCC calculations and reports can be produced.

Tasks and resources added to the system hierarchy window may be added into the Data Store B, Figure 1. This provides a mechanism to ensure that all of the tasks and resources necessary for a LCC analysis can be seen in the Gantt and Pert views if required.

The system hierarchy window provides for a system design to be created consisting of a hierarchy of component parts. The system may consist of one or more major subsystems, such as a fleet of cars (sedan, coupe, wagon).

One of the key requirements for LCC analysis was to be able to create versions of the system being studied so that different versions could be compared. This would allow for the system to be “frozen” at key milestones throughout the project life.

The need for a simple way to enter information led to the design for the library window. The purpose of the library window was for task, resource and system component libraries to be made available to the user. This would permit the user to create custom libraries of tasks, resources and system components and to be able to re-use the libraries in multiple projects. The libraries become separate data storage objects that may be files or database objects.

The use of library files provided a simplification of the overall integration of LCC within the software application. How would a typical Project Manager know what system components, resources and tasks were the minimum necessary to successfully create the project plan and then to carry out the LCC calculations? By providing a complete template the issue for a project manager becomes what information is needed to successfully gain meaningful reports, and the ToDo window is used to provide a suitable guide based upon the outcome of the automatic decision intelligence provided.
The ToDo window was created as a way to identify to the software application user the steps or information that must be completed or provided to facilitate the LCC calculations. A level of intelligence was introduced into the design by allowing the user to double click on an entry in the ToDo window and to for the cursor to be moved to the appropriate step or location for information to be entered.

An example might be a project for the introduction of a fleet of aircraft into the Military. A project manager could open an aircraft template library file that contained system components, resources and tasks appropriate to this project and then drag and drop all or some of the library items into the SAV.

The next operation is to carry out a preliminary calculation step that can be done manually or automatically. The result will be a list of items in the ToDo window. The user removes each item in the ToDo window by double clicking on the item and then entering the information at the location highlighted by the application. The user then moves back to the ToDo list and actions the next item in the list until all the items are gone.

At this point the user may perform LCC calculations and attain reports suitable for presentation to the project team or to the organisations executives.

5. Calculations and Reports

The successful integration of the LCC data model with the Project Management data model now meant that calculations and subsequent reports could be produced. To perform calculations data is extracted from both data storage objects, combined and processed.

Calculations successfully designed and implemented include:
- Availability
- Life Cycle Costs
- Support Rationale
- Research, Development, Testing & Evaluation Costs
- Maintenance
- Deployment
- Annual Costs
- Annual Costs (Inflated)
- Annual Costs (Discounted)
- Sensitivity
- Monte Carlo

6. Research Support and Outcomes

The research has led to the development of Pipercove System Analysis® [7] which is an Add-in for Microsoft Office® Project. The research was supported in part by a Government COMET grant [8].

At the time of writing this paper, Pipercove System Analysis® has just been released and was used in a pre-release commercial training course from which positive feedback was received. RMIT University has become the first University to introduce a course [9] utilising this software based upon successful demonstration of capability and features.

7. Conclusion

The research has identified that project managers when provided with suitable training and software applications can gain appropriate knowledge of systems analysis practices and techniques and can then carry out these practices and techniques to successfully achieve a systems analysis.

The research has identified a way to integrate project management with a system analysis technique; Life Cycle Costing and that using this methodology other systems analysis techniques can be similarly integrated.

A major outcome of the research is the proposal for the SAV to become an integral part of all project management software applications.

The research proposes project management in the 21st century broadening its scope to include systems analysis as a fundamental principle to be learned by all project managers and to be included in the project management body of knowledge used for project manager accreditation.
8. References


[7] Pipercove System Analysis® is software application which is copyright, trademarked and owned by Pipercove Software Pty Ltd. http://www.pipercove.com/. The author is a Founding Director of Pipercove Software.


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Method to Integrate Life Cycle Costing into Project Management

Mark A. Gregory, Member, IEEE and Hong Ren Wu

Abstract—This paper presents a method to integrate life cycle costing (LCC) into project management. The integration of life cycle costing into a project management software application is shown to be a framework that could be used to permit other specialist activities to be integrated into a generic environment used to carry out project management planning. The research aims to provide project managers in all organizations with access to outcomes from specialist activities, e.g., LCC analysis, and thereby reducing the need for a specialist to carry out the analysis. A common approach to data element information storage, management and manipulation is provided by the framework developed during the research and this may provide the impetus needed for organizations to request suitable data element information from vendors.

Index Terms—Engineering management, project management, engineering education, technical risk, risk analysis

I. INTRODUCTION

PROJECT management in the 21st century is a fundamental activity relying upon a new breed of project managers who must be a natural salesman who can establish harmonious customer relations and develop trusting relationships with stakeholders [1].

Project managers fulfill their role in part by working with people and information. The modern project manager is required to perform the project management planning activity, to oversee the implementation of the project management plan, and to maintain contact with project sponsors, the project team and third party organizations. An important aspect of the project manager’s routine is to ensure that the project management planning process activity is given a high priority and constantly reviewing the project management plan.

