Risk management of building project budgets

Simon Howard Jackson

A thesis submitted in partial fulfilment of the requirements of
Sheffield Hallam University
for the degree of Master of Philosophy

December 2000

ABSTRACT

Risk management of building project budgets - A thesis by Simon Howard Jackson, submitted in December 2000, in partial fulfilment of the requirements of Sheffield Hallam University for the degree of Master of Philosophy.

All too often major public building projects make the national headlines for being financial disasters, rather than significant engineering achievements that contribute to the improvement of our built environment. This research is concerned with the development of a conceptual risk management model, to be used by quantity surveyors, during the establishment of initial budgets for building construction projects.

The thesis is introduced with a discussion about the problem and challenge of accurate budgeting in the UK Construction Industry. Literature is then reviewed in the development of the risk management discipline, including consideration of the various definitions of both *risk* and *risk management*. The research then focuses on the establishment of the capital cost of construction for building projects, which also deals with a detailed assessment of risk management systems, tools, and techniques. A selection of commercial risk management software is also appraised.

Industrial application of risk management when estimating initial budgets for building projects is investigated by use of a postal questionnaire survey of 125 quantity surveying practices in the UK. Budget estimating base methods are clarified, causes of cost overruns are identified, and, in particular, the awareness, use, and performance of risk management tools and techniques is determined. Eleven structured interviews with professionals are carried out to validate and qualify the survey findings.

Based on this research a model is developed representing a risk management system framework which embraces the best performing tools and techniques. A project is selected as a case illustration and the use of the integrated model is demonstrated within a quantity surveying practice.

Conclusions are drawn from the research, including the requirement to facilitate risk management within a qualitative framework. Risk itself is identified as presenting both problems and opportunities, and the quality of information, interpretation of language, change, and human inputs, all have an influence on establishing accurate building project budgets.

It is recommended that further research should attempt to understand more clearly the issues of uncertainty, risk attitude, and change. This includes the possible development of a standard financial risk rating scale for the construction sector, coupled with the monitoring of industrial risk trends, and assessment of information on the reasons why building project budgets change from their initial estimates.

CONTENTS

Chapter 4 - Risk Management Tools, Techniques, and Software

Chapter 6 - Development of a Conceptual Model for Risk Management of Building Project Budgets

Chapter 7 - Demonstration of a Conceptual Risk Management Model in a Quantity Surveying Practice

Chapter 8 - Conclusion

References and Bibliography

Appendices

LIST OF FIGURES

LIST OF TABLES

ABBREVIATIONS

APM	Association for Project Management
ASTM	American Society for Testing and Materials
BCIS	Building Cost Information Service
BQ	Bills of quantities
BSI	British Standards Institution
CIB	Construction Industry Board
CQS	Chartered Quantity Surveyor
DETR	Department of the Environment, Transport, and the Regions
ed	editor
eds	editors
EMV	Expected Monetary Value
et al	and others
GFA	Gross Floor Area
HM	Her Majesty's
IRM	Institute of Risk Management
IT	Information Technology
KPIs	Key Performance Indicators
m	Million
m^2	Square metre
M+E	Mechanical and electrical
MERA	Multiple Estimating using Risk Analysis
NAO	National Audit Office
PMI	Project Management Institute
QS	Quantity Surveyor
RADR	Risk adjusted discount rate
RIBA	Royal Institute of British Architects
RICS	Royal Institution of Chartered Surveyors
t&t	tools and techniques
UK	United Kingdom
VAT	Value Added Tax

ACKNOWLEGEMENTS

Acknowledgement is due to the key people involved in the supervision of this research at Sheffield Hallam University's "Centre for the Built Environment". Particularly to Dr Paul Stephenson and Professor Alan Griffith, but also to Mr Julian Smith and Professor Pritpal Mangat. At the various stages of the work they contributed in their own individual ways by providing help and motivation. Appreciation also is extended to Ann Wilson and Susan Biggin for providing efficient and friendly administrative support.

The kind responsiveness of the various professionals in the Construction Industry was much obliged, and the staff at Sheffield Hallam University's "Learning Centre" provided reliable support in obtaining essential literature.

Finally, I would like to thank my family, in particular my Mother, who was there to the end to provide encouragement to keep me going, and to Elena, who kept me company during some potentially very lonely evenings and weekends working.

CHAPTER 1 - INTRODUCTION

1.1 Introduction

All too often major public building projects make the national headlines for being financial disasters, rather than significant engineering achievements that contribute to the improvement of our built environment. In the mid-1990s, a British Government investigation revealed that more than one quarter of construction schemes finished over budget (HM Treasury, 1995). Further to this, a survey of Construction Industry clients found that nearly one third complained that their projects generally over-ran budget (Barrick, 1995). This problem continued through the latter part of the decade with the Construction Clients Forum (1997) reporting that sixty per cent of clients said that cost targets were not being met. At the start of this new decade, only forty-five per cent of projects are being completed within budget (Department of the Environment, Transport and the Regions (DETR), 2000a). The Construction Industry has, therefore, acquired a poor reputation for delivering projects over budget.

This chapter sets the scene for this research. It begins by presenting some actual project examples illustrating the above problem, and then proceeds to view how the British Construction Industry and, in particular, its professional quantity surveyors, are responding to the challenge of accurate budgeting. The chapter will also explain the focus and limitations of the work, including the aim and objectives, and an overview of the research methodology. A chapter-by-chapter explanation of the structure of the thesis is also provided, and, as with every chapter, a concise summary is made at the end.

1.2 The problem of cost overruns in the Construction Industry

On numerous occasions the problem of construction cost overruns has been investigated by the British Government's National Audit Office (NAO). Examples of building projects include the British Library, Guy's House, and Portcullis House. The British Library officially opened in 1998, and is one of the largest public buildings ever erected in Britain. At £511m, it was three times over the original budget (Harlow and Syal, 1995). Blame was directed towards politicians and the government agency management team who continuously changed the project's personnel and the responsibilities of individuals (Spring, 1997). There was also criticism of the contractual arrangement used, which adopted a cost-reimbursement approach, meaning that the consultants and contractors had little financial incentives to keep within the cost limits.

The second example concerns the third phase of a hospital redevelopment project. At £152m, Guys House doubled its original budget (NAO, 1998). Some cost increases were reported as being unavoidable due to changes in the health service's statutory requirements, building regulations, and a new liability for VAT, but, other increases might have been avoided. These include increases due to failure to freeze design, significant design changes, delays to the building works, inflation, a large number of disputes and claims associated with the construction, and the insolvency of major works package contractors. The NAO's recommendations included the need to have complete and realistic costings backed up by a full risk analysis, to identify the risks involved in using a particular contract strategy, and to take appropriate action to minimise them.

The third example of the problem is the new parliamentary office building which stands opposite the Houses of Parliament in London (Barrie, 1999a). At £250m, Portcullis

House's budget has also doubled (Wheeler, 1998). Built on a difficult site with a unique project brief, these factors have led to this becoming one of the most expensive building ever constructed in Britain (Barrie, 1999b). The original budget estimate was first revised after the cladding works package tender came in well over budget, and the budget had to be increased again when problems were caused by complications with an underground station sitting directly below the site (Barrie, 1997a). A statement from a Member of Parliament set out justification for the increased costs as attributed to inflation, delay in handing over the site, and for approved additional design costs (Baldock, 1999). The latter includes bronze cladding to extend the life of the building, electronic door locks, internal security measures, the inclusion of the parliamentary information systems network, and increased health, safety, and fire regulations.

At the start of a new decade, history is repeating itself, with another new parliamentary building grossly exceeding its original budget limit. The Holyrood Project in Glasgow will not be complete until 2002, but since the original 1998 feasibility cost estimate of £90m, it is now expected to cost £195m (Scottish Parliamentary Corporate Body, 2000). The main reason for the addition was the need for extra space requirements, which almost doubled, and therefore led to knock-on effects of increased contingency, fees, VAT, fitting-out, and programme delays. The problem that is common to each of these project examples is "change".

Flanagan and Tate (1997) have discussed how the process of change in the Construction Industry, and the environment, now seems to be never ending and hectic. However, they clearly state that, what has not changed is the importance of effective cost control from the early stages of design through to project completion, and that clients want certainty of price and projects constructed within budget. They explain how change has come about by reference to four pressures:

> *"1. Society is having to cope with rapid technological and sociological change at a pace never seen before. Managing risk, avoiding unpleasant surprises, ensuring value for money and speeding up the overall project delivery time is important for clients."*
>
> *"2. The second pressure is that construction projects are more complex. This has been brought about, in part, by the requirement of the clients who know what they want to achieve. In brief, clients' requirements are becoming more complicated and more demanding."*
>
> *"3. The third pressure stems from the increased number of groups who have an interest in a projects."*
>
> *"4. The fourth pressure stems from modern practice in design, where new ideas, techniques, materials and components are used."*
>
> Flanagan and Tate, 1997.

In construction, therefore, change means risk. One Chief Executive of a construction company said that "*As long as you are capable of assessing the risk, the margins you can achieve by working in construction are ok*" (Barrie, 1997b). This view was reinforced by another head of a construction firm who said that "*If you're not going to be a risk taker in construction, you should leave the industry*" (Barrie, 1997c). However, more recently, although the industry is currently enjoying a busy time, there are headlines about well established contractors going into receivership (Allen, 2000). One builder said that "*Banks on the whole don't like construction, because it always* *involves too much risk*" (Jones, 2000). Therefore, although risk is inherent in construction, one thing is certain, it is not easy to manage.

1.3 The challenge of cost certainty for building project budgets

With change, there appears to be evidence of a vicious circle present in building construction, where innovation attempt to improve the value for money of projects, but this is then followed by increased complexity, and therefore, an increased degree of uncertainty faced. However, when methods of mitigating this risk have been developed, further innovation again leads to new complexities, and thus, to more uncertainty. No matter how many times professionals look back and try to learn from the problems that have been overcome in the past, this will always be a challenge that the Construction Industry faces. What is now required are improved management methods that can help design and construction teams to react quickly and effectively to evolving situations where there is no historical information available. The challenge facing the Construction Industry is to deliver projects within budget.

At the beginning of the last decade, Brandon (1990a) stated that in construction the new orthodoxy is to accept risk and uncertainty. He explained that it has been recognised that the key decisions are made in the very early stages of the design process, and the task, therefore, is to discover techniques, procedures, and information support that will improve decision-making at this critical point. Nearly ten years later, Brandon (2000) said:

> "... *we realise that we cannot actually forecast the future particularly well*" ...
> "*our job is to assess what the risks might be in the future, but, at the same time,*

bring in management processes that allow us to minimise the risk or adapt to changing circumstances" ... "there is a world of difference between predicting the future and thinking intelligently about it, and I wonder whether sometimes we place too much emphasis on trying to get tools which will predict (sometimes you have to do that), but what we should be doing is thinking intelligently about it and creating the paradigms that will allow us to have an improved society in the future."

Brandon, 2000.

Attempts are being made to improve the Construction Industry's poor reputation. In 1994, Sir Michael Latham set out an agenda for action, which demanded changes in culture, attitude, and procedures, with the objective of ensuring value for money and certainty of outcome (Latham, 1994). Latham said that "*No construction project is risk free. Risk can be managed, minimised, shared, transferred, or accepted. It cannot be ignored*". This work was followed in 1998 with a report by Sir John Egan, "Rethinking Construction" (DETR, 2000b). The "Construction Best Practice Programme" was subsequently set up, supported by the DETR and the Construction Industry Board (CIB), to raise awareness of the benefits of best practice, and provide guidance and advice to UK construction and client organisations so that they have the knowledge and skills required to improve the ways that they work (CIB, 2000). The main focus is transformation of outdated management practices and business cultures, and risk management is one of fifteen new business improvement themes proposed.

In addition to the above initiatives, under a corporate governance code that came into effect last year, directors of listed firms must now carry out an assessment of the way they handle risk (King, 1999). This means that directors have to take a systematic look at the risks that their company faces, and must provide a full description of how they do this to satisfy auditors and shareholders requirements. The issues include health and safety, financial procedures, environmental risks, and regulatory compliance. The code means that, for the first time, directors will have to comment on what they are doing about risk in their annual reports. A Finance Director of a construction company said that "*the code is a heavy compliance burden for contractors in a high-risk industry*", but welcomed the idea that businesses would be more transparent, and it is a good opportunity to show that the industry is "*trying to put its house in order*" (King, 1999).

In an attempt to avoid bidding for loss-making jobs, and also to examine their financial and operating controls, a major contractor has hired management consultants to examine its risk management strategy (White, 2000a). The Chief Executive said "*It could well be that spending half a million pounds on a soil investigation is worth it in order to avoid a major delay at a later date*". White (2000b) also reported on how a major contractor is to invest in a internet based knowledge management system to allow staff access to detailed information on past projects. This will contain information about where projects went well, and how problems were overcome, or could have been avoided.

Seeley (1996) explained that cost management has become the most important single facet of the work undertaken by the quantity surveyor (QS), with the prime objective of controlling construction costs and obtaining value for money, set against perceived performance expectations. Recently, chartered surveyors have been asked by the Government to provide information for construction "Key Performance Indicators"

(KPIs) for cost predictability (Martin, 2000a). This is one of ten headline KPIs that were produced by the DETR in response to Sir John Egan report (DETR, 2000c). The new survey will provide cost predictability both from inception (commitment to invest), and start on site (commit to construct), to final completion (available for use).

In the early nineteen-nineties, the Royal Institution of Chartered Surveyors (RICS) produced a report concerning the future role of the Chartered Quantity Surveyor (RICS, 1991). It emphasised the need to provide more accurate and robust forecasts of construction costs. Particularly, new services were needed in the areas of early cost advice, cost control, and the market forecasting which will add value to the client's business and, in doing so, raise the profession's profile. Three years after this report was published, one practice carried out a survey and found that clients believed that they would get a more effective service from quantity surveyors with risk analysis, rather than with traditional cost control methods (Crosher and James, 1994). Several clients said that the consultants should draw attention to areas of risk at the earliest possible date. A couple of years later, the (former) Chief Executive of the RICS warned:

> *"No construction project is risk free and the industry cannot afford not to manage risk" ... "The range of construction risk - contractual, design, health and safety, site, phasing, along with political, environmental and social considerations - are potentially overwhelming" ... "No major capital project should be undertaken without a full risk assessment."*
>
> Makin, 1996.

Fortune and Lees (1996) surveyed the use of early cost advice techniques for construction cost forecasting in the UK. Within their conclusions, they stated that the research did not fully identify all the risk analysis models used by practitioners. They recommended that future work in this area should address the establishment and evaluation of risk analysis strategic cost advice models currently used by practitioners.

Towards the end of the last decade, a "QS think tank" was set up by the RICS. The objective was to look forward and develop a vision of where chartered surveyors working in construction would be in five to ten years time (RICS, 1998a). The findings identified forces driving change, looking ahead to the needs of the customers during this next decade, and pointing to the professional skills that must be acquired to successfully serve the market after 2000. Factors driving change included the global economy, the market, and the IT revolution. When considering the needs of the customer, clients said that the things that matter to them most include, among others, setting the budget, cost certainty, and risk management - which should be more than just inserting a contingency. The report concluded that if the quantity surveyor is to add value to clients projects, the skills of the profession must be re-addressed, and growth areas included initial cost planning, detailed cost planning, cost management, monitoring work ("*participants will need a detailed understanding of risk management*"), and project management ("*risk management will probably be expected as a standard service*").

Last year, one of the findings in a survey of twelve thousand quantity surveyors revealed that over half of respondents think that their traditional cost modelling role is under threat, and likely to be replaced with software packages in the near future (Cavil, 1999). Three-quarters of respondents strongly believed that, unless they start to offer a new range of services, their business will be taken away by other professionals, such as accountants and management consultants. The chairman of one leading quantity surveying practice recently said that:

> *"Construction risk is what we are all about. By that, I mean we advise on what can go wrong in the process of arriving at the construction phase, in construction activity itself, and in the life-cycle of the built structure."*
>
> Ainsley, 2000.

Clearly, considering the problem domain of risk management of building project budgets, there is a need to develop new models that will enable quantity surveyors to rise to the challenge of providing more certainty in their initial budget estimates. This leads to the definition and focus for this research.

1.4 Aim and objectives of this work

The principal aim of this research is to develop a conceptual risk management model, to be used by quantity surveyors, during the establishment of an initial budget for a building construction project. In achieving this aim, the main objectives of the work are to:

i. acquire an understanding of the concepts of risk, and risk management systems, particularly related to the principles of building project budgets;

ii. clarify the methods used by quantity surveyors to estimate initial budgets for building projects;

iii. investigate which risk management tools and techniques are used by quantity surveyors when estimating initial budgets;

iv. appraise risk management software tools and determine their potential contribution to the budget risk management process; and to

v. develop, implement, and demonstrate a risk management model in a quantity surveying practice.

The perceived conceptual model should produce improved decision-making information for quantity surveyors and their clients when the key decisions are being made in the critical very early stages of the design process.

1.5 An overview of the research methodology

To satisfy the first objective of the work, a review of literature related to risk management and building project budgets will be carried out to gain a clear understanding of risk, and the inauguration and development of the risk management discipline. An appreciation of the key concepts will be acquired, which will form the basis for the development of the research.

The postal questionnaire method will be used for industrial investigations. A pilot study sent to a select sample group will be followed by a more focused survey posted to a larger sample size. Interviews with practitioners will be carried out to validate the questionnaire findings, and also to elicit more specific information about the methods and techniques used. These industry investigations are intended to satisfy the second and third objectives of the work.

The fourth objective will be achieved by reviewing the commercial market for project risk management software. To fulfil the final objective, the literature reviews, questionnaire results, interview findings, and software appraisal will be consolidated and used as the foundation for the development of the conceptual risk management model. Through direct involvement in a professional practice, a working appreciation of the office's culture and procedures will be gained, together with an understanding of the current approach used for risk management. A suitable past project will be selected for case illustration, and the model will be implemented and validated. A detailed explanation of this research methodology is included within appropriate chapters of this thesis.

1.6 Limitations of this study

This thesis is primarily concerned with the practice of the Chartered Quantity Surveyor operating in the Construction Industry. The work relates to the capital cost of building construction, and, therefore, not to other project costs which may include, for example, life cycle costs, land costs, design team fees, legal expenses, and taxation. The focus is from the clients' viewpoint of establishing an initial budget for building projects, rather than from the general contractors' perspective, who may need to set a different budget when bidding for the clients' works at a later project stage. The work is intended to point to transitional, rather than final, solutions.

1.7 Structure of this thesis

The thesis consists of eight chapters. Following this introduction, Chapter 2 will review the literature related to risk management and construction research. The concept of risk will be defined, and the development of risk management will be discussed, generally within the global economy, and more specifically in construction research. The conventional intuitive approach to risk management will also be considered.

Chapter 3 will explain how a building project budget is conventionally established, and will then review the literature related to both budget and project risk management systems. Attributes and deficiencies in existing systems will be identified and discussed.

Chapter 4 will consider the key literature related to building project budgets and risk management tools and techniques, and review a selection of the commercial risk management software that is available.

Chapter 5 will include the industrial investigations related to the applications of risk management by quantity surveyors when estimating initial budgets. The methodology for questionnaires and interviews will be explained, and the interpretation of the results and findings discussed, particularly related to risk management tools and techniques.

Chapter 6 will develop the conceptual model for risk management of building project budgets. The methodology for consolidation of the literature reviews and industrial investigations will be explained. This will lead to the selection of the most appropriate system, tools, and techniques, and a model will be proposed for budget risk management. Optional software enhancements will be considered.

Chapter 7 presents the demonstration and validation of the conceptual model within a quantity surveying practice. The methodology will be explained, and refinements to the original model will be discussed, together with feedback obtained from the selected practice.

Finally, Chapter 8 will draw key conclusions from the work, and suggest recommendations for further research, including possible enhancements to the proposed conceptual model.

1.8 Summary

The Construction Industry has a poor reputation for delivering projects over budget. On numerous occasions, the problem of construction cost overruns has been investigated by Government, and recommendations for improvements include the need to have complete and realistic costings backed up by a full risk analysis. What is common to the problem is "change", but the process of change in the Construction Industry now seems to be like a viscous circle. However, what is not changing, is the importance of effective cost control from the early stages of design through to project completion. Clients want cost certainty. No construction project is risk free, and the difficult challenge facing the Construction Industry is to deliver projects constructed within budget.

It has been recognised that the key decisions are made in the very early stages of the design process. The task is to discover techniques, procedures, and information support that will improve decision-making at this critical point. This should involve assessing what the risks might be in the future, and bringing in management processes that allow minimisation of the risk or adaptation to changing circumstances. There is a difference between predicting the future and thinking intelligently about it. What is needed are methods that will encourage intelligently thinking.

Attempts are being made to improve the Construction Industry's poor reputation. These include work by Latham, Egan, DETR, RICS, and private sector companies. Further work should address the use of risk management models by practitioners for early cost advice of building construction. Financial construction risk is what quantity surveyors are primarily concerned with, but, if they are to add more value to projects, the skills of the profession must be re-addressed. Risk management has been suggested as a key potential growth area. Therefore, the principal aim of this work is to develop a conceptual risk management model, to be used by quantity surveyors, during the establishment of initial budgets for building construction projects.

CHAPTER 2 - RISK MANAGEMENT AND CONSTRUCTION RESEARCH

2.1 Introduction

Risk management was described as "*the hot project management topic of the decade*" (Association for Project Management, 1998), with the 1990's seeing a vast amount of new literature in the field. The objective of this chapter is to set the scene, from inauguration of the topic, through its development, to the current position. An appreciation of the key concepts of risk will be acquired which will be used as the basis for the development of the research in the following chapters. The chapter will first put risk management into perspective by defining risk and explaining the history and development of risk management as a formal discipline. It will then become more focused within the context of the construction research.

2.2 Defining risk

The origin of the word *risk* is thought to be either from the Arabic word *risq,* or the Latin word *risicum* (Wharton, 1992). The Arabic word signifies "*anything that has been given to you* [by God] *and from which you draw profit*", and has connotations of a fortuitous and favourable outcome. The Latin word, however, originally referred to the challenge that a barrier reef presents to a sailor, and clearly has connotations of an equally fortuitous but unfavourable event. There are other differing views regarding the origin, some explain that it entered the English language in the mid 17th century, coming from the French word *risqué*, and that in the second quarter of the 18th century the Anglicised spelling began to appear in insurance transactions (Flanagan and Norman, 1993). However, others state that the use of word derives from the early Italian *risicare*, which means "*to dare*" (Bernstein, 1996).

The origin of the word is not important to this work, rather, the use and meaning in society is more pertinent, and there are some indications that its use is on the increase. The frequency of world-wide report articles containing the keyword "risk" doubled between 1992 and 1995 (Smallman, 1997). This was a study of apparent trends in media reporting, and it cannot be taken as authoritative research. However, as the author explains, when coupled to issues discussed by other authorities, it is possible to infer that the world may indeed becoming a riskier and more uncertain place.

Risk is a difficult word to define because it is used in so many different ways (Crockford, 1991). One attempt to address this problem was by Britain's Royal Society, a pre-eminent scientific institution, who organised a working group to participate in a study of risk (Adams, 1995). Unfortunately, the social scientists, with the exception of the economists, could not agree with the physical scientists, and they were therefore not able to take a collective view about the subject. A report was published, but the Society stated in the preface that it was "*not a report by the Society*", that "*the views expressed are those of the authors alone*", and that it was only "*a contribution to the ongoing debate*" (Adams, 1995).

Adams (1995) explains that risk and uncertainty have assumed the role of technical terms in the risk and safety literature since 1921, when Frank Knight pronounced in his work "Risk, uncertainty and profit" that *"If you don't know for sure what will happen, but you know the odds, that's risk, and if you don't even know the odds, that's uncertainty".* Adams continues by explaining that uncertainty is defined by Knight as inescapable, it is the realm not of calculation but of judgement - there are problems where the odds are known, or knowable with a bit more research, but these are trivial in comparison with the problems posed by uncertainty.

There are various different definitions of risk included in dictionaries, international standards, and construction management text, and some examples are included in Appendix "A". Most definitions focus on the unpleasant side of risk, and yet risk is potentially very profitable (Carter et al, 1996). Both the probability and impact of risk are capable of quantification, and this permits a numerical definition that is much quoted in statistical treatises, which is generally as follows:

"risk exposure = impact value x probability of occurrence."

Carter et al, 1996.

It is noted that an exposure can be valued negatively or positively. The beneficial (or positive) alternative is not usually included in statistical treatises, but necessary in view of the desirable risks. This interpretation that risk includes both downside and upside variations in the values involved is also supported by others (e.g. Institute of Civil Engineers and the Faculty and Institute of Actuaries (1998) and British Standards Institution (2000)). A report published last year by the Institute of Chartered Accountants in England & Wales (1999) also emphasises the positive nature of risk:

> *"Since profits are, in part, the reward for successful risk taking in business, the purpose of internal control is to help manage and control risk appropriately rather than to eliminate it."*

Institute of Chartered Accountants in England & Wales, 1999.

Effective risk management is therefore not just about preventing things from going wrong, it is also about helping things to go right and ensuring that opportunities are fully exploited to create value and competitive advantage (Rayner, 2000).

Like uncertainty, the word hazard is also sometimes used interchangeably with risk. Strictly speaking, a hazard is usually considered to be something that might go wrong with adverse consequences, whereas a risk is a multiple of the cost of that hazardous consequence and its probability of occurrence (Edwards, 1995). For example, a hazard can have a likely maximum adverse consequences of £100,000, but, with a 1 in 10 probability of occurrence, is a £10,000 risk (e.g. 100,000 x 0.1). Together with uncertainty and hazard, risk is commonly used as a synonym for danger or threat (Institute of Civil Engineers et al, 1998).

In construction, Flanagan and Norman (1993) explain that the environment within which decision-making takes place can be divided into three parts, those being certainty, uncertainty, and risk. Certainty exists only when one can specify exactly what will happen during the period of time covered by the decision. Uncertainty is when there is no historical data or previous history relating to the situation being considered by the decision-maker. Their research found that there is general consensus that a decision is made under risk when a decision-maker can assess, either intuitively or rationally, the probability of a particular event occurring.

On reviewing the definitions of risk it is perhaps not so surprising that there is some confusion and debate about the subject and, to conclude this debate for the purposes of this study, it is more relevant to select a definition which suits the specific problem faced. The definition of risk considered to be most appropriate is that provided by Raftery (1994):

> *"Risk and uncertainty characterise situations where the actual outcome for a particular event or activity is likely to deviate from the estimate or forecast value."*
>
> Raftery, 1994.

Therefore, throughout this thesis the word risk will be used to include uncertainty, hazards, danger, and threat.

2.3 The intuitive approach to risk management

The management of risk has traditionally been applied instinctively, meaning it remains implicit, being controlled by judgement informed from experience (Godfrey, 1996). This judgement is usually built up over time through individuals working in and developing an understanding of their profession, or a "knowledge-base" can reside in the corporate experience of a company, developed by the personnel within it (Flanagan and Norman, 1993). Flanagan and Norman (1993) explain that sometimes decision-makers cannot justify their reasoning, and that this is called intuition, which is a "gut feeling" about a situation and the best course of action to take. They state that whilst this is probably rooted in experience, it is much more difficult to define, because experiential judgements can be justified, whilst those based on intuition cannot. Many decision-makers are said to place great emphasis on following their feelings, rather than their thoughts, and this can lead to several problems with relying totally only on the intuitive approach (Flanagan and Norman, 1993). These problems include individual bias, attitude towards risk, reporting errors, and group decision-making.

Flanagan and Norman (1993) explain how the judgement and intuitive ability of humans is flawed by numerous biases which distort the way one interprets the past, predicts the future, and makes choices in the present. For example, sometimes a person may take a previous event as being representative, when often it is not. This is because it is tempting to solve problems on the basis of extrapolating the past into the future, and it takes a lot of wisdom, skill, and nerve to use information that disagrees with past experiences (Flanagan and Norman, 1993).

Boothroyd and Emmett (1996) explain that risks have a tendency to attract enterprise, and the prospect of potential loss can add a sense of excitement. Some look forward to taking risks, since the rewards from doing so might far outweigh their gains from other possible safer actions, and since "*nothing ventured, nothing gained*". However, many ignore risk because they hope that, by doing so, risks will not appear, but, to ignore risk is to accept it, thereby accepting also its consequences - which may prove disastrous! This highlights the second problem with the intuitive approach, that being attitude towards risk. People's attitude towards risk may alter, with the passage of time, and from the outcome of situations they face, though individuals are generally either risk averse, risk neutral, or risk seeking.

The reporting of estimates and figures by one person from another leads to a third problem with the intuitive approach. There are fertile conditions for error when a cost estimate is produced by a consultant and is then reported to a senior decision-maker (Raftery, 1994). For example, a consultant may indicate that there is a good chance that a project will cost a certain amount. Similarly, an advisor may state that there is a reasonable chance that a project can be completed for less than a certain figure.

However, these statements could mean different things to different people. For example, is a "good" chance a 9 in 10, an 8 in 10, or a 6 in 10 probability? Is a "reasonable" chance an 8 in 10, a 7 in 10, or a 5 in 10 probability? These differences could be very significant to a decision-maker choosing between various options. Raftery (1994) therefore proposes that the best that can be done to minimise this problem of reporting is to make explicit as many assumptions as is possible.

A fourth problem with the intuitive approach is group decision-making. Flanagan and Norman (1993) conclude that when a group of people discuss a risk-taking problem, they usually arrive at a riskier solution than the average of their own previous individual solutions. The risky shift phenomenon states that groups influence decision-making towards positions of higher risk a significantly greater number of times than not, and under almost any conditions. Flanagan and Norman (1993) suggest two possibilities for this. One is that risk taking, by implying boldness, may in society be more socially desirable than conservatism, and most people think of themselves as no less risk taking than anyone else. So, when opinions are aired in a group, those of lesser risk bent tend towards an increase in risk taking, seeking to be seen as courageous rather than cowardly. The second reason suggested is that, as a result of the emotional bond between discussants, an individual feels less of a personal responsibility for failure of risking options he would decline if deciding alone.

Despite the above problems, experience is probably the strongest means available to the decision-maker, and, together with intuition, sometimes provides the only available method. However, this does not mean that the approach will always give the best solution, and an element of this research is to find out if the intuitive approach can be improved upon by using a more formal approach to risk management.

2.4 Development of the risk management discipline

Underlying all judgements, decisions, and evaluations, there is the "risk factor" (De Bono, 1992). Organisations and individuals need to make venture or entrepreneurial choices, as there are rarely rewards without risks being taken. Davis (1996) believes that risk management dates as far back as the Old Testament, with the Egyptian pharaoh and Joseph predicting seven years of plenty followed by seven years of famine. However, Bernstein (1996), hypotheses that the revolutionary idea that defines the boundaries between modern times and the past is the mastery of risk, and the notion that the future is uncertain, "*more than a whim of the gods*", and that men and women are not passive before nature. He believes that the ability to define what may happen in the future and to choose among alternatives lies at the heart of contemporary societies, with risk management guiding us over a vast range of decision-making. Bernstein believes that the modern conception of risk is rooted in the Hindu-Arabic numbering system that reached the West seven to eight hundreds years ago, and that the serious study of risk began during the Renaissance, when people broke loose from the constraints of the past and subjected long-held beliefs to open challenges.

As we have recently entered a new century, Kloman (2000) has looked at the milestones that helped shaped the risk management discipline in the past hundred years. He states that risk management is an extension of our human nature, and he names the most notable political, economical, military, scientific and technological events as being:

> *"The major wars, from Russo-Japanese, World War I and II, and Korea, to the regional conflicts that have followed, the advent of the automobile, radio, television, and the computer, the Great Depression, global warming, the atom bomb and nuclear power, the rise and fall of communism, derivatives fiasco, and the entire environmental movement have affected the development of risk management. Major catastrophes did so more directly: the Titanic, the Triangle Shirtwaist fire, Minimata Bay, Sevesto, Bhopal, Chernobyl, Three Mile Island, Challenger, Piper Alpha and Exxon Valdez, to some of the more obvious. Earthquakes, typhoons, cyclones and hurricanes continued to devastate populous regions, and their increasing frequency and severity have stimulated new studies on causes, effects, and prediction, all part of the evolving evolution of risk management."*
>
> Kloman, 2000.

Yet Kloman (2000) believes that the most significant milestones are the new ideas, books, and actions of individuals that have simulated the discipline. His list begins with the proliferation of social insurance schemes, leading to the provision of state pensions in most countries, and signalling a shift from individual responsibility to corporate and government responsibility.

Chapman (2000) explains that risk is intensifying and becoming more complex, dynamic, and global. With memories of the high-profile business collapses of the late 1980s and early 1990s, boards are required to demonstrate higher levels of accountability. Under the London Stock Exchange "Combined Code on Corporate Governance", directors of UK incorporated listed companies are required to review the effectiveness of their systems of internal control, including risk management, at least annually (Chapman, 2000). The guidance for directors on the combined code explains what is expected of boards, and states that:

> "*A company's system of internal control has a key role in the management of risks that are significant to the fulfilment of its business objectives.*"
>
> Institute of Chartered Accountants in England & Wales, 1999.

These steps are firm evidence that risk management is more than just another management "buzz" phrase, and that it is now becoming established as a new discipline within the world economy. At this point, it is therefore useful to consider the definitions of risk management, and the one provided by the Institute of Risk Management (1994) is as follows:

> "*Identification, analysis and economic control of those risks which can threaten the assets or the earning capacity of an enterprise.*"
>
> Institute of Risk Management, 1994.

However, similar to the definition of risk, there are various different definitions of risk management included in dictionaries, standards, and construction management texts. Some examples are included in Appendix "B". On reviewing this list, it is also clear that there is some reason to deliberate about the subject. Valentine (1999) suggests that it is currently difficult for risk management to be recognised as a management discipline when there is no governing code of practice, and no common process or methodology. However, he recognised that the situation is changing.

When considering the list of dictionary definitions of risk in Appendix "A", one may interpret that risk management is a insurance subject. However, as Crockford (1991) explains, it is more of a management subject and, although insurance can play a very important part, it is not the only solution to be thought of, nor, in most cases, the first one. Risk management is more about analysing the nature and causes of a problem, and using the results to eliminate or reduce the danger, and enhance the possible rewards.

Flanagan and Norman (1993) explain that a risk management system is a model, and it provides a means to identify, classify, analyse, and then respond to risk, helping to reduce reliance upon raw judgement and intuition. The inputs to the model are provided by humans, but the brain is given a system on which to operate, providing *"a back up for our unreliable intuition"* (Flanagan and Norman, 1993). They say that a model can be thought of as having two roles, first, it produces an answer, and second, it acts as a vehicle for communication, alerting us to factors we might not otherwise consider.

The principal aim of this research is to develop a conceptual risk management model to be used by quantity surveyors, during the establishment of an initial budget for a building construction project, to provide improved decision-making information (see Chapter 1). For the purposes of this study, the definition considered to be most appropriate is that provided by the Project Management Institute (1996):

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

2.5 Risk management research in construction

Edwards and Bowen (1998a) have carried out a review of the literature in construction risk management research. They found that, in terms of publications in authoritative English language media, the 1960s marks the stage where substantive treatment of the topic first begin to appear in construction publications. The results of their temporal analysis reveal three interesting points:

i. Applications of "quantitative theories and techniques" to construction progress slowly at first, but accelerate quite rapidly from the mid-1970s;

ii. Around the mid-1980s, "systems theory" approach becomes a popular vehicle for the development of construction risk management; and

iii. Interest in a "soft system" approach made a modest start at about the same time as the applications phase.

Figure 1 shows Edwards' and Bowen's (1998a) categorisation of project and construction risks. Using risk sources as a basis, the primary classifications are natural and human. Natural risk occur outside human agencies or systems, while human risks arise within humanly organised systems. Note that the lists of construction risks shown against each sub-category is not intended to be exhaustive. Concerning the applications of risk management in construction, Edwards and Bowen found that the main fields of research are in quantitative risk analysis in the managerial and technical categories of risk (e.g. contract bidding, cost estimation, and construction scheduling). The political, economic, financial, and cultural categories of risk are largely under represented in the research literature, as are risks associated with quality assurance and occupational health and safety.