Shenhar, Levy and Dvir [2] conclude that project success has four dimensions: project efficiency, impact on the customer, the business impact on the organization, and opening new opportunities for the future. This research considers how technical risk can be better managed to assist project managers achieve project success.

Project managers today come from different backgrounds and may have project management qualifications from universities or other institutions. Project managers may be trained using one of the project management methodologies, such as that offered by the Project Management Institute Guide to the Project Management Body of Knowledge, also known as the PMBOK Guide [3].

Project management software applications are available to assist project managers with development of the project management plan.

Often the process of learning about the project management planning tools commences during study programs completed near the beginning of a project manager’s career or through exposure to project management planning tools whilst a member of a project team.

Life Cycle Costing (LCC) is a technique that provides project managers with a means to gain an understanding of technical performance and whole of life costs for the system being studied. Blanchard and Fabrycky [4] state that the value of an LCC analysis is in its application and availability to the project manager: “The results of such an analysis must be to the proper depth, must be timely, and must be responsive to the designer/manager involved in the decision making process”.

The research presented in this paper identifies a method to integrate LCC into project management. The research outcome is to provide project managers with a simple, easy to use, integrated environment where the project
management planning activity and a life cycle costing analysis can be completed in a complimentary manner.

II. LIFE CYCLE COSTING

A. Projects and Life Cycle Costing

Managing project risk is a project management process that is ongoing through the project life cycle [3]. LCC is a technique that provides an understanding of technical performance and whole of life costs, and this research proposes that LCC is a useful tool that can be used by project managers when managing project risk.

In recent decades LCC has attracted more attention and is being adopted more widely. Already LCC is required to be used in medium and large projects for Government and Defence projects in many countries. LCC is a technique that is carried out using simulations or models. LCC simulations and models may be targeted towards a particular system under study. LCC has been adopted by the construction industry [5] and by organizations implementing ISO 14040 [6] on Life Cycle Assessment (LCA).

B. Impediments

Several of the impediments to effectively using LCC during a project were summarized during an audit by the Australian National Audit Office (ANAO) of the use of LCC in the Australian Department of Defence in 1998 [7].

The audit identified that:
--to be effective LCC analysis requires suitable information for each component of the system being studied. Obtaining this information may be difficult and time consuming.
--enforcement of the policy for the use of LCC throughout the acquisition life cycle was lacking.

The ANAO noted that project teams were not always able to gain access to specialists who would typically carry out the LCC analysis. The availability of technical specialists in the Defence Department was shown by the ANAO to be limited causing a significant impediment to LCC being adopted by project teams.

In many other organizations access to specialists to carry out technical analysis may not be possible for a variety of reasons. One reason may be that the cost of maintaining a technical specialist on staff or using a consultant to carry out technical analysis makes it impractical for the organization to adopt LCC for all projects.

To address the aforementioned impediments, the research aim is to reduce the need for project teams to access technical specialists to carry out technical analysis by providing a simple to use automated integrated software application.

Software applications that provide a modern integrated approach to project management, technical analysis and LCC are being called for. Robert Deemer [8], the Chairman of the Committee on Advanced Engineering Environments (AEE) for the National Academies of the Aeronautics and Space Engineering Board, USA, called for the implementation of advanced engineering environments to be implemented that would:
--‘Use advanced computational, communications, and networking facilities and integrate tools to create integrated virtual and distributed computer-based environments linking researchers, technologists, designers, manufacturers, suppliers, and customers’ and
--‘An ideal AEE would encompass concept definition, design, manufacturing, production, and analyses of reliability and cost over the entire life cycle of a product or mission in a seamless blend of disciplinary functions and activities’.

This research has identified an approach to remove the impediments to LCC being available to all project teams throughout the project or system life time. The effect of removing the impediments will be to promote a greater understanding of LCC as a technical risk management tool and to provide greater visibility of technical risk within the project team and to the project sponsors.
C. Responsibility

Managing project technical risk is a project management process activity that should be carried out for the project or system life-time. Often during the project or system life-time changes to personnel occur; project managers, project team members and project sponsors.

Jan Emblemsvag [9] wrote “I believe that one of the prime reasons for this lack of interest in LCC is that it has mainly been associated with engineering: Life cycle costs are the costs of some technical ‘stuff’ sometime in the future that the engineers worry about. But who cares about a distant future when most decision-makers are either in a new position, retired, or even fired? In fact according to The Economist, an average American CEO only has a position for 18 months before he or she is removed. Or equally common, who cares about the impact on other people’s budgets? Apparently, LCC concerns many issues that stretch beyond most organizational short-term needs, functional boundaries, and present issues”.

Often it is difficult to determine the system history, when a problem originated, and who was responsible. Determining responsibility can be difficult, and is made more difficult when the technical risk management processes are not maintained for the life-time of the project or system.

A smooth and effective way to transition responsibility for technical risk management during the project or system life-time is needed.

The research presented in this paper identifies an integrated environment that provides the opportunity for project managers to keep LCC analysis information up to date whilst maintaining the project management plan. Project managers are the key personnel
who are required to maintain the project management plan and by adding a more effective means for project managers to maintain the LCC activity an improvement in technical risk visibility and responsibility can be achieved.

D. Integration Aims and Outcomes

Providing a more integrated LCC and project management environment facilitates timely information gathering, analysis and retrieval for both the LCC analysis and the project management planning activity. The integrated environment may be utilized by the project manager for the duration of the project or system life-time thereby achieving an outcome that provides a framework to increase the value of the LCC analysis to project managers.

The project management planning activity utilizes information that is also used in an LCC analysis. Integration of the two activities ensures that shared information is kept in synchronization between the two activities and thus provides a clearer picture of the effects that occur when something changes.

An integrated environment provides a new approach to technical risk management that is more open to project team members, project sponsors and associated organizations.

III. METHOD

A. Description

The method to integrate LCC and project management is shown in Fig. 1. A generic project management tool (PMT) is shown as a software application consisting of several layers of functionality. The PMT consists of a user interface for entering and manipulating data and calculations used to generate outcomes and reports. A PMT provides the capability to store and retrieve data from data storage. Data storage may be a disk file or a Structured Query Language (SQL) server.

To identify the functional modules that are added to the PMT they are grouped in Fig. 1 into what is called the System Engineering Tool (SET). To carry out an LCC analysis, data is required and calculations performed to achieve the analysis outcomes. The research has shown that it is possible to create a framework that would permit the substitution of different data and calculations to that needed for the LCC analysis and therefore it was decided to broaden the terminology to talk about the possibility of a framework that permits any of the system engineering specialist activities to be integrated with the generic PMT.

This paper presents research concerned with the integration of LCC with project management within a new framework that enhances existing project management software applications.

B. Data Elements

Common data elements to both the LCC analysis and the project management planning activity were identified as tasks, resources, time and costs. Each of these common data elements may have a number of properties.

A generic PMT may provide the user with user interface views based on common methods to represent the data elements, e.g., PERT, Gantt Charts or spreadsheet, and capability to manipulate the data elements: tasks, resources, time and costs. Many of the generic PMTs today are multi-user software applications that provide a range of related features, calculations and reports. The features provided by a generic PMT may include task optimization, resource leveling and other capabilities aimed at providing the project manager with ways to manipulate the data elements with the outcome being a more optimized project management plan.

The LCC analysis requires the introduction of an entity that may be called a part or a component. The system being studied consists of one or more components assembled in a certain manner. The component is a data element that includes properties. The properties may change depending on the LCC model used to carry out the LCC analysis. Examples of component properties for a typical LCC model are:

--reliability,
--maintainability,
--logistic,
--sustainability,
--environmental,
--cost, and
--operational requirements.

The LCC analysis may also include a grouping of tasks called activities. An activity may or may not have associated resources or time and may consist of tasks that may be contiguous or separated in time. It was therefore useful to include activities as a separate data type.
C. Modules

1) Templates: may be provided with access to more than one LCC model or to other specialist activities (e.g., Activity Based Costing, reliability analysis methods, and maintainability analysis methods). The use of templates, (Fig.1), would enable the user to be provided with a user interface, calculations and reports that match the LCC model or specialist activity currently selected. The templates would be able to be selected or deselected as required by the user, and the library, guide and ToDoList modules would reflect the active template. The active template would be visually identified to the user. If the user only wanted to carry out the project management planning process without activating one of the templates, the software application would provide this option.

2) Library: Access to a library of system components (data elements) was added to permit information to be retrieved from data stores, such as a disk file or SQL server. The library module provides the user with the capability to create new library data stores and to create, edit or change existing system components within the data stores. The purpose of the library module is to facilitate a mechanism to reduce the time taken to gain access to appropriate data elements. A multi-user software application enables the data element management process to be delegated to one of the project team members. The team member with this responsibility may then gain access to the system component information in a format suitable for use within the software application from the vendor.

3) System Version Control: To facilitate identification of the effects of changes the integration method includes introducing the concept of revisions or versions. The system being studied may change over time and it is helpful to be able to carry out a comparison analysis or summation analysis with earlier versions. This feature may also be helpful when doing a what-if analysis. The version module provides users with the capability to create system versions and to freeze, copy or edit a previously frozen system version. It is important to maintain a history of the complete system under study, because over time the system may change significantly not only due to changes in the physical build but also due to changes in the system operational or other requirements. It would be useful to the project manager to be able to reflect on the effects of changes to the system or project outcomes over time.

4) Guide: The integration methodology includes the introduction of a guide similar to guides or wizards found in many software applications today. The guide is normally used with a user is preparing a new system for study and prompts the user with a series of questions requiring answers. The purpose of the guide is to ensure the basic information needed to carry out a LCC analysis has been entered.