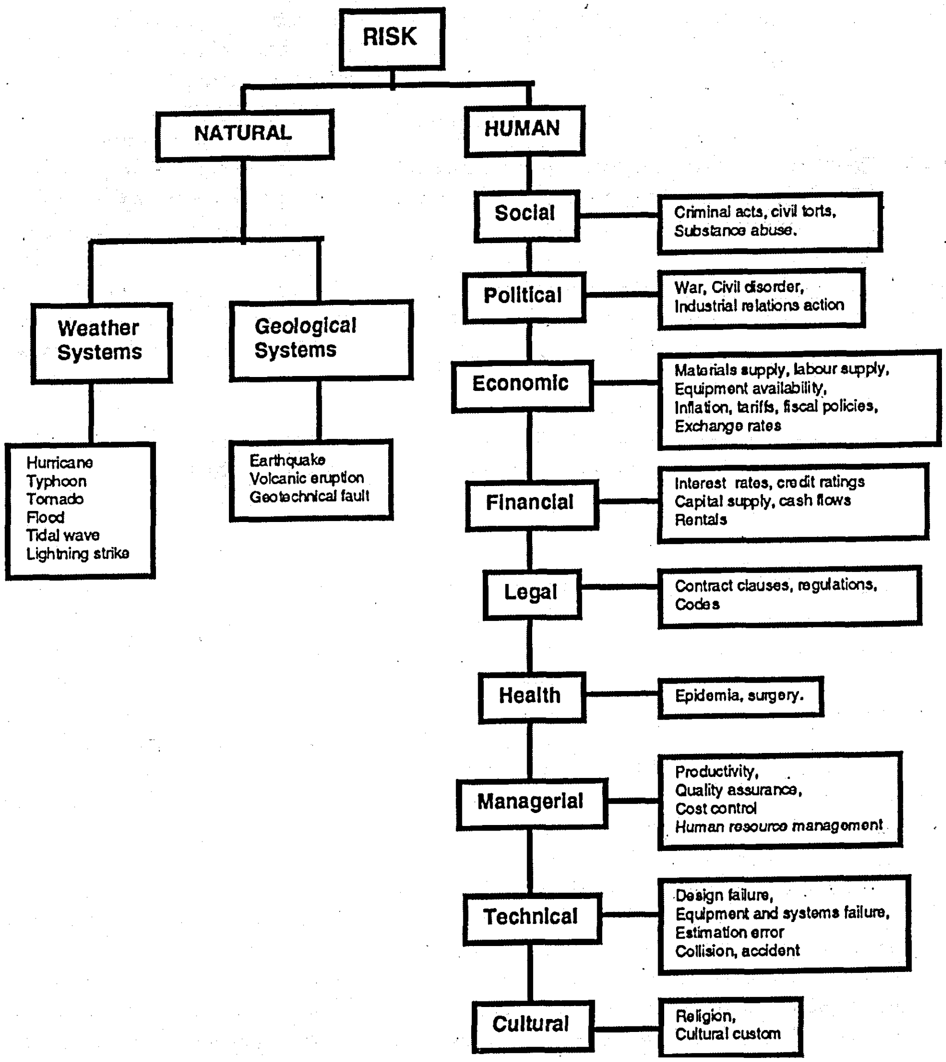


Figure 1 - Categorised project and construction risks (Source: Edwards and Bowen, 1998a)

Edwards and Bowen (1998a) explain that risk management systems have generally been thoroughly expounded in the literature, although more so in text books than in journal papers. However, they highlight that identification of construction risks deserves more investigation, and that categories of risks should be explored in terms of nature of occurrence, impact, and response alternatives. With reference to the third point from Edwards and Bowen (1998a), the soft system approach, they summarise that research into the human aspects of construction and project risk management has concentrated upon three areas:

- The establishment of subjective probabilities;
- The exploration of heuristics and biases; and
- Surveys of risk management practices in the construction industry.

Concerning the first of these, they state that none of this work appears to have resulted in more than a limited application by construction professionals. Confirming that the measurement of probability is alien to most decision-makers, who are happy to take an intuitive approach, but reject procedures which require more formal treatment.

Edwards' and Bowen's (1998a) review of soft systems literature also reveals that other important aspects of risk management, such as the risk profiles of project participants, the learning effect of risk experiences on risk attitudes, and the interpersonal communication of risk, have received little attention to date in construction-related research. The people problems of construction risk management are currently being subjected to a substantial research effort, directed mainly at the establishment of subjective probabilities, the exploration of heuristics and biases, and the nature and extent of risk management practices in the construction industry. Generally, the findings of their study of survey based research supports the proposition that construction professionals lack an adequate understanding of the rationale and formal processes of project decision-making under risk and uncertainty. It seems that very few participants in the building procurement process use formal mathematical techniques of risk analysis or systematic approaches to risk management.

2.6 Summary

Although risk can be defined differently for every situation, for the purpose of this work, risk is defined as characterising *"a situation where the actual outcome for a particular event or activity is likely to deviate from the estimate or forecast value"*. The management of risk has traditionally been applied instinctively, using judgement and intuition from experience, and this probably remains the strongest means available to the decision-maker. However, there are problems with this method, including biases, attitudes, reporting, and group decision-making.

In some sectors, formal risk management is now established as a management discipline, but the breadth of the topic and possible scope of applications is infinite. For the purpose of this study, risk management is defined as *"the processes concerned with identifying, analysing, and responding to project risk, including maximising the results of positive events and minimising the consequences of adverse events"*. It is suggested that a more formal model approach to risk management could enhance the intuitive approach, and possibly overcome some of the problems identified.

Within the domain of construction research, the main fields of work have been in quantitative risk analysis in the managerial and technical categories of risk. The political, economic, financial, and cultural categories of risk are largely under represented, as are risks associated with quality assurance, and occupational health and safety. The identification of risks also deserves more investigation, together with the people problems. It seems that very few participants in the Construction Industry use formal techniques for risk management, perhaps preferring to take the intuitive approach.

CHAPTER 3 - BUILDING PROJECT BUDGETS AND RISK MANAGEMENT SYSTEMS

3.1 Introduction

Some twenty years after applied construction risk research commenced in the 1960s, systems theory became a popular vehicle for the development of construction risk management, with a growth rate of publications almost matching that of the applied research (Edwards and Bowen, 1998a). Taylor (2000) discusses introducing risk management into the professional office, and states that before starting to look at risk management in practice, there has to be a framework through which risk may be managed. This framework is called a risk management system. Taylor explains that little purpose would be served if the practice simply set up a selection of risk management methods and said to staff, "*Here they are, now use them*". The objective of this chapter is to review the literature related to both budget and project risk management systems. Attributes and deficiencies of existing systems will be identified, and this will lead to the selection of the most appropriate framework for development of a conceptual model. The chapter will begin by explaining how a building project budget is conventionally established.

3.2 Establishing building project budgets

3.2.1 Conventional budget determination

From early times people have needed an indication of what a new building is going to cost before work is started on it, with the New English Bible, Luke, Chapter 14, saying:

"Would any of you think of building a tower without first sitting down and calculating the cost, to see whether he could afford to finish it? Otherwise, if he has laid its foundations and then is not able to complete it, all the onlookers will laugh at him. "There is a man", they will say, "who started to build and could not finish."

Ferry et al, 1999.

Estimating the final cost of a building is not an easy task, because numerous factors interact and effect the reliability of a quantity surveyor's price forecast, including the extent of design information available, the availability of historical price data related to the type of project under consideration, and the familiarity with the type of project in hand and projects of similar nature (Flanagan and Norman, 1982). One view is that every cost estimate is a guess based on assumptions of scope, time, quality, technological uncertainty, and resource (HM Treasury, undated). Given the uncertainties as to whether risks will occur or not, it is impossible to predict the out-turn cost of a project with absolute certainty (HM Treasury, 1999). This is because at the beginning of a project sufficiently detailed information is simply not available to foresee the future with clarity (Wideman, 1995). However, a primary measure of success in preparing a budget estimate is predicting the project final cost at project inception, and:

"It cannot be over emphasised that an estimate that fails to predict the out-turn cost with some degree of certainty is of little value."

HM Treasury, 1999.

The task of the client's quantity surveyor is to forecast the winning tenderer's forecast, without access to the contractor's data, and with many more inherent uncertainties caused by not having a design or, perhaps, even a site (Raftery, 1994). The difficulty is that, often when the initial budget is being set, there is only sketchy information available about the details of the building and, at this early stage of the project, the budget is established and it is this first figure that becomes indelibly imprinted in a client's mind (Flanagan and Norman, 1993).

Martin (2000b) explains how many surveyors will have taken a telephone call at the end of the day, from a client who has just seen a site that would be perfect for a new development, and wants to know, the same evening, what it would cost to construct. In this situation, the surveyor must consider the following points:

- what do I need to know about the proposed building;
- what information do I need to cost such a scheme, and where can I find it; and
- the first figure which I give will be remembered by the client.

Trying to determine exactly what kind of development the client has in mind is difficult, particularly when the client is also busy calculating the amount of profit he could make on the investment (Martin, 2000b). In this situation, even the client sometimes cannot answer all the questions. So establishing both what the client wants and, what needs to be assumed, is an important aspect in the advice provided, particularly later when adjusting the estimate if the project is sanctioned.

A further complication is that there is also some dispute as to what is actually being forecast, and it is therefore important for the quantity surveyor to be clear about the different purposes of estimates for a project, and how they should be evolved, because the types of estimate needed by clients will differ according to individual organisation requirements (Thompson and Perry, 1992). In general terms, the pre-contract cost consideration for a building project develops in the following way:

• *Feasibility*	*Prepare feasibility studies and determine the budget.*
• *Outline Proposals*	*Consider with client and design team alternative strategies and prepare cost plan.*
• *Scheme Design*	*Carry out cost checks and update cost plan if necessary.*
• *Production Information*	*Carry out cost checks.*
• *Tender Action*	*Prepare reconciliation statement.*

Royal Institution of Chartered Surveyors, 1998b.

Reference to design stages are to the Royal Institute of British Architects (RIBA) "Plan of Work" (RIBA, 1973), and refer to the main stages through which a project design typically passes.

A general principle applies throughout the cost planning process, that any agreed budget is seen as the maximum cost, and the quantity surveyor should, at all times, work with the other design team members to satisfy the client at a lower cost if possible, whilst still maintaining the desired objectives for quality and function (RICS, 1998b). It is recommended, as a matter of importance, that before and during the formulation of the client's brief, the quantity surveyor, in consultation with other members of the design team and client, should undertake such feasibility studies as may be necessary to ensure that the client's requirements can be reasonably accommodated within the finance available for the project (RICS, 1998b). The clients budget is established as a result of these studies. This leads to the following definition of budget:

> *"Budget is the total expenditure authorised by the client which is the responsibility of the design team at the end of the feasibility stage."*
>
> Royal Institution of Chartered Surveyors, 1998b.

Once the budget has been established, it provides the first cost plan for the project, and the framework for the actual design to be developed (RICS, 1998b). This thesis is concerned with the initial budget estimate produced by the quantity surveyor for a client, that which the client often uses to sanction a project. A commercial property developer may use this figure to bid for and purchase a site, the exact timing of this estimate will vary slightly from project to project. At this stage little is likely to be known about the building except its general size, and this is usually the place where the quantity surveyor will use a "single price rate" methods of estimating costs, i.e. the size of the building is measured, in one form or other (e.g. gross floor area or number of units), and the resulting quantity is multiplied by a single price rate to give the estimated total cost (Ferry et al, 1999).

3.2.2 Contingency percentage allowance

The most commonly used technique of allowing for risk in a building project budget estimate is to simply add on a percentage figure (Hayes et al, 1986). This figure will vary depending on the stage of development that the project is in, for example, at inception a plus or minus figure of 20% might be used for the initial budget, and, as detailed design continues, the risk should become smaller, e.g. cost plan +/- 15%, and tender +/- 10% (Turner, 1990). Although the contingency percentage allowance technique is the easiest and most used technique, it has a number of weaknesses (Hayes et al, 1986):

- the percentage figure is, most likely, arbitrarily arrived at and not appropriate for the specific project;
- the tendency is to double-count risk because some estimators are inclined to include contingencies in their best estimate;
- a percentage addition still results in a single-figure prediction of estimated final cost, implying a degree of certainty that is simply not justified;
- it only reflects the potential for detrimental or "downside" risk, the approach does not highlight any potential for cost reduction. It may therefore be used to hide poor management performance; and
- because it captures all risk in terms of a cost contingency, it tends to direct attention away from time and performance quality risks.

In addition to the above weaknesses, it does not encourage creativity in estimating practice, allowing it to become routine and mundane, which can propagate oversight (Thompson and Perry, 1992). The British government's procurement guidance agrees that the contingency percentage allowance technique is weak, and states that:

> *"The risk allowance should be calculated for identified risks and not be just guessed as a percentage of the total (the term "contingency" should not be used)."*

HM Treasury, 1999.

3.2.3 Elsie expert system

"ELSIE" is a computer software expert system, now called "Lead Consultant". It provides consultancy advise at the strategic planning stage of the development process, i.e. before design takes place (Ferry et al, 1999). It takes the level of information available in a client's brief and, through linked database modules, translates the information into a series of reports, including:

- Initial budget - How much will the development cost;
- Time - How long will the development take;
- Procurement - What is the contractual relationship between parties to the development process; and
- Appraisal - What is the profitability of the scheme.

Ferry et al (1999) explain that in the budget system a solution is postulated by the software from over two-thousand "rules", and the user can then modify the answers by changing up to one-hundred and fifty variables which have been derived. To arrive at the first solution, the software asks between twenty-four and thirty questions and, depending on the answers given, it generate variables on size, shape and specification, instantly giving a response (in terms of cost) of a changing in any one of them. In use on multi-million pound projects, the results have proved to be within plus or minus five percent of the expected tender figure, and Ferry et al believe that this is better than could be expected if several estimators were asked to undertake the same task with the same information. In addition, it is claimed that the speed of calculation when information may be scarce is far quicker than could be accomplished manually with the same information. However, currently, there are only three broad categories of building type available, together with a system for mechanical and electrical engineering services, but others are being developed. Ferry et al (1999) explain that at the present time, machines do not have the capability to sense and diagnose in the same way as humans, consequently there will always be a need for consultants to check and possibly modify the solution suggested until the technology improves very substantially.

3.3 Budget risk management systems

3.3.1 Dearle & Henderson

Yates (1986) hypotheses that risk analysis is not so much a technique, as a term that describes a way of looking at a problem, and that it involves identifying the key factors that might affect an estimate, and then assessing the probability and extent of the effect. He says that the application of risk analysis to construction cost estimates will vary, however, some aspects he believes are universal:

- Risk factors - In each case it will be necessary to list the key factors that affect a construction estimate;
- Limits of risk analysis - It is essential to define the limits of risk analysis. In this way, events having a very remote chance of occurring are not included and wasteful estimates are avoided; and
- Forum for risk analysis - A formal structure should be developed if risk analysis is to be applied effectively. For construction projects, in which progress meetings are common, a workshop comprising key members of the team is probably the most satisfactory structure.

The method proposed for dealing with probabilities is "Monte Carlo simulation" (see Chapter 4), and Yates (1986) states that an important aspect for those participating in risk analysis is developing an attitude of mind, whereby they think in terms of the chances of events occurring.

3.3.2 Science and Engineering Research Council

Hayes et al (1986) suggest that the adoption of a systematic approach to risk management of building project budgets will produce estimates expressed in terms of ranges, rather than as a single figure. They propose that a proper approach should feature the following:

- Preparation of a best estimate based on the known and defined work, i.e. excluding allowances for uncertain work and risk;
- Clear identification and quantification of specific risk sources in a project;
- Separate assessment of risks to both cost and time of the project;
- Quantification of risk in terms of potential for both over-runs and under-runs on best judgement estimated, using tolerances or ranges; and
- Use of contingencies only for specifically identified items of work.

A further concept is proposed by Hayes et al (1986) is, that of "risk exposure", which is the amount of risk still not accounted for financially, and they state that any estimate should clearly spell out these exclusions. In developing this work further, Thompson and Perry (1992) found that some clients take the original estimate and apply a variety of other methods of allowing contingencies for risk. These include:

- Using estimating manuals containing risk checklists with contingency ranges defined for each risk;
- Refining the estimate by reference to historical project cost databases and correlation with current input prices;

- Identifying specific risks and allocating contingencies to those risks - the contingency amount can be released only by pre-defined events specified in the risk management strategy; and
- Building and using a project risk model using risk analysis software.

3.3.3 Flanagan et al

Flanagan and Stevens (1990) state that the main purpose of the tasks performed by the quantity surveyor must be to enable business, whether it be on behalf of the client or contractor, to take the right risks. They present a risk management process which involves the three stages shown in Figure 2. However, there is no detailed discussion of the identification and classification of risk, nor on the response strategies, but instead they concentrate on the risk analysis stage using Monte Carlo simulation (see Chapter 4).

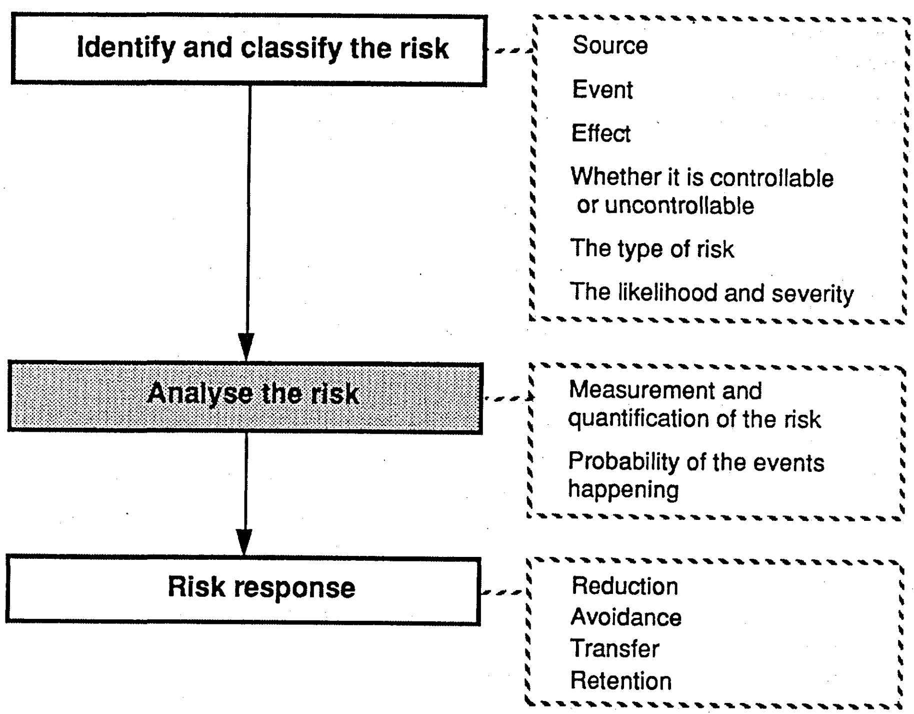


Figure 2 - Flanagan and Stevens (1990) risk management process

Flanagan and Norman (1993) develop the above process and form five stages of project risk management:

1. Risk identification - Identify the source and type of the risks;
2. Risk classification - Consider the type of risks and its effects on the person or organisation;
3. Risk analysis - Evaluate the consequences associated with the types of risk, or combination of risks, by using analytical techniques. Assess the impact of risk by using various risk management techniques;
4. Risk attitude - Any decision about risk will be affected by the attitude of the person or association making the decision; and
5. Risk response - Consider how the risk should be managed by either transferring it to another party or retaining it.

3.3.4 Wideman

Wideman (1995) agrees with most experts that the earlier it is in the life of a project life-cycle, the less information is available, and the higher the potential risk of error in estimating the cost. At time of approval for a project, he recommends that several categories of project uncertainty should be recognised, these include major unpredictable risks, lower order risks, and inflation and interest during construction.

Wideman (1995) explains that the major unpredictable risks include those that are entirely unforeseeable, some that are probably inevitable, but the magnitude of these cannot be predicted. They include such items as very severe weather, unforeseen major legislative changes, political policy changes, national disasters, and so on. Wideman suggests that these risks should not be allowed for in a project's budget because it would not be possible to arrive at a sensible allowance. Instead, he proposes that they should be reconsider at the highest management level, where it must be decided whether or not management are comfortable with the risks in question. Similarly, any adjustment for inflation or interest should be shown as a separate line item, preferably at an intermediate summary level.

Wideman's (1995) system is mainly concerned with assessing lower order risks, this typically mean those associated with the identified scope of work for the project. He suggests that a practical way of identifying and dealing with these is to hold a team brainstorming session devoted to this purpose. To avoid getting swamped in too much detail, focus is limited to the "vital few" by involving Paereto's Law of distribution, or the "80/20 Rule", as it is better known. Wideman's system is summarised as follows:

1. Assemble a group of five to ten people who have knowledge and experience in the various aspects of the project;
2. Brainstorm all the things that could go wrong. Use the "risk wheel" shown in Figure 3 to stimulate ideas. This diagram is used as a memory trigger and to integrate risk identification with other project management functions. List each item as a single line statement. This should produce a long inventory of possibilities;
3. Identify the top 20% that appear to have the greatest impact and probability on the project's cost and schedule, and re-list them on approximate descending order of significance;
4. Conduct a "What if" analysis on the worst item;
5. Develop a plan to avoid, solve or reduce the problem;
6. Ask how could the situation be turned to advantage;

7. If the response is to make some provision in the contingency allowance, then also take a majority opinion on the probability of occurrence. The items can then be included in a tabular layout using the "expected value" technique (see Chapter 4);
8. Repeat steps 4 through to 7 on the remaining items until the "top 20% list" of worst items has been accounted for; and
9. Factor appropriate steps into the plans for the project.

Wideman (1995) explains that cost risks arise from variations in both cost and time, therefore, it is desirable to undertake formal risk assessment on both estimates for the project. He suggests that this can be done by a modern quantitative risk assessment combining distributions in a computer network programme. However, he cautions that formal cost-schedule risk assessments should only be conducted by those knowledgeable in the methodology.

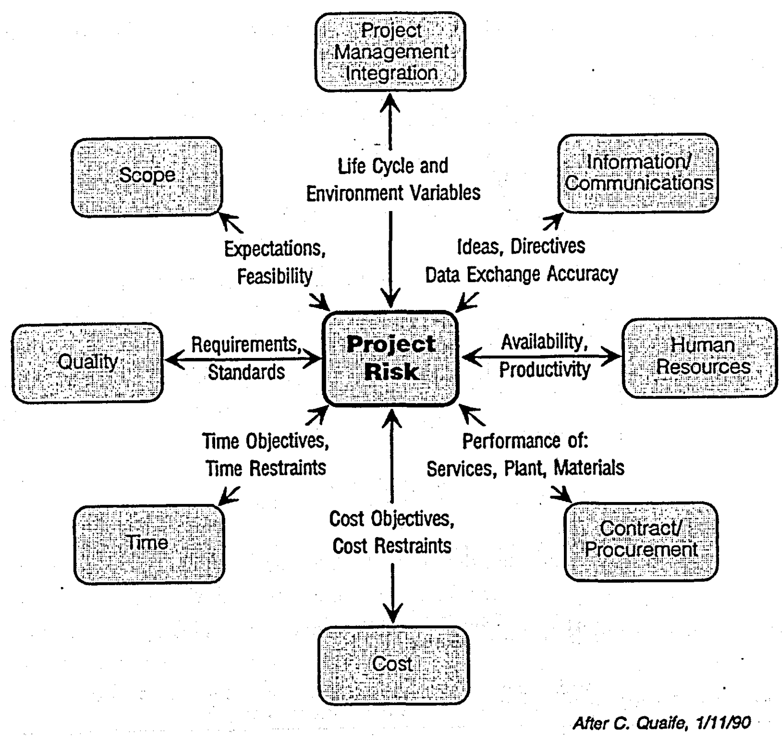


Figure 3 - The risk wheel (Source: Wideman, 1995)

3.3.5 American Society for Testing and Materials

The American Society for Testing and Materials' (ASTM) (1998a) designation E1946-98, "Standard Practice for Measuring Cost Risk of Buildings and Building Systems", establishes a procedure for measuring cost risk for buildings using Monte Carlo simulation and "sensitivity analysis" (see Chapter 4). The procedure for calculating building cost risk is summarised as follows:

1. Identify critical cost elements;
2. Eliminate interdependencies between critical elements;
3. Select "probability density function";
4. Quantify risks in critical elements;
5. Create a cost model;
6. Conduct a Monte Carlo simulation;
7. Interpret the results; and
8. Conduct a sensitivity analysis.

Concerning the elimination of interdependencies between elements, it is suggested that the practice works best when there are no strong interdependencies, and, where there are highly dependent variables, they should be combined, or the common component extracted as a separate variable (ASTM, 1998a).

The ASTM (1998b) designation E1369-98 lists procedures for treating risk in the economic evaluation of buildings, and the recommended steps are:

1. Determine appropriate economic measure (s) for evaluating the investment;
2. Identify objectives, alternatives, and constraints;

3. Decide whether an uncertainty and risk evaluation is needed, and, if so, choose the appropriate technique;
4. Compile data and establish assumptions for the evaluation;
5. Determine risk attitude of the decision maker;
6. Compute measures of worth and associated risk;
7. Analyse results and make a decision; and
8. Document the evaluation.

3.3.6 BP Amoco

Noor and Rye's (2000) first requirement for a successful risk-weighted estimate is having a well documented estimate to serve as a baseline. This should represent the most likely cost, based on the available information. The report must include all assumptions and information sources, regardless of the amount and quality of information available. The base cost estimate must not contain any hidden contingencies or allowances, any miscellaneous costs must be documented and justified. Noor and Rye believe that a well conducted risk analysis session cannot compensate for a poor estimate, and the estimate must, therefore, be reviewed and accepted first by the project team.

Following acceptance of the base estimate, a "ranging session" is carried out. This consists of three parts:

1. A short presentation on the risk analysis process;
2. Development of the "influence factors"; and
3. Determination of the effects on the influence factors on the cost estimate ("ranging").

The participants of a ranging session should include the key members of the project team (e.g. the cost estimator, discipline engineers, project manager, budget/financial control representatives) and a "risk facilitator". In some cases, contractors may also be invited to attend.

At the onset of the ranging session, participants are given an overview of the risk management process, along with some guidelines on how the ranging session will be conducted (Noor and Rye, 2000). The important rules that must be followed during the session are highlighted, these being that project specific details such as the location, the type of facility, and the technology to be used, should be fixed. If different options are being evaluated, they should be considered separately to ensure that the risk analysis results are specific to one particular case.

The second stage is the development of "influence factors". These are independent issues that are likely to have an effect on the base estimate. Participants are urged to consider all the possible factors that might have an effect, and leads to the development of a list of benefits and concerns. This has the added value of providing the project team with a checklist of issues that they may need to address as the project is developed further. Once all the issues are identified by the team, the influence factors are developed. This procedure involves the consolidation of the list of benefits and concerns into influence factors that should represent major cost related issues.

The process of paring down the list of benefits and concerns into influence factors can be lengthy and tedious, and, as an alternative, a standard list could be presented to the group instead (Noor and Rye, 2000). This list could be prepared from previously completed risk analysis sessions on similar projects, and such a list helps to initiate discussion among the team. This approach is said to be a more expedient method, however, it is stated that the main drawback is that some participants may focus only on the issues shown on the prepared list. Consequently, they do not identify the issues associated with all of the possible scenarios. The risk facilitator has to ensure that the list of influence factors is thorough by challenging the group to consider all other possibilities.

In the third part of the ranging session, the effect of the influence factors on the cost estimate is determined, and a cost-influence matrix for the base estimate is created. An example of a typical cost-influence matrix is shown is shown in Figure 4. A range around the base estimate is a measure of the variation in the base cost, e.g. -5% / +15%. The net effect of all the ranges that are due to each influence factor is computed at the bottom of the cost-influence matrix. The Monte Carlo simulation technique is then proposed, to assess the effect of the influence factors on the base cost estimate using the data from the cost-influence matrix. Another component of the results displays the relative effect that each of the influence factors have on the base estimate by using sensitivity analysis.

Noor and Rye (2000) explain that about 150 risk-weighted cost estimates have been prepared for a variety of projects. These range from deep water exploration and production projects to refinery and chemical plant projects, and include new projects and improvements to existing facilities. They conclude that one of the benefits is in the manner in which contingencies are assigned to the project costs. Traditionally, contingencies were incorporated into deterministic cost estimates as a line item usually between 5% and 15% of the base estimate, but risk-weighted estimates have yielded smaller contingencies. Consequently, less money is tied up on the project. It is suggested that the results can also help in the development of effective risk mitigation and management plans.

Cost Component		%	Influence Factors						
Description	Base Cost in US$		1 Equip. Market	2 Materials Market	3 Labor Unc.	4 Design Unc.	5 Environ. Unc.	6 Schedule Unc.	7 Value Practices
Equipment Costs	2,225,000	-	5			0	15		5
		+	15			15	5		5
Bulk Material Costs	1,650,000	-		5		25			10
		+		10		25			15
Labor Costs	1,587,500	-		6	5	10		25	5
		+		10	25	0		15	5
Indirect Costs	2,400,000	-		5	20	5		5	10
		+		10	15	10		10	5
Import Fee & Taxes	475,000	-	5	10					
		+	10	5					
Effect on Total		-							
		+							
Total Base Estimate	8,337,500								

Figure 4 - Cost-influence matrix

(Source: Noor and Rye, 2000)

3.4 Project risk management systems

3.4.1 Science and Engineering Research Council

Thompson and Perry's (1992) and the Norris et al (1993) system is in two main stages, risk analysis and risk management. Risk analysis is further divided into two sub-stages, a "qualitative analysis" and a "quantitative analysis". An initial qualitative risk analysis is essential as it allows the main risks to be identified by, for example, checklists, interviews, or brainstorming sessions. This is then usually associated with some form of assessment, which could be the description of each risk, or a subjective labelling of each risk (e.g. low/high) in terms of its probability of occurrence. A sound aim is to identify the key risks, perhaps between five and ten, for each project, which can then be analysed and managed in more detail. Their quantitative analysis sub-stage often involves more sophisticated techniques, usually requiring computer software. This is considered to be the most formal aspect of the whole process, requiring measurement of risk in cost and time estimates, and probabilistic combination of individual uncertainties. They recommended that companies new to risk management start slowly, perhaps even ignoring the quantitative sub-stage, until a climate of acceptability has been developed for risk management in the organisation. Finally, risk management involves the formulation of management responses to reduce and control the main risks identified in the analyses.

3.4.2 HM Treasury

HM Treasury (1993) explains that formal risk analysis is usually carried out as part of the project management service in conjunction with the work of the cost consultant. The first stage of the process, risk identification, usually consists of three parts. These being, understanding the content of the base estimate, reviewing the likely sources of potential risk, and identifying the potential risks and compiling the project "risk register". As with Thompson and Perry's (1992) and the Norris et al (1993) system, this is then followed by both qualitative and quantitative assessments, as shown in Figure 5.

HM Treasury (1993) has been superseded by HM Treasury (1997), which states that the aim of risk management is to ensure that risks are identified at project inception, their potential impacts allowed for, and, where possible, their impacts minimised. The systematic risk management process proposed consists of three main phases:

1. Identification - to determine what the risks are;

2. Assessment - to determine the likelihood of the risk occurring and their potential impacts; and
3. Monitoring and control - to identify options for dealing with risks and monitoring implementation of the preferred options.

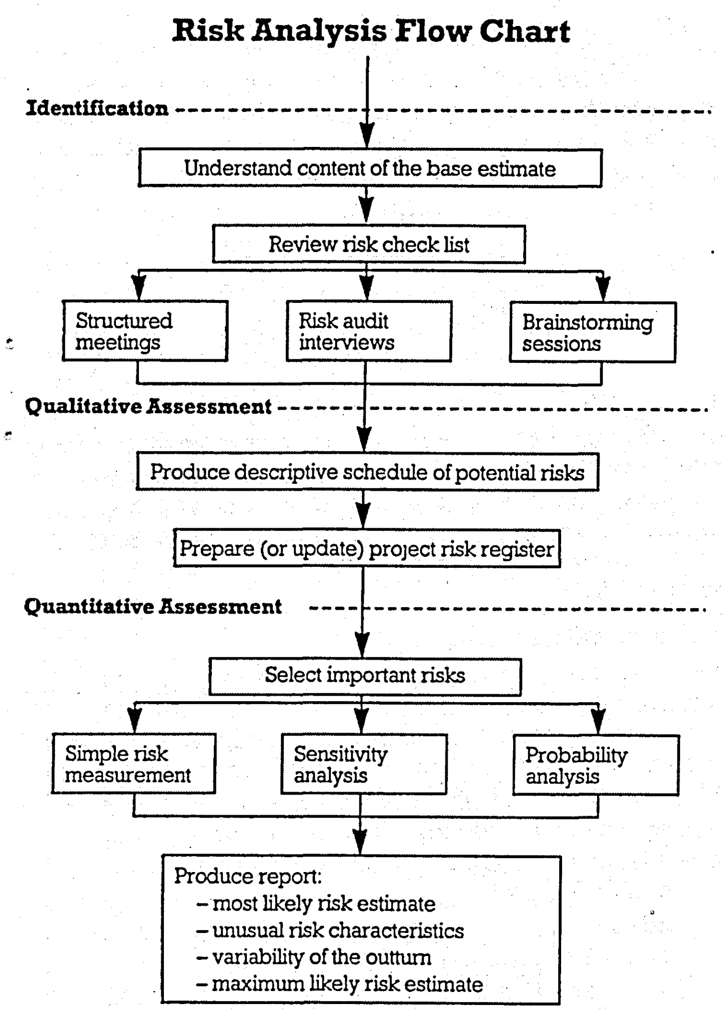


Figure 5 - HM Treasury's (1993) risk analysis flow chart

Similar to Thompson and Perry (1992), Norris et al (1993), and HM Treasury (1993), the assessment phase is split into qualitative and quantitative sub-stages. Concerning risk monitoring and control, it is recommended that care should be taken when considering the management actions available to ensure that the potential impact of each risk is not outweighed by the direct costs to the department from the cost of reducing the risk, transferring the risk, or all management and administrative time, consultants fees and other charges associated with managing and dealing with the risk (HM Treasury, 1997). A "risk management plan" should be prepared and updated regularly to summarise the risk management process.

3.4.3 Gardiner & Theobald and Bovis

Boothroyd and Emmett (1996) present risk management aimed at helping the project team make decision by identifying, classifying, and quantifying the risks, and then managing and controlling them. They emphasise that identification is the most important phase of the process, because no action can be taken on a risk that has not been recognised. Similar to Yates (1986), identification should be done during a "risk workshop" at the start of the project. Risks should then be classified by their potential impact on the project and their likelihood of occurrence, and the major risks prioritised and quantified to provide the client with the most likely total cost of the project.

Technique such as Monte Carlo simulation should be used to provide minimum, maximum and most likely risk allowances, and the process continued by recommending optimum actions for mitigating risk items, with each risk allocated to a team member to co-ordinate a response. The status of risks are then reviewed at meetings throughout the project to ensure that they are being managed effectively, and also to identify any new risks that have arisen. They recommend that a "risk manager" maintains regular contact with the project team between meetings, to ensure satisfactory progress is being made.

3.4.4 Construction Industry Research and Information Association

As Boothroyd and Emmett (1996) suggest, a risk management framework should normally involve several members of the project team lending their range of skills and experience. However, Godfrey (1996) explains that it can also be useful for an individual to follow the process alone. Similar to HM Treasury (1993), the main outcome of this process is then usually presented as a risk register. It is recommended by Godfrey that it helps to condense the register into a concise form to clarify issues and reach sound conclusions. As the project develops, the register retains only the parts that continue to matter. Godfrey's systematic process is illustrated in ten steps, as shown in Figure 6.

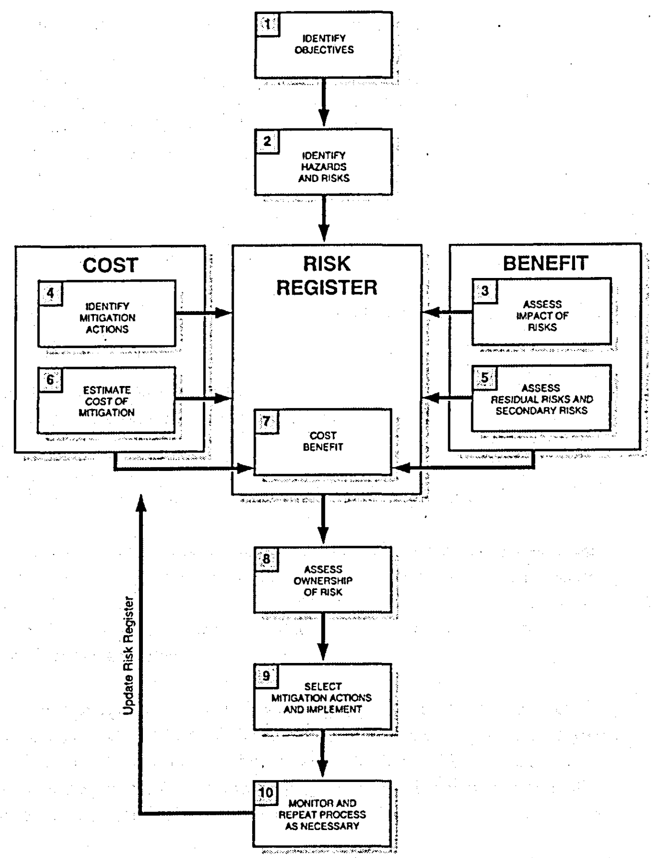


Figure 6 - Godfrey's (1996) systematic risk management process

3.4.5 Project Management Institute

Included within the Project Management Institute's (PMI) (1996) "*A Guide to the Project Management Body of Knowledge*", is a section concerned primarily with risk management. This process is made up of four stages, as shown in Figure 7. Risk identification determines which risks are likely to affect the project, and it is highlighted that it is important to understand that even the most thorough and comprehensive analysis cannot identify all of the project risks. The second stage, risk quantification is concerned with evaluating risks and interactions to assess the range of possible outcomes, and it is primarily concerned with determining which risks warrant a response.