5) ToDoList: The ToDoList is different to the guide in that its purpose is to provide the user with a list of actions requiring their attention. The purpose of the ToDoList is to implement a set of rules that would highlight actions that should be performed by the user prior to or whilst carrying out an LCC analysis. One such example of the importance of the ToDoList is to highlight to the user data elements that have missing information or have default information that should be updated. The ToDoList is also used to identify irregularities in the system structure and other aspects of the system design, e.g. identifying components that have been incorrectly placed in the system hierarchy.

6) Calculations: The calculations module includes the mathematical algorithms that will be performed during the LCC analysis. The results of the calculations may be added to the data store or provided to the user interface or reports modules. Examples of the calculations that would be performed during the LCC analysis may be found in the Cost Analysis Strategy Assessment (CASA) software program [9]. CASA is an important LCC model that is suitable for use in a range of Government and Defence projects.

7) User Interface: The user interface provides a view to the components, system, library, ToDoList, and reports. The software application would also include explanation and help views. The user interface would be designed to match the generic PMT software application. In principle the user interface would be designed to be a simple representation of the information to be displayed, to be flexible and to be user friendly. The user interface view implemented in the research prototype utilizes dockable windows that may be repositioned by the user to suit the user’s preference.

8) Reports: The reports module would provide the capability to create reports, charts, or summaries and to permit the user to store, print or transmit the reports, charts or summaries to recipients. Reports can be created as PDF, XML or HTML documents for dissemination and storage. Reports identified during the research and implemented in the
research prototype are:  
--Availability  
--Life Cycle Cost  
--Support Rationale  
--Research, Development, Testing and Evaluation  
--Maintenance Man-Hours per Month and Maintenance Personnel per Location  
--Deployment Data  
--Annual Cost  
--Annual Cost Comparison  
--Summation  
--Risk Analysis Sub-Model  
--Sensitivity Analysis

Fig. 2. Complete cost report generated using CASA [9].

Fig. 3. Total cost calculated using prototype.

D. Research Outcomes

The research included development of a prototype software application. The prototype software application was based on a generic PMT and the SET was added to it. This provided an opportunity to test the integration method and to analyze the results. A generic PMT was selected based on the availability of an application programming interface (API) that would enable the SET to be integrated.

The LCC model implemented in the prototype was the CASA [10] LCC model. The CASA software application is provided with
two sample data sets. Both data sets were used during the prototype testing. The results for the data set entitled Tenderer A Full Data are shown in Fig. 2 and Fig. 3.

For the purpose of the prototype testing the research outcomes were identified as

--Successfully integrating a SET and generic PMT
--Successfully carrying out project planning and LCC Analysis using the integrated software application

The research outcomes were successfully achieved. The prototype calculated results for the sample data set Tenderer A Full Data were compared with results generated using CASA [10]. The LCC cost results presented in Fig. 2 and Fig. 3 show that the total costs were calculated with a small difference

IV. CONCLUSION AND FURTHER WORK

The method developed in this paper identifies how to method presented in this paper identifies how to integrate LCC into project management. The research outcome is to provide an environment where the project management planning process and LCC analysis may be completed at the same time. The reason for integrating these activities is to provide the project manager with more timely access to the critical information needed to ensure project success is achieved.

The research has identified that the method presented in this paper can be used to permit the integration of other specialist activities into project management.

The reason for wanting to integrate LCC into project management is to provide the project manager with timely accurate information using an environment that is familiar to the project manager and used often. The research aims to provide project managers with an environment that provides more information about the project or system being studied, particularly by making available outcomes that have previously been the province of specialists and separated software applications.

There has always been a cost to organizations associated with carrying out specialist activities such as LCC analysis. The impediments to carrying out an LCC analysis for many organizations has been the additional cost of a specialist to carry out the LCC analysis and the cost associated with getting access to the information needed to do the LCC analysis. The research aims to remove both of these impediments by creating a framework software application that can be used to train project managers in how to carry out a LCC analysis at the same time the project manager learns how to do project management planning and by providing a mechanism to gain access to system component from a range of data sources and formats.

Organizations may, as familiarity with the new software grows, begin to request from vendors the data element information needed to carry out the LCC analysis because project managers, project teams and project sponsors will know that the project management software application will perform a LCC analysis if the data element information is provided. Gaining access to the data element information will enable the organization to build a data store of this data element information thereby re-enforcing the process within the organization.

This research has concentrated on specialist activity, LCC analysis, and it is left for future research to apply the framework method and integrate other specialist activities into the PMT as templates that can be selected by the project manager in much the same way that the project manager can swap between a PERT view and a Gantt Chart view of the data element information. It is envisaged that future research will be possible into integrating more of the specialist activities (e.g., quality, reliability or maintainability analysis) into the generic PMT as part of the SET thereby moving some part of the way towards the AEE envisaged by Robert Deemer [8].

The addition of a ToDoList module to the framework has been identified as an important concept because the purpose of this entity is to implement rules that will cause actions that need to be carried out by the project manager to be highlighted. The rule set may be further developed as future research and applied to other specialist activities as they are added to the framework. The research into the ToDoList rule set is considered to be a significant requirement for the aim of this research was to provide the project managers with access to new features available when they are carrying out the project management planning process and for which they do not need specialist training to carry out in much the same way we have seen the use and changes to calculators over the years.

The research provides a contribution by identifying an approach to make managing technical risk more visible to project managers,
the project team and the project sponsors throughout the life-time of the project system. Reducing technical risk is a priority that should be raised through more visibility of technical analysis outcomes and is needed today because project outcomes may include more complex systems. The research also contributes by identifying a means to provide longevity to knowledge of the technical risk associated with a project system.

References


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TRManager – Technical Risk Manager

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ABSTRACT
This paper presents research into the development of a new information management technique called Technical Risk Manager. Project management involves the use of processes and information management techniques to aid decision making in the pursuit of project success. Project success may be achieved by meeting time, cost or performance criteria. Current project management practices focus on achieving time and cost project success criteria by using three information management techniques developed in the 1950s: Gantt, PERT and Critical Path Method. Technical Risk Manager has been developed to provide an information management technique that may be used to aid project management decision making in the pursuit of achieving the performance project success criteria.

Keywords: Technical Risk, Management Information Systems, Systems Engineering, Project Management, Informatics

1. INTRODUCTION
Project managers apply Project Management (PM) principles and processes as a basis for how a project will be carried out. Project success is often measured using time, cost and performance criteria.

Throughout the project life cycle, the project manager actively seeks information to gauge progress and to permit decision making. In particular, the project manager seeks information about those areas of the project that are viewed as critically important to project success, and which, if carried out incorrectly, will result in project failure. The project manager will utilise Information Management Systems (IMS) to manage the project information.

Technical risk (TR) may be defined as “the risk that a system will not reach its performance goals, development will not be within the specified timeframe and / or it will cost more than estimated due to technical developmental and maturity risks” [1]. Technical Risk Management (TRM) is the act of planning and executing systematic identification and assessment of technical risks, and implementing means to avoid or mitigate the effects of risks if they reach an unacceptable level.

This paper provides results of research into managing technical risk information. A new information management technique called Technical Risk Manager (TRManager) is presented. A survey carried out at the PMOz 2005 conference [2] highlighted deficiencies and issues associated with existing IMS utilised by project managers. The survey results indicate that project managers are confronted by inadequate knowledge of TR and a lack of integrated IMS with which to implement TRM. These issues appear to be related: the lack of TRM capable integrated IMS suitable for all project managers may also point to a reason why project managers have poor knowledge of TRM concepts and application.

Black [3] reports that “Increasingly, Government customers and Industry contractors seek better methods to identify and manage technical, schedule and cost risk.” The survey conducted by Black of participants at an Aerospace conference in 1998 found that 39 per cent of respondents expect engineers to play the major role in risk management, whereas 33 per cent place that responsibility on the cost estimators, and 14 per cent elsewhere. Black’s survey results highlight the variability of risk management approaches being utilised and the lack of a consistent approach due to unsatisfactory existing methods and IMS.

This paper presents a research outcome that highlights the compatibility between TRManager, Gantt, PERT and CPM. By adding TRManager to existing IMS that already incorporate Gantt, PERT and CPM, project managers will be able to carry out time, cost and performance management using an integrated IMS.

2. SURVEY
The survey was conducted during a session of the PMOz 2005 conference [2], held in Brisbane between 30 August and 1 September 2005. The annual PMOz conference regularly attracts several hundred project managers as attendees and PMOz 2005 was no exception. During the chosen session a total of 40 surveys were given out, one to every person in the session. Twenty two surveys were completed and returned, giving a response rate of 55 per cent. The purpose of the survey was to obtain a ‘snapshot’ of active project managers’ knowledge of TR and TRM tools.

Survey questions
The survey questions were designed to establish the project managers' backgrounds, education levels, corporate knowledge and perception of their organisations' spending on PM activities, including PM IMS.

The six areas identified in the survey were:

1. Corporate information  2. General PM information  
3. Personal information  4. PM tools  
5. Life Cycle Costing (LCC)  6. Activity Based Costing (ABC) 

The survey was designed to provide evidence of the project manager’s TR knowledge and knowledge of TR related analysis techniques and associated methods. Survey questions relating to TR aimed to identify more than a cursory understanding of what TR is and how one would go about TRM.

The survey design was to enquire about two specific analysis techniques that can be used by a project manager whilst carrying out PM and TRM. The two specialist activities (ABC and LCC) were selected because in 2003, Emblemsvag [4] developed an approach called Activity Based Life Cycle Costing (ABLC) that is a synthesis of ABC and LCC. Information gathered for a LCC analysis is also used when carrying out TRM. LCC models have been enhanced by adding technical parameters to the project system elements thus providing whole of life costing and TRM using an integrated model.