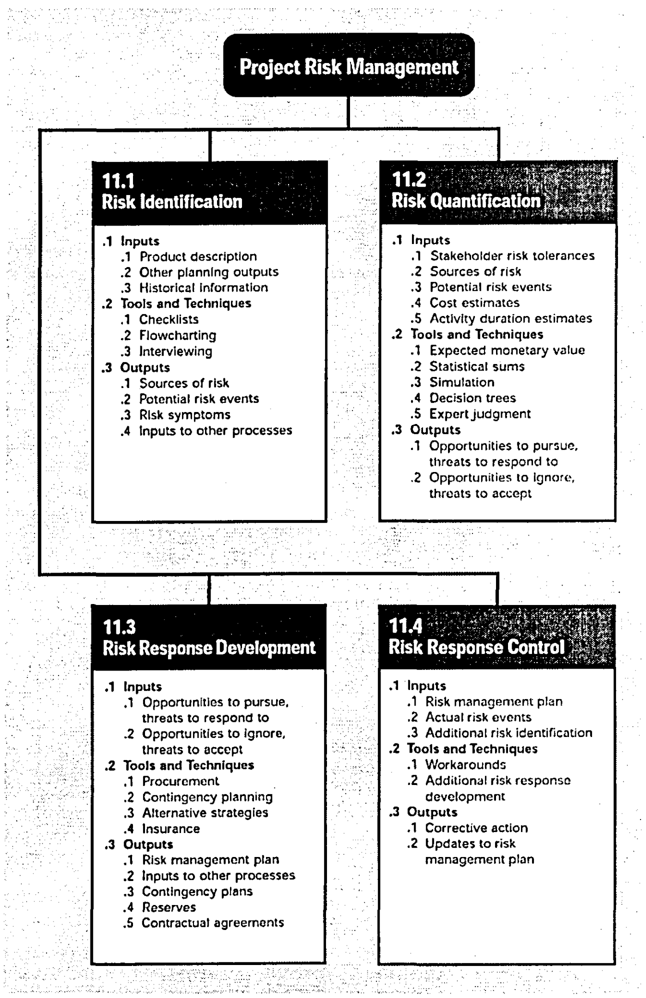


Figure 7 - PMI's (1996) project risk management overview

Risk response development defines enhancement steps for opportunities, and response steps to threats, with a key outputs being the risk management plan (PMI, 1996). This should document procedures that will be used to manage risk throughout the project. It will also report the results from identification and quantification processes, covering who is responsible for managing various areas of risk, how the initial outputs will be maintained, and how contingency plans will be implemented from warning "triggers". Finally, risk response control involves executing the risk management plans, and responding to changes in risk over the course of the project. Thus, when significant changes occur, the basic cycle is repeated, therefore requiring control and iteration. As with Godfrey's (1996) system, each process may have involvement from one or more individuals, or group of individuals, based on the needs of the project. Although the processes is presented as discrete elements with well defined interfaces, in practice, they may overlap and interact in different ways.

3.4.6 Association for Project Management

Chapman and Ward (1997) and Simon et al (1997) explain that the most specific risk management processes are described in terms of phases (stages), which are decomposed in a variety of ways, some related to tasks (activities), and some related to deliverables (outputs/products). Their generic project structure is more detailed than most specific processes discussed so far, and may be summarised as follows:

1. Define the project for risk management purposes.
    - Project should have well defined objectives, scope, strategy and an outline plan;
2. Focus the risk management process.

- The purpose of this stage is to define the scope and strategy of the risk management process (as distinct from the strategy of the project), and to plan it in operational terms as a project in its own right;

3. Identify the risks and responses.
    - An approach should be adopted to risk identification that gives confidence in the project team's ability to complete the list of risks;
    - All stakeholders should be consulted, and external opinions should be sought where appropriate and practical;
    - Lessons from historical information should be accessed;
    - Promote an open response from the individuals approached;
    - After the risk has been identified it should be validated;
4. Assessment of the risks.
    - The risks identified should be described and characterised sufficiently to allow effective risk assessment to be conducted;
    - As well as the individual potential effect of each risk, there may be additional effects from a combination of risk occurrences. The combined effect of all the risks should be assessed;
    - The relative significance of each risk identified should be assessed, in terms of the threat it poses to achieving the project's objectives;
    - Develop the analysis structure, clarify ownership issues, estimate in terms of scenarios and numbers, and evaluate the numbers and scenarios;
5. Plan the project and the management of its risk.
    - The planning phase uses all preceding effort to produce a project base plan ready for implementation, and associated risk management plans (actions)

for the project management process. Ensuring that these plans are complete and appropriate is the purpose of this phase.

6. Manage the project and its risk.
   - The management phase is ongoing once the project is implemented, and is concerned with monitoring actual progress with the project and the associated risk management plans, responding to any departures from these plans, and developing more detailed plans for the immediate future. The key deliverable is diagnosis of a need to revisit earlier plans, the basis of control, and initiation of re-planning as necessary.

Simon et al (1997) explain that some broad general features of the above system when applied earlier in the project life cycle include it being less quantitative, less formal, less tactical, more strategic, more creative, and more concerned with the identification and capture of opportunities. They say that the formalisation is central to capturing the benefits as part of the communication processes involved, and the level and kind of communication the process can generate can lead to significant culture changes within organisations. These changes can be quite fundamental, and they can be very complex, thus, the iterative nature of the process is central to "*keeping it simple*", therefore using early passes of the process to identify the areas that need more detailed assessment in later phases (Chapman and Ward, 1997).

3.4.7 Institution of Civil Engineers et al

The Institution of Civil Engineers and the Faculty and Institute of Actuaries (1998) process is a comprehensive and systematic process, similar in scope to the Chapman and Ward (1997) and Simon et al (1997) system. It is designed for managing risks in capital investment projects. This process covers the entire life of a project from inception to completion. Generally, process launch is conducted early in the investment life-cycle. Risk review is conducted before each of the project's key decisions or intervals. Risk management is then conducted continually between risk reviews. Finally, process close-down is conducted at the end of the investment life-cycle, or on premature termination.

3.4.8 British Standards Institution

The British Standards Institution's (BSI) (2000) BS 6079-3 system is, similar to PMI (1996), a project management standard. It is entitled "*Guide to the management of business related project risk*". It sets out a five stage process of context, risk identification, risk analysis, risk evaluation, and risk treatment, as shown in Figure 8. The model outlined is shaped by two generic perspectives that can be applied to any kind of business or project. First, defining the relationship between the business and its projects. And second, modelling the decision-making process associated with activities at different levels within either the business or project. Similar to Chapman and Ward (1997), Simon et al (1997), and the Institution of Civil Engineers et al (1998), the process is thorough and includes definitions, a glossary of tools and techniques, and a list of common examples of business and project risk.

3.5 Summary

A primary measure of success in preparing a budget estimate is predicting the final cost at project inception. The problem is that when the initial budget is being set there is little information about the building, but a budget is established, using a single price rate method of estimating. The most commonly used technique of allowing for risk in a project budget is the contingency percentage allowance. This is a intuitive approach that has significant weaknesses, and the term "contingency" should therefore not be used. Perhaps if the percentage allowance figure was arrived at more scientifically, then the technique would have more substance.

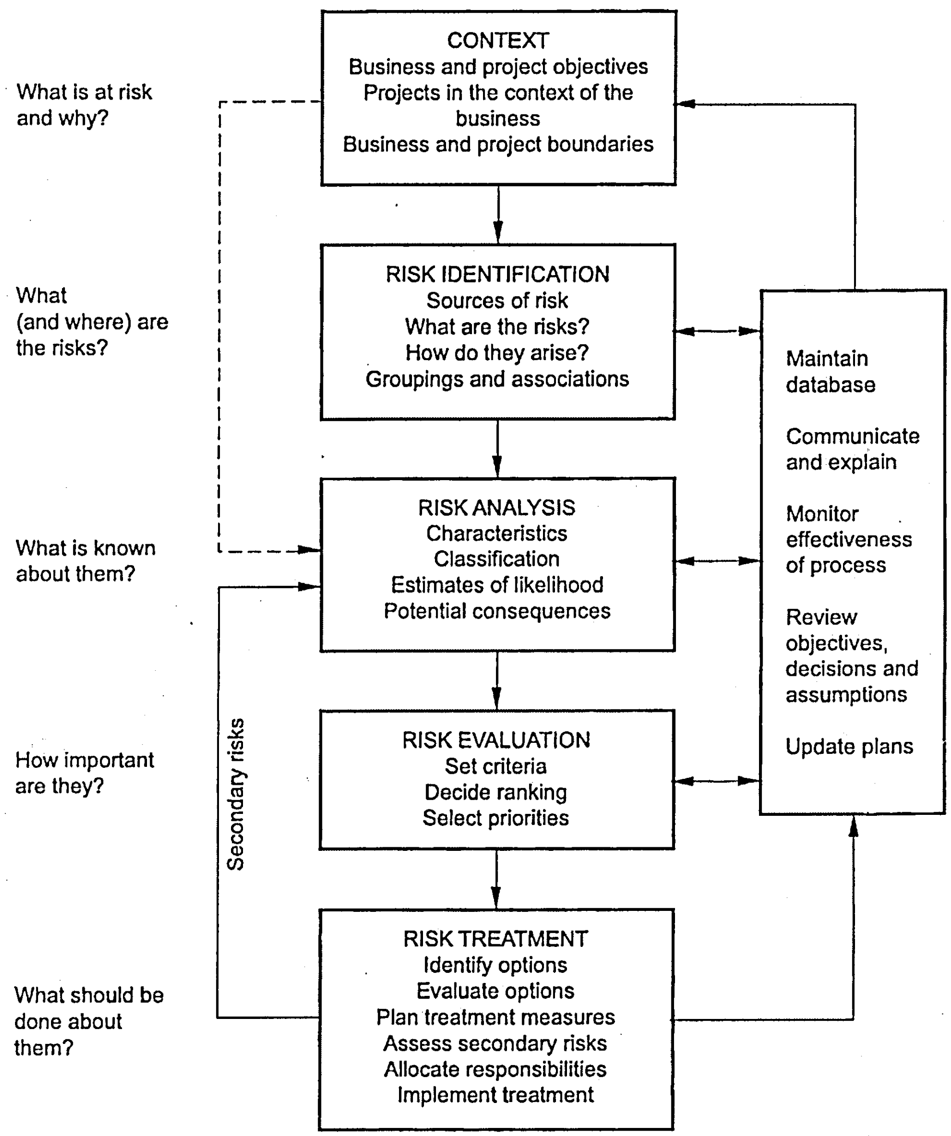


Figure 8 - BSI's (2000) risk management process

Various "budget risk management systems" have been proposed for construction projects. Some aspects of these systems are common, e.g. preparation of a baseline estimate, identification of the key risks that affect the estimate, quantification of the risks, and use of a formal structure. The adoption of a systematic approach to budget risk management will also usually produce an estimate expressed in terms of a range, rather than as a single figure. This is often achieved by using the Monte Carlo simulation technique. Several attributes of "project risk management systems" are also becoming standard practice, e.g.:

- Focusing the context of the risk management process objectives prior to its launch;
- Using a risk manager to facilitate the risk management process;
- Obtaining a clear understanding of a project's objectives in advance of starting the risk management process;
- Prioritise risk management efforts on only the main project risks;
- Adapting an iterative and interactive risk management process throughout the lifecycle of a project;
- Allowing functionality of the risk management model by either a team or an individual; and
- Delivering outputs as risk registers and risk management plans.

The above characteristics of both the budget and project risk management systems should be incorporated as an integral part of the proposed model development work. However, a potential problem with these existing systems is the time taken to implement them. The quantity surveyor is often under extreme pressure to produce an initial budget estimate, often in minimum time constraints. Therefore, there may not be adequate time to, say, hold a formal brainstorming workshop with the whole design team. In addition to this, the client may prefer to receive the risk report at the same time as the budget estimate, rather than several days later.

Further deficiencies identified in the current systems include the need to have well documented project objectives and a baseline budget estimate before starting the risk management process, meaning that the risk management process usually follows the completion of the project brief and budget estimate. It would, however, seem to be more appropriate to apply the risk management system to the process of preparing a brief and an initial budget estimate, instead of separating the operations. A further shortcoming in literature is that, although the generic nature of systems provide a good theoretical starting point for model development, the guidance lacks specific "step-by-step" procedures for particular specialised system applications. There is also a neglect of practical case illustrations demonstrating the implementation of the suggested systems.

The proposed conceptual model should tackle these issues, and, in particular, it should address the need for a more integrated approach to the process of project definition, budget preparation, and risk management. The model should provide an auditable framework of internal control within a practice, and, through step-by-step guidance, it should be validated with practical case illustrations. The process of preparing an initial budget estimate for a building project places the quantity surveyor in a leading consultancy position for initiating the risk management process. There is, therefore, great opportunity for the quantity surveyor to be proactive by producing the first, and possibly most critical, assessment of financial construction risk for the client.

CHAPTER 4 - RISK MANAGEMENT TOOLS, TECHNIQUES, AND SOFTWARE

4.1 Introduction

In 1985 the Royal Institution of Chartered Surveyors (RICS) arranged a quantity surveyors research and development forum to explore some of the reasons why the Construction Industry in general, and the quantity surveying profession in particular, had been slow to adopt the philosophy and techniques of risk analysis (Wilson, 1985). Two reasons were identified, the first was culture related (e.g. education, mystique, perceptions, subjectivity, contingency), the other reason suggested derive from the current state of the technology of risk analysis (e.g. software availability). Since this early forum, risk management literature and commercial products have progressed. The objective of this chapter is to consider the key literature related to building project budgets and risk management tools and techniques, and to review a selection of the commercial software available (Association for Project Management (APM), 2000). The performance of each will subsequently be evaluate for use with the proposed conceptual model.

4.2 Risk management tools and techniques

4.2.1 Subjective probability

Subjective probability is the degree of belief or confidence placed on the possible occurrence of a risk by a decision-maker, on the basis of evidence or information available (Flanagan and Norman, 1993). This is preferable to objective probability because decisions are unique, and, in a sense, conditions change continuously, meaning it is impossible to obtain past observations of similar events from which to estimate objective probabilities (Flanagan and Norman, 1993). However, Flanagan and Norman (1993) explain that the problem is that subjective probability might generate a self-fulfilling prophecy by an individual, and it is, therefore, a rather arbitrary measure of risk, leading to bias. All objective and subjective evidence available should, therefore, be used in the assignment of subjective probabilities.

4.2.2 Monte Carlo simulation

Whilst the contingency percentage allowance is the most commonly used technique for risk management of building projects budgets, Monte Carlo simulation is the one which has received most coverage in construction literature. It is called Monte Carlo simulation because it makes use of random numbers to select outcomes, rather as a ball in a roulette wheel stops to select a winning number (Flanagan and Stevens, 1990). Flanagan and Norman (1982) suggest a step-by-step risk analysis technique for building project budgets using Monte Carlo simulation, the results of which allow the presentation of the most likely range within which the tender price will lie, and give the probability that the tender price will not exceed a given limit. This work is developed further by Flanagan and Stevens (1990), who explain that Monte Carlo simulation generates hypothetical mean unit price rates for each elemental category in the cost plan for a proposed building. These hypothetical rates are taken from probability distributions with the same statistical properties, that is, probability density function, as those which characterise the original sample data from which the mean unit price rates were estimated. The hypothetical rates are then used to build up a total price forecast for the proposed building. If this exercise is repeated a sufficiently large number of times, it will be possible to obtain a picture of the probability density function which characterises the total price, and so to determine the most likely total price.

The successful application of Flanagan et al's above method is presented in a case study on a warehouse building, during the cost planning stage. It is concluded that Monte Carlo simulation does not provide the solution to eliminating risk in the forecasting of construction price, but it is a valuable tool that encourages the design team to focus on the "what if" questions and to consider the range of possibilities that might occur. Flanagan et al state that, in order for risk analysis to be adopted by quantity surveyors, it must prove itself to be economically viable for both clients and the professional advisers, but, given the opportunity, it will become an everyday technique within the construction industry. Seeley (1996) also believes that the use of risk analysis using Monte Carlo simulation and output data including confidence limits will become, in time, the *de-facto* standard for all construction cost calculations.

Hawkins and Solomon's (1989) initial experience of using Monte Carlo simulation software showed that the technique works very well in practice by helping quantity surveyors to communicate more detail in their estimates. They said that not only are the surveyors forced to face the fact that risks on costs exist, but their minds are focused on the important issues that could affect costs. Newton (1992) also favours the use Monte Carlo simulation in construction cost estimating, but, however, says genuine concerns remain, because, in a sense, it is all too easy, as building costs exhibit few of the clean features required for the statistics. He also says that there is little firm evidence to support or challenge the degree of asymmetry assumed in the elemental probability distributions, neither is there any real clarity regarding the extent and implications of correlations between element costs. Newton does, however, conclude that, relative to conventional practice where asymmetry and correlation problems simply get ignored, the application of Monte Carlo simulation is to be encouraged, because the dynamics of building costs now demand that quantity surveyors move more fully to embrace the ideas of risk management.

Concerning the problem with asymmetry in probability distributions highlighted by Newton (1992), one of the most commonly adopted assumptions in modelling construction costs using Monte Carlo simulation is the triangular distribution as elemental probability density function. Chau (1995) has challenged the validity of this supposition. He found that the underlying distribution of the elements is asymmetric with a long thin tail towards the right, and that the triangular distribution does therefore lead to bias. Wall (1997), however, believes Monte Carlo simulation literature overplays the importance of choice of which distribution to use to represent input variables, and underplays the importance of assessing and including correlations between the variables. He presents simulation runs of a cost model including and excluding correlations, and concludes that correlations must be included in simulations, otherwise the analysis leads to serious mis-assessment of risk.

4.2.3 Sensitivity analysis

Sensitivity analysis is a simpler form of risk analysis than Monte Carlo simulation and works by determining the effect on the budget by changing the value of one of the risk items. This can be done by constructing a table in a spreadsheet to recalculate the cost of an item by adjusting the best estimate by plus or minus a range of percentages (e.g. +/- 5%, +/- 10%). A method of including several risks on one graph is proposed by Hayes et al (1986), see Figure 9, which provides a useful way of comparing the effects of changes for different risk against the total estimate using a "spider diagram". The shallower the gradient of the line on the graph, the more sensitive will construction costs be to change from a risk.

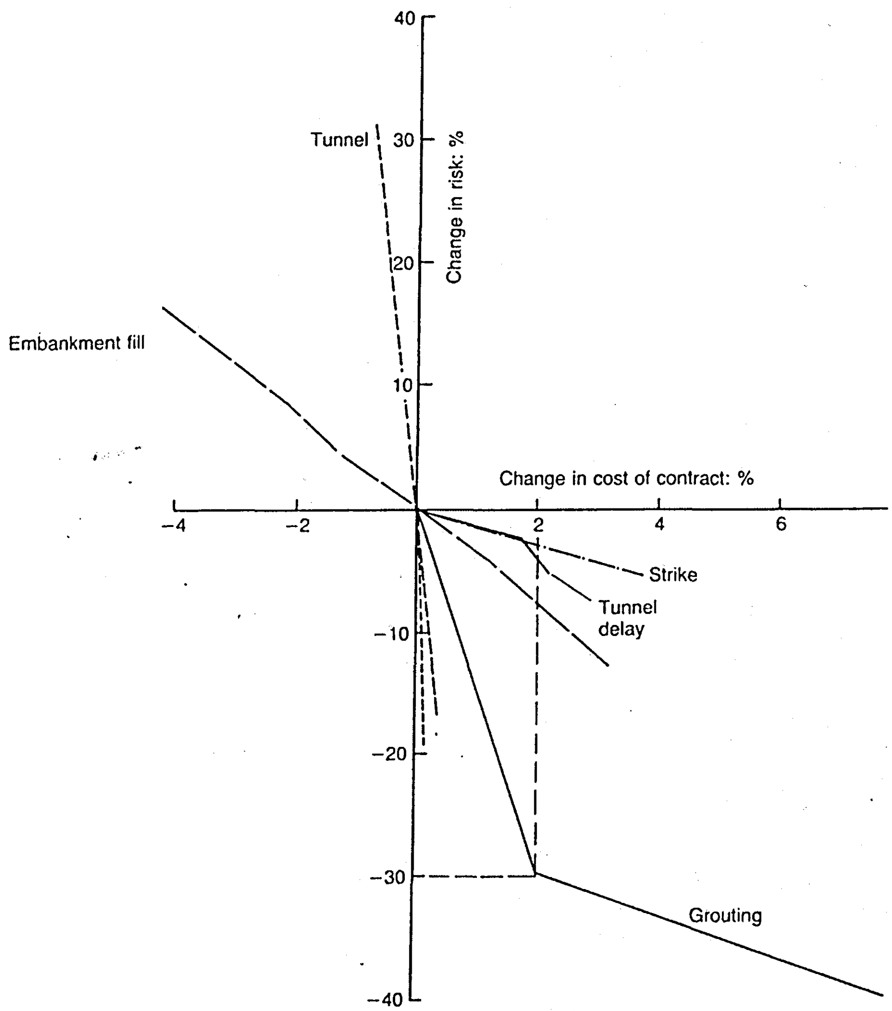


Figure 9 - Sensitivity analysis spider diagram
(Source: Thompson and Perry, 1992)

Flanagan and Norman (1993) suggest "scenario analysis" as another form of sensitivity analysis for risk analysis of a building project budget. This tests the alternative options of a project by identifying the key variables together and their monetary values. An example is presented at the early concept stage of a project, where, by minimising the amount of circulation space, the architect is looking at various different layouts of the building to optimise the net to gross floor area. The provision for car parking is also considered, which might be stipulated by the local authority's requirements. It is demonstrated in Figure 10 that the quantity surveyor could present various scenarios showing the impact on the cost change for the changes in floor area, the expenditure on car parking, and, in addition, forecasts on inflation. Each scenario is based upon the most likely, the optimistic, and the pessimistic estimate, and the results shown represent the range of possible outcomes.

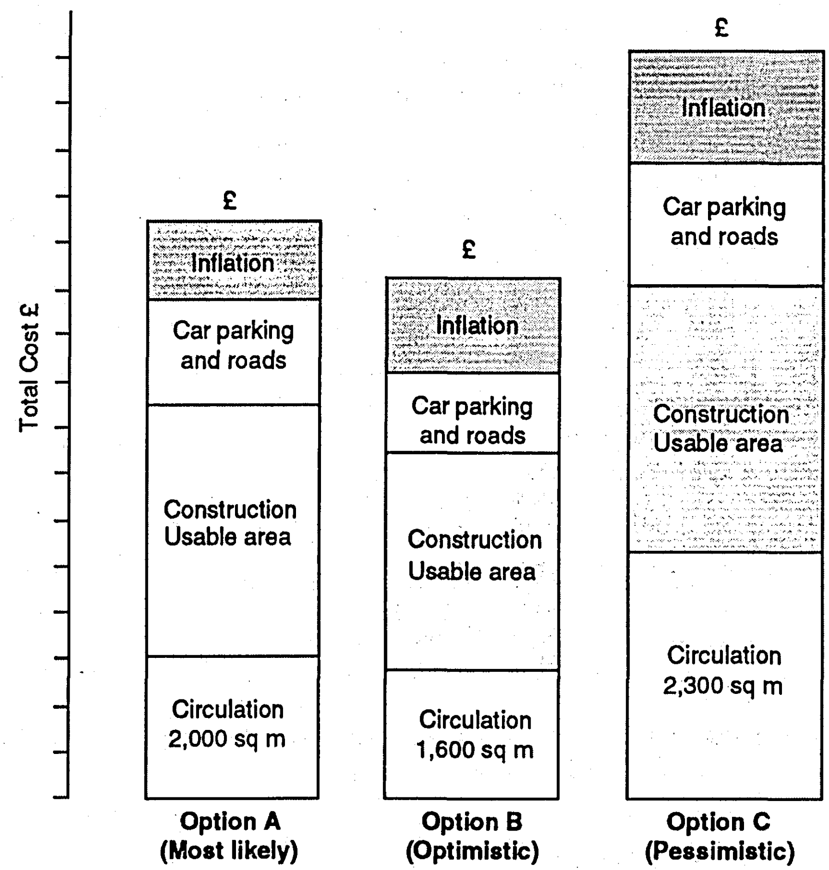


Figure 10 - Scenario analysis
(Source: Flanagan and Norman, 1993)

In the these examples no quantitative measure of the possibility of each outcome has been placed upon the options, although, as Flanagan and Norman (1993) explain, it is possible to add such a measure. Flanagan et al (1987) have shown that probability contours can be added to a spider diagram, albeit with application to a life cycle costing example. Hayes et al (1986) conclude that the main problem with the sensitivity analysis technique is that it only looks at risks in isolation, whereas, in reality, it is likely that some combination of the risks will occur.

4.2.4 Expected monetary value

The expected monetary value (EMV) approach takes the testing of scenarios one stage further by considering the probability of occurrence of each scenario (Raftery, 1994). Flanagan and Stevens (1990) present a risk analysis approach using EMV, which again works by giving each identified risk a three point estimate, including the most likely price, the lowest price, and the highest price, and then assigning a probability figure for the chance of each event occurring. An example of the need to replace a existing gas main to a site is given and, based on the information available to the quantity surveyor, the base estimate allows for some modifications to the existing main, the best case is to assume no work is required, and the worst case is that substantial work is needed to modify the main. By multiplying the price of each option against its respective probability value, an average risk allowance is determined.

The advantage of the EMV technique is that it solves some of the limitations of sensitivity analysis because it explicitly allow for the probability of change in input values, and therefore produce a risk-adjusted outcome (Raftery, 1994). The limitations of the EMV technique resolve around the value of the probability itself, which is usually arrived at subjectively, and it is therefore possible that it may not provide the best practical advice for a specific project decision.

The EMV technique is a way of considering the severity (cost impact) and likelihood (probability) of a risk, and, Flanagan and Norman (1993) have developed a matrix to view risky events by consider the likelihood of damage being caused to adjoining buildings as results of piling on site, as shown in Figure 11. This helps decision-makers to consider the risk consequences in a structured way, and Boothroyd and Emmett (1996) explain that such a matrix can be used during a risk workshop to help focus the project team's mind on where the risks lie. They say that, in most cases, the numerical values for probability and consequences can be arithmetically combined to give comparative value, and therefore allow the highest project risks to be prioritised.

Likelihood / *Severity*	Improbable	Rare	Possible	Probable	Very likely
Negligible (up to £100)	Retain	Retain	Retain	Retain	Retain
Small (£100 - £1,000)	Retain	Retain	Partial Insurance	Partial Insurance	Partial Insurance
Moderate (£1,000 - £5,000)	Retain	Partial Insurance	Insure	Insure	Insure
Large (£5,000 - £50,000)	Insure	Insure	Insure	Insure	Insure
Disastrous (over £50,000)	Insure	Insure	Cease activity	Cease activity	Cease activity

Figure 11 - Severity/likelihood matrix
(Source: Flanagan and Norman, 1993)

4.2.5 Multiple Estimating using Risk Analysis

Multiple Estimating using Risk Analysis (MERA) uses the EMV theory, but in a more complex way. Beeston (1986) describes the technique, and two types of risk allowances are defined:

- *Fixed risk allowance* - a sum of money which will either be incurred as a whole, with an estimated probability, or not at all. The *average risk allowance* for the item is calculated by multiplying the fixed risk allowance by the probability; and
- *Variable risk allowance* - can occur to varying degrees so no fixed sum of money can be allocated to it. The *average risk allowance* for it can be approximated by estimating the sum of money which has a probability of 0.5 (i.e. an even chance) of being exceeded. At the same time a sum must be estimated which has a probability of 0.1 (i.e. a one in ten chance) of being exceeded, this is the *maximum likely risk allowance.*

By totalling the average risk allowances above, this consolidates the risk allowance to produce a combined risk allowance which can be added to the base estimate to provide an alternative project estimate, called the *average risk estimate* for the project. As well as an average risk estimate it is considered desirable to also quote a figure which would be exceeded with only a small probability, a *maximum likely risk allowance*, this is the sum of the base estimate and a combination of the individual item *maximum likely risk allowances.* This combination is done after the important problem of dependence between items has been dealt with, and, for simplicity, items are treated as either completely dependent or completely independent. Items with a large degree of dependence are grouped by adding their risk allowances together, and then related to as a single independent item.

To combine the maximum likely risk allowances of independent items, the concept of a distribution of possible risk allowances is used. This distribution includes all possible values of the allowance for an item covering the whole range of probabilities from zero to one. The values are arranged about the average, not necessarily symmetrically, and to define the required part of the distribution, only two parameters are needed, the average, and the spread in the upward direction. The average for an item has already been calculated as the average risk allowance, it therefore remains to measure the upward spread. For variable risk allowances this concept is straightforward, it is the difference between the average risk allowance and the maximum likely risk allowance.

To calculate a notional spread for the artificial distribution of a fixed risk allowance requires further assumptions and, in Beeston's (1986) opinion, oversteps the boundary of reason. He says it seems better to use the fixed risk allowance itself as the maximum likely risk allowance, the upward spread is then the difference between it and the average risk allowance, as for the variable risk allowances. The spread of the distributions are combined by summing their squares and taking the square root of the total, corresponding with the standard procedure for combining standard deviations of distributions of independent variables. The result of this calculation is a combined spread, which can be added to the average risk estimate for the project to produce the maximum likely estimate for the project.

Barnes (1989) explains that MERA was adopted by the now privatised "Property Services Agency", a division of the UK Department of the Environment, which was responsible for the procurement of military buildings. He highlights that, in theory, there is a potential problem with MERA if only one very costly item is at risk and included in the estimate with a low probability, thus producing the situation where its disproportionate cost would destroy the principle of "swings and roundabouts". In reality, he says that this should never happen since such an item would ring alarm bells to indicate a bad brief or design solution, and resources would be applied to solving that problem before going any further.

Mak et al (1998) and Mak and Picken (2000), explain how, in 1993, the Hong Kong government implemented the MERA technique for capital cost estimating in its estimating for the planning of public works projects, and indicate initial success in using the method to reduce unnecessary and exaggerated allowances for risk caused when using other techniques (e.g. the contingency percentage allowance). However, Raftery (1994) believes that MERA is really a method of probabilistic estimating, rather than a method of risk analysis, and it is a mechanistic and rather inflexible technique that does not promote creative thought, nor does it encourage the project team to do something about the results.

4.2.6 Decision tree analysis

At the beginning of most building projects there are several different routes that may be followed, and the decision-maker is therefore faced with a variety of possibilities. The decision tree is suggested as a graphical means of bringing together the information needed for these decisions, as it can show the possible courses of action available, and, combined with EMV, can provide a measure of the value for each possible outcome (Hayes et al, 1986). Figure 12 shows a typical example of a decision tree on construction costs.

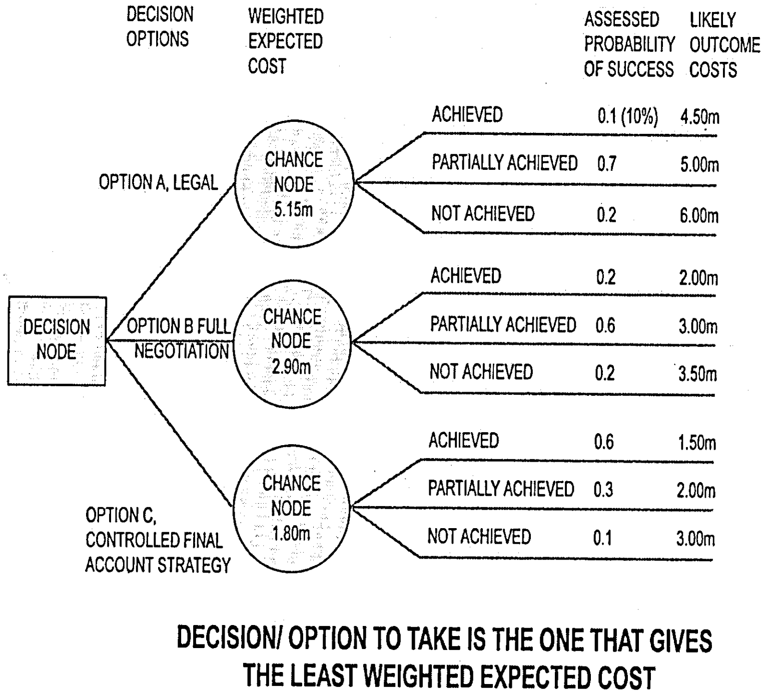


Figure 12 - Decision tree analysis
(Source: Boothroyd and Emmett, 1996)

4.2.7 Prompts and checklists

Checklists contain questions on specific areas, often based on past project experience, and they can be structured to rapidly identifying sources of risk (BSI, 2000). They can, however, sometimes be overly prescriptive and overlook risks which are not based on past project performance. Godfrey (1996) recommends not using checklists because they tend to identify the usual. Instead, prompt lists are preferred, as they can be used to stimulate specific risk identification. Godfrey proposes a "what can go wrong list", and suggests the use of records from hindsight reviews and case study examples. Prompt lists ensure that a broad range of categories of project risk are examined, and can be a useful focus of attention during a brainstorming session (BSI, 2000). Most of the construction risk management texts reviewed include lists of possible project risks that could be used as prompts.

4.2.8 Brainstorming

Brainstorming involves generating ideas about what might go wrong, and works better with a group, but can be done individually (Godfrey, 1996). A workshop environment gives the opportunity to experiment with different viewpoints, and lateral thinking is encouraged, thus resulting in some ideas that individuals might normally reject out of hand if working alone (RICS, 1999). Godfrey (1996) explains that it is helpful to appoint a facilitator whose role is to combine the function of workshop chairman and helmsman, and to record the process on a flip chart. Discussions should initially be kept as open as possible by discouraging criticism and, once identified, possible risks can then be discussed constructively (BSI, 2000).

4.2.9 Risk adjusted discount rate

Risk adjusted discount rate (RADR) may be calculated as follows (ASTM, 1998b):

$$\text{RADR} = \text{RF} + \text{AR1} + \text{AR2}$$

where:

RF = Risk-free rate;

AR1 = Adjustment for normal risk encountered in the operation; and

AR2 = Adjustment for extra risk above or below normal risk.

Whilst this formula is probably more applicable for calculating the life cycle costs of a building design, this could perhaps also be interpreted as follows:

RF = Risk-free baseline estimate;

AR1 = Adjustment for normal contingency percentage allowance;

AR2 = Adjustment based on judgement, intuition and "gut-feeling".

RADR is, therefore, typically an estimate based on the quantity surveyors best judgement, and, what is required, is for the quantity surveyor to make explicit any of the risk allowances that may sometimes have been previously hidden. Perhaps to improve this method, it could be possible to employ a classification system, where each building element or project type has a different level of risk adjustment (AR1), and a different risk premium adjustment (AR2), thus minimising the bias that might be found in project evaluation (Flanagan and Norman, 1993).

4.2.10 Decision matrix

A decision matrix is a representation of the options that are open to the decision-maker, the factors that are relevant, and the outcomes (Flanagan and Norman, 1993). This can be done using a simple table, with the options shown in rows, and the factors shown in columns. Subjective probabilities can be assigned to the various outcomes from which expected monetary values can be calculated.

4.2.11 Risk register

A risk register is a body of information listing all the risks identified for the project, explaining the nature of each risk and recording information relevant to its assessment and management (Chapman and Ward, 1997). Williams (1993) explains that this is the most common administrative device for keeping track of risks. A risk register consists of a simple collection of risk statements, each pro forma containing, for example:

- the "owner" of the risk;
- the estimated likelihood of its occurrence;
- the project objectives on which it impacts (e.g. scheduling, cost, some specification or performance measures), and the estimated severity of its impact;

- work-breakdown items and/or PERT activities influenced; and
- possible contingency plans, to prepare for the event of the risk occurring, secondary risks, or knock-on effect.

Williams, 1993.

An alternative, or addition, to a risk register is to use a "cost-influence matrix" (Noor and Rye, 2000) (see Chapter 3).

4.3 Risk management software

4.3.1 Simulation

"@Risk" is a simulation add-in for spreadsheets which integrates via an additional toolbar. It is a quantitative method that seeks to determine the outcomes of a decision as a probability distribution using the Monte Carlo simulation or Latin Hypercube method (Palisade, 2000). A value of a cell can be replaced with one of thirty-seven probability distribution functions, and graphics are used to present results, e.g. histograms, cumulative curves, summary graphs. Target values can also be added for "what-if?" analysis and sensitivity can be presented using a tornado chart. "@Risk" has been available for ten years and is reported to have the largest share of the market, being specified as standard on many large Ministry of Defence contracts (Croll, 1995). It is part of a "DecisionTools Suite" which also includes:

- "TopRank" - determines which cells affect results the most and ranks them in order of importance;
- "RiskView" - helps to select or create the most appropriate probability distribution from a sketch;

- "BestFit" - uses optimisation algorithms to find the distribution which best fits any available data; and
- "PrecisionTree" - to create "influence diagrams" and decision trees.