The integration of ABC and LCC by Emblemsvag made ABC and LCC very suitable choices as the specialist activities to be included within the survey. ABC and LCC are both independently well established and broad analysis techniques that are used in many organisations today.

**Life Cycle Costing and Activity Based Costing**

LCC is a method which provides an understanding of the whole of life cost of a project system. When additional technical information associated with the project system elements are added, LCC models can be used to analyse the technical performance of a project system. Cost Analysis Strategy Assessment (CASA) [5] developed by the US Department of Defence is one example of a model that incorporates LCC and TRM capability.

LCC was originally developed in the early 1960s by the US Department of Defence to increase the effectiveness of government procurement [6]. LCC is a process used to determine the sum of all costs associated with a product or service over the life-time of the product or service and may be considered a technical and economic assessment process [4].

In the 1970s and 1980s, LCC was further developed and extended to include whole of life costs associated with the design, manufacture and use of the system being studied. Today LCC models have been adopted by many countries, including Australia, as a requirement for medium and large procurements within Government Departments and Organisations. Many industries are also adopting LCC as a mandatory activity to be conducted on all new projects.

ABC is an accounting method identified by Cooper [7][8] and Cooper and Kaplan [9] in the 1980s, initially at the Harvard Business School, which allows businesses to identify operating costs by analysing activities. Costs are assigned to specific activities, such as planning, R&D, implementation or in-service support, and the activities are then associated with different products or services. The ABC method enables a business to analyse activities and identify where profit or loss is occurring.

ABC techniques were initially adopted by some of the business mass media, consultants and business schools as a means of enhancing organisational efficiency, and addressing the limitations and pitfalls of traditional management accounting. Today ABC is current, well defined and used within many organisations.

**Survey response**

The survey respondents were active in 10 of the 17 Industry areas identified in the survey. The largest group of respondents were employed in Government Administration and Defence (28 per cent); the second largest group in Construction (18 per cent); followed by Electricity, Gas and Water Supply (13 per cent).

Thirty per cent of the respondents indicated that their organisation possessed a written company PM guideline. Those that indicated that there was a guideline provided details of the wide range of competing standards, methodologies and approaches in the PM arena.

Twenty-two percent of respondents indicated that their organisation used an in house methodology and 22 per cent indicated that their organisation adopted all of the approaches provided in the survey question. Some of the methodologies identified were Prince2 [10], PMI IT Management Methodology, Defence Procurement Management Methodology and PMBOK [11].

The survey respondent’s academic qualifications were reasonably spread with the largest groups having a Bachelors degree (27 per cent), a Masters degree by coursework (22 per cent) and either a Diploma or a Graduate Diploma (27 per cent). One of the respondents had no formal qualification. None of the survey respondents possessed a Masters Degree by research or a PhD. Overall the survey respondents’ academic qualifications indicated a group of people who had carried out academic programs where they may have been introduced to PM concepts and specialist activities such as LCC and ABC, though the specifics of the academic program was not sought.

Half of the survey respondents indicated they possess a PM qualification from a professional body. Roughly equal numbers had either a Project Management Professional or a Registered Project Manager qualification.

About 88 per cent of the survey respondents indicated that their organisation used Microsoft Office Project (MSProject) [12] as their PM tool. This response highlights the current market penetration achieved by MSProject.

Respondents indicated they use a range of software applications for specialised activities, highlighting the number of such applications on the market. 40 per cent of the respondents use MSProject in combination with other software applications to carry out cost, time and performance management.

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Respondents reported that the major weaknesses of the project management tools and TR software applications that they used in their organisations were importing and exporting data, communicating with other tools, permitting team members to communicate information and compatibility. About 45 per cent indicated that communication between tools was a major weakness; approximately 40 per cent thought communicating information between team members was a major weakness, and about 30 per cent indicated that compatibility of applications was a major weakness.

About 30 per cent of the respondents indicated that importing data was a major weakness with the tools and software applications being used. TRM methods, including LCC, use system models that are built with component information often provided by vendors and the survey highlights the problem of importing data into the software applications being used by the respondents’ organisations.

More than 50 per cent of the respondents indicated that they could not import task and resource information from a data source into the software application being used for TRM. Seventy-seven per cent of respondents indicated that their PM planning tool would not permit them to import task and resource information from a data source or library.

About two thirds of the respondents indicated knowledge of LCC and ABC, although when asked to write a definition of the terms, the descriptions were vague or inadequate in 40 per cent of responses. About 30 per cent of the responses adequately described LCC and ABC.