Similar simulation products to "@Risk" include "Crystal Ball", "PRA", "Predict! Risk Analyser" and "RiskMaster" (APM, 2000). A typical output graph is a histogram, as shown in Figure 13.

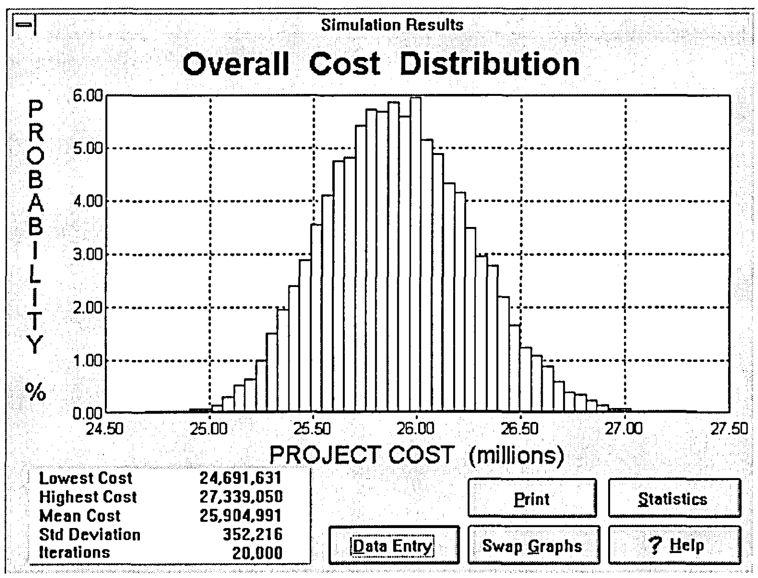


Figure 13 - PRA cost simulation histogram
(Source: Katmar Software, 1999)

4.3.2 Decision modelling

Similar to the "@Risk" "PrecisionTree" tool, "Definitive Scenario" software uses influence diagrams to graphically illustrate decision situations and present the relationship between variables in a model, as shown in Figure 14 (Definitive Software Inc, 2000). Again using Monte Carlo simulation, it integrates with spreadsheets to present results as either an S-curve or histogram. The key difference with this software compared to "@Risk" is that it runs Monte Carlo simulation from an influence diagram, rather than a worksheet table. The software can also perform sensitivity analysis.

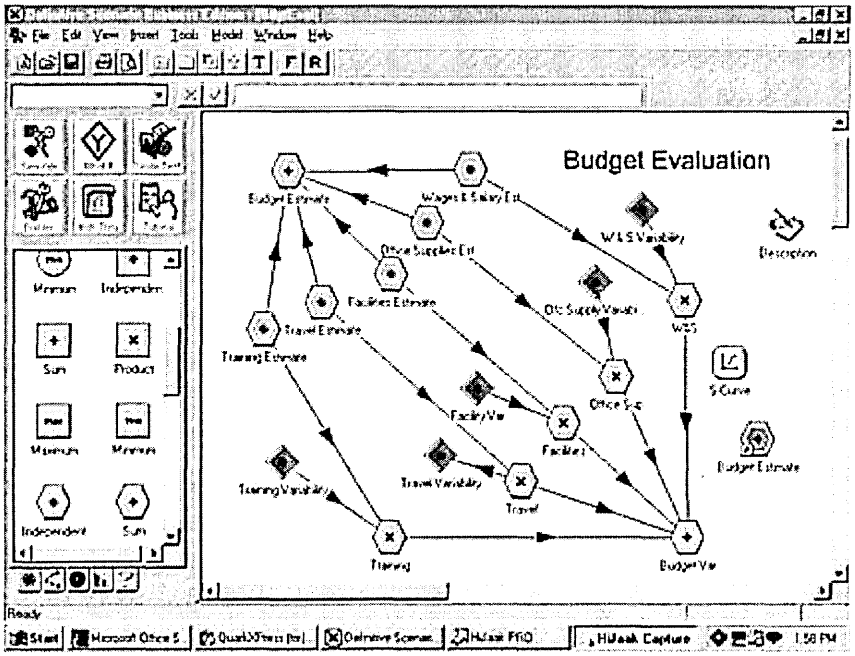


Figure 14 - Definitive Scenario influence diagram (Source: Definitive Software Inc, 2000)

A similar decision modelling software is "DPL" (Decision Programming Language), which offers synthesis of influence diagrams and decision trees which assist in structuring focused analyses (Applied Decision Analysis, 2000). An influence diagram shows the relationships among the important decision and uncertainty variables, whereas a decision tree defines a decision sequence or chronology, that is, the order in which decisions are made, uncertainties are resolved, and impacts are felt. The software has a graphical interface that facilitates drawing, model building, and processing diagrams. It includes colour-coded symbols that represent uncertainties, values, and decisions, thus enabling users to construct an intuitive graphical representation of a problem and then the diagrams become the focus for developing insights and consensus on the nature of the risk. The decision tree output can be configured to show the "risk profile" (cumulative probability distribution) for one or more specific strategies.

4.3.3 Databases

"Pandora" is a database risk register for holding details of risks enabling them to be classified according to probability and impact on cost, performance, and time, and including the allocation of responsibility for managing and controlling the problems (BMT Reliability Consultants Limited, 2000). It contains features to help users with the risk management process by using data entry screens which include:

- The project and stage to which the risk relates, and the people with responsibility for managing the risk;
- Time-scale information, to allow the management of the risks to be planned effectively as part of the project management process;
- Details of the risk, such as reference number, title, category and description; and
- The probability of the risk occurring, and the likely impact on cost, performance and timescale.

"Pandora" also maintains a full history of the way risks change throughout the life of a project, and includes a comprehensive management information system report designed to give an up-to-date review of the current status of risks, both before and after any actions have been taken, as shown in Figure 15. This is a useful means of showing how well the risk is being managed. For defence contractors it is the tool preferred by the Ministry of Defence Procurement Executive for use on bids and contracts on behalf of the Ministry of Defence (BMT Reliability Consultants Limited, 2000).

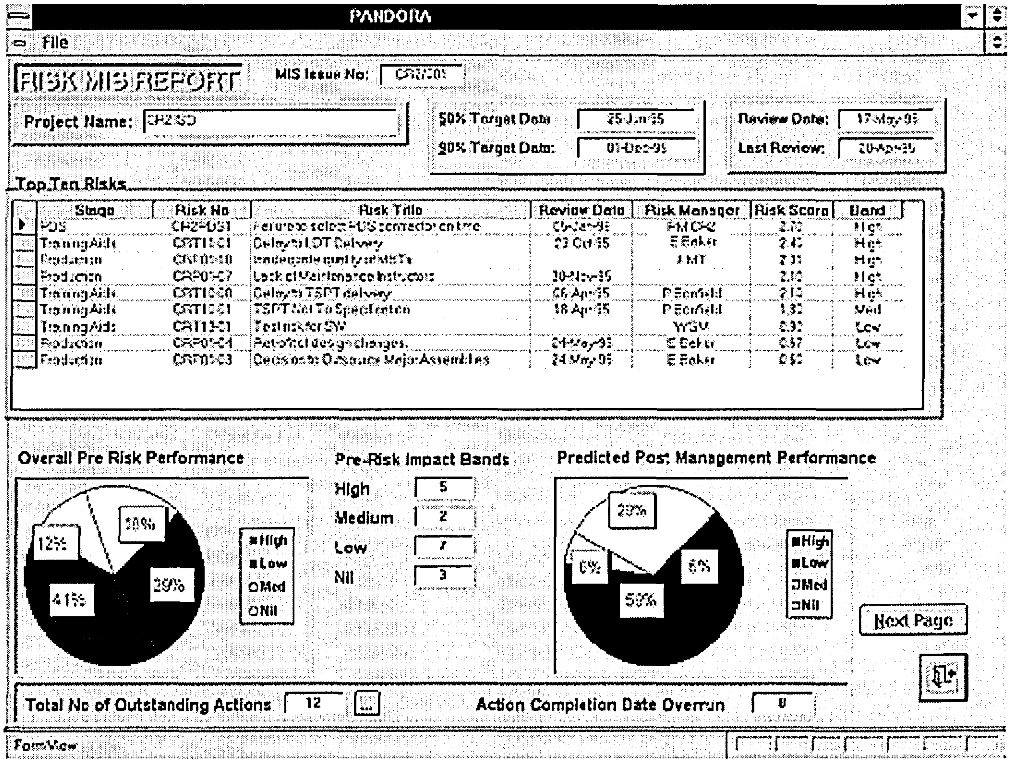


Figure 15 - Pandora's management information system report (Source: BMT Reliability Consultants Limited, 2000)

An addition to "Predict! Risk Analyser" is "Predict! Risk Controller", which allows both qualitative and quantitative data to be stored in a risk register that provides a formalised means of logging risk information across multiple projects. It provides "*flexible risk recording, tracking, communication, analysis, reporting, data storage and retrieval functionality as a basis of efficient project management*" (Risk Decisions Limited, 2000). Its comprehensive functionality includes a probability-impact grid, risk ownership and status, and automatic issuing of system-generated "trigger" reminders from a database via e-mail. An audit trail of all changes made to the database can be accessed from remote sites.

"Ris3" software was jointly developed by "Line International" and the "Defence Evaluation Research Agency", and provides a full audit trail which is supported by a history log for each risk held within a risk register (Line International Limited, 2000). The design provides both qualitative assessments and quantitative analyses, and reports are available which can be customised with ranking, ordering, and filtering selectors. Additional features include an "options comparison", cross references to work breakdown structures (programme packages), probability-impact grid, and Monte Carlo simulation generated statistical data for selected risks, reporting either time or cost. The software also enables users to communicate all report options to the team members, local management, or the customer, either locally or remotely, using their standard e-mail facility. There is also "RisGen", an add-in that enables generic libraries to be maintained, and from which risk registers can be assembled. Risk descriptions, risk consequences, and risk reductions are stored in three separate library locations and combined either to create a standard user selection or to create a specific risk register.

"Risk Radar" is a database to "*help project managers identify, prioritise, and communicate project risks in a flexible and easy-to-use form*" (US Department of the Navy, 1999). Each risk has a user-defined risk management plan and a log of historical events, as shown in Figure 16. The number of risks in each probability-impact category can also be displayed by time frame, as shown in Figure 17.

4.3.4 Programme management

The principles of "@Risk's" Monte Carlo simulation have also been applied to project schedules in order to determine the likelihood of finishing a project on time (Palisade, 2000). A programme management package such as "Microsoft Project" is used as the

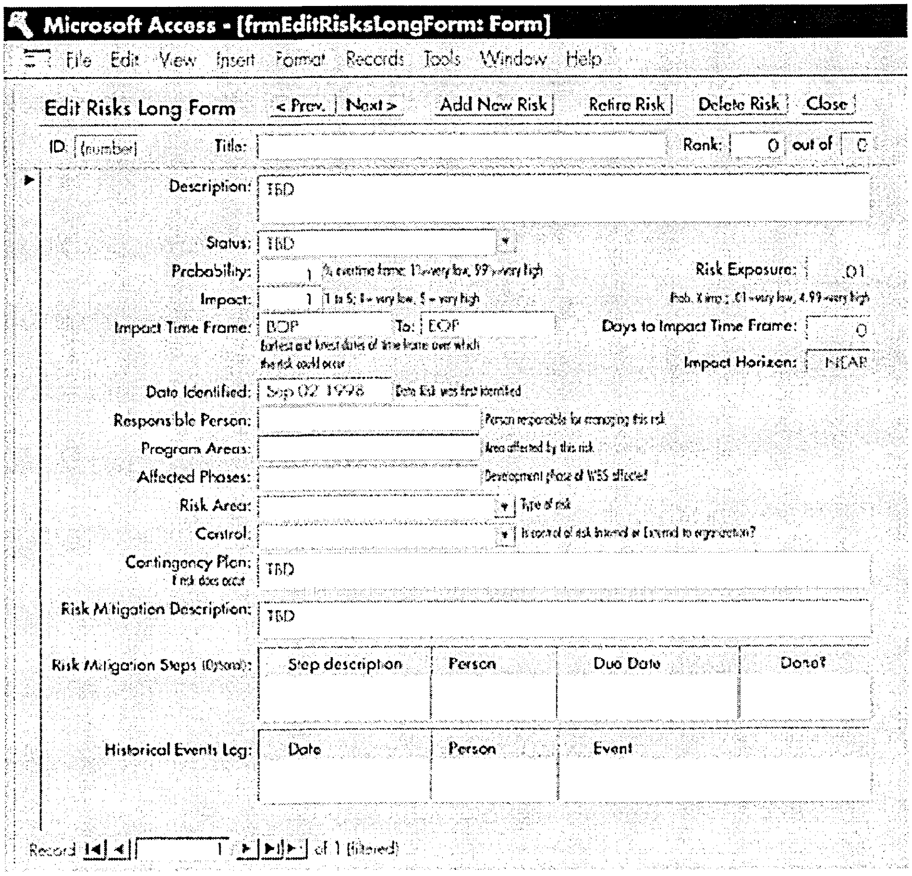


Figure 16 - Risk Radar long form

(Source: US Department of the Navy, 1999)

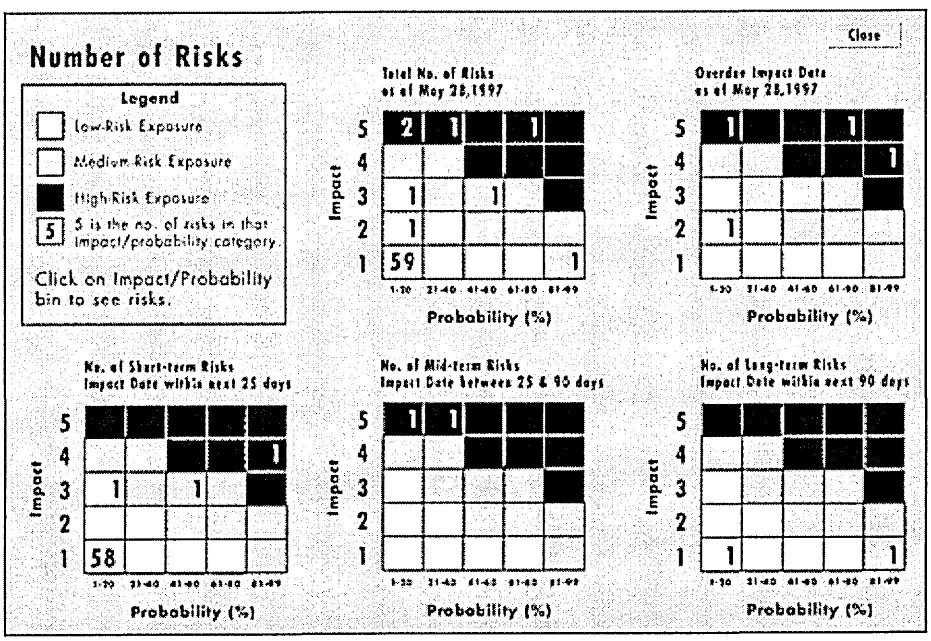


Figure 17 - Risk Radar probability-impact matrices

(Source: US Department of the Navy, 1999)

basis, rather than a spreadsheet, allowing resource cost constraints to also be analysed. "Monte Carlo" is similar to "@Risk for Projects", and users can evaluate the whole project, or individual segments, based upon quantifiable measures of risk (Primavera Systems Inc, 2000). "Riskman" software helps track risks, their causes, mitigation actions, events, and risk budgets, in conjunction with "Microsoft Word" for reports, "Microsoft Excel" for metrics, "Microsoft Project" for planning, and "Microsoft Access" for storage (Riskdriver, 2000). After building a project programme with "Microsoft Project", risk impacts, probabilities, and exposure are assessed in cost, time and performance dimensions, and Monte Carlo simulation helps to assess the project end date and cost. Figure 18 shows typical budget output graphics from the "Riskman" software.

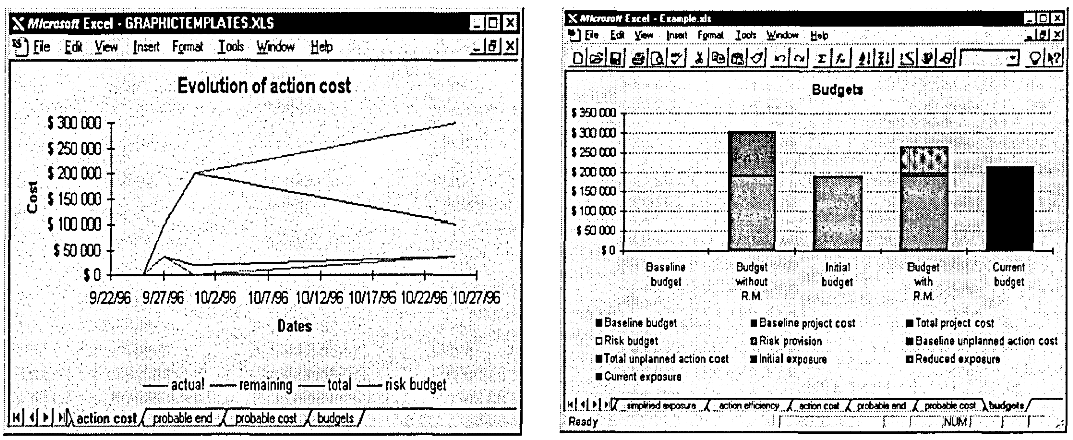


Figure 18 - Riskman budget analyses
(Source: Riskdriver, 2000)

4.3.5 Methodologies

"DMT" (Dependency Modelling Tool) supports a complete risk analysis methodology called "Dependency Modelling" that uses "*top-down, goal-oriented logic to help build strategic models*" (Dependency, Risk & Decision Support, 2000). The technique argues that risks associated with the durations and costs of the activities within a project cannot be seen in isolation from other risk aspects, and that if this dependency aspect is not properly considered it could lead to serious problems for the whole undertaking (Webb, 1997). With the methodology, one is invited to consider the project for the principal facets that have a bearing on the end goal, these facets are termed "paragons" and they must represent some desirable feature such as "adequate staffing" or "competent project manager". A relationship between these paragons should then be created and one must consider what could go wrong by modelling the chain of events that comes from a failure. This allows a dependency tree to be generated, such as that shown in Figure 19.

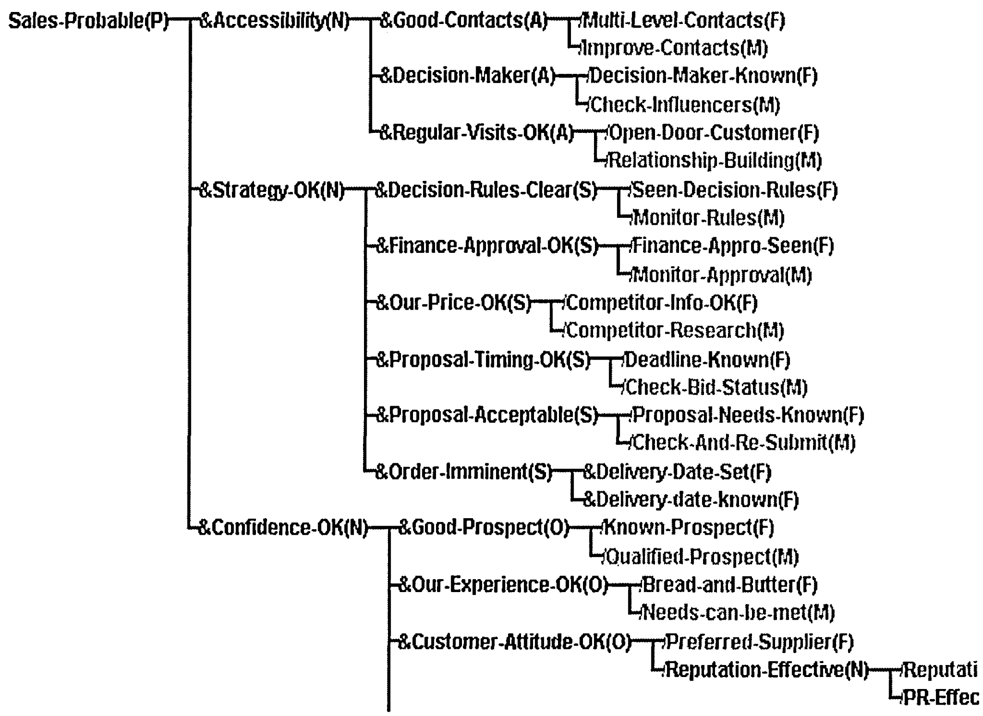


Figure 19 - DMT dependency tree
(Source: Dependency, Risk & Decision Support, 2000)

Cost information and measures of likelihood must be added to enable a sensitivity analysis to be performed and show which events are most likely to have an effect on the project (Webb, 1997). A "countering" strategy can be entered into the model and the effect on the end goals established, which then may be used to assess the cost-effectiveness of employing any particular contingency approach. Results are given in relative terms, in the sense that the effectiveness of a countering strategy is given as a percentage effect on the end goal for each percentage worsening of the situation. Thus, an economic analysis in absolute cost terms is not possible and it is not a modelling tool that will produce estimates in probabilistic terms. It is intended to show failure paths, their severity, and the relative effectiveness of countermeasures.

A second methodology is the "Lichtenberg Method" (also known as the "Successive Principle") which is used for the risk model building process of the "Futura" package (Lichtenberg, 2000). Data emerges during group sessions by "*focusing the attention on the uncertainties rather than the knows*", and information is captured and modelled live using the software (DA Futura International, 2000). The process is designed to generate a top-down view of the task in which the key risks are exposed, and detail is avoided, except where it has a beneficial effect on the analysis. A neutral "Process Facilitator" leads a selected multi-disciplinary "Analysis Group" which represents all important aspects of the task in question. Figure 20 shows the three stages of the methodology.

Stage 1 involves a qualitative assessment comprising agreement of a statement of purpose, a brainstorming session in which all risk issues in the project are noted, the grouping of similar issues into overall influences, and finally, describing the assumptions and possible scenarios for each influence (DA Futura International, 2000). The second stage, quantitative assessment, then follows, using "triple" estimates to reflect the uncertainty associated with specific items or activities. A small number of items in the calculation structure are considered first, and more items or activities are then added by breaking down the most uncertain aspects into more detail ("successive calculations"). The third stage is where action plans are agreed in order to control the key risks and the model is then updated at suitable intervals to reflect the current level of knowledge and progress on the project.

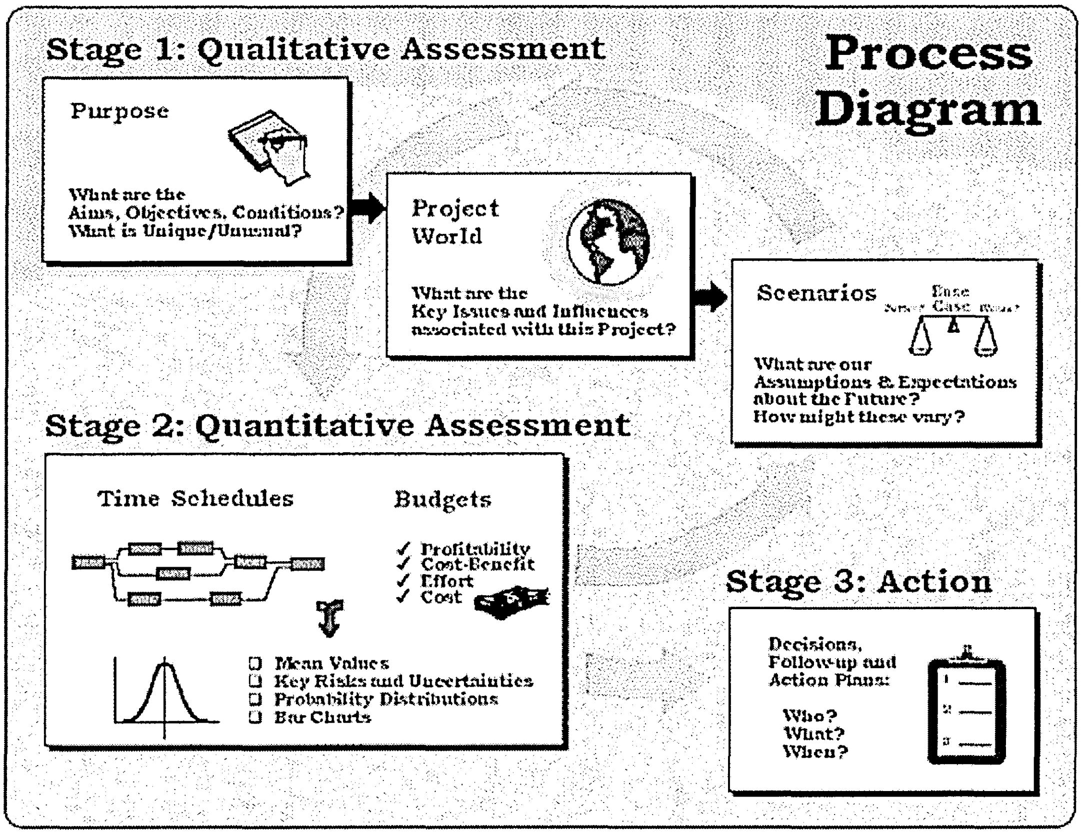


Figure 20 - The Futura process diagram
(Source: DA Futura International, 2000)

4.3.6 Expert systems

"RiskTools" system uses a technique called "Dynamic Risk Mapping" which is a four step methodology that facilitates the gathering and structuring of risk data, and the processing of that data to support and guide management decisions (Carma Limited, 2000). The method is fully supported by seven modules in the "RiskTools" software suite which automate the tasks:

1. "RiskScan" - Data gathering;
2. "RiskMap" - Data structuring;
3. "RiskBase" - Database viewing;
4. "RiskBase Builder" - Database building;
5. "RiskRate" - Data weighting;
6. "RiskReward" - Data analysis; and
7. "RiskReport" - Report generation.

Underlying technologies for "RiskTools" include:

- Knowledge-based systems - Information on an area of human expertise is stored explicitly in the form of rules, and a logical 'inference engine' uses the rules to reach conclusions;
- Monte Carlo simulation - This can be used when certain quantitative information is available about the relationships between factors in a risk management scenario;
- Dynamic networks - A mathematical modelling technique which can be used when only qualitative information is available about a risk management scenario. Neural network technology can then be used to draw qualitative inferences from a suitably constructed model of these data, which can combine the experience of several different people; and
- Intelligent spreadsheets - Advances in software engineering have resulted in the construction of specialised add-on packages which greatly enhance the already impressive capabilities of modern spreadsheet programs.

4.3.7 Multimedia

"Risk in Action" is a computer based simulation training software that puts the user in the role of project manager in charge of guiding a major department store chain into e-commerce (APM, 2000). It allows students to experience the process of identifying and prioritising risk, and choose the best plan to offset the impact and manage the project from start to finish.

4.3.8 Enterprise solutions

"Active Risk Manager" is a web-based "enterprise solution" designed to track both business and project risk across an organisation (Strategic Thought Limited, 2000). The provision of the facility for intranet, internet, and extranet publishing enables remote access of real-time risk information by team members, managers, or clients across a number of geographical sites. The system integrates with programme management software, and it can map any size of project or business breakdown structure, or a number of interrelated projects can be linked together. The system provides automatic warning notification of any risk using global parameters, related to levels of acceptable risk, that can be set through the use of "traffic lights". The tool claims to allow top management to "drill down" through the structure and find the root causes for high levels of risk without wasting time and resources.

A similar product is "Messa/Vista", which is a project environment built upon web technology that provides a "*distributed project infrastructure that helps people to communicate, collaborate and manage shared tasks in an integrated way*" (Benett, 1998). This is a high-end risk register offering with the facility to create custom interfaces to other applications, "*aiming to cover the virtual project waterfront by acting as a rich services environment*" (Benett, 1998).

4.4 Summary

This chapter has looked at the various risk management tools, techniques, and software that could be utilised in a model for risk management of building project budgets. The successful application of Monte Carlo simulation has been presented in various case studies during construction cost planning. However, a question remains as to how the technique would work at the initial budget stage, where an elemental breakdown of the estimate is not usually available. Concerns also remain because building cost exhibit few of the clean features required for the statistics, and there are debates over the use of probability distributions and the implications of correlation. Perhaps the problem could be better solved by undertaking knowledge elicitation from a range of experts, rather than trying to interpret historical project information.

Sensitivity analysis provides a useful way of comparing the effects of changes against the total estimate, and scenario analysis compares the alternative options of a project by identifying the key variables. The expected monetary value approach takes the testing of scenarios one stage further by considering the probability of each option, and a severity/likelihood matrix can be used to help focus on where the risks lie. Decision trees provide another graphical means of bringing together the information needed for considering alternatives by showing the possible courses of action available. However, the limitation with each of these technique resolve around the value of the probability itself, which is usually arrived at subjectively. Multiple Estimating using Risk Analysis (MERA) has been successfully used to reduce exaggerated contingency allowances.

However, MERA's mechanistic approach does not promote creative thought or encourage the project team to respond to the results.

More qualitative, than quantitative, techniques include prompts, checklists, brainstorming, and risk registers. Checklists tend to identify the usual, whereas prompt lists can be used to stimulate specific risk identification and ensure that a broad range of categories of project risk are examined. Prompts can be a useful focus of attention during brainstorming, which can be done individually, but a workshop environment gives the opportunity to experiment with different viewpoints. A risk register is the most common administrative device for keeping track of risks.

Commercial risk management software is available in the form of straightforward Monte Carlo simulation, decision tree modelling, database risk registers, programme management, to more sophisticated high-end offerings using unique methodologies, artificial intelligence, and web-based technologies. Before selection for the conceptual model framework, work is needed to determine the performance of such tools, techniques, and software, for use when preparing initial budgets for building construction projects. This will be the focus of the industry investigations in the next chapter.

CHAPTER 5 - APPLICATION OF RISK MANAGEMENT WHEN ESTIMATING INITIAL BUDGETS FOR BUILDING PROJECTS

5.1 Introduction

Attempts have been made to meet the challenge of cost certainty within the Construction Industry through various risk management tools and techniques that have been developed (see Chapter 4). Fortune and Lees (1996) surveyed the use of early cost advice techniques for construction cost forecasting in the UK, and, within their conclusions, stated that the research did not fully identify all the risk analysis models used by practitioners. They recommended that future work in this area should address the establishment and evaluation of risk analysis strategic cost advice models currently used by practitioners. Further to this, Edwards and Bowen (1998a) have found that, generally, construction professionals lack an adequate understanding of the rationale and formal processes of project decision-making under risk (see Chapter 2). They also highlighted that the identification of risks deserves more investigation, and, therefore, recommend that categories of risks should be explored in terms of nature of occurrence.

In filling these recognised gaps in literature, the object of this chapter is to investigate the awareness, use, and performance of risk management tools and techniques by quantity surveyors when estimating initial budgets for building projects. The chapter will also examine the base methods used for estimating, and will try to determine the nature of cost overruns occurring due to the problem of change (see Chapter 1). It is anticipated that the findings from this work will be consolidated with the review of literature and software, and used to develop a conceptual risk management model, to be used by quantity surveyors, during the establishment of an initial budget for a building construction project.

5.2 Methodology for industrial investigation

5.2.1 Pilot investigation

An initial review of risk management literature was carried out, and the main conclusions from this was that risk in building construction is a very broad subject, relevant to every process and each person involved. Although the literature was a useful starting point, it was difficult to focus research efforts, so, in an attempt to narrow the definition of the study, a range of key Construction Industry personnel were identified from media publications (e.g. Building Magazine and Construction News) for informal discussions. A list of fifty professionals was created, and included clients, developers, project managers, engineers, contractors, quantity surveyors, and architects.

Each professional was then questioned by telephone, in a semi-structure manner, on risk in the building design and construction process. This covered the topics of procurement, types of building, building elements, time, cost, quality, and also about the awareness and use of risk management tools and techniques. This then helped produce a questionnaire format (see Appendix "C"), used as a pilot postal investigation. The form was designed with "open" style questions, to:

- permit the respondent to formulate their own style of responses;
- permit greater freedom of expression;
- create no bias because of limited range of responses; and
- allow respondent to qualify their response.

Wilson and McClean, 1994.

The questionnaire was mailed in April 1995 to the same select sample used for telephone discussions. Following the results of this pilot investigation, it was necessary then to review further literature, before ultimately focusing the industrial research efforts by carrying out a larger survey. This time the focus was on risk management tools and techniques used by quantity surveyors when estimating initial budgets for building projects.

5.2.2 Questionnaire survey

The experience gained from the open style pilot questionnaire assisted with the development of a more "closed" format response approach, meaning that less time was required for delegates to complete questionnaires because there was multiple choice prompting of answers to questions. This also meant it would be easier to analyse the results of an anticipated larger sample response size. The questionnaire designed consisted of six main questions and, with the exception of the third question, a closed style format was maintained, where the respondents were asked to answer by choosing between a number of alternatives (see Appendix "D"). However, space was still provided for respondents to formulate there own type of response or qualify their answers.

Twenty-one risk management tools and techniques were identified from the pilot investigation and literature review (particularly from Flanagan and Norman (1993) and Raftery (1994)). It was, however, necessary to exclude some methods suggested by the pilot group of respondents, as the methods were considered to be management techniques in their own right (e.g. "quality systems" and "value engineering"). Space was still left on the questionnaire for respondents to add other tools and techniques not listed. Much thought was given to the structure and sequence of the questions and to the information requirements for final coding of the results, with the listing of tools and techniques starting with those thought to be most familiar to the professionals (e.g. professional judgement and intuition, contingency % allowance).

Following a successful pre-test of the new questionnaire with a pilot survey of respondents in Sheffield, the method used was to mail a questionnaire to professional quantity surveying practices accompanied by a cover letter (see Appendix "D"). The latter introduced the subject, indicated the time to complete the questionnaire, offered confidentiality of identity (no personal details were asked for), and, finally, to motivate the respondents to complete and return the form, offered feedback on the conclusions made from the research, and a pre-paid return envelope was enclosed. Practices were selected from the "Chartered Surveyors Geographical Directory" published by the Royal Institution of Chartered Surveyors (RICS, 1995), which is divided into ten UK regions. The largest town in each region was selected and the questionnaire was mailed in May 1996 to a total of five hundred practices. Delegates were asked to reply within three weeks of receipt, after which the answers were entered into a computer spreadsheet, followed by logical cross-checking. References to the method discussed are described by Ashworth (1999), Descombe (1993), Fortune and Lees (1994), Heather and Stone (1991), and Wilson and McClean (1994).

5.2.3 Interviews

The research methodological approach for validation and qualification of the survey results involved knowledge acquisition to supplement the primary data collection from the postal questionnaire. This second tier of information collection involved conducting detailed interviews (as discussed by Stephenson and Oxley (1985) and Ashworth (1999)) with a focus group of quantity surveying practices. Twenty firms were approached in the Sheffield area. The practices were initially contacted by telephone, and a partner or director of the practice was briefly introduced to the research project. The possibility of a meeting in three to four weeks' time was discussed, and a day and time agreed. The details were confirmed in writing and confidentiality of identity of discussions was offered. Two days before each meeting, an open style list of questions for discussion were faxed to the interviewees (see Appendix "E"). As contact time was anticipated to be limited to around forty-five minutes, this approach was hoped to give the interviewees time for prior consideration of their answers, and hopefully to create a more relaxed first meeting.

Two weeks in advance of the bulk of interviews, two pilot-meeting were carried out to ensure the efficacy of the questionnaire. The result was that only minor modifications were needed for the final approach used. Meetings took place in March 1997 and, following a five to ten minute introduction with a "PowerPoint" presentation, lasted between twenty-five minutes and two hours. By the end of the sample, a similar pattern of answers had emerged, there were only a small number of exceptions to the norm, thus giving confidence in the general findings reported hereafter. Meetings were followed-up with courtesy letters, which included a summary of the main findings from the research.

5.3 Pilot investigation findings

From the fifty pilot questionnaires mailed out, a twenty per cent success response rate was achieved. However, some of the questionnaires were returned from prominent industry sources saying that the form was too complicated or too general. This indicated the need for a finer research definition, so the varied findings of this initial investigation were considered together with the literature review, and brainstorming sessions were used to decide on a narrow focus for further research. Generally, what was clear at this stage, was that systematic risk management was still a fairly "grey" subject to most, and thus the research could have taken one of many possible directions. The key findings from the pilot investigation are now discussed.