Less than one third of the respondents indicated that LCC and ABC had been used in their organisations. The major reason cited for not using LCC and ABC was that someone, typically identified as an engineer, needed to be trained. This response points to an ongoing perception that LCC is a specialist activity to be completed by someone other than the project manager (e.g. an engineer) or not at all. This outcome of the survey correlates strongly with the survey conducted by Black [3]. Combined with the weaknesses identified in available software tools, the survey highlights two impediments preventing project managers from carrying out TRM. The first impediment is training in TR methods, such as LCC. The second impediment is access to TRM capable integrated software applications that can be used to carry out this specialist activity as an integral part of the PM processes. The benefit of removing these impediments would be to empower project managers with the capability to carry out TRM as a standard activity in the same way that project managers carry out scheduling, planning and critical management of project time and cost.

3. FOCUS ON THE PROJECT MANAGER

Let us consider the second impediment, the lack of TRM capable integrated IMS. The outcome of the research to solve the second impediment is the proposal that PM must incorporate TRM more directly and therefore PM IMS should have TRM incorporated.

Generally project managers become familiar with PM IMS and are trained in their use while completing undergraduate or PM qualifications, or through experience gained as a member of a project team. PM IMS are fundamental to the profession and used by the majority of project managers because they permit project scheduling and are inherently useful for measuring time and cost over the project life-time. Important capabilities provided by a PM IMS are the Gantt Chart, Program Evaluation and Review (PERT) and Critical Path Method (CPM). PERT was developed by the U.S. Navy in cooperation with Booz-Allen Hamilton and the Lockheed Corporation for the Polaris submarine project in 1958. CPM was developed by DuPont, Inc., about the same time. The Gantt chart was developed around 1917 by Henry L. Gantt, a pioneer in the field of management studies.

The PM IMS is in essence a delivery platform for Gantt, PERT and CPM, each developed separately, yet each integrated into modern PM software applications. This can be done because Gantt, PERT and CPM all use four common core data elements: time, cost, tasks and resources.

This research presents an approach to solving the second impediment by adding TRM methods to currently available PM IMS. This approach would provide new capabilities to existing PM IMS. Earlier research [13] has shown that this is possible, because a LCC and TR method such as CASA uses the same four core data elements used by Gantt, PERT and CPM with some variations on how the information type is identified.

For a specialist TR engineer, risk is often represented in terms of complex information. As Jarrett [14] explains, however, the corporate executive is the decision maker who ultimately deals with risk decisions, and “even if it were possible to develop complex representations of risk accurately, it is difficult for the executive to deal with them. Instead, the executive is able to deal with a few scenarios and possible cases, and only with three general levels of conceptual risk associated with them: High Risk, Medium Risk, and Low Risk.”

Jarrett makes an important point that supports the proposal presented in this research that new capabilities added to a PM IMS should present outcomes in a way that matches the level of understanding of project managers and executives rather than specialist engineers. This would provide a satisfactory solution to the second impediment currently preventing project managers from carrying out TRM.

The solution to the first impediment preventing project managers from carrying out TRM, that is, lack of training in TR methods, becomes immediately solvable with the development of a TRM capable PM IMS. This new PM IMS can be used in PM training courses as a logical extension to training in how to use Gantt, PERT and CPM.

Identification of the impediments preventing project managers from carrying out TRM has led to a prototype of TRManager being incorporated into an existing PM IMS. A LCC and TR add-in to MSPProject was created and this capability has been used for two years in a postgraduate engineering course at RMIT University [15][16].
Feedback from the course participants indicated that more than 80 per cent of the participants found they were able to improve their understanding of LCC and TR and how to carry out TRM.

4. TRMANAGER

Data Elements
Modern IMS that implement Gantt, PERT and CPM utilise four core data elements: time, cost, tasks and resources.

Parameters may be associated with the core data elements to provide more information about the purpose of an individual core data element. Relationships are created between the four core data elements to build an understanding of what is occurring as time progresses. For example, a task may be carried out by resources (people) utilising resources (material).

An example of the application of parameters to the core data elements is the use of qualifiers for the type of a resource data element. MOP [12] identifies three types of resource data elements: work, material and cost. MOP versions prior to 2007 only identified resource data elements as being either work or material. The use of parameters to qualify the four core data elements and to enhance the core data element applicability to model calculations permits IMS to adapt as new techniques and models are implemented.

The number of parameters associated with the four core data elements is related to the techniques and models being employed within an IMS. The parameters may be considered to be at a second level in the information hierarchy. Parameters are only identified as information associated with a data element.

The research identified that when TRManager was incorporated into an IMS the information hierarchy dimensions increased. The number of dimensions in the information hierarchy was found to be dependent on the model being used within TRManager. For example, when CASA was selected as the model to be used within TRManager the information hierarchy increased by two levels.

The research found that at the top level the four core data elements are sufficient to implement LCC and TR models or techniques within TRManager. This is a key finding that permits TRManager to integrate into existing PM IMS.

The principal change occurs at the second level in the information hierarchy. To integrate LCC and TR models or techniques into TRManager and to integrate with an existing PM IMS it is necessary to include a system resource type. For example, when the prototype TRManager was added to MSProject the resource type list was enlarged to include a system type. This meant that the resource type list became work, material, cost and system.