First, delegates were asked what aspects of the design and construction process they perceive as being the main areas of risk (Pilot Questionnaire, Section "B" - see Appendix "C"). However, similar to the literature review, the answers were very broad in nature (possibly because of the range of different professionals and small sample size of ten). It was, therefore, difficult to classify the results or to reach any consistent conclusions. The questionnaire also sought to find out what techniques were being used for risk management (Section "C"), and the perceptions of risk management ranged from management methods such as quality management, value engineering, and team working, to Monte Carlo simulation, sensitivity analysis, and professional judgement. The results showed that the general awareness of other risk management tools and techniques appeared to be low, when compared with the availability of methods in published text. There also seemed to be some resistance to using quantitative risk analysis tools, with one respondent stating that it is their company policy not to use statistical analysis, and another saying that they avoid computer based exercises because they are "*too abstract and depend on all the assumptions being made when inputting the data*". The general conclusion was that a more "hands-on" approach is preferred, in which every member of the project team takes part and takes responsibility, "*rather than rely on some Monte Carlo external expert*".

The next question prompted professionals to propose possible industrial areas which may be worthy of research and development. The following possible improvements to risk management practice were suggested:

i. *"Development of techniques that can be used at the earliest opportunity in the life of design development of construction concept phase, rather than used as a check when things may appear to be going wrong;*
ii. *Making risk management a routine part of project appraisal, rather than treating it as a "bolt-on" optional extra;*
iii. *Acknowledging the vital importance of a full definition of what is to be built, before it is procured and commenced on site;*
iv. *Better awareness of the possible range of cost outcomes a building project might take;*
v. *Striking a balance between providing information that is detailed and accurate, with providing a risk management approach that is meaningful to the project team and involves them in the process;*
vi. *Techniques to review multiple project options;*
vii. *An easy way of using Monte Carlo simulation;*
viii. *Awareness in the field, such as "how to" guides.*
ix. *Risk analysis tends to be too often concentrated on time and money without taking into account the quality of the product;*
x. *Techniques to control the risk of "fitness for purpose"; and*
xi. *How contractors assess the risk premium in "Design and Build" procurement."*

Concerning procurement routes (Section "D"), contractual arrangements apportion the risk between the client and contractors, and the risk percentage remains the same in all forms of contract, it is merely a case of with whom the greatest proportion of the project risk is allocated. Procurement routes each have their strengths and weaknesses, but the important thing is to identify the procurement route which is most appropriate to the project, depending on the clients' objectives. Clients must, therefore, be aware of the risks in each option when deciding which route to take. Traditional procurement theoretically works by allocating most of the design risk to the client, and most of the construction risk to the contractor, but, in practice "*so much is abused that risk is hardly recognised let alone managed*". It is claimed that "*a traditional contract provides a balance of risk between employers and contractor, but risk which the contractor can sometimes exploit*".

In "Design and Build" procurement systems the contractor is paid to assume greater risk and this is reflected in the mark-up, with contractors usually "*hiding their risk premium in elements or design sums*". One consultant claimed that Design and Build works by "*disposing all design and construction risk on to one party but at the risk of getting the product wrong*". A contractor disagreed with this by claiming "*It is the most effective form of contract because the contractor has full responsibility and overall control of both disciplines, and, in addition, more flexibility is available to the contractor in remedying unforeseen events*". With Design and Build there should be very little risk of additional costs from the client's point of view, but, again, another consultant argued that, although it is often regarded as a low risk form of contract:

> "*Design and Build can in fact be the highest risk form of contract there is with the danger that the client will secure, on time and on budget, precisely the building he does not need. Putting it in over simplified terms, the more one*

controls the risk of time and money by contracting it out, the more one looses control of the product".

Design and Build can be very good for time, cost, and quality certainty, but only if the time is spent early on deciding "*exactly what is required*", and the greater the tendency towards single point responsibility and less fragmentation of the building process, the lower the overall risk of disputes. With Design and Build the contractor bears more risk, whereas with "Management Contracting", the client does. If organised and administered properly they should both cope well, however, "*the more fast track they become the more management techniques are needed*". Construction Management works by the client taking control of the risk position at the trade contract level. One client uses "Guaranteed Maximum Price" contracts and transfers the financial risk to contractor, and therefore claims to "*avoid risk*".

Risk may be associated with funding, location, and the nature of the client, but may have nothing to do with the type of construction work (Section "E"). There is a stronger relationship between lack of project definition and increased risk exposure. Nevertheless, refurbishment and repairs are generally thought to be the type of construction that carries the greatest risk, especially where work is phased around client's employees and their continuous trading. They add to all the risk of design and construction in new-build, the risk of uncertainty in the base building, and the older the building usually the less record information, meaning many unknowns, such as asbestos and dry rot. These types of risks are "*unforeseeable rather than unforeseen*", and sometimes it is not possible to know the full scope of works until the contractor starts taking the existing building apart.

One main contractor said that there is considered to be less cost risk in refurbishment as "*money can often be made from variations that generally occur throughout the construction period, but demolition can be high risk from a safety point of view*". Generally, new-build construction projects probably have the least risk, providing effective controls are in place and maintained, but "*work underground can sometimes be very unpredictable*".

When referring to building type (Section "F"), according to one consultant this is considered irrelevant to the riskiness of a project:

> "*For example, a green field site using low tech, familiar and standard products for a non sophisticated building, might still turn out to be a very risky project, if for example, the client briefing process is inadequate. Equally, a highly complex, heavily constrained project, developed within an infill and contaminated site might proceed with minimal risk if proper planning investigation and appropriate selection of resources is achieved. Further to this, a relatively simple project in terms of the internal risk profile may be dramatically influenced by an externality, hence, for any of our risk management systems we need to develop key questions concerning the impact of such externalises (e.g. change of central government, global economic events, even the weather)*".

A contractor agreed that risk is not related to building type, but rather to "*details received at tender stage, the site conditions, or proximity to adjacent buildings*".

Over half of respondents said that mechanical and electrical services are the building elements that provide the greatest risk (Section "G"), this is because of the:

- *"tendency to be defined at a later stage, sometimes leaving it to subcontractors to develop;*
- *mismatch in the way they are designed and procured by contrast with the way the rest of the building is designed and procured;*
- *general weakness of services consultants, leading to design failings;*
- *communication routes for parties, which are often poor and ill defined; and*
- *reliance on specialists, who sometimes take advantage of their specialist knowledge at the expense of others".*

Other elements considered to be risky include "*anything involving partial knowledge of the unknown (e.g. foundations, tunnelling, excavations)*". Substructure problems include unforeseen ground conditions and adverse whether, and, if the setting-out is not accurate, the remainder of the building could be affected. Also, risky elements are those involving novelty or innovation (e.g. curtain walling, new cladding systems, structural glazed facades), and, furthermore, scaffolding can be difficult to estimate because main contractors must foresee all requirements at tender stage in order that subcontract packages do not overrun budget.

5.4 Postal questionnaire survey

5.4.1 Response rate

Of the five-hundred questionnaires mailed out, one-hundred and twenty-five were returned completed within the stipulated time, giving a response rate of 25%. This was considered to be an acceptable sample size with no need for sending reminders. Figure

21 shows the percentage of respondents from each of the regions making up the total UK sample. The sample excludes 2% of replies which failed due to practices merging or closing. Delegates were asked for information about the size of their firm in terms of number of employees (Postal Questionnaire, Question "Q1" - see Appendix "D"). For observation reasons, the practices who responded have been categorised into large (over ten Chartered Quantity Surveyors (CQSs)), medium (six to ten CQSs), small (two to five CQSs), or sole (one CQS), as shown in Figure 22. In comparison with a recent league table of the top one-hundred quantity surveying firms, the top sixty-six would be classified as large, from sixty-seven to seventy-ninth would be medium, and the remainder in the table are small (Osborne, 2000). Therefore, Figures 21 and 22 confirm that a reasonably representative sample of responses was obtained. However, it should be noted that it is not the intention of this research to draw comparisons between the different practice sizes or regions.

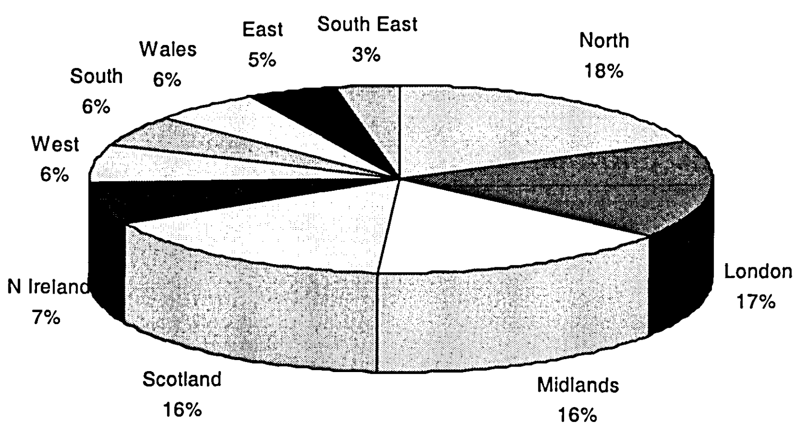


Figure 21 - Regional distribution of survey respondents

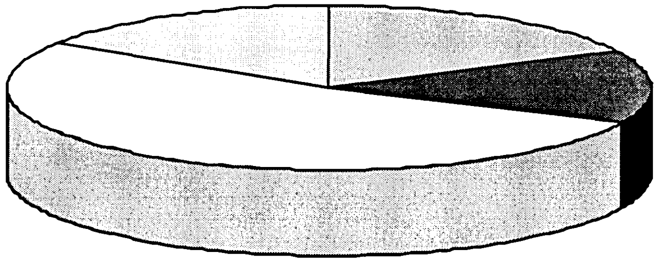


Figure 22 - Size of survey respondents practices

5.4.2 Budget estimating base methods

The first key results from the survey refer to the "base method" used when estimating initial budgets for building projects (Question "Q2"), and the most commonly used method is "cost per square metre (m^2) floor area", which is used by 92%, nearly all of the respondents. Also highly used, by about two thirds, is the "functional unit method" (e.g. cost per bed, per seat, per vehicle). In addition to this, over a third of respondents use the "approximate quantities" method. From the questionnaire layout it was also possible to calculate that 68% use the "cost per m^2 floor area" method most often, and that 17% using "approximate quantities" most often, with only 1% using the "functional unit method" most often. Together with the other three methods shown in Figure 23 (e.g. "Elsie", "elemental cost planning", "own system"), a few respondents also use other methods such as "BCIS", "cost per cube", "previous similar internal projects", and "inspiration".

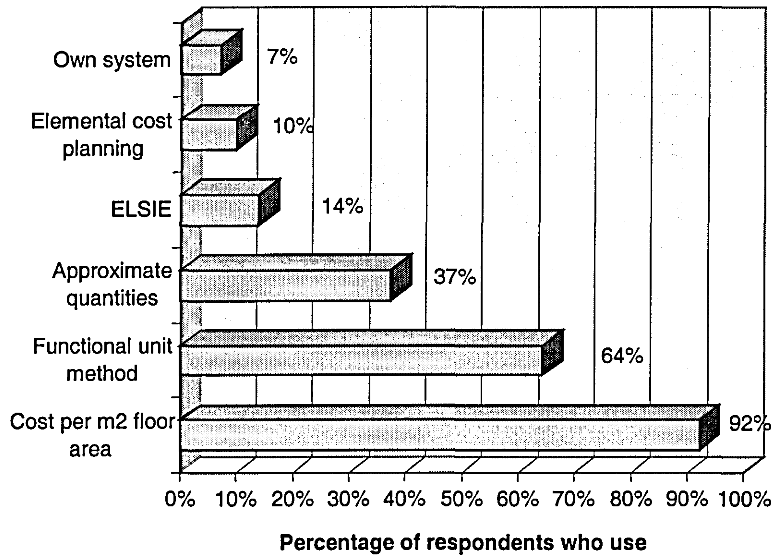


Figure 23 - Base methods used for estimating initial budgets

5.4.3 Causes of cost overruns

Concerning the perceived main causes for making building projects finish over budget, an open style question was put to surveyors asking them to list up to five main reasons why they think building project costs sometimes exceed the initial budget estimate (Question "Q3"). From the 114 successful questionnaires (this section was not included in the pilot study of Sheffield), 341 reasons for cost overruns were abstracted, making an average of approximately three answers per delegate. The answers were entered into a database, and coded to three levels, using the keywords in the replies given. The codes were then sorted, and categories of causes for budget cost overruns were then established. The analysis of the results defined fifteen categories of reasons. These are ranked in Table 1, together with descriptive examples and percentage breakdowns. The four highest scoring causes are "changes to project", "incomplete design", "lack of

Rank	Reason	Number of responses	Examples (percentage of responses in category)
1	Changes to project	50	client driven change (76%); design variations (24%).
2	Incomplete design	36	incomplete design at tender (38%); generally too much design development (33%); initial design inadequate or lacks detail (28%).
3	Lack of information	32	general lack of information (44%); at tender(38%); at brief (19%).
4	Poor quality brief	31	lack of detail and definition, badly developed, incomplete, or incorrect (84%); client not know what they want (16%).
5	Budget estimate preparation	29	poor cost advice (31%); inadequate contingency allowance or assessment of risks (31%); base method used for calculation (21%); stubborn client attitude (17%).
6	Consultants services	26	architects/designers attitude, input, whims, understanding of cost and value (46%); M&E estimates (25%); inadequate cost control (21%); designers awareness as to areas of cost risk and subsequent risk management (7%).
7	Poor project management	24	design management (21%); contract and site management (17%); control (13%); communication routes (13%); sub contractor and supplier interface and management (8%); leadership (8%); lack of value management (8%); approach (4%); decision-making (4%).
=8	Lack of time	19	unrealistic design development periods (47%); delays by employer and client driven speed (32%); no time to carry out realistic budgets or cost control (11%); unrealistic construction periods (11%).
=8	Unforeseen works and site conditions	19	ground works (53%); site conditions, constraints, restrictions, Murphy's Law - basically things go wrong (37%); dry rot or asbestos in refurbishment's (11%).
10	Poor preparation and planning	15	generally (40%); pre tender (33%); inadequate surveys and investigation of existing site conditions (27%).
11	Contractor claims	14	aggressive or claims conscious contractors, contractors risk pressure, late information release (100%).
=12	Commercial pressures	13	fee competition (46%); tight bidding conditions (31%); confrontational approach of industry (15%); corner cutting clients (8%).
=12	Incompetent staff	13	inexperience, too optimistic, intuition, knowledge, qualifications, team, personal or practical skills(70%); consultants (23%), contractor (7%).
14	Wrong procurement route	10	contract used, inappropriate allocation of risk in contract document (100%).
15	External factors	8	changes in pricing conditions, indices, inflation, statutory factors, market trends (100%).

Table 1 - Reasons for causing building projects to finish over budget

information", and "poor quality brief", with 50, 36, 32, and 31 answers respectively. From this table it is possible to observe that quantity surveyors believes that the client is often to blame for cost overruns, and, in the highest category, "changes to the project", the client accounts for 76% of examples.

5.4.4 Awareness and use of tools, techniques, and software

The next section of results concerns the awareness of risk management tools and techniques (Question "Q4"). Table 2 shows the twenty-one tools and techniques (t&t or T&t) that were identified in the background work to the survey, together with the percentage of respondents who have heard of them. "Contingency percentage allowance" is the only t&t to have been heard of by all respondents, although 99% have heard of "professional judgement and intuition". T&t that are also well known include "prompts/checklists", which was heard of by 89% (possibly high because of ISO 9000 quality systems), "brainstorming", heard of by 82% (possibly high because it can form part of "value engineering"), and "Elsie", which is an expert system made specifically for the quantity surveyor, heard of by 73%.

With reference to the use of risk management tools and techniques, Table 2 also shows the ones which most respondents use are "professional judgement and intuition" and "contingency % allowance", used by nearly all respondents. Of the other t&t that are relatively well known, "prompt/checklists" and "brainstorming" are both also well used and remain third and fourth in this "B" ranking, whereas "Elsie" fell sharply from 5th to 10th with only 14% of respondents using it. Over a third of those surveyed use "subjective probability" and "sensitivity analysis", and, whilst "MERA" was low at 14th in the awareness ranking, it jumped to 8th place in the use ranking. However, this is

Tool / technique	Awareness		Use			
	Rank A	Percentage who have heard of	Rank B	Percentage who use	Rank C	Use expressed as a percentage of those who have heard of
Contingency % allowance	1	100	2	98	2	98
Professional judgement and intuition	2	99	1	99	1	100
Prompts / checklists	3	89	3	79	3	89
Brainstorming	4	82	4	59	=4	72
ELSIE	5	73	=10	14	14	19
Sensitivity analysis	6	61	6	34	7	56
Subjective probability	7	54	5	37	6	69
Monte carlo simulation	8	52	=8	18	10	35
Risk-adjusted discount rate	9	46	7	22	8	48
Decision tree	=10	42	=12	13	12	31
Decision matrix	=10	42	=10	14	11	34
Expected monetary value	12	33	=12	13	9	39
Algorithms	13	26	14	6	13	23
MERA	14	25	=8	18	=4	72
Stochastic decision tree	15	18	15	3	15	17
Means-end chain	16	17	=16	2	18	12
Utility theory	17	15	=16	2	17	13
Bayesian theory	18	13	=16	2	16	15
Portfolio theory	19	11	=19	0	=19	0
Stochastic dominance	=20	9	=19	0	=19	0
Delphi peer group	=20	9	=19	0	=19	0

Table 2 - Awareness and use of risk management tools and techniques

still a low usage level with only 18% of respondents who use it. Never used are "portfolio theory", "stochastic dominance", and "Delphi peer group".

Table 2 also shows the use expressed as a percentage of those that have heard of t&t. "Professional judgement & intuition" is the only one to be used by every respondent who has heard of it, although "contingency % allowance" and "prompts/checklists" both came near with 98% and 89% respectively. Most respondents who have heard of "brainstorming", "MERA", and "subjective probability" also use these t&t, and around half of those that have heard of "sensitivity analysis" and "risk adjusted discount rate" use these t&t as well. Around a third use "expected monetary value", "Monte Carlo simulation", "decision matrix", and "decision trees", whilst "Elsie's" decline in the use rankings remained low at 14th place in this "C" ranking, being used by only 19% of those that have heard of it.

The questionnaire also asked those that are aware of t&t if they always use them, just sometimes, or never at all (Question "Q4"), and these results are shown in Figure 24. "Professional judgement and intuition", "contingency % allowance", and "prompts/checklists" are used by most respondents all of the time, i.e. 94%, 81%, and 73% respectively. Besides these three t&t, there is only one other which is always used by around a third of respondents who have heard of it, this being "brainstorming", by 32%, and this is then followed by "subjective probability", which is always used by a quarter of those that have heard of it. In addition to the three t&t never used, four others are only used sometimes, these being "stochastic decision tree", "Bayesian theory", "means-end chain", and "utility theory".

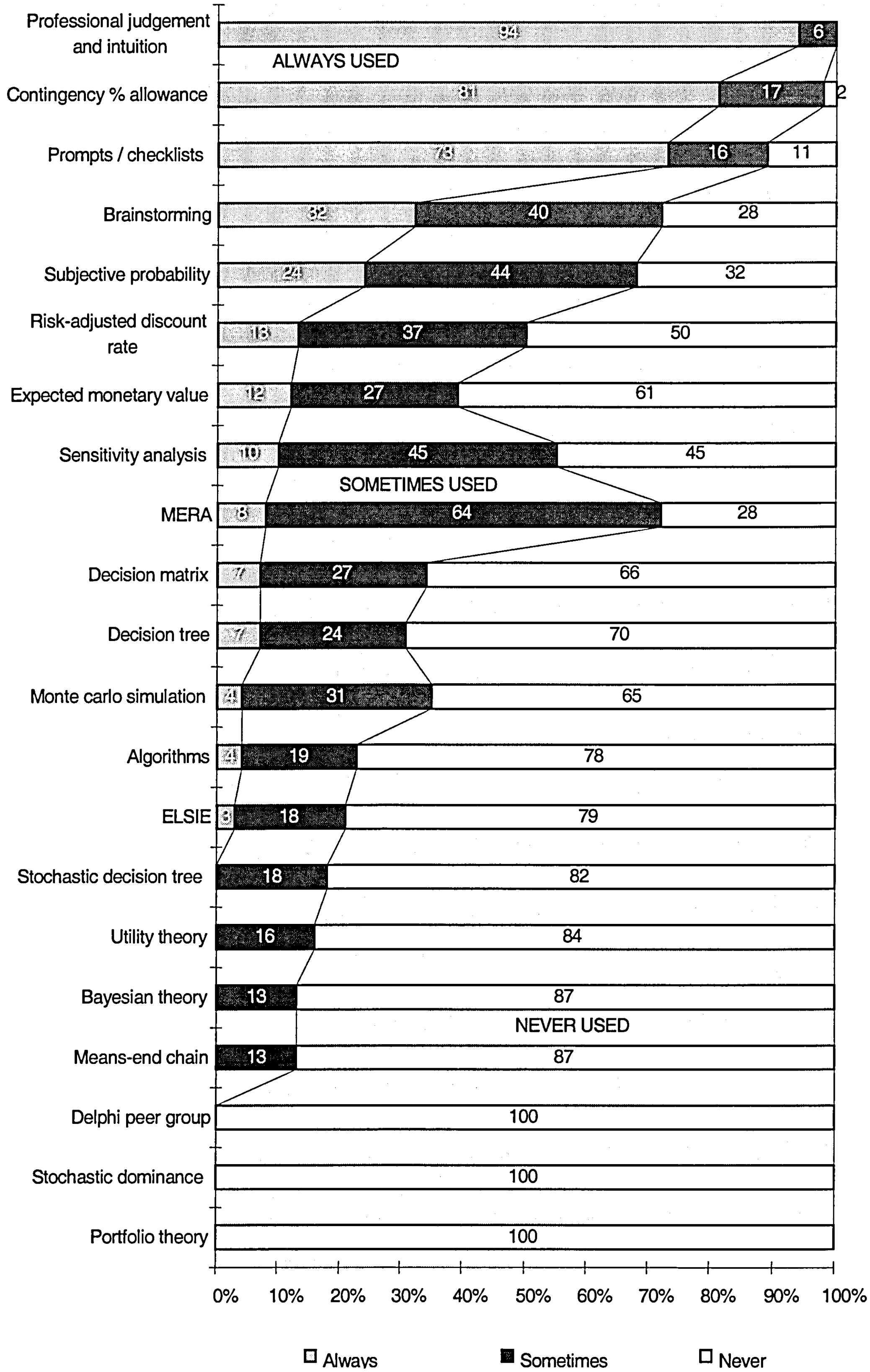


Figure 24 - Use of risk management tools and techniques

The questionnaire also asked delegates about their awareness and use of other risk management tools and techniques not identified on the questionnaire, and about bespoke practice system which are used. Only nine respondents listed other t&t they have heard of, these included "pricing books", "BCIS", "value engineering", "HAZOP", and "HAZAN". Twenty-four (19%) of the respondents have their own system, which included "consultation", "certainty analysis", "quantities check", "training", "measured estimate", "+/- from mean (ranged estimate)", with "experience" and "in-house database" / "historical records" proving to be the most common of these. One firm had an in-house dedicated risk management section.

Concerning software used to support risk management tools and techniques, "spreadsheets" and "in-house" products are the most commonly used software. Others included "@Risk", "Crystal Ball", and "ProAct", but really the size and range of answers from the sample is insufficient to draw any strong observations. Table 3 summarises the findings.

5.4.5 Performance of tools and techniques

The questionnaire attempted to benchmark the performance of risk management tools and techniques (Question "Q5"), and, in this section, those surveyed were asked whether t&t performed "excellent", "good", "fair", or "poor". Only two t&t are thought to perform excellent by a quarter or more of respondents who knew how they performed, "professional judgement and intuition" by 29%, and "prompts / checklists" by 25%. Only three others are thought to perform excellent by more than 5% of respondents, these being "brainstorming" by 18%, "contingency % allowance" by 14%, and "MERA" by 9%. In the next category, good, four t&t are thought to be good by over half of

Software	Respondents used by	Tool or technique used for
Spreadsheet	7	Contingency % allowance; Subjective probability; Sensitivity analysis; MERA; and Risk-adjusted discount rate.
In-house product	7	As above plus: Professional judgement and intuition; and Decision matrix.
@RISK	3	Subjective probability; Monte Carlo Simulation; and Algorithms.
Crystal ball	2	Monte Carlo simulation.
ProAct	1	Algorithms
Everest	1	Contingency % allowance
Root mean squared	1	MERA

Table 3 - Use of risk management software

those who know how they perform, these being "professional judgement and intuition" by 63%, "contingency % allowance" by 55%, "prompts / checklists" by 53%, and "brainstorming" by 51%. Over a quarter also thought seven other t&t performed good, these being "MERA" by 46%, "sensitivity analysis" by 42%, "subjective probability" by 41%, "expected monetary value" by 35%, "risk adjusted discount rate" by 33%, "Elsie" by 31%, and "decision trees" by 29%. The results are shown in Figure 25.

Most t&t fell into the fair performance category, and three are thought to perform fair by more than three-quarters of those that know how they perform, these being "Delphi peer group" by 82%, "Bayesian theory" by 81%, and "utility theory" by 77%. Between 40% and 60% also thought thirteen other t&t perform fair, but poor performing t&t include

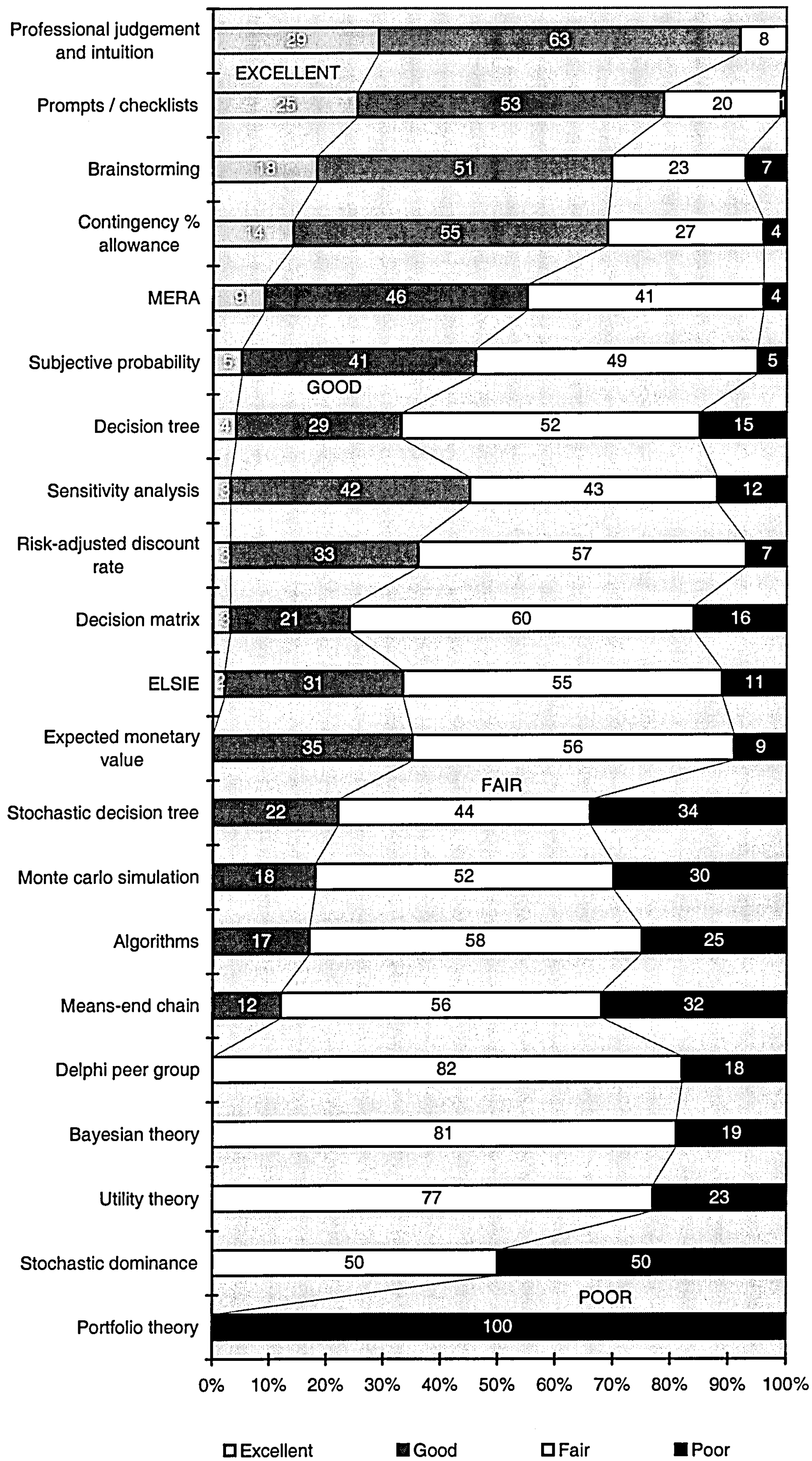


Figure 25 - Performance of risk management tools and techniques

"portfolio theory", which is thought to perform poor by all those that know how it performs (note this has the lowest sample size of only seven). Another t&t thought to be significantly a poor performer is "stochastic dominance", thought so by half of those that know how it performs - this also carries the second lowest sample size of eighteen. Around a third think "means-end chain", "stochastic decision tree", and "Monte Carlo simulation" perform poor, and about a quarter think "algorithms" and "utility theory" do.

Of those that have heard of t&t, some respondents said they "don't know" how they performed. Some also left this section of the questionnaire blank, the reason for this is possibly because they don't know (or maybe because the questionnaire was unclear). Most respondents (92%) either don't know or did not state how "portfolio theory" performs, and this was followed closely by "stochastic dominance" with 82%. Also about two thirds of respondents don't know or did not state how four other t&t performed, including "Delphi peer group", "Bayesian theory", "algorithms", and "stochastic decision trees". Around a half of those surveyed don't know or did not state about six others, these being "means-end chain", "Elsie", and "utility theory", "Monte Carlo simulation", "decision trees", and "expected monetary value", and around a third don't know or did not state about "decision matrix", "risk-adjusted discount rate", "sensitivity analysis", "MERA" , and "subjective probability".

5.4.6 Reasons for non-use of tools and techniques

Finally, the main reason for not using tools and techniques (Question "Q6") is due to "lack of understanding". Also, "lack of clear benefit" and "reliability/accuracy" are two other main reasons for non-use. In summary, the reasons for non-use are "lack of understanding", by two thirds or more of responses for "risk-adjusted discount rate", "MERA", "subjective probability", "stochastic decision tree", and "Bayesian theory". "Lack of clear benefit" is the reason by 32% for "decision matrix", 31% for "utility theory", 23% for "algorithms", 22% for "stochastic decision tree", "decision tree", and "means-end chain", 21% for "Bayesian theory" and "portfolio theory". "Reliability/accuracy", is the reason by a quarter for "brainstorming" and "prompts and checklists", 22% for "means-end chain", and 18% for "stochastic dominance". "Cost", reason by 19% for "Elsie", 14% for "Delphi peer group", and 11% for "MERA", and "lack of IT facilities", reason by 14% for "Elsie", 9% for "sensitivity analysis", and 8% for "Monte Carlo simulation". Other reasons included "not client driven", "not suitable", "too theoretical", "lack of clear benefit", or "timescale prohibits learning".

A summary sheet showing the full results for each tool and technique is included in Appendix "F", which also explains when respondents only sometimes use t&t.

5.5 Validation and qualification of the survey results

5.5.1 Focus group

Of the twenty firms identified in the Sheffield area, it was possible to arrange a mutually convenient meeting time with eleven. Therefore, there were nine withdrawals from the original twenty contacted by telephone. This section presents the results of the interviews with quantity surveyors who were questioned (see Appendix "E") about how they prepare initial budget estimates and allow for the risks inherent in their figures, with particular emphasis on the main causes for cost overruns identified in the postal questionnaire survey. The aim of this section, therefore, is to develop the body of survey results by questioning more about how quantity surveyors estimate budgets, and identify, analyses, and advise clients on the management of the cost risk element of an initial estimates.

5.5.2 Budget estimate preparation

The first objective of this study was to examine how the quantity surveyor prepares a budget estimate (Interview Question, Question One - see Appendix "E"). The questions put to the surveyors were targeted to the initial budget preparation. The survey findings showed that the most commonly used method for determining the initial budget for a building project is the calculation of a "cost per square metre" of floor area. This was confirmed in this study, as all eleven quantity surveying practices used this commonly accepted method. The preparation of an initial budget using the "cost per square metre method" is computed as follows:

Measurement of gross floor area	x	Determination of cost rate per square metre	=	Budget estimate

The first task for the quantity surveyor is to measure the gross floor area (GFA) for the building. The quantities are measured from the drawings of floor plans, with dimensions taken between the internal faces of the external walls. It is also necessary to measure the external works surrounding the building, such as paving, landscaping and access roads, as they can account for a significant proportion of the total construction costs. In some instances, no drawings will have been prepared so the quantities must be determined by considering the clients' anticipated needs, through liaison with designers and specialists, allowing for planning restriction and building regulation, and, preferably, notes and photographs from a site visit.

This general process may differ when estimating for refurbishment, repairs, and alteration works, where, to achieve accuracy, it is necessary to carry out a more detailed investigation of the site. Works will involve existing buildings and facilities which could prove hazardous to the proposals, so sufficient information must normally be gathered to allow "approximate quantities" to be determined. Four of the practices interviewed said that, through experience, they could not always rely on a "cost per square metre" estimate for new-build projects either, and preferred to determine an estimate using "approximate quantities". The principal difficulty of using this method arises when few drawings were available. In addition, when drawings could be made available it was recognised that time was always a premium. All of the interviewees commented that on many projects they were expected to produce the initial budget for a proposed development based solely on verbal description of client needs on the telephone. Moreover, it was stated that the clients frequently specified both the available budget and timeframe and expected the surveyor to work the elemental breakdown for the project around these parameters.

The second stage of the process of producing a "cost per square metre" estimate often proves to be more difficult, as it involves determining a cost rate to be applied to the GFA. Interviewees agreed that, in practice, the process relies heavily upon the judgement of the individual, based predominantly on experience of similar projects and an expectation of what is likely to be a "winning bid" for those contractors who might tender for the work. The process of producing a "cost per square metre" estimate can be expected to take as little as half an hour, but can also take up to a number of days, depending on the size and complexity of the project, or the time made available by the client. Different rates will normally be determined for preliminaries, substructure, superstructure, external works, and contingencies. From the interviews, it was also possible to determine the principal "cost drivers" used when establishing budget costs, as shown in Table 4.

Information available	- drawings	Location	- market conditions
	- client brief		- indices, trends
	- photographs		
		Consultations	- colleagues
Knowledge of team	- client		- design team
	- architect		- contractors
	- engineers		
	- contractors	Nature of projects	- size
	- specialists		- shape
			- complexity
Specification	- building elements (e.g. M&E services, finishes, frame)		- storeys
		Site conditions	- uncharted services
	- quality level (e.g. high, medium, low)		- mining (bell pits)
			- unregistered tipping
	- external works (e.g. paving, access roads, services)		- existing foundations
			- surcharge of disposal of certain materials
			- foundations
Cost analyses	- previous similar schemes		- archaeological history
			- existing buildings
	- update using BCIS indices		- ground investigation
			- contamination
	- in house database		- history of site access
	- outturn cost/bid figures		- awkwardness of site
		Resources	- materials, plant, labour prices
Judgement	- experience		
	- intuition		
	- gut feeling	Contingency	- client
			- design development
Programme	- start time		- surveyor's "bunse"
	- time span		
	- intensity (e.g. speed)		
	- procurement route		
	- contract form		

Table 4 - Principal cost drivers when budget estimating

It was said that the greatest difficulties of producing a budget estimate occur when working with clients or designers who the surveyor has not worked with before. To allow for unforeseen items or possible changes made by others, surveyors often build into their rates a hidden contingency, the slang for this is "bunse" allowance. This could be between two and five per cent depending on the confidence in the information available. However, against the professional conduct of a chartered surveyor, some interviewees sadly commented that the rates can sometimes reflect how much their practice really needs the work, and, if there are areas of great risk, they might not tell the client because they do not want to scare him away. These commercial pressures also mean that estimates cannot always be completed "*right first time*", as the client always wants "*answers yesterday*".

Frequently, several of the interviewees referred to a portfolio of previous projects to give the client a benchmark total cost, while several others relied upon "guess-timates" based on experience. Practices were asked if they used building price books and the Building Cost Information Service (BCIS), but only two said that they utilised these sources and then only as a check. In all these situations, it is interesting that little attention appears to be given basing the estimate on highly accurate and robust information, instead budget estimates appear to be based on professional judgement and intuition, which might be more accurately described as a "gut feeling".

The final stage of the budget determination process is to deliver feedback to the client. This is often a delicate task, where it is essential for the surveyor to advise the client clearly on just what building works they can expect for the budget figure determined. The client is usually given a set of assumptions that have been made in reaching a project cost, and it is of paramount importance that the client knows which items have been included and excluded, with the reasons underlying these. Some respondents commented that they sometimes try to give the client a range of possible figures within which the project budget may lie. A reason for this may be that the surveyor may deliver the findings through a telephone discussion, and experience suggests that the client tends to remember the first figure stated. Where action had been taken based upon this initial quote, calculations of site purchase and investment returns were erroneous leading to considerable acrimony between the surveyor and the client. It was agreed by all the interviewees that the most realistic way to report an initial budget estimate, where so many intangibles were evident, was to give the client a ranged estimate. However, it was freely stated that often clients insist on a definitive budget figure and, whilst a figure was provided, there was often considerable reluctance to do so. To protect themselves the surveyors often added an extra high "bunse" sum at the last minute as a safeguard.

5.5.3 Risk management approach

The second objective of the interview process examined how the quantity surveyor identifies, analyses, and responds to the risk within the budget estimate (Question Two and Three). During this part of the interview, particular reference was made to the main categories of causes for cost overruns identified, and the most commonly used risk management tools and techniques (both as described in the previous section of this chapter).

The first stage in the process of risk management is risk identification. During the interviews, it was generally found that most practices do identify the risks from the main categories of causes for cost overruns, and form some judgement of their likely implications. However, it was clear from detailed discussions that the conceptualisation of risk is made intuitively based on the experience of similar projects. There was a feeling that while risk is considered to be rather remote at the time of developing the initial budget, it did always preoccupy the thoughts of the surveyor when preparing an estimate. Anticipating risk within abstract and intangible aspects of the project, such as team communications and information co-ordination, was cited as being most problematic. There was little difficulty where specific risks were clearly seen, for example, in considering poor ground condition or asbestos removal. The methods used for identifying risks included brainstorming, checklists (e.g. major quantities), procedural prompts (e.g. BCIS elemental breakdown), and professional judgement based on experience or intuition, although it was clearly identified that systematic risk management practice was disparate and uncommon. For example, the first of these, brainstorming, was normally done informally, as opposes to a structured workshop session, which is only done occasionally by three of the firms interviewed.

Considering the identification of the four main causes of project cost overrun, the respondents confirmed that clients are the root cause of changes to the project. Given this, the surveyor could easily justify any increase in the budget and advise their client in advance of any decision being taken. Several interviewees said that an incomplete brief is the most common complaint (see below), and one surveyor commented that the client frequently ignored requests for updated information. The architect was also blamed for changes by a number of the respondents, and it was found that the surveyor must keep referring back to the original specification to remind designers of its content, as it was normal practice for the them to attempt to "slip-in" additional aesthetic items. In addition to these difficulties, some variations were said to be simply "unforeseeable" at the time of budget preparation.

Incomplete design was always expected at the initial budget stage, and is usually a problem. The complete design does not become clear until the tender stage or, too frequently, after the bills of quantities have been prepared. It was said that some clients are greatly concerned at this situation because costs can quickly escalate, at times almost beyond the surveyor's control. All the interviewees commented that more clients were actively considering non-traditional forms of procurement as an alternative approach, with Design and Build being pursued more and more in favour of traditional systems.

Lack of information, like incomplete design, was also cited by all interviewees as being commonplace, presenting varying degrees of difficulty depending upon the circumstances of the individual project. Where projects were similar to those estimated for previously, much information could be taken from in-house case documentation. The real difficulties emerged on new projects, where guesswork determined the outcomes, particularly where no site investigations have been done. One respondent commented interestingly that his practice welcomed the lack of information on some projects, as it allowed an opportunity to be more involved in decision-making and maintain a degree of control over both the client and designer, placing the surveyor almost in the role of lead consultant.

Concerning poor quality brief, the brief must include information addressing client's needs, space requirements, use of building materials, specification, quality levels, service provision, and site conditions. Over half of those interviewed stated that they thought it was their responsibility to work in association with the client and designers to determine the brief, and, thereafter, price it accordingly. The general response was that it is a poor excuse for cost overruns, and every professional involved must make it their job to clearly understand the client's needs. Nonetheless, these respondents together with those remaining recognised the problems created by an inadequate briefing process. They said that they were often placed in a position by clients not investing enough time or money to prepare a proper brief, and having to make their own experienced assumptions about the project, and thus allow a contingency element to cover the uncertainties.

Moving on to the next stage of the risk management process, analysis and quantification of risks, as few of the interviewees adopted a formal mechanism to identify risk, it was not surprising to see that few applied formal risk analysis procedures to make contingency allowance assessments. Two interviewees stated that they had used "MERA" and "Monte Carlo simulation" techniques, but, all interviewees said that they felt uncomfortable applying formal mechanisms with which they had little awareness and understanding (Question Five). Six of the eleven practices admitted that they were unaware of many of the formal risk analysis techniques available for application and, moreover, were unaware of the literature which was available. All interviewees stated that, even where risks were identified, they could not be quantified accurately, and therefore a guess was made as to likely implications. A contingency allowance would be added to cover the anticipated risk, and a further allowance made to "cover themselves", even if this was only a notional allowance.

It was freely admitted by some that the "cost per square metre" of floor area method was often very inaccurate. With all the added "gut feeling" contingencies, this led to very suspect estimates which clients sometimes queried, but, often ordinarily accepted. Hence the "approximate quantities" method was said to be preferred as anomalies could be accompanied by the surveyor's assumptions, and this led to less friction with the client over any misunderstanding of the budget. Most of the respondents stated that a practice they commonly follow is to present the cost of risk separate from the works budget, again, sometimes presented in the form of a range. The client could then clearly see where, and why, the risk had been identified, and therefore better appreciated the difficulty faced by the surveyor in providing the total cost for the project, and thus decide what risk allowance to include for.

All the respondents were in agreement that professional judgement and "gut feeling" played an important part in allowing for such risks. While brainstorming was used as a formal discussion mechanism on particular projects by two of the practices, and another recommended that junior staff referred to checklists, the usual safeguard adopted was to make a "open" contingency allowance in the budget, frequently up to five per cent, and in particular instances, the allowance was as high as ten per cent.

The final stage concerns the response to risk, and, as there are many variables to consider when calculating a "cost per square metre rate", over half of the respondents said that they try to manage risk by developing the estimate based on "approximate quantities" at the earliest opportunity. This, of course, depends on there being sufficient information, upon time availability, and the responsiveness of the client. Other quick checks may be done, such as functional unit, shape check or wall to floor ratio, but rarely does this get advanced into a full detailed elemental cost plan (Question Four).

It was recognised by respondents that, whilst it is not always possible to put figures against changes in project status each month, a useful mechanism for discussing a budget with the client is to record anecdotal information in a table, which at least keeps an undetermined element active until its cost can be accurately calculated. Therefore, as one interviewee said, "*words can be just as important as numbers*". The process of continuous update is essential in refining information, reviewing project uncertainty, and coming to terms with the real potential for risk.

Respondents cited another risk management approach, introducing "risk workshops" when developing major projects, and these proved to be a useful aid to risk management. Such brainstorming meetings allowed the surveyor to meet regularly with, not only the client and architect, but also principal suppliers and specialist contractors. Experiences of the interviewees had indicated that some clients use these workshops in an attempt to transfer risk to contractors and suppliers. However, it was explained that this needed to be carefully managed if subsequent difficulties of disputes between parties was to be avoided, and, therefore, should be done in the early stages of contract negotiations, or when the procurement route is being formulated.

5.6 Summary

Following the response to the postal questionnaire survey of quantity surveying practices, it may be summarised that the:

- "cost per square metre floor area" is the most commonly used base method for estimating initial budgets for building projects;
- main categories of causes for cost overruns are related to changes to project, incomplete design, lack of information, poor quality briefing, and budget estimate preparation;
- awareness of most risk management tools and techniques is low;
- most use of tools and techniques is a combination of "professional judgement and intuition", "contingency percentage allowance", "prompts/checklists", and "brainstorming";
- key reason for non-use of tools and techniques is due to lack of understanding; and that
- excellence is rarely achieved in performance of tools and techniques.

Following interviews with practitioners to validate the above results, and qualify the findings, it was found that the preparation of initial budget estimates based on the "cost per square metre of floor area" is generally considered to be risky, and, when possible, an "approximate quantities" base method is preferred by most quantity surveyors.

Despite the availability of much published guidance literature encompassing risk management, it was apparent that the majority of practices demonstrated a lack of awareness for, and understanding of, formal risk management approaches. Cost determination is often based upon professional judgement and intuition gained from experience. Therefore, systematic risk management techniques are rarely used for determining the items, and magnitude of risks, when preparing initial budget estimates. Further research is needed to establish the true potential of how many of the, almost unused, risk management tools and techniques perform.

Although it is accepted that perhaps there is no holistic and practical replacement for professional judgement and intuition when determining a project budget, it is suggested that risk appears to be treated, at times, in an extremely ad hoc fashion. Greater client confidence might be achieved by implementing a formal structured approach to the identification, analysis, and response to project risk. In the same way that the client organisation must undertake risk assessment as an inherent duty in meeting current health and safety requirements, so risk assessment could perhaps be a integral part of project budget determination.

Clients must be made more aware of the aspects and elements of their projects that can give rise to budget risk. Moreover, they must understand clearly the influence that they have over project definition, and the part that they can play in alleviating project uncertainty. Only through greater consultation between the quantity surveyor and the client can such an outcome evolve. The surveyor must assist the client and the other consultants to clearly define their needs and recognise that late changes to project specifications can be extremely problematic, in addition to being costly. Having identified risk within a period, again, the surveyor must work more closely with the client to implement systematic risk management processes. To achieve this in practice, it is clear that quantity surveyors will need to be more aware, and update their knowledge base and applied skills in risk management theory. Surveyors should strive for excellence in performance of the risk management methods they use - if they are to rise to the challenge of providing more certainty in their cost estimates.

CHAPTER 6 - DEVELOPMENT OF A CONCEPTUAL MODEL FOR RISK MANAGEMENT OF BUILDING PROJECT BUDGETS

6.1 Introduction

The key decisions for a new building project are made in the very early stages of the design process, and a primary measure of success is estimating the final cost at project inception (see Chapter 3). The problem is that, when the project budget figure is being prepared by the quantity surveyor, there is little information about the proposed building in question, and a figure is normally determined by using a single price rate method (see Chapter 5). The preparation of the first estimates based on this procedure carries an element of risk, and creates a situation where the actual expenditure may deviate from the original estimated figure.

It is therefore perhaps surprising that a systematic approach to risk management is rarely followed. Instead, the management of risk is intuitive, using judgement and intuition from experience (Jackson et al (1997), Mok et al (1997), and Edwards and Bowen (1998b)). Greater client confidence might be achieved by implementing a formal structured approach to risk management. The task, therefore, is to use the best systems, tools, techniques, and softwares that are available to improve decision-making by providing better information at the critical inception stage of a project. This chapter is primarily concerned with developing a conceptual risk management model to be used by quantity surveyors during the establishment of an initial budget for a building construction project.

6.2 Methodology for model development

The methodology for development of the conceptual model consisted largely of consolidating previous research work, which included literature reviews and industrial investigations (see Chapters 2 to 5). This led to selection of an appropriate budget risk management framework for the model (see section 6.3 hereafter). Using a simplified analysis of the questionnaire survey findings, tools and techniques (t&t) were chosen for utilisation and integration within the model (see section 6.4 hereafter). Prior to development of the model, the rational behind modelling theory was also considered by reference to additional text.

The work of Byrne and Cadman (1984) states that the objective of modelling is to enable a problem to be studied, analysed, and adjusted, in order to arrive at the best solution, and the merit that any model can give depends upon the extent to which the model can be regarded as truly representing the problem structure. They suggest that if formal models are applied correctly, then they can produce the following results:

(a) *"They force decisions to be made in a logical and consistent fashion, with as much quantitative and qualitative precision as is possible given the constraints of time and resources. On the whole, this means a much more extensive analysis of the problem;*

(b) *The formal approach improves the attitude of the decision-maker to the quality of his own decision, particularly where those decisions are usually of the intuitive kind. This is because the methods force the decision-maker to be much more specific about the criteria on which a decision is to be based, and to be consistent in the application of those criteria to successive decisions. If the decision-maker* *cannot be consistent, then he is forced to change that set of criteria or to accept his own internal inconsistency; and*

(c) Such an approach enables errors to be traced, even if this is only with hindsight, thereby improving similar decisions at a later time."

Whatever the complexity of the system that is being modelled, Byrne and Cadman (1984) believe that it is worth attempting to devise as simple a structure as possible, because such a model should be efficient in terms of the time, cost, and effort taken to develop it, capable of being widely interpreted and easy to alter. They say models of the development process are easy to devise, not needing extensive mathematics calculating capacity. Flanagan and Norman (1993) also explain that forecasting is a non-mechanistic process, which is not restricted to a pure mathematical evaluation of trends, and outputs can, therefore, be qualitative and quantitative, with every situation being limited by constraints like time, funds, or data.

Chapman and Ward (1997) affirm that planning for the risk management process begins with selecting an appropriate model, or set of models, and that the degree of complexity is a key aspect of designing effective risk management procedures. They believe that successful modelling requires approaches that are simple, flexible, easily understood, appropriate to the situation, and able to cope with low quality data. Concerning simplicity, they say that modelling involves a learning process and can be elaborated as understanding develops, but, in general, they suggest that it is best to "*keep it simple*" and "*make it more complex only when it is useful to do so*".

Taylor (2000) suggests that the model management structure is about function, not size of practice, believing that the functions are the same whatever the size of practice. Differences are only of scale and the need to separate the same skills into "compartments" or "specialisations". Further to this, Taylor states that the model framework is not invalidated if one person exercises several functions, because, in this simple example, the sole practitioner carries out all the functions.

6.3 Framework for the model

What is apparent from the risk management systems reviewed is that they each use different names for phases, and the terminology is varied and therefore confusing (see Chapter 3). For example, risk identification and risk analysis are sometimes separated as two individual stages, or they are combined and called risk assessment or risk review. In addition to this, risk response is sometimes called risk response development, planning, evaluation, treatment, control, mitigation, or risk management. It is also evident that project risk management systems are becoming more and more comprehensive and, therefore, as a consequence, are very complex. Perhaps the project risk management systems are even too involved and demanding for the challenge facing the quantity surveyor when preparing an initial budget for a building project.

Gray (1995) has discussed how risk management may be integrated differently into the role of the project manager, with the traditional view being that risk management is only a part of the project manager's function. An almost opposite view is also explained by Gray, which is based on the idea that the main purpose of project management is to manage the risks in a project, and this is summed up in the term "risk-driven" project management. The third view provided by Gray is closer to the portrayal of risk management set out in this thesis. This being that it illustrates the fact that risk management has to be considered in all aspects of project management, but there are also some tasks which most project managers would expect to delegate to consultants or external specialists.

Concerning this latter view by Gray (1995), in the context of this thesis, the client project manager's delegated task is to the quantity surveyor for the preparation of an initial budget estimate, with an associated risk report. Here, some clients require a "snap-shot" of the risks to a project, with a first risk assessment, provision of a one-off risk register, and an estimate (Boothroyd and Emmett, 1996). This is essentially the focus of the proposed conceptual model. Perhaps following this risk management initiation stage, the project manager would then take on the role of facilitating the continuation of the risk management process, and, therefore, the task of implementing the recommended responses to the risks identified and analysed in the quantity surveyor's report.

In selecting a suitable risk management framework for the proposed conceptual model, it is necessary to take into consideration the risk management systems identified. Whilst each of the various risk management systems have useful attributes which could be incorporated into the proposed model, only Flanagan and Stevens' (1990) system presents a clear concise diagrammatic overview of the budget risk management process framework (see Figure 2 in Chapter 3). This shows three stages of "identify and classify the risk", "analyse the risk", and "risk response". Similar project risk management systems have also been proposed by Hayes et al (1986), Raftery (1994), Tweeds (1996), Smith (1999), and the Royal Institution of Chartered Surveyors (1999).

Each explain that the risk management cycle consists of the three stages of "identification", "analysis", and "response", with loops back, as shown in Figure 26.

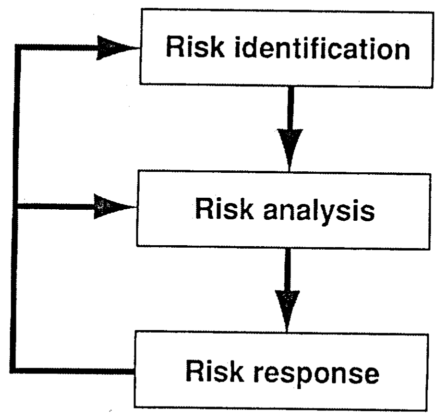


Figure 26 - Raftery's (1994) risk management cycle

This is the preferred basic system framework, and is therefore selected as a starting point for development of the proposed conceptual model. This system framework is chosen primarily because of its simplicity and ease of understanding. The system diagram is also useful insofar as it focuses the mind in a systematic way on risk management (Raftery, 1994), and is consistent with the preferred definition of project risk management by PMI (1996) (see Chapter 2).

A noticeable omission from Figure 26 is a stage for evaluating risk attitude. Considering that one objective of systematic risk management is to reduce bias (see Chapter 2), it is surprising that more systems do not include this phase. Flanagan and Norman's (1993) and ASTM's (1998b) frameworks are the only systems to explicitly have a risk attitude component. However, all model development work has limitations, and, similarly, it was also decided that this risk attitude stage was to be excluded from the proposed conceptual model. Should the basic three stage structure prove to be successful when tested, then future research efforts could consider the uncertainty of risk attitude in the initial model.

6.4 Assessment of tools, techniques, and software for the model

To be functional, a risk management framework requires t&t. This section therefore assesses risk management tools, techniques, and software (see Chapter 4) to be utilised through integration within the proposed conceptual model. The emphasis will be on the selection of those t&t included in the industrial investigation research (see Chapter 5). However, a pertinent finding from the review of recent risk management literature was the recognition of a growing number of t&t that are also suggested for use with risk management systems. Since the postal questionnaire survey was designed, the following addition t&t have been identified:

- Structured interviews, workshops, risk registers, influence diagrams (Boothroyd and Emmett, 1996);
- What can go wrong analysis, fault trees, event trees, questionnaires (Godfrey, 1996);
- Flowcharting, procurement, contingency planning, insurance, workarounds (PMI, 1996);
- Latin hypercube sampling, risk triggers (Tweeds, 1996);
- Assumption analysis, project evaluation and review technique (PERT), controlled interview and memory (CIM), databases, criticality analysis (Simon et al, 1997);
- Risk matrix, trend schedule (ICE et al, 1998);
- Breakeven analysis, mean-variance criterion, co-efficient of variation, certainty equivalent technique (ASTM, 1998b);
- Research (RICS, 1999);

- Decision conferencing, strategic assumption surfacing and testing (SAST), strategic options development and analysis (SODA), soft systems methodology (SSM), strategic choice, systems dynamic modelling, assumption analysis, cumulative frequency plots, decision analysis, HAZOP study (BSI, 2000);
- Fuzzy analysis (Wong et al, 2000); and
- Prototyping, benchmarking, quality management, training programs, and customer satisfaction surveys (Raz and Michael, 2001).

This adds a further forty-three t&t onto the original list of twenty-one, making a total of sixty-four. Though each of these deserve consideration for use in the proposed model, it is preferred to concentrate selection efforts on the original list of t&t identified for the industrial survey investigations, because this survey work produced a large amount of useful information for evaluation and selection of t&t.

Interpretation of the numerical findings from the t&t survey analysis is not straightforward, and, therefore, it was necessary to simplify the data that was generated. Table 5 substitutes the original survey results' data with a basic graphical analysis, and a one to five scale is used starting from "very low" up to "very high", with the t&t then being re-ranked in terms of the newly weighted performance scores. The simplified graphical "performance" weightings considered appropriate were calculated for each t&t by using multipliers of three for the percentage of excellent responses, two for good responses, one for fair responses, and minus one for poor responses. On a scale of "very low" to "very high", the points scored for a tool or technique to achieve a "very high" rating must have been equivalent to an 80% excellent rating from respondents, that is a score of 240 points (80 multiplied by three). For a "high" rating, an equivalent point score of 80% good must be

Rank by performance	Tool / technique	Performance	Awareness	Use	Use by aware	Frequency of use	Main reasons for non-use		
							Lack of understanding	Lack of clear benefit	Reliability / accuracy
1	Professional judgement and intuition	□□□□	□□□□□	□□□□□	□□□□□	□□□□□	nil	nil	nil
2	Prompts / checklists	□□□□	□□□□□	□□□□	□□□□□	□□□□□	□□	□	□□
3	Contingency % allowance	□□□□	□□□□□	□□□□□	□□□□□	□□□□□	nil	nil	□□□
4	Brainstorming	□□□□	□□□□□	□□□	□□□□	□□□	□□	□	□□
5	MERA	□□□	□□	□□	□□□□	□	□□□□	□	nil
6	Subjective probability	□□□	□□□	□□	□□□□	□□	□□□□	□	□
7	Risk adjusted discount rate	□□□	□□□	□□	□□□	□□	□□□□	□	□
8	Sensitivity analysis	□□□	□□□□	□□	□□□	□	□□□	□	□
9	Expected monetary value	□□□	□□	□	□□	□□	□□□	□	□
10	ELSIE	□□□	□□□□	□	□	□	□□	□	□
11	Decision tree	□□□	□□□	□	□□	□□	□□□	□□	□
12	Decision matrix	□□□	□□□	□	□□	□□	□□□	□□	□
13	Algorithms	□□	□□	□	□□	□	□□□	□□	□
14	Delphi peer group	□□	□	nil	nil	nil	□□□	□	□
15	Bayesian theory	□□	□	□	□	□	□□□□	□□	□
16	Monte Carlo simulation	□□	□□□	□	□□	□	□□□	□	□
17	Stochastic decision tree	□□	□	□	□	□	□□□□	□□	□
18	Utility theory	□□	□	□	□	□	□□	□□	□
19	Means-end chain	□□	□	□	□	□	□□□	□□	□□
20	Stochastic dominance	□□	□	nil	nil	nil	□□□□	□	□
21	Portfolio theory	□	□	nil	nil	nil	□□□	□□	□

Very high □□□□□ *High* □□□□ *Moderate* □□□ *Low* □□ *Very low* □

Table 5 - Simplified interpretation of the tools and techniques survey results

achieved (80 multiplied by two), for a "moderate" rating, an equivalent point score of 80% fair must be achieved (80 multiplied by one), for a "low" rating, between 0 to 79 points, and for a "very low" rating less than zero (negative).

For the simplified graphical ratings of t&t awareness, use, use by aware, and non-use categories, the calculation method was easier. Over 80% of respondents were required for a "very high" rating, 60-79% for a "high" rating, 40-59% for a "moderate" rating, 20-39% for a "low" rating, and 1-19% for a "very low" rating. Where the percentage was zero, then "nil" was entered in the table. The only remaining column on the table is frequency of use, which measured the split between "always" and "sometimes" used responses, and a similar scale was applied with this scoring, "very high" if always used by over 80% of respondents, "high" if always used by 60-79%, "moderate" if always used by 40-59%, "low" 20-39%, and "very low" if always used by 0-10%.

Following this simplified tabulated analysis it was then easier to narrow down the list of t&t to be considered for inclusion in the proposed conceptual model by using only the results for performance. Performance was therefore the main criteria, and a "moderate" score was set as a minimum acceptable level. This ranking method thus meant that only the first twelve t&t were to be assessed further for selection in the proposed conceptual model. However, in addition, it was decided to include Monte Carlo simulation because of its significant coverage in recent literature (see Chapter 4), which indicates that advancements in software mean that this tool is perhaps performing better now then when the survey was undertaken.

It is useful to review some of the comments made during the industrial investigations (see Appendix "F"). The highest ranked t&t in Table 5 is professional judgement and intuition, and this is what most professionals rely on to manage the risks in initial building project budgets. This method also applies to the use and interpretation of results, from all other t&t, as they always depend on this as a basis. However, to perform successfully, it is necessary to select the right mix of people with relevant knowledge and skills, from experience and training, as results will differ greatly from individual to individual. The weaknesses of this method include bias, attitudes, reporting, and even group decision-making (see Chapter 2). However, the survey results summary sheet for this method showed that 93% of respondents use it all the time (see Appendix "F"). Comments from the industrial investigations included, "*it can only be used where the surveyor has pervious relevant experience of similar projects*", "*it is essential*", and there is "*no substitute*", but it "*needs to be used with care*".

The second ranked t&t is prompts and checklists. The industrial investigations found that 66% of practices always use prompts or checklists (see Appendix "F"). The main use by quantity surveying practitioners is for "major quantities" checklists, or the BCIS elemental breakdown (as a prompt list), but, as with shape or wall-to-floor ratio checks, these approaches are normally used for the "approximate quantities" base method of estimating, rather than the "cost per square metre" method. Other survey comments from respondents include, they "*helps cross checking*", are "*a good starting point making sure things are not forgotten*", "*can be used to support other t&t*", but, "*omission is the main reason for failure*".

Following professional judgement and intuition, the most commonly used t&t for allowing for risk in a project budget is the contingency percentage allowance, which is always used by 82% of practices (see Appendix "F"). This third ranked t&t is an intuitive approach that has significant weaknesses, and it is stated by HM Treasury (1999) that the term "contingency" should not be used (see Chapter 3). Chapman also cautions against the unfettered use of contingency allowances for risk, noting that unspecified contingencies simply tempt people to use these for other purposes (cited by Edwards and Bowen, 1998b). Edwards and Bowen (1998b) argue that the use of a contingency amount is a "*reasonable practice*" because for consultants to spend time in speculating upon a myriad of potential construction risk events would be counterproductive, and the task would be overwhelming. Comments from the industrial investigations suggest that the contingency percentage allowance method is "*used as check on risk study output*", "*based on assessment of identified risks*", or "*when all other methods fail*".

Brainstorming is the fourth ranked t&t in Table 5. Survey respondents say that this method provides "*cross fertilisation of ideas*", "*pools ideas and experiences*", and "*there is always someone with better or different ideas*" (see Appendix "F"). However, its performance depends on "*personalities*" and "*who leads*". Also, brainstorming is "*mostly used in conjunction with others t&t*", "*just prior to finishing a robust estimate*", "*informally*", or "*with designers to compile a list of core probabilities*".

The sixth and seventh ranked t&t in Table 5 are subjective probability and the risk adjusted discount rate (RADR) respectively. Eighth ranked is sensitivity analysis, where results can be presented in tables or graphs, and there are several advantages of using the technique (ASTM, 1998b). First, it shows how significant a single input variable is in determining project outcomes, second, it recognises the risk associated with input, third, it gives information about the range of output variability, and fourth, it does all of these when there is little information, resources, or time. A comment from a survey respondent said that this "*usually gives good substance to contingency percentage allowance*" (see Appendix "F").

"Elsie", ranked tenth, is a computer expert system. This software is probably the type of product that many quantity surveyors believe is likely to replace their traditional cost modelling role in the near future (Cavil, 1999) (see Chapter 1). Perhaps the model proposed hereafter could be further developed as a fifth module to "Elsie". However, only two percent of survey respondents use the "Elsie" software, and, further to this, it can only be used for appropriate types of buildings.

Generally, risk analysis software may not even be necessary for good risk management (Raftery, 1994). Although it is not practically possible to carry out simulation without access to software, the number crunching exercise may well be the least important part of the total time spent dealing with the identification, analysis, and response to project risk (Raftery, 1994). This development work for the conceptual model views software only as a optional add-on that could perhaps be used to enhance the performance of the model. The possible use of software is therefore discussed following presentation of the model (see section 6.6 hereafter).

The penultimate t&t to be considered for the proposed model is the decision tree. A comment from the survey said that "*appropriate weightings are essential*" (Appendix "F"), and this could be achieved using expected monetary values to provide a measure of the value for each outcome. The final t&t to be considered for the model is decision matrices, which is a representation of the options available and the relevant influence factors. Where possible, attempts will be made hereafter to integrate each of these t&t into the proposed model.

In summarising the above assessment of risk management tools, techniques, and software, the following thirteen t&t will be used within the proposed conceptual model:

1. Professional judgement and intuition;
2. Prompts and checklists;
3. Contingency percentage allowance;
4. Brainstorming;
5. MERA;
6. Subjective probability;
7. Risk adjusted discount rate;
8. Sensitivity analysis;
9. Expected monetary value;
10. Elsie;
11. Decision tree analysis;
12. Decision matrix; and
13. Monte Carlo simulation.

The above t&t will be utilised together with the conventional budget estimating base methods (e.g. Approximate Quantities, cost per square metre floor area, and functional unit). A risk register will be used as the administrative devise for recording and monitoring the risk management process (see Chapter 4).

6.5 The proposed conceptual model

6.5.1 An overview of the model

Risk management should not be complicated or burdensome, it needs to be integrated into a firm's daily operations (Flanagan and Norman, 1993). Therefore, what is required for success is a model that can be easily incorporated into existing practices, at minimal cost and time, without additional fee to the client, initiating the risk management process to be subsequently carried through the project lifecycle by the client's lead consultant. As a starting point for discussing the proposed conceptual model, a diagrammatic representation of the integrated budget risk management process is shown in Figure 27. The model is shown in the centre of the figure, and includes the system, tools, and techniques that will allow risk in the budget estimate to be identified, analysed, and responded to. The model is further broken-down into twelve step, as follows:

1. Peruse the information that is available;
2. Identify the risks that could present a problem when preparing the estimate;
3. Analyse the risks that could threaten the accuracy of the estimate;
4. Respond to the challenge presented by the risks;
5. Prepare the most likely estimate of cost for the project;
6. Review the status of the risks during the preparation of the initial estimate;
7. Produce the report for the baseline budget estimate;
8. Focus on the required content of the risk management report;
9. Identify the risks in the baseline estimate;
10. Analyse the risks and quantify the range of possible outcomes;
11. Recommend response actions to improve the certainty of the baseline estimate; and
12. Produce the budget risk management report.

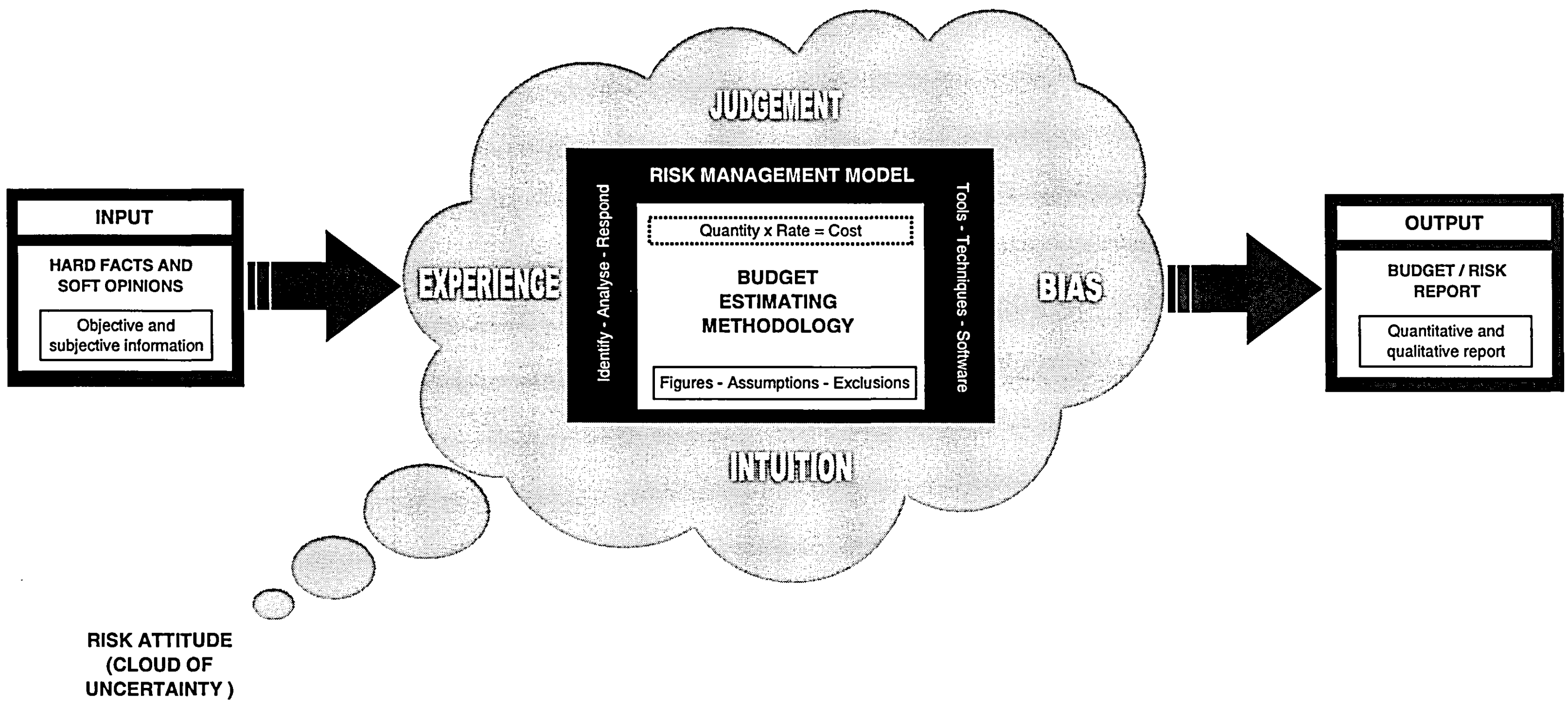


Figure 27 - An integrated budget risk management process

The model is surrounded by a "cloud of uncertainty" (the grey area in Figure 27), which includes the user's professional judgement, intuition, experience, and bias. Inputs to the model are provided by project participants (e.g. client, designers, specialists, authorities) and the quantity surveyors, who may have obtained knowledge or opinions prior to starting the risk management process (e.g. from site visits, attending meeting, telephone discussions). The input information could be quantitative (e.g. site investigation, cost data, plot ratio, measurements) or qualitative (e.g. brief, specification, photographs, notes). Outputs (deliverables) from the model include a budget estimate accompanied by a risk management report. The output information will also be both quantitative (e.g. cost breakdown, ranged estimates) and qualitative (e.g. assumptions, exclusions, recommended risk response strategy).

Note that the model is limited because it will not try to assess the biases in the "cloud of uncertainty". Biases are perhaps something the client should consider at a higher management level, e.g. when selecting the team of consultants and quantity surveyors. Also, a process for delivering objectives of health and safety related risks are likely to need separate consideration, and the "Health and Safety Executive" provide specialist guidance in this area (Royal Institution of Chartered Surveyors, 1999). However, from the list of eleven suggestions made by industry professionals of improvements to risk management practice (see Chapter 5), it is possible to encapsulate five of them in the model, these being:

- *"Development of techniques that can be used at the earliest opportunity in the life of design development of the construction concept phase, rather than used as a check when things may appear to be going wrong;*

- *Making risk management a routine part of project appraisal, rather than treating it as a "bolt-on" optional extra;*
- *Better awareness of the possible range of cost outcomes a building project might take;*
- *Striking a balance between providing information that is detailed and accurate, with providing a risk management approach that is meaningful to the project team and involves them in the process; and*
- *Awareness in the field, such as "how to" guides."*

In Figure 28, the conceptual budget risk management model is represented diagrammatically, in two distinct phases. The model will be activated by the quantity surveying team upon receipt of project information. "Phase I" of the risk management model comprises the first seven steps, and therefore begins when the quantity surveying team receive information for a project (e.g. brief, drawings, and specification). The first task of the team is to study the information and identify the risks which could inhibit accurate estimating. Upon compiling a list of risks, the team can then analyses them to determine their probability and impact. This quantification process allows the risks to be ranked. Finally, the team can propose ways of responding to the risk (e.g. request more information or contact specialists). The results are then presented in a risk register, which should be reviewed regularly as the team develop a better understanding of the project, or when more information becomes available.