The new system resource data element may now have parameters associated with it depending on the LCC and TR model being used. A system resource data element that is being used in the CASA model includes about 20 level three information hierarchy parameters. One of the CASA level three system resource parameters is Reliability Growth. Reliability Growth types include as level four parameters None, Annual, Duane and Item.

Models
Research into TRM identified that industry specific TRM models have been developed. The TRM models may be based on TR or integrated with LCC models. The calculations and outcomes presented by the models are tailored to the industry application.

The US Department of Defence has implemented several hybrid LCC and TR models, examples of which are CASA and Automated Cost Estimating Integrated Tools (ACEIT) [17].

The EIO-LCA model [18] considers the environmental impact of a project system and permits environmental life cycle analysis. The example data set provided with the model includes analysis of the environmental impact of automobile and light truck manufacturing.

TRManager provides an environment where one or more TRM models may be integrated within an IMS. TRManager includes a list of selectable models permitting models to be added or removed from the list. This feature of TRManager permits industry specific models to be made available within a PM IMS. A project manager working within the packaging industry would be interested in seeing TRM models being provided within TRManager that are applicable to environmental impact and life cycle assessment.

Initial research found there are now more than 50 different TRM models used regularly within industry. TRManager may incorporate one or all of the models. Each model may necessitate different level three and four information hierarchy parameters. Whilst this may be straightforward to implement using modern computing systems it is not practical to include models if the users of the system are not likely to ever use the models. Therefore, a PM IMS that incorporated TRManager should include an installation step that would let the user select which TRM models to install.

TRManager Diagram
The TRManager diagram may be altered to reflect the IMS that it is incorporated into. The information that the TRManager diagram would provide includes the system, resources and tasks. Therefore within the TRManager diagram the resource system type data elements would be presented independently of the other resource types.

The research identified that many of the TRM models aggregated resources and tasks into activities. An example activity could be Transport which combines one or more individual tasks or resources. Another example of an activity is System Deployment, which may include one or more tasks associated with deploying the project system.
TRManager would facilitate information display that is system and activity based, Fig. 1, or timeline based, Fig. 2. In Fig. 1 the computer system resource data element consists of three child components: case, hard drive and power supply.

When the information is displayed using a timeline the diagram may be similar to a Gantt Chart or Network Diagram [12] with modification to display the system resource data elements associated with a particular task when a pointer is moved over the task. In Fig. 2, each task has an active location identified by the black triangle which would be used as a point where if the pointer was moved over the triangle the system resource data elements associated with the task would be displayed.

The research found that system resource data elements and associated parameters may be stored in a repository and made available for use in the PM IMS through a library capability. Vendors may provide this information as a requirement when delivering a system or service.

In some situations, the system resource data element may contain default values for the associated parameters when first added into the project system under study. The use of colours or dotted lines would permit a visual alert to be provided to the user to indicate that one or more of the system resource data elements may need to be changed. TRManager would simplify this process by initiating a link between the visual alert and the location of the parameter field that needs a new or different value. This link may be activated by the user “double clicking” on the system resource data element.

TRManager Reports

The TRM models presented through TRManager would include calculations and reports. The research identified that the reports would be selectable through the IMS reports list. The IMS may have reports associated with the Gantt, PERT and CPM techniques and other reports associated with features that have been added to the IMS.

The IMS reports list would be dynamic so that it would include the currently active TRM model in TRManager. If the active TRM model or technique was changed then reports in the IMS reports list would change to reflect the reports offered by the currently selected TRM model or technique.

5. CONCLUSION

This paper has presented a new information management technique called TRManager. TRManager integrates with and complements the existing project management techniques, Gantt, PERT and CPM. The benefit of TRManager is to provide an integrated environment where project managers can carry out time, cost and performance management.

The research was supported by the results of a survey of project managers. The survey was designed to examine the participants’ understanding of PM planning tools, access to TRM capable integrated software tools, and their understanding of two specialist activities, one of which is TRM related and the other cost related. The survey results showed a correlation with earlier research by Black [3] and Jarrett [14]. The research has identified two impediments to project managers carrying out TRM directly and proposed a solution to the two impediments. The research proposes the use of a PM planning tool as the delivery platform for TRM and argues that this is a fundamental logical extension of the inclusion of Gantt, PERT and CPM within PM planning tools. The new PM and TRM integrated tools can be used initially as part of operational availability and the calculated value had fallen below the system or sub-system target value then the data elements may be identified by a different colour to the other data elements or by a dotted line around the data elements. The research identified that the use of the stop light colours (red, yellow and green) were an effective way to highlight to project managers the current status of key project success measures.
the future project manager’s education and then throughout the project managers career. Feedback from University course participants who have used a PM planning tool that has had LCC functionality added indicated that 80 per cent of students found using LCC within the PM planning tool made the process of learning about TR methods and TRM easier. Project managers with a better understanding of technical risk will have acquired important knowledge that will enhance their ability to ensure project success.

6. REFERENCES