"Phase II" of the model follows a similar routine but begins on completion of the team's estimate. The team start by focusing on the required content of the risk management

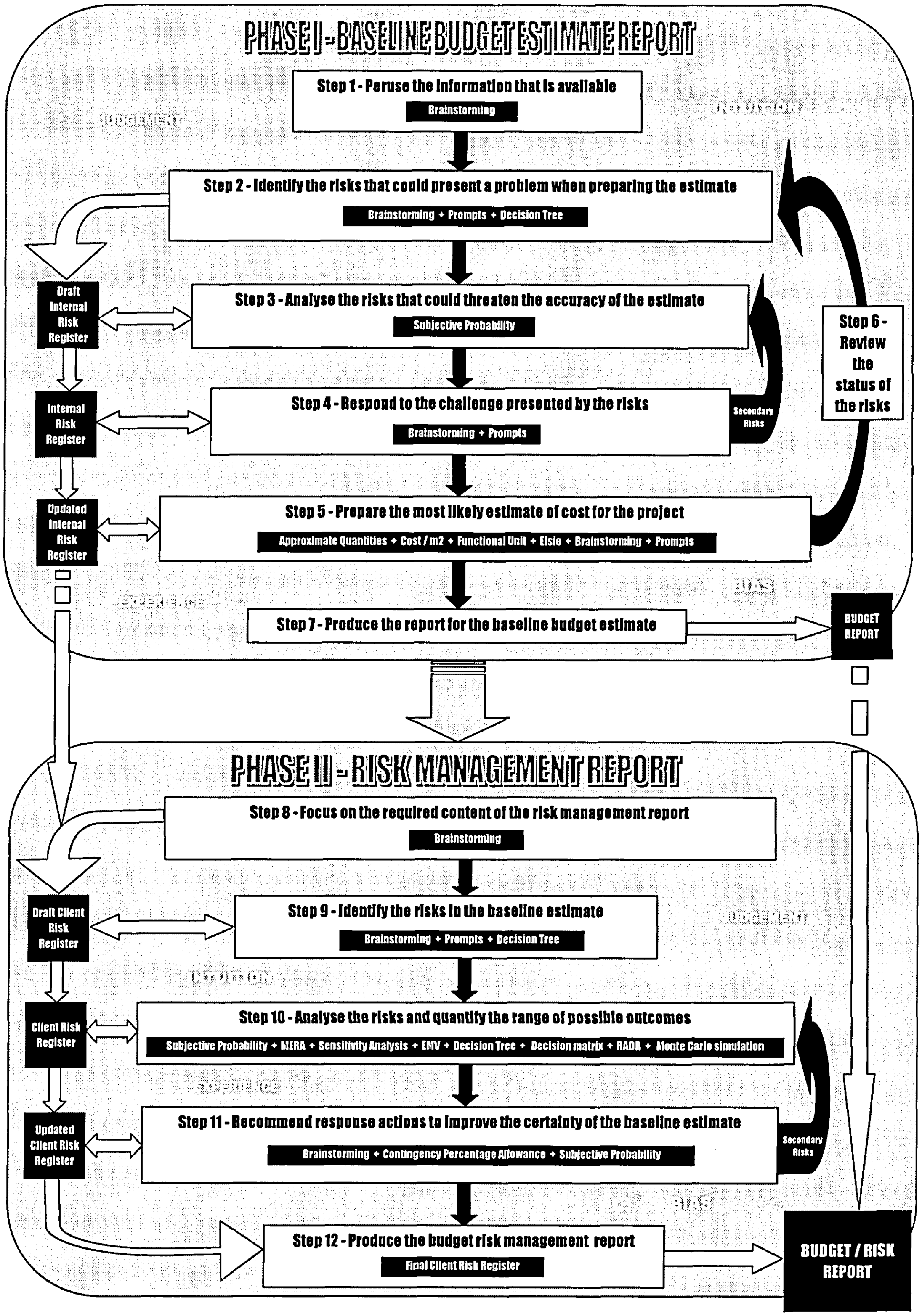


Figure 28 - The conceptual budget risk management model

report for the client, and then brainstorming a list of final risks, followed by more detailed analysis, in turn leading to prioritised suggestions for mitigating action. On completion of both phases, a team brainstorming meeting might be carried out to determine a overall project "risk rating" score for the estimate (e.g. low risk, medium risk, or high risk). This meeting would not necessarily just include project personnel, but also other consultants or contractors, who might be able to add their experience to the risk assessment conclusions. Finally, the project risk register is revised for the client to reflect the "Phase II" exercise.

As with Godfrey's (1996) system, each step of the model may have involvement from one or more individuals, or group of individuals, based on the needs of the project, and, although the process is presented as discrete elements with well defined interfaces, in practice, they may overlap and interact in different ways (PMI, 1996). Note that, at this initial stage, the model is less concerned with strategic issues, such as procurement route, contract strategy, or insurance, than how to improve the accuracy of the budget estimate. Such other factors will be decided by the design team, project manager, and client, perhaps in another level of risk register (Lewis, 1999). Both phases of the model will now be explained in detail, step by step.

6.5.2 Phase I - Baseline budget estimate report

Phase "I" of the model is concerned with the internal control of risk management by a quantity surveying practice when preparing an initial baseline budget estimate. This is in contrast to phase two, where the aim is to deliver a report on risk to the client. To some extent, this first stage is formalising what is often done instinctively by professionals.

Step 1: Peruse the information that is available

Look closely at all the project information that is at hand, and jot down any things that could present a problem when preparing the estimate, that come to light as working through the material.

➢ Note that this information may include the client's brief, project specifications, drawings, site investigation reports, photographs, minutes, and hand-written notes from telephone conversations, site visits, or meetings. However, the quality and sources of information can differ greatly, depending of the nature of the project, and the people involved - such as the client, design team, contractors, and various authorities. A standard risk identification pro-forma may be used to record things that could present a problem when preparing the estimate.

Step 2: Identify the risks that could present a problem when preparing the estimate

Brainstorm to expand on the list of items noted in Step 1, of things that could impede the preparation of an accurate estimate. Consolidate this new list with the list produced in Step 1. Clearly describe each identified item, group similar items together, and eliminate any duplication.

➢ Note that, at the initial brainstorming stage, it is best to avoid making judgements about duplication, or the importance of a risk, as, on its own, a risk may be minor, but, in combination, it could be very serious (Godfrey, 1996). Also, note that the identification of implausible risks may stimulate identification of an obscure but substantial risk, and it is critical to spend sufficient time creating a comprehensive list of risks because, unless a risk is identified, it cannot be consciously managed

(Godfrey, 1996). Question if sufficient time and resources are available to provide an accurate estimate, and, after brainstorming ideas, use a prompt sheet, such as the list of principal cost drivers for estimating an initial budget in Table 4 (see Chapter 5), or the RICS (1998b) list of information requirements for preparing a budget. Finally, consider using a decision tree to put some illustrative structure to the list of risks identification, and to help ensure the list is complete (Flanagan et al, 1987).

Step 3: Analyse the risks that could threaten the accuracy of the estimate

Refer to the consolidated list of items produced in Step 2. Enter the defined list into the draft standard risk register. Use a probability-impact matrix to evaluate the likelihood of each item presenting a problem when preparing the estimate, and the potential impact on the accuracy of the total project estimate. Assign values for each of these two parameters. Calculate a "risk factor" score by multiplying the assigned probability value by the assigned impact value for each risk item. Rank the risk items in descending order using the risk factor scores. Decide on a cut-off point where reasonable judgements and assumptions can be made about the low risk items and, therefore, limit the list of risk items by prioritising only those risks that have the greatest risk factor, and therefore need a response.

- Note that the objective of this risk analysis stage is to decide which risks need to be managed, and which can be left to their own fortune, and, in this instance, it is necessary only to get a approximate assessment, and, what is particular to a project, rather than what is common to all similar projects, often pinpoints the risks most in need of management action (Godfrey, 1996). A standard risk analysis probability-impact matrix pro-forma may be used.

Step 4: Respond to the challenge presented by the risks

Refer to the prioritised list of items produced in Step 3. For each of these items, brainstorm to generate ideas about how the risk factors for each might be reduced. Select the perceived most viable response action to each risk. Brainstorm again to determine if there are any "secondary risks" from the suggested responses - these are risks that may materialise through implementation of the proposed responses. If secondary risks are apparent, loop back to Step 3 and analyse, in a similar manner as before, the secondary risk items, i.e. by considering their probability and impact values to calculate risk factor scores. Repeat this response / analysis loop until the perceived optimum solutions may be confidently decided. Select personnel responsible for implementing the chosen risk response actions and therefore delegate responsibility of items to appropriate participants. Finally, produce the internal risk register and then monitor the action at regular intervals until satisfactory results are achieved.

- Note that possible responses to risk may include, for example, pursuing information research by consulting specialists, site visits and investigations, requesting design information such as drawings, specifications, schedule of accommodation requirements, or plot ratio, and consulting a library or the BCIS for historical pricing data. See the RICS (1998b) list of sources of cost information. The availability of resources will usually restrict the range of feasible response solutions, and, in some instances, where time is very limited, the best response may simply be a telephone call to someone who may provide help or give an opinion.

Step 5: Prepare the most likely estimate of cost for the project

Prepare the first budget estimate by following one of the conventional base estimating methodologies for calculating building construction costs. The best approach is to produce an elemental "approximate quantities" estimate, and then validate the outcome using "Elsie", or by benchmarking elements against other similar projects. However, time, information, and software limitations may mean that sometimes the more basic "cost per square meter floor area" or "functional unit" methods can only be used. When working through and developing the estimate, "flag-up" any items that have not previously been identified, and also incorporate any new information that becomes available as a result of the response actions taken in Step 4. Use the BCIS list of building elements as a prompt, to ensure that all items are included.

➢ Note that major unpredictable items should not be included in the estimate because it is not possible to arrive at a sensible allowance, instead, they should be excluded and then reconsidered later by the client (Wideman, 1995). Also, do not include any "bunse" or "contingency percentage allowance" sums in the estimate.

Step 6: Review the status of the risks during the preparation of the initial estimate

Review the risk status at regular intervals during the preparation of the initial budget estimate, again, by followings Steps 2 to 4, and include any items that were identified during Step 5. Upon satisfactory completion of the first estimate, check all mathematical computations and the major quantity measurements used for the estimate, and then move on to Step 7.

- Note that this review step could be done once per day, once per week, or even once per month, depending on the time available to produce the estimate. However, due to commercial pressures, it may not always be possible to carry out this step.

Step 7: Produce the report for the baseline budget estimate

Summarise the main construction elements of the baseline first figure. Support the estimate with a cost break down and a statement of inclusions, in as much detail as is possible, with explanation of the quality and specification parameters, and a schedule of accommodation. Be explicit, list all the provisional lump sum allowances, assumptions made, sources of information used, and items that have been excluded.

- Note that the baseline estimate represents the perceived most likely cost, based on the information available (Noor and Rye, 2000). Refer to the RICS (1998b) guidance for a recommended format for the budget report.

6.5.3 Phase II - Risk management report

Whilst the previous phase of the model was concerned with the internal control of a quantity surveying practice's system, Phase "II" applies to the delivery of a risk management report to the client that provides an enhanced view on the level of risk that is inherent in the baseline estimate. It is preferable that this report accompanies the baseline budget estimate. However, depending on time and circumstances, it is possible that it may be delivered at a later date, particularly if other members of the design team are to be involved in this second phase of the risk management process.

Step 8: Focus on the required content of the risk management report

Brainstorm to determine what content is preferred in terms of a risk management report for the client in question. Decide on what qualitative and quantitative output is expected, and acceptable, with the resources and time available to produce the report.

- Note that it is useful to consider what column headings should be included in the risk register.

Step 9: Identify the risks in the baseline estimate

Understand the content of the baseline budget estimate report, and highlight the key items that could deviate and cause the actual cost outcome of the project to change from the baseline figure. Brainstorm to generate a new list of any other things that were not identified in Phase "I", but that could still influence the total outcome. Clearly describe each highlighted item and influence factor identified, group similar items together, and eliminate any duplication.

- Note that the identification of risks is about making best use of the information and experience available, it requires people to be systematic and creative, and the best way to achieve this is to assemble an appropriate team (Raftery, 1994). A brainstorming "workshop" that includes a range of consultants is preferable (Boothroyd and Emmett, 1996). After the brainstorming session, it may help to refer to the original Phase "I" list of risks as a prompt, or consult the list in Table 1 (see Chapter 5) of reasons for causing building projects to finish over budget. However, it is important to understand that even the most thorough and comprehensive analysis cannot identify all of the project risks (PMI, 1996). Also, consider the notes on brainstorming accompanying Step 2 of Phase "I".

Step 10: Analyse the risks and quantify the range of possible outcomes

Refer to the list of risk items produced in Step 9. As in Step 3, consider the likelihood of each risk occurring, and the possible impact on the total baseline estimate, assign values for these two parameters to calculate a new risk factor score for each item. Again, rank the items in descending order using the risk factor scores. This time, decide a cut-off point where risks can reasonably be left to their own fortune, therefore, limit the list of risk items by prioritising on only those items that have the greatest risk factor and which need to be evaluated in more detail. Analyse the key risks using quantitative t&t to allow interpretation of the range of variances for the "best case" cost (i.e. the optimistic opportunities), and the "worst case" cost (i.e. the pessimistic problems). Separately total the sums of the best and worst estimates to give the range of possible outcomes. Make probabilistic adjustments to the range of figures to provide a risk-adjusted total estimate for the project. Summarise the results in a risk register.

- Note that a sound aim is to prioritise the key risks, perhaps between five and ten, which can then be analysed and managed in more detail (Thompson and Perrys (1992) and Norris et al (1993)). The most suitable quantitative t&t are "MERA", "sensitivity analysis", "EMV", "decision trees", "decision matrix", "RADR", and "Monte Carlo simulation". When selecting t&t it should be acknowledged that no single method can be labelled the best one in every situation, what it depends on is the circumstances, and the following factors: availability of data; availability of resources (time, money, expertise); computational aids (for example, computer services); user understanding;

ability to measure risk exposure and risk attitude; risk attitude of the decision-maker; level of risk exposure of the project; and the size of investment relative to the institution's portfolio (ASTM, 1998b). However, it is best to keep analysis as simple as is possible and only make it more complex when it is useful to do so (Chapman and Ward, 1997). The primary concerned is with determining which risks warrant a response, i.e. the opportunities to pursue (or ignore), and the threats to respond to (or accept) (PMI, 1996).

Step 11: Recommend response actions to improve the certainty of the baseline estimate

Refer to the analysis summarised in the risk register produced in Step 10. Explain the method adopted to mitigate the risk so far. Brainstorm to generate ideas for reducing the cost range of each item in the risk register, and hence, suggest the information and actions necessary to improve the certainty of the outcome of future project estimates. Select the perceived most viable response action to each risk. Brainstorm again to determine if there are any secondary risks from the proposed responses that have been suggested and, if secondary risks do become apparent, loop back to Step 10 and analyse them using quantitative t&t. Repeat this response / analysis loop until the optimum solutions can be confidently decided. Revise the risk register and include a concise summary of the recommended response actions. Finally, consider the risk register information and the analysis data produced, calculate the percentage deviation of the risk-adjusted estimate from the baseline estimate, and compare it to the "contingency percentage allowance" that is usually expected for the type if project at hand. Classify the current risk status of the project by assigning a project "risk rating", e.g. high, medium, or low.

- Note that it is necessary to define enhancement actions for opportunities, and response actions for threats (PMI, 1996). Response actions to control risks are referred to as risk mitigation and, even if the impact of the risk is difficult to quantify, the identification of effective mitigation actions can still be very useful (Godfrey, 1996). Also, note that care should be taken when considering the management actions available to ensure that the potential impact of each risk is not outweighed by the direct costs of reducing the risk, transferring the risk, or all management and administrative time, consultants fees and other charges associated with managing and dealing with the risk (HM Treasury, 1997).

Step 12: Produce the budget risk management report

The key deliverable of the report is the risk register, including a project risk rating, risk-adjusted estimate, range of possible outcomes, and recommended response actions. It is preferable if this table can be summarised in a concise format. However, the report should be supported with appendices, that may include the risk analysis results (any graphical decision aids should be provided), an explanation of the methodological approach taken (with reference to t&t used), a list of people involved, and guidance on how the results should be interpreted.

- Note that the words produced from the risk management process are just as important as the numbers, and in preparing the report it is important to be impartial. Care must be taken not to be biased in reporting, or to use subjective wording that could be misinterpreted.

"Step 13" and beyond

The next steps are to be taken by the client, perhaps first in deciding whether or not to build. The client must delegate ownership of risks, assign related "triggers", determine review intervals and contingency plans, decide on the risk management plan for the project, and, in particular, decide whether to retain, reduce, transfer, or avoid risks. Further, the client and project team must also look for new risks as the work proceeds, monitor existing risks, and check that response strategies are being implemented. The quantity surveyor may adopt a similar twelve step procedure when preparing the next cost estimate as design develops. These subsequent modelling issues should be the focus of future research efforts. In the meantime, clients could perhaps insist on this initial model being implemented, but, also allow the necessary time and fees to enable it to be successful carried out.

6.6 Optional software enhancement to the model

There is a rapidly increasing variety of software available for project risk management (see Chapter 4). Whilst software is not essential for functionality of the proposed conceptual model, there are benefits in using computer technology to improve efficiency and help to facilitate tasks which cannot easily be undertaken manually. Therefore, software could improve performance of the model, and optional software enhancements to each step of the model will now be discussed.

In Phase "I" of the model, Steps 1 and 2 are primarily concerned with risk identification. Databases (e.g. "Ris3") and expert systems (e.g. "RiskTools") will enable generic libraries of risks to be maintained and used as prompts for brainstorming. Decision modelling packages (e.g. "Definitive Scenario" and "DPL") can then be used to construct decision trees or influence diagrams which add graphical structure and definition to the risk items. These help to ensure completeness of risks definitions and highlight the dependencies between the items identified. A methodology software that supports dependency modelling is "DMT", which also provides the sensitivity analysis which may be undertaken in Steps 3 and 10. "DMT" software then leads to a further function for the formalisation of response strategies, i.e. for subsequent Steps 4 and 11.

The key risk analysis tool used in Step 3 of the model is a probability-impact matrix. Database software (e.g. "Ris3" and "RiskRadar") provide probability-impact grids that allow the number of risks in each category to be displayed by time frame, providing a historical log of events. Similar to Steps 1 and 2, databases and expert systems can be used for Step 4 to enable generic libraries of risk response options to be maintained, and therefore, again used as prompts for brainstorming.

For the budget estimating procedure in Step 5, bespoke in-house spreadsheets, databases, or commercial estimating software could be used for approximate quantities, cost per square metre, and functional unit base methods. The "Elsie" expert system may then be utilised for validation and qualification of the estimate. Again, databases can be used as prompts for brainstorming. Step 6 is a review stage which could utilise the same software as Steps 2 to 5, whilst Step 7 may use common word processors for the supporting text that should be included in the baseline budget estimate report. The latter may possibly be linked to the results from the software used in Steps 1 to 5.

Phase "II" of the model perhaps demands more utilisation of software packages. Step 8 is concerned with focussing on the required content of the client risk management report, which, together with appendices from quantitative computer outputs, will usually take the form a risk register. Risk register software (e.g. "Pandora", "Predict! Risk Controller", "Ris3", and "Risk Radar") uses database technology and is also linked to all other steps of the conceptual model. Whilst a simple basic risk register could easily be constructed in a database, spreadsheet, or word processor, risk register databases provide additional functions that enable risks to be effectively classified, recorded, and monitored. This is achieved by using special data entry screens to maintain a history of the ways in which risks change throughout implementation of the risk management process. This is, therefore, perhaps the most important software tool for use with the conceptual model. It can provide tracking of the whole process and improve communication. High end risk register software (e.g. "Active Risk Manager" and "Messa/Vista") use web-based enterprise technology that could enable surveyors, designers, and the client, real time access to information from different geographical sites. Risk registers can also integrate with other software tools (e.g. simulation, programme management, and probability-impact matrices), therefore providing automated transfer of information. Some risk register databases also have such additional simulation and modelling modules built-in.

Step 9 of the conceptual model could use similar risk identification software to that described for Step 2, whilst Step 10 demands the greatest need for software enhancement because of the option to quantify the range of possible outcomes. This could include using simple spreadsheets for subjective probability, MERA, sensitivity analysis, EMV, decision matrix, or RADR (as is often done by practitioners - see survey results in Table 3 of Chapter 5), or by using more sophisticated simulation (e.g. "@Risk", "Crystal Ball", "PRA", "Predict! Risk Analyser" and "RiskMaster") and decision modelling (e.g. "@Risk PrecisionTree", "Definitive Scenario", "DPL", and "DMT") packages for Monte Carlo simulation or decision tree analysis respectively. Further to this, simulation and decision modelling software can both be integrated, and these softwares can also provide sensitivity analysis. Programme risk management software (e.g. "Monte Carlo", "@Risk for Projects", and "Riskman") can be used to apply Monte Carlo simulation to determine the likelihood of finishing a project on time, allowing resources to be analysed, which could thus lead to budget cost implications.

Step 11 relates to developing risk response strategies to improve the certainty of the estimate, and softwares discussed for Step 4 applies, perhaps with the addition of spreadsheet software for calculating a final risk rating for the project. Finally, Step 12, production of the budget risk management report, is primarily concerned with the risk register output. This, merged together with the baseline budget estimate report produced in Step 7, may be an acceptable budget / risk report output. However, it is likely that a word processed document may also be used, with links to other software used in the conceptual model, and then possibly presented to the client using a presentation package such as "Microsoft PowerPoint". Further to this, expert systems (e.g. "Elsie" and "RiskTools") have automated report generation capabilities.

In providing software which attempts to facilitate the risk management process in a group workshop situation, the "Futura" package is a methodology which perhaps could be utilised by the proposed conceptual model, particularly for Phase "II". "Futura" is particularly useful for capturing ideas during a brainstorming session. However, the software does not support the complete process of the conceptual model and, although it may provide a good tool, the best answer would be to develop bespoke software that replicated each of the twelve steps of the model. This may provide the opportunity to utilise artificial intelligence computer technology, similar to, or even integrated with, the "Elsie" package.

Finally, Multimedia software (e.g. "Risk in Action") could help with the initial implementation of the conceptual model by educating personnel to think about risk in a more systematic way. The role-play scenario experience could assist with the transformation from the intuitive to a formal risk management approach, which requires developing a new attitude of mind and a culture change within an organisation. Such training tools could allow individuals to learn at their own pace, which would reduce the need for arranging resource-demanding group seminars.

With so much software available, and such potential sophistication, it would be easy to believe that by using some of these computer tools a new level of confidence and certainty would be introduced where it did not exist before (Webb, 1997). Furthermore, Webb (1997) explains that to assume this is to misunderstand the fundamental nature of risk as it applies to project work. Risk management software, if intelligently applied and acted upon, will undoubtedly improve the chances of any project achieving its goals; it will not, however, remove the fundamental uncertainty that lies beyond the control of those in charge of the project, nor will it ensure that unforeseen risks will not materialise during the course of the work (Webb, 1997). Software can help in the process of decision-making, but the output it gives is only as good as the information entered by the people involved in implementing the model.

6.7 Summary

An integrated conceptual budget risk management model has been developed for use by quantity surveyors during estimation of budget figures for building projects. The model is in two distinctive report generation phases, and consists of twelve uniquely defined steps. Attributes of existing systems have been utilised and consolidated together with best performing tools and techniques. The additional resulting risk report should improve client decision-making by providing better information support to estimates.

The development work has also tackled deficiencies in existing systems, in particular, the proposed conceptual model is better because the process starts at the same time as the preparation of an estimate, rather than requiring a baseline estimate first. The model provides the flexibility to enable the process to be made as simple or complex as desired. It can be used by an individual or a team, and it does not require software to be functional, but both people and computers can enhance performance. The model provides an auditable framework of internal control within a practice, and is supported by step-by-step guidance. A risk report can be delivered at the same time as the baseline budget estimate report.

The model will produce both qualitative and quantitative information to communicate awareness of the key risks facing the client and project team. It provides an infrastructure that can be implemented at minimal initial cost, but also has a framework that will facilitate the use of more sophisticated methods. This will therefore accommodate the increasingly strong demands of today's clients in the Construction Industry, and could help to place the quantity surveyor in a leading strategic position for initiating the risk management process for a building project.

CHAPTER 7 - DEMONSTRATION OF A CONCEPTUAL RISK MANAGEMENT MODEL IN A QUANTITY SURVEYING PRACTICE

7.1 Introduction

This chapter is concerned with the demonstration of a conceptual risk management model (see Chapter 6) in a quantity surveying practice. The aim of the model is to provide improved decision-making information for clients, and, therefore, the model will be tested, herein, with case illustrations. The surveying practice used for demonstration of the model was first introduced to risk management in 1996, through a brief review of literature (largely based on HM Treasury, 1993) that was carried out by one of the practice's surveyors, and then presented as an internal report. The firm was, therefore, very keen to participate in this research work, and most pleased to receive a practical update on the subject that would demonstrate more clearly how risk management could be implemented.

The selected practice was a medium sized British quantity surveying firm, operating world-wide, and comprising of a number of specialised teams. Each team was responsible for different stages of the building procurement process, and specific services to "blue chip" clients. The team within the practice chosen for demonstration of the model was solely responsible for providing strategic level construction cost advice to a significant overseas building client. The personnel consisted of a team leader, with two senior, two services, one intermediate, and two assistant quantity surveyors, supported by six administration staff, and overseen by a visiting regional director.

In the latter part of 1997, the director set out the two year service objectives for the team to undertake. This included the need to provide the client with accurate cost estimates, that incorporate quality informative reporting, over as broad a technical range as possible. This demanded that the commentary in the team's budget estimate reports should "*provide a risk assessment to identify the areas that require ongoing specific review as the project proceeds*", and, therefore, to alert the client of the key cost drivers for projects. The director also recommended that, if circumstances permit, the team should try to enhance the client's knowledge of these developments, and, to achieve this, should prepare a practical update paper on risk management. This groundwork setting in the practice was most beneficial, and perhaps fortuitous, for demonstration of the conceptual model. In particular, because of the director's requests, which added some incentives to motivate the team to showing an interest in the research.

7.2 Methodology for demonstration of the model

In selecting an appropriate quantity surveying team for demonstration of the model, it was necessary to make some initial enquires about the suitability of practices. Ten firms, of varying sizes, were approached for consultations in the middle of 1997. Discussions regarding the logistics of implementing such a major practical research exercised were undertaken, by telephone and interview, with practice partners or directors. It was generally and mutually agreed that the best way for the research exercise to succeed in a practical industrial environment was for the researcher to join a firm as a quantity surveyor, and, within his responsibilities, take on the role of managing the demonstration of the conceptual risk management model.

Concerning the success of a risk management system, Taylor (2000) stated that the most important ingredient is the relationship between the lead principal and the person appointed to manage the system (the "risk manager"). He explains that the lead principal may be too distracted with affairs of state to become embedded in the minutiae of operating the system, whereas the risk manager may not have the authority to ensure that the whole practice implements the system. Therefore, the two roles must complement each other, and the risk manager must have the full support of the lead principal. Although Taylor's work was published after the demonstration of the model, it reflects very closely the methodological approach used for model demonstration. In particular, his list of the remit of a risk manager comprises key features adopted by the researcher, i.e.:

- *"Taking policy instructions from the lead principal and liasing with him and the other principals;*
- *Formulating and working within budgets;*
- *Drafting procedures, consulting as necessary and producing the working documents;*
- *With the lead principal, explaining the system to the practice and securing acceptance by those who will work within it;*
- *Receiving feedback from the practice on the system and updating material;*
- *Ensuring that the system is operating as intended, by assessment or audit; and*
- *Presenting a regular digest of operation of the systems, including assessment or audit, to the lead principal and making recommendations for change."*

Taylor, 2000.

The main differences between Taylor's (2000) work and the methodology adopted, was the titles used for the people who were responsible for demonstration of the system. In the collaborating practice, the lead principal was entitled the "team leader", whilst the risk manager (i.e. the researcher) was called the "intermediate quantity surveyor / risk management facilitator" (hereafter referred to as "the facilitator"). The use of the title risk manager is also discouraged by others, for example, Lewis (1999) explains that a common reason for risk management failing is when one person is seen as responsible for managing risks, thus, allowing everyone else to shirk their own responsibility. However, he does say that, although there is no place for a "risk manager", there is certainly a place for a risk specialist, and their role involves facilitating the risk management process with the team and co-ordinating responses.

A further pertinent issue facing the demonstration of the model, again, subsequently discussed by Taylor (2000), is that formalised risk management costs money, and, as Taylor explains, the bulk of effort is in setting up the system. However, with the exception of the drafting of standard pro forma's and risk registers for use with the conceptual model, most of the system development was completed by the facilitator in advance of him joining the practice, and, therefore, this was not a potential major cost that needed to be born by the firm. Taylor goes on to state that it should not be necessary to allocate any further funds for applying procedures on projects, as staff should already be expected to absorb the cost of choosing the right working methods for their job, and this, therefore, is just a development of what they should be doing anyway. This concept, to a fair degree, was also accepted by the chosen practice. However, the demonstration of the model did become secondary to any new or on going core quantity surveying project duties for the client, which always commanded priority. Therefore, it was, regrettably, a question of the facilitator being patient and anticipating that a quiet period would become apparent, where demonstration of the model could be achieved.

Taylor (2000) also states that the major part of the cost of maintaining the risk management system is the risk manager and his administration. However, in addition to this, there are further potential major expenses for the purchase of software and the appropriate training of staff. Concerning the former of these two, although the possible purchase of software was discussed with the team leader, there was no practice finances available to do this. Concerning the latter, systematic risk management is a management tool, which, for best results, requires practical experience and training in the use of techniques, but, once learnt, supports decision-making and informs instinctive judgement (Godfrey, 1996). Therefore, after comprehensive background discussions with the team leader about the conceptual model, the facilitator was given authority to arrange and deliver a series of three in-house training seminars for the team. These educational sessions took place during 1998, and time was limited to two hour periods, therefore, only a total of six hours was available for team training prior to demonstration of the model.

The first seminar presented by the facilitator introduced the problem of risk in construction estimating, and the resultant challenge facing the team (see Chapter 1). Within this meeting, the facilitator held a team brainstorming session, concerning problems commonly experienced by the team when preparing a budget estimate. It was found that the main risks facing the team were:

- Poor quality information, e.g. drawings and specifications;
- Time pressure to deal with volume of work, e.g. staff resources and disruption; and
- Sources of cost data, e.g. limited feedback from the client, no live project information, diversity of project types, and reluctance of external sources to provide cost information.

The second seminar progressed to introduce the basic theory of systematic risk management, including explanation of the definitions, philosophy, benefits, and limitations, and making critical comparisons with the intuitive approach that was being used by the practice (see Chapter 2). Also, the various risk management systems (see Chapter 3), and tools and techniques (see Chapter 4) were explained, and questionnaire survey results were presented (see Chapter 5). In the third and final seminar, the facilitator presented the conceptual model to the team (see Chapter 6), and suggested how it could be initially implemented on case illustrations. The training sessions also proved to be useful for the facilitator by providing early positive interest from the team.

The first case illustration of the conceptual model was carried out by the risk management facilitator, with the team leader, during the middle of 1999, on an initial budget estimate prepared (by the team leader) six months prior. The facilitator offered guidance throughout the demonstration process, but remained impartial with respect to the results produced. As recommended by Thompson and Perry (1992) and Norris et al (1993), emphasis was on the qualitative aspects of the model, rather than the quantitative tools and techniques. The latter could be incorporated at a later time, if a climate of acceptability was achieved in the office for formal risk management to become standard practice. Where necessary, minor refinements to the model were made during the case illustration.

Shortly after completing the first case illustration, the model was validated with a different quantity surveyor in the team. The validation exercise used the same project, but, at a later stage of the design development. Here, the senior surveyor concerned had prepared a pre-tender budget estimate, one month prior to the model demonstration, using bills of quantities prepared by another quantity surveying practice. The reason for deciding to use the same project was that it would help to test the model by allowing comparison of the output produced for the differing quality of input information available. It should be noted that, whilst it was originally considered preferable to implement the model on a live project, it was thought too risky to attempt this, as it was generally agreed that there was a long learning process, and a change of culture required, before this goal could be attempted with more confidence. Chapman and Ward (1997) have explained that, like a project, a risk management model also has its own risks, which also need to be considered. Examples of these risks include disruption of core services, business continuity, model failure, and client dissatisfaction.

Following completion of the two case illustrations, the model was refined from lessons learned, and a (confidential) internal paper was prepared by the facilitator, and sent by the team leader to the client. This was also the point where the researcher's direct vocational involvement in the practice came to a predetermined end. The content of the report included an explanation of the problems faced by the team when preparing a budget estimate for construction projects, risk management theory was then discussed, the framework of the model was postulated, and the case illustration provided. In the conclusion to the paper, it was explained that this was only a starting point, and, if the model was to reach its full potential, a long commitment to learning was required, particularly if more sophisticated techniques and software tools were to be utilised. Finally, the report contained a list of references for further recommended reading.

One year after the report was sent to the client, the office's team leader was approached by the researcher and subsequently interviewed. Through several exchanges of e-mail messages during the middle of 2000, feedback was obtained in order to draw further conclusions as to the practical performance of the conceptual model.

7.3 Demonstration of the conceptual model

7.3.1 Project for the model case illustrations

The project used for demonstration of the model concerns the proposed construction of a major new manufacturing development that comprises five three story factory units, accommodating extensive handling and processing plant, including a high pressure cleaning system, freezing, and cold store equipment. Ancillary building proposed for the development include a security gate house, weigh bridges, transformer buildings, water storage tanks, pump houses, resource banks, and fuel tanks. Also, between the enclosed site boundary and the adjacent main road, it is proposed to build a further set of ancillary buildings, comprising several rows of shops, small booths, and toilet blocks. In addition, a network of access roads and parking for cars and trucks is included, together with all necessary site utilities. Application of the conceptual risk management model will now be illustrated on this project.

7.3.2 Phase I - Baseline budget estimate report

Step 1: Peruse the information that is available

All information about the project was initially sent by courier direct to the quantity surveying practice's team leader, there was no prior telephone call or correspondence, however, this was commonplace for the client, who simply expected the job to be done. After understanding the requirements (i.e. to prepare an initial budget estimate for the proposed building construction project), the team leader selected which surveyor had the necessary experience, and was available to prepare the estimate. In this situation, it was himself (hereafter referred to as "the surveyor").

The only information that was available at the beginning of the surveyor's involvement was an architect's concept design report, together with twelve A1 drawings, showing conceptual general layouts, sections, and elevations, at a scale of 1:500, and the site layout drawings at 1:2000. For confidentiality reasons, it was not possible for the surveyor to communicate with other consultants direct, queries were, therefore, made through the client. In addition to this problem, the site was too far away for the surveyor to visit it in the time allowed by the client to produce the estimate.

To start the internal control risk management process (i.e. Phase "I"), the facilitator provided the surveyor with a standard "risk identification note pad pro forma for Step 1", and asked him to identify, whilst working through the documents for the first time, anything that could present a problem when later preparing the estimate. Three items were listed by the surveyor, as shown in Figure 29, and, for possible future reference, a prefix letter ("N" for noted) was used.

Step 2: Identify the risks that could present a problem when preparing the estimate

Following the perusal of information in Step 1, the facilitator provided the surveyor with a "risk identification brainstorming pro forma for Step 2", and then asked him to dedicate some time to reflect solely on the information that was available, and, therefore, to try and think of further items that could impede the preparation of an accurate estimate. Seven additional items were identified by the surveyor, as shown in Figure 30. On completion of this brainstorming session by the surveyor, the facilitator consolidated the brainstorming pro forma, together with the note pad pro forma produced in Step 1, by typing them up into a single list.

The facilitator then asked the surveyor to consider the typed list of items, and to indicate links, by simply drawing lines and arrows, where similar items could be grouped together. The facilitator then provided the surveyor with two risk identification prompt sheets (the list of principal cost drivers, see Table 4 in Chapter 5, and the RICS (1998) list of information requirements), and asked him to study them to check that his list of items was complete. Following reference to the two prompt sheets provided, the surveyor made no changes because he believed that he had already identified the main project specific problems faced. However, in addition to this, the facilitator asked the surveyor to consider using decision tree analysis, also to check the completeness of the list, but, having had no experience of using such a tool, the surveyor did not feel that it was beneficial, or time effective, to do so.

RISK IDENTIFICATION NOTE PAD PRO FORMA FOR STEP 1
Look closely at all the project information that is available, and jot down any things that could present a problem when preparing the estimate.
N/1 No area schedule, small scale general layout drawings only. N/2 Small scale drawings for only one of the five main factory buildings, all of which differ in area. N/3 Brevity of specification - virtually none.
NOTES FOR USERS OF THIS PRO FORMA
Note that project information may include the client's brief, project specification, drawings, site investigation reports, photographs, minutes, and hand-written notes from telephone conversations, site visits, or meeting. However, the quality and sources of information can differ greatly, depending of the nature of the project, and the people involved.

Figure 29 - Risk identification note pad pro forma for Step 1

RISK IDENTIFICATION BRAINSTORMING PRO FORMA FOR STEP 2

Reflect on the information that is available, and brainstorm any things that could impede the preparation of an accurate estimate - to expand on the list produced in Step 1.

B/4 The effect that the sheer size of the project would have on the cost, e.g. the overall estimate would be very sensitive to small changes in rates or specification etc.

B/5 No details of extensive external works, including a link road.

B/6 The extent and specialised nature of the building and processing equipment - no details.

B/7 No current information in the team's cost library for a development of this nature.

B/8 The scope and cost of the external utilities for such a development - no details.

B/9 The difficult nature of the ground - hard rock.

B/10 Lack of detail for extensive ancillary buildings.

NOTES FOR USERS OF THIS PRO FORMA

Note that, at this initial brainstorming stage, it is best to avoid making judgements about duplication, or the importance of a risk, as, on its own, a risk may be minor, but, in combination, it could be very serious. Also, note that the identification of implausible risks may stimulate identification of an obscure but substantial risk, and it is critical to spend sufficient time creating a comprehensive list of risks because, unless a risk is identified, it cannot be consciously managed. Question if sufficient time and resources are available to provide an accurate estimate.

Figure 30 - Risk identification brainstorming pro forma for Step 2

Finally for Step 2, the facilitator gave a "risk identification framing pro forma for Step 2" to the surveyor, and asked him to eliminate any duplication in his consolidated list, and to ensure that each of the items that remained were clearly defined, and as concise as possible. The surveyor's revised list comprised seven defined items, as shown in Figure 31, newly numbered by the facilitator with an "F" (for "framed") prefix for future reference.

Step 3: Analyse the risks that could threaten the accuracy of the estimate

With the things that could present a problem when preparing the estimate defined in Steps 2, it was now possible to begin constructing the first internal risk register for the project. The facilitator began by typing the surveyor's revised list of seven items (shown in Figure 31) into a draft risk register. Next, the facilitator provided the surveyor with the part completed risk register, and asked him to use the standard "risk analysis probability-impact matrix pro forma for Step 3" to evaluate the likelihood of each item presenting a problem when estimating, and the potential impact on the accuracy of the total project estimate. The resulting probability-impact matrix is shown in Figure 32.

Following this first analysis, the facilitator then calculated a "risk factor" score by multiplying the assigned probability value by the assigned impact value for each risk item, and then ranked the items in descending order in the draft risk register. Next, the facilitator asked the surveyor to decide on a cut-off point, where reasonable judgements and assumptions could be made about the low risk items. With only seven item listed, it was decide by the surveyor that a prioritised cut-off point was only necessary for one

RISK IDENTIFICATION FRAMING PRO FORMA FOR STEP 2

Look at the attached consolidated list of items identified so far. Group similar things together, eliminate any duplication, and clearly describe each remaining item.

F/1 No accommodation schedule or specifications, only limited small scale drawings available.

F/2 Unique project, no suitable cost data in team library.

F/3 Due to the size of the project, the overall estimate will be very sensitive to small rate variations.

F/4 No details of extensive external works.

F/5 No details of extensive external utilities.

F/6 No details of extensive building cold stores and specialised processing equipment.

F/7 The difficult nature of the ground – hard rock.

NOTES FOR USERS OF THIS PRO FORMA

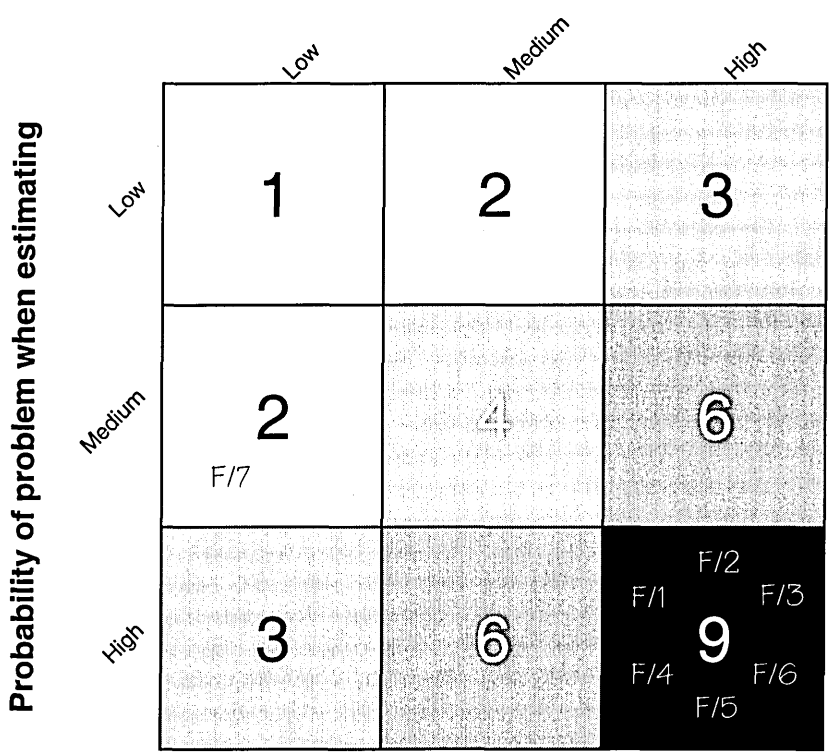
Note, to check that the consolidated list is complete, refer to prompt sheets such as the list of principal cost drivers for estimating an initial budget, or the RICS list of information requirements for preparing a budget. Also, as a further check, consider using decision tree analysis.

Figure 31 - Risk identification framing pro forma for Step 2

RISK ANALYSIS PROBABILITY-IMPACT MATRIX PRO FORMA FOR STEP 3

Refer to the attached risk register. Use the probability-impact matrix below to evaluate the likelihood of each risk occurring, and the possible impact on the accuracy of the total estimate. Write each item's reference number in the perceived position of the matrix.

Potential impact on the accuracy of the total project estimate



NOTES FOR USERS OF THIS PRO FORMA

Low = 1 Medium = 2 High = 3

Examples of "risk factor" calculations:
High Probability and High Impact = 3 x 3 = Risk Factor 9
Medium Probability and Low Impact = 2 x 1 = Risk Factor 2

Note that the objective of this risk analysis stage is to decide which risks need to be managed, and which can be left to their own fortune, and, in this instance, it is necessary only to get a approximate assessment, and, what is particular to a project, rather than what is common to all similar projects, often pinpoints the risk most in need of management action.

Figure 32 - Risk analysis probability-impact matrix pro-forma for Step 3

item ("F/7"), which had a risk factor of 2. The surveyor said that it would be possible to make a notional allowance for this within the rates applied. This left only six items in the draft risk register, all with a maximum risk factor of 9, as shown in Table 6.

Step 4: Respond to the challenge presented by the risks

In continuing the development of the draft risk register shown in Table 6, the facilitator provided a standard "risk response brainstorming pro forma for Step 4", and asked the surveyor to generate ideas about how the risk factors for each item might be reduced. Here, with the exception of item "F/1", only one response action was suggested by the surveyor for each item, as shown in Figure 33. The facilitator next asked the surveyor to brainstorm again to determine if there are any "secondary risks" from the proposed responses, and, here, problems were identified for "F/1", "F/5" and "F/6", as seen in the "secondary risk brainstorming pro forma for Step 4" in Figure 34. The facilitator then asked the surveyor to loop back to analyse these secondary risks in a similar manor to Step 3, and, again, both items produced a maximum risk factor score of 9 (see Figure 34).

The facilitator then asked the surveyor to brainstorm again to generate ideas about how the risk factor for each of these secondary risks might be reduced with further response action, and here, for the "F/1/S" secondary risk (inaccuracy caused by interpolation from small scale drawings), the response proposed was to make the client aware that, in the circumstances, interpolation is the best available solution (see Figure 34). For the "F/5/S" and "F/6/S" secondary risks (confidentiality of project revealed to others), the surveyor proposed that all staff involved should not give details of the identity of the

INTERNAL BUDGET RISK REGISTER (PART COMPLETE DRAFT - TO STEP 3)

Ref.	Estimating problem identified	Probability of problem when estimating	Potential impact on the total project estimate	Risk ranking factor	Proposed response action [and secondary response action]	To action	Review date and intervals
F/1	No accommodation schedule or specifications, only limited small scale drawings available.	High	High	9			
F/2	Unique project, no suitable cost data in team library.	High	High	9			
F/3	Due to the size of the project, the overall estimate will be very sensitive to small rate variations.	High	High	9			
F/4	No details of extensive external works.	High	High	9			
F/5	No details of extensive external utilities.	High	High	9			
F/6	No details of extensive building cold stores and specialised processing equipment.	High	High	9			
~~F/7~~	~~The difficult nature of the ground – hard rock.~~	~~Medium~~	~~Low~~	~~2~~			

Table 6 - Draft internal budget risk register for the case illustration

RISK RESPONSE BRAINSTORMING PRO FORMA FOR STEP 4

Refer to the prioritised list of items produced in Step 3. For each of these, brainstorm to generate ideas about how the risk factors for each might be reduced.

F/1/R Request more information or build-up the estimate using global building and site areas, with interpolation where necessary.

F/2/R Look at some basic building types and use comparative rates or costs. i.e. cost/m^2 or other functional units.

F/3/R Carefully review the final estimate by discussing the level of pricing with other senior staff.

F/4/R Use judgement to apply a typical cost/m^2 to cover a suitable balance of hard and soft landscaping.

F/5/R Discuss with specialist disciplines, use judgement, and include a provisional allowance (s).

F/6/R Discuss with specialist disciplines, excluded from main estimate, and indicated a notional price range within the report.

NOTES FOR USERS OF THIS PRO FORMA

Note that, possible responses to risk may include, for example, pursuing information research by consulting specialists, site visits and investigations, requesting design information such as drawings, specifications, schedule of accommodation requirements, or plot ratio, and consulting a library or the BCIS for historical pricing data. See the RICS (1998) list of sources of cost information. The availability of resources will usually restrict the range of feasible response solutions, and, in some instances, where time is very limited, the best response may simply be a telephone call to someone who may provide help or give an opinion.

Figure 33 - Risk response brainstorming pro forma for Step 4

SECONDARY RISK BRAINSTORMING PRO FORMA FOR STEP 4

Select the perceived most viable response action to each prioritised item. Brainstorm again to determine if there are any secondary risks from the suggested responses.

Secondary risks identified		Analysis loop
F/1/S	Inaccuracy caused by interpolation from small scale drawings.	Risk factor = 9
F/2/S	Nil.	-
F/3/S	Nil.	-
F/4/S	Nil.	-
F/5/S	Confidentiality of the project revealed to others.	Risk factor = 9
F/6/S	Ditto.	Risk factor = 9

Proposed responses to secondary risks

F/1/S/R Make the client aware that interpolation is the best available solution in the circumstance.

F/5+6/S/R Inform all other staff involved, hereafter, that details of the identity of the project should not be given to external parties consulted for specialist information.

Note - no further responses are proposed as the optimum solutions have been decided.

NOTES FOR USERS OF THIS PRO FORMA

Secondary risks are problems that may materialise through implementation of the proposed responses. If secondary risks are apparent, loop back to Step 3, and analyse the secondary risk items, in a similar manner as before, i.e. by considering their probability and impact values to calculate risk factor scores. Repeat this response / analysis loop until the perceived optimum solutions may be confidently decided.

Figure 34 - Secondary risk brainstorming pro forma for Step 4

project to any external party consulted for specialist information (see Figure 34). The facilitator again asked the surveyor to brainstorm any secondary risks from the additional responses proposed, but, after consideration, the surveyor said that he was confident that the optimum solutions had been decided.

The facilitator next typed-up all the information in the pro forma's for Step 4 into the draft risk register, and then asked the surveyor to check the content, select personnel responsible for implementing the chosen risk response treatment, and, therefore, to delegate (if necessary) responsibility of items to appropriate staff. Finally, the facilitator asked the surveyor to decide how to monitor the response action by inserting a review date in the draft risk register, together with subsequent review intervals required, until satisfactory action is achieved. This allowed the first internal risk register to be completed, as shown in Table 7.

Step 5: Prepare the most likely estimate of cost for the project

Five further pro forma's were developed for use with Step 5, and the facilitator therefore provided the surveyor with the following:

- A "risk identification note pad", which asked the surveyor to "flag-up" any additional things that present a problem when preparing the estimate;
- An "estimate assumption note pad", which asked the surveyor to list all the assumptions that he includes within the estimate, together with those made by others that are involved in the project;
- A "provisional allowance note pad", which asked the surveyor to list all the provisional lump sum allowances that he includes within the estimate, but not to

INTERNAL BUDGET RISK REGISTER

Ref.	Estimating problem identified	Probability of problem when estimating	Potential impact on the total project estimate	Risk ranking factor	Proposed response action [and secondary response action]	To action	Review date and intervals
F/1	No accommodation schedule or specifications, only limited small scale drawings available.	High	High	9	Request more information <u>or</u> build-up estimate using global building and site areas, with interpolation where necessary [Inform client if interpolation used].	TL	10/06/99 then every 2 days
F/2	Unique project, no suitable cost data in team library.	High	High	9	Look at some basic building types and use comparative rates or costs. i.e. cost/m^2 or other functional units.	TL	10/06/99 then every 2 days
F/3	Due to the size of the project, the overall estimate will be very sensitive to small rate variations.	High	High	9	Carefully review the final estimate by discussing the level of pricing with other senior staff.	TL	On completion of the first estimate
F/4	No details of extensive external works.	High	High	9	Use judgement to apply a typical cost/m^2 to cover a suitable balance of hard and soft landscaping.	TL	10/06/99 then every 2 days
F/5	No details of extensive external utilities.	High	High	9	Discuss with specialist disciplines, use judgement, and include a provisional allowance (s) [All staff to retain confidentiality of the project's identity].	M&E	10/06/99 then every 2 days
F/6	No details of extensive building cold stores and specialised processing equipment.	High	High	9	Discuss with specialist disciplines, excluded from main estimate, and indicated a notional price range within the report [All staff to retain confidentiality of the project's identity].	M&E	10/06/99 then every 2 days

Table 7 - Internal budget risk register for the case illustration

include any contingency percentage allowance sums for any items;

- An "estimate exclusion note pad", which asked the surveyor to list all things that he excludes from the estimate, and to note that major unpredictable items should not be included in the estimate; and
- a "source of information note pad", which asked the surveyor to list all the sources of information used when preparing the estimate, including any new information that becomes available as a result of the response actions in Step 4.

The surveyor's estimate was prepared by applying indicative cost per square metre rates to the buildings and site development areas, that were measured from the drawings. There was insufficient time or resources to produce elemental approximate quantities, and the practice did not have the "Elsie" software to validate the estimate. Also, as the cost per square metre rate was used, there was little benefit for the surveyor to ensure that all items were allowed for by using the BCIS list of building elements as a prompt, because this was said by the surveyor to be only really useful for the approximate quantities method. Instead, the various cost per square metre rates of the estimate were "benchmarked" by comparing them to other similar projects.

Step 6: Review the status of the risks during the preparation of the initial estimate

Midway through preparation of the estimate, Step 2 to 4 of the conceptual model were repeated for all newly identified items. However, there was not time available to update the information contained in the risk register, instead, for speed of completing the task, it was possible to adapt and use the same pro forma's handed out in Step 5. Whilst working through and developing the estimate, four further items were identified. These were numbered with a "Q" (for "query") prefix, as shown in Figure 35. The following analyses and responses were subsequently carried out:

- "Q/1" produced a risk factor of 3, and response "A/1" was made - see Figure 36;
- "Q/2" produced a risk factor of 6, and response "P/1" was made - see Figure 37;
- "Q/3" produced a risk factor of 4, and response "E/1" was made - see Figure 38;
- "Q/4" produced a risk factor of 6, and response "A/2" was made - see Figure 36;

For the next part of the Step 6 review, the facilitator asked the surveyor to work through the internal risk register (see Table 7), from top to bottom, and review the status of each risk response action proposed. For item "F/1", two response actions had been proposed in the register. The first was a request for more information. However, this was not received, therefore, it was necessary for the surveyor to build-up the estimate using global building and site areas, with interpolation where necessary. The assumptions made were recorded in the estimate assumption note pad pro forma (see Figure 36), as items "A/3", "A/4", and "A/5".

For item "F/2", the proposed response action was implemented and the sources of information referred to were recorded in the note pad pro forma in Figure 39, as items S/3. This was also the case for item "F/3", with response item "S/4". For item "F/4", judgement was used to apply cost per square metre (cost/m2) rate to cover a typical balance of hard and soft landscaping, but no assumptions were recorded. For items "F/5" and "F/6", the response action was delegated to another surveyor ("M&E") in the team who contacted specialists to obtain information, and the sources of information were recorded as item "S/5" (see Figure 39). Also, for "F/6", the exclusion of the cost

RISK IDENTIFICATION NOTE PAD PRO FORMA FOR STEP 5

Whilst working through and developing the estimate, "flag-up" any things that present a problem, that have not previously been identified.

		Analysis risk factor	Response ref.
Q/1	Some of the proposed ancillary buildings are located within the existing car parking zones, will a reinstatement of existing surfaces be required?	3	A/1
Q/2	It is understood that the nature of the land necessitates extensive site preparation works, which have been estimated by others in the concept design report - can their figure be accepted, or is a further estimate required?	6	P/1
Q/3	An overhead high tension electricity line will need to be relocated before development can commence - is an estimate required?	4	E/1
Q/4	We have measured the total gross floor area of buildings from the drawings, however, we note that the concept design report shows a figure of 20% higher?	6	A/2

NOTES FOR USERS OF THIS PRO FORMA

Note that the estimate should represent the perceived most likely cost, based on the information available. Prepare the first budget estimate by following one of the conventional base estimating methodologies for calculating building construction costs. The best approach is to produce an elemental "approximate quantities" estimate, and then validate the outcome using "Elsie". However, time, information, and software limitations may mean that sometimes the more basic "cost per square meter floor area" or "functional unit" methods can only be used. Use the BCIS list of building elements as a prompt, to ensure that all items are allowed for. Refer to the RICS guidance for a recommended format for the budget report.

Figure 35 - Risk identification note pad pro forma for Step 5

ESTIMATE ASSUMPTION NOTE PAD PRO FORMA FOR STEP 5

List below all assumptions that you make and include within the estimate.

A/1 As the external ancillary buildings are located within the existing car parking zones, it is assumed that a certain amount of making good and/or reinstatement of existing surfaces is required (response to Q/1).

A/2 The difference in gross floor area of buildings may be linked to either the method of measurement adopted, or the small scale drawings and our interpretation areas. However, we have assumed that our measure is correct (response to Q/4).

A/3 The general layout drawings supplied for the factory units are for one unit only. Measurement of the remaining units has been achieved by adjusting the areas of the one unit where information was available in accordance with the basic differences shown at ground level on the large scale site layout drawing. Measurement of the ancillary buildings was also taken from the site layout drawings (response to F/1).

A/4 With the exception of the five factory units, we have assumed that all other buildings and structures will be of single story construction (response to F/1).

A/5 It is assumed that the factory units will be constructed to a sound, but basic specification, with clean washable finishes where necessary, and requiring special steel flooring, and drainage sumps, in the manufacturing and stock holding areas (response to F/1).

A/6 Ground assumed to be all hard rock (response to F/7).

NOTES FOR USERS OF THIS PRO FORMA

It is important to be explicit about all assumptions made by all those parties involved in the project.

Figure 36 - Estimate assumption note pad pro forma for Step 5

PROVISIONAL ALLOWANCE NOTE PAD PRO FORMA FOR STEP 5
List below all the provisional lump sum allowances that you include within the estimate.
P/1 It is understood that the nature of the land necessitates extensive site preparation works, and the estimate prepared by others in the concept design report has been used as a provisional lump sum allowance (note that this is the response to Q/2).
NOTES FOR USERS OF THIS PRO FORMA
Do not include any "bunse" or "contingency percentage allowance" sums for any items in the estimate.

Figure 37 - Provisional allowance note pad pro forma for Step 5

ESTIMATE EXCLUSION NOTE PAD PRO FORMA FOR STEP 5

List below all items that you exclude from the estimate.

E/1 Exclude the cost of an overhead high tension electricity line, needing to be relocated by authorities before development can commence (response to Q/3).

E/2 Exclude the costs for the factory units furniture, fittings, and equipment, for which there are no schedules or specifications for type and quality. We believe that the addition of furniture, fittings, and equipment, to produce a turnkey tender, could result in an overall increase to the gross rate of perhaps 50% or more (response to F/6).

NOTES FOR USERS OF THIS PRO FORMA

Note that major unpredictable items should not be included for in the estimate because it is not possible to arrive at a sensible allowance, instead, they should be excluded and then reconsider later by the client.

Figure 38 - Estimate exclusion note pad pro forma for Step 5

SOURCE OF INFORMATION NOTE PAD PRO FORMA FOR STEP 5

List below all the sources of information that you use when preparing the estimate.

S/1 Architect's concept design report.

S/2 Twelve A1 drawings, showing conceptual general layouts, sections, and elevations, at a scale of 1:500, and the site layout drawings at 1:2000.

S/3 The estimated figures were compared with the team's estimate for the analysis and pricing of the bills of quantities for a new, modern, similar type of factory in a different city. The gross rates for the various types of the main and ancillary building ranged between -30% or +30%, but still, exclusive of certain items of specialised equipment (response to F/2).

S/4 Carefully review the final estimate by discussing the level of pricing with other senior staff, Ms. SS and Mr. ME (response to F/3).

S/5 Telephone discussions with suppliers and subcontractors, ABC & Co. and XYZ Ltd. supplied rates (response to F/5 and F/6).

NOTES FOR USERS OF THIS PRO FORMA

Incorporate with the estimate any new information that becomes available as a result of the response actions taken in Step 4.

Figure 39 - Source of information note pad pro forma for Step 5

of the factory units furniture, fitting, and equipment, was noted in the estimate exclusions note pad, as item "E/2" (see Figure 38).

Although the groundwork "hard rock" item "F/7" was eliminated from the internal risk register (see Tables 6), the surveyor still realised that an assumption had to be made in his pricing, and this was, therefore, recorded in the assumptions pro forma as item "A/6" (see Figure 36). Perhaps, in hindsight, this item should have been retained in the risk register, as an evaluation of its importance was possibly made too early. In future use of the model maybe no risks should be cut-off the register until Phase "II", rather, to just limit the detailed analysis and response process to the greater problems identified. Further to this, it is quite plausible that the risk factor for items could change when the surveyor(s) gains a deeper understanding of the information available.

Finally, for Step 6, upon satisfactory completion of the first estimate, all mathematical computations and major quantity measurements were checked for accuracy by an assistant surveyor.

Step 7: Produce the report for the baseline budget estimate

The surveyor's original budget estimate report for the client comprised seven pages, with an outline cost estimate for the proposed development. Contents also included a brief introduction explaining the methods used, a project description (statement of inclusions / quality and specification parameters), project documentation available, a break down of twenty-two cost items, a schedule of gross floor areas, and the surveyor's comments on the estimate. The text commentary included provisional lump sum allowances, assumptions made, sources of information used, and items excluded were explained. It is argued that much of the key information could, however, be summarised more effectively in a project risk register, as will now be developed in Phase "II" of the conceptual model.

7.3.3 Phase II - Risk management report

<u>Step 8: Focus on the required content of the risk management report</u>

The first step of Phase "II" of the model case illustration was to determine what content is preferred in terms of a risk management report for the client in question. This took the form of a one-to-one meeting between the facilitator and surveyor, and perhaps was more of an interview than a brainstorming session. The client for this case illustration project "*tends to view matters in black and white*", and ideally likes to see the quantity surveying team produce an estimate equal to the lowest tender, as their funding will be based on this. Consequently, the client "*does not accept contingency percentage allowances*", but, if the surveyors have any doubts or reservations regarding the pricing, they are expected to "*qualify the estimate in words*". They may also make due allowance for unknowns within pricing. However, the client is, in turn, answerable to a high level budget department, and, if the team have difficulty in estimating projects with specialist designs and installations, the client is appreciative of any sensible advice, comments, or qualifications, that should be attached to the budget estimate report. These attachments should show to what degree the project has been understood and researched, despite any difficulties, and in some instances, estimated items may be described as provisional.

In deciding what output is expected and acceptable, with the resources and time usually available to produces a risk report, the following enhanced information targets were proposed by the facilitator, and subsequently agreed by the surveyor:

- A definition of the key estimating problems identified;
- Calculation of a risk factor score for ranking of problems;
- Explanation of the method adopted to mitigate the estimating risk;
- Recommended possible further action to improve the certainty of the estimate; and a
- Team "risk rating" for the total project estimate.

It was decided that the best means of structuring this risk report for the client would be, similarly to Phase "I", in a concise, but well defined, budget risk register format, perhaps limited to a single A4 sheet of paper. The output would, therefore, be mainly qualitative, rather than quantitative. The main reason for this was that the client was seeking a definitive, rather than risk qualified, estimate of construction costs, and it was thought that, in the circumstances, the best that could be done would be to highlight the key estimating problems faced, prioritise them for possible future client action, explain the method adopted to respond to the challenge, and suggest optional future actions to improve the certainty of outcome. In addition, concerning the five bullet points above, the team "risk rating" for the total project estimate would instantly give the client an indication of risk level of the project, relative to other projects in the portfolio.

Concerning the utilisation of quantitative tools and techniques, these methods were not well understood by the surveyor or the client, further to this, software to support such methods was not available in the practice. It was anticipated that, should the qualitative aspects initially prove to be successful and viable, then the model could continue to be developed by incorporating these sophisticated tools at a later stage.

Step 9: Identify the risks in the baseline estimate

As the same surveyor had undertaken Phase "I", he already fully understood the content of the baseline budget estimate report, and the key items that could deviate and cause the actual cost outcome of the project to change from the baseline first figure. When asked by the facilitator to spend further time to reflect and brainstorm to generate a new list of any things that were not identified in Phase "I", but could still influence the total outcome, no further items were listed. The facilitator therefore suggested that the surveyor could involve other people in this step, to make best use of experience available within the team, in a brainstorming workshop. However, on this occasion, the surveyor chose not to involved other members of staff, as they were all very busy with other tasks in the office. Instead, the facilitator then provided the surveyor with a list of reasons for causing building projects to finish over budget (see Table 1 in Chapter 5), but, similarly to Step 2, no further risks were identified. Perhaps the lack of increase to the number of risks identified in Phase "I" showed that, by adopting the internal control risk management model, the surveyor was also identifying the things that could pose a risk to the client.

Step 10: Analyse the risks and quantify the range of possible outcomes

The facilitator asked the surveyor to refer to the internal project risk register completed in Step 4 (see Table 7), together with those items identified, analyses, and responded to during development and review of the first estimate, in Steps 5 and 6 respectively (see

Figure 35 to 39). Similarly to Step 3, the facilitator asked the surveyor to consider the risk factors previously calculated, and, where appropriate, to make any required revisions. However, despite the response actions implemented in Phase "I", the surveyor made no adjustment to the original risk factor scores. All items (from Table 7 and Figure 35 to 39) were therefore compiled by the facilitator in a draft client risk register, and ranked according to their risk factor score.

The surveyor was then asked to decide a cut-off point, for risks that can reasonably be left to their own fortune, and, therefore, to limit the list of risk items by prioritising on only those risks that have the greatest risk factor and need to be evaluated in more detail. It was explained by the facilitator that, some published guidance texts recommend that a sound aim is to prioritise the key risks, perhaps five and ten in number, which can then be analysed in more detail (e.g. Thompson and Perry, 1992, and Norris, et. al, 1993). The same cut-off point as Phase "I" was decide by the surveyor, that is, for items which had a risk factor of less than the maximum score of nine. This, again, left only six items in the draft client risk register, which, incidentally, were exactly the same items that were included in the completed internal risk register in Phase "I" (see Table 7).

The next task suggested by the facilitator was the further analysis of the key prioritised risks, by using quantitative tools and techniques, to allow the interpretation of the range of variance between the best case cost and the worst case cost, and then ultimately to make probabilistic adjustments to provide a risk-adjusted total estimate for the project. However, despite receiving some training and notes from the facilitator on MERA, sensitivity analysis, EMV, decision tree analysis, decision matrix, and Monte Carlo simulation, the surveyor preferred to keep the analysis simple, because the primary concern of determining which risks warrant a response by the client had already been achieved through the probability-impact matrix analysis risk factor scores. Also, it could be argued that, a further reason for not using a more sophisticated quantitative approach, was due to lack of time, and computational aids.

The facilitator next asked the surveyor if he would be happy to present a risk register to the client, that consisted of six risks, that were each of identical (maximum) risk factor scores. The surveyor did not believe that this was a problem, because it clearly underlined the level of uncertainty surrounding his estimate. However, he did feel that it would be preferable to put the risks into some refined ranking order, even if the difference was only nominal, and, as the surveyor had some experience of using "value engineering" techniques, he suggested to the facilitator that the use of a weighted comparison tool could be used (such as that described by Dell'Isola, 1997). Although the facilitator preferred the use of a more detailed probability impact matrix (e.g. a 5 x 5 grid, instead of 3 x 3), it did seem inappropriate to change the matrix mid-way through the model case illustration. In addition to this, the facilitator thought that it was a positive sign that the surveyor was suggesting an idea, and, by taking on board his proposal, would motivate the surveyor more by making him feel that he had contributed to the development of the model.

The technique proposed by the surveyor worked by comparing the potential impacts of each risk item against each other, and scoring, on a 1 to 4 scale, whether impact is equal

(1 point), greater by "minor" (2 points), greater by "medium" (3 points), or greater by "major" (4 points). The total score for each risk was then calculated by summing the points together, and this determined the final ranking of risks for the client. The resulting "risk ranking impact-comparison matrix" is shown in Figure 40. To complete this tenth step. However, the facilitator summarised the results in the draft client risk register, but, it was preferred by the surveyor not to show the comparison matrix scores to the client, instead, simply to use the analysis for ranking purposes. Finally, risks were numbered with an "R" (for "risk" prefix), from top to bottom.

Step 11: Recommend response actions to improve the certainty of the baseline estimate

In Step 11 the facilitator provided the surveyor with the typed analysis summarised in the draft client risk register produced in Step 10, and asked him to brainstorm to generate ideas for reducing the cost range of each item, and hence, suggest the information and actions necessary to improve the certainty of outcome of possible future estimates for the project. This meant defining enhancement actions for opportunities, and response actions for threats, and it was emphasised by the facilitator that, although during the analysis stages of the model (Step 10) risks were not quantified in detail, the identification of effective responses can still be very useful.

Upon completion of the surveyor's brainstorming session to generate risk response ideas, the facilitator asked the surveyor to select the perceived most viable response action to each risk. The facilitator warned the surveyor that care should be taken when considering the management actions available, to ensure that the potential impact of each risk is not outweighed by the direct cost of reducing the risk, transferring the risk,

COMPARISON OF POTENTIAL IMPACT

	F/2	F/3	F/4	F/5	F/6	Total score	Ref.	Revised ref.
F/1	F/1 - 3	F/1 - 3	F/1 - 3	F/1 - 3	F/1 - 2	14	F/1	R/1
F/2		F/2 - 2	F/4 - 3	F/5 - 3	F/6 - 3	2	F/2	R/5
F/3			F/4 - 3	F/5 - 3	F/6 - 3	0	F/3	R/6
F/4				F/5 - 2	F/6 - 2	6	F/4	R/4
F/5					F/6 - 2	8	F/5	R/3
F/6						10	F/6	R/2

Points:

1 Equal impact.

2 Greater impact - Minor.

3 Greater impact - Medium.

4 Greater impact - Major.

Problem:

F/1 No accommodation schedule or specifications, only limited small scale drawings available.

F/2 Unique project, no suitable cost data in team library.

F/3 Due to the size of the project, the overall estimate will be very sensitive to small rate variations.

F/4 No details of extensive external works.

F/5 No details of extensive external utilities.

F/6 No details of extensive building cold stores and specialised processing equipment.

Note:

i. The final ranking of risks was determined by the above total scores.

Figure 40 - Risk ranking impact-comparison matrix

or all the associated management and administrative time and fees. On selection of response actions, the facilitator asked the surveyor to brainstorm again to determine if there are any secondary risks from the proposed responses. However, no secondary risks were identified, and it was, therefore, unnecessary to loop back to Step 10. The facilitator revised the client risk register, which now included a concise summary of the recommended response for the client to consider implementing. The completed client budget risk register is shown in Table 8.

It can be seen that the possible further response actions to improve the certainty of the estimate are mainly related to the production of better information, e.g. outline specification and drawings. Another interesting, but perhaps not surprising, response proposed, was to allow the team more time to carry out external research, and to do an "approximate quantities" estimate on receipt of better information. The surveyor also emphasised, in risk reference "R/6", that risk is inherent in a project of this scale, thus, confirming that, no matter how thorough and comprehensive the model may be, it cannot control all risks, and, to a certain degree, there is a need to accept some level of residual risk in an estimate.

The final task of Step 11 was for the surveyor to consider the completed risk register, and all information produced by the risk management model, and to classify the risk status of the project by assigning a project "risk rating" score. Had more detailed quantitative analysis been possible, this may have been derived by calculating the percentage deviation of the risk-adjusted estimate from the baseline estimate, and comparing it to a typical "contingency percentage allowance" usually expected for this

CLIENT BUDGET RISK REGISTER **RISK RATING FOR THE TOTAL ESTIMATE = HIGH RISK**

Ref.	Estimating problem identified	Probability of risk in the estimate	Impact on the total project estimate	Risk ranking factor	Method adopted to mitigate the estimating risk	Possible further response action to improve the certainty of the estimate
R/1	No accommodation schedule or specifications, only limited small scale drawings available.	High	High	9	Estimate built-up using global building and site areas, with interpolation where necessary.	Produce an outline specification, together with larger scale plan, section, and elevation drawings for each building.
R/2	No details of extensive building cold stores and specialised processing equipment.	High	High	9	Discussed with specialist disciplines, excluded from main estimate, and indicated a notional price range within the budget estimate report.	Produce an outline specification and drawings for the cold stores and the specialised processing equipment. Contact suppliers for advise.
R/3	No details of extensive external utilities.	High	High	9	Discussed with specialist disciplines, judgement used to include a provisional allowances.	Produce an outline specification and drawings for the external utilities.
R/4	No details of extensive external works.	High	High	9	Judgement used to apply a typical cost / m^2 rate to cover a suitable balance of hard and soft landscaping.	Produce an outline specification and drawings for external works.
R/5	Unique project, no suitable cost data in team library.	High	High	9	Study of basic building types and use of comparative rates, i.e. cost / m^2 and other functional units.	Allow more time for the quantity surveying team to carry out detailed external research, and to do an approximate quantities estimate on receipt of better information.
R/6	Due to the size of the project, the overall estimate is very sensitive to small rate variations.	High	High	9	Careful review of the final estimate, including discussing the level of pricing with other senior staff.	Need to accept that a risk of this nature is usually inherent in a project of this scale.

Table 8 - Client budget risk register for the case illustration

type of project. However, as this was not viable (also because contingency percentage allowances are never used with this client), it was only possible for the surveyor to take an informed view, based on the enhanced budget information available to him in the client risk register, and to classify the project by simply assigning a budget estimate "risk rating", of "high", "medium", or "low". Again, the surveyor preferred not to involve other members of the team in this process. It was, however, agreed between the facilitator and the surveyor, that this was a rather subjective way to end such a comprehensive process. However, from a learning point of view, it was useful, because it highlighted an aspect of the model which could be developed in the practice to provide a useful instant executive evaluation of the overall budget risk. This could then be most helpful for the client when needing to make quick strategic executive decision to proceed, or otherwise, with the project.

Step 12: Produce the budget risk management report

The finally step of Phase "II", and also of the model, was to produce the budget risk management report. Before delivering the report to the client, the facilitator asked the surveyor to check that there was no bias in the report from using subjective wording that could be misinterpreted. The resulting key deliverable of the budget risk report was the risk register shown in Table 8, including the recommended response actions, and a estimate risk rating score. In this first instance, although no quantitative risk-adjusted estimate or range of possible outcomes was produced, the risk register was summarised concisely, in an executive tabulated format, on one side of an A4 sheet of paper.

The budget risk report could, perhaps, be improved upon in the future, with appendices that may include the graphical decision aid of risk analysis results from the software, an explanation of the methodological approach taken, including reference to tools and techniques used, a list of people involved, and guidance on how the quantitative results should be interpreted. However, it was accepted by the surveyor that this first case illustration attempt was a starting point that provided the basic, but essential, infrastructure within the practice, with the potential to make the systematic risk management process more sophisticated in the future. It was also agreed that the words produced from the risk management process were just as important ("*if not more?*") as the numbers that may be generated from computer software. The next steps, which are outside the boundaries of this model, are to be taken by the client, in perhaps deciding whether or not to continue with the project.

7.3.4 Validation of the model

Approximately six months after the first estimate was produced for the above case illustrated project, further information was subsequently provided to the quantity surveying practice. During this intervening period the team had no involvement in the project, and, therefore, had no direct control of the cost or influence on the development of the design. For the purpose of this research, it could be argued that the practice was consequently consulted to provide a revised estimate for the client due to the initial high risk in the first estimate. The second budget estimate report was prepared by a different (senior) surveyor, but the surveyor was not provided with the knowledge of the first conceptual model case illustration results. Therefore, validation could be assumed to be on a completely different project. This was agreed between the facilitator and the team leader to be, in the circumstances, the best means of initially testing the model.

The general scope and description of the project remained very similar to before, however, the design information had advanced significantly. The project documentation provided to the practice now consisted of six bound copies of the bills of quantities (BQ), and three sets of drawings, including site works and standard details (but still for only one of the main factory buildings). All the bills of quantities were entitled "Tender documents", while the drawings were stamped "Draft final design". The surveyor pointed out that the bills of quantities provided by the client could more accurately be described as a schedule of works, and, for some items, it was the responsibility of the tendering contractor to quantify and value these items from the detailed drawings. Therefore, in several instances, it appeared that the tendering contractors were required to provide a design input into the project. However, no specification or contact conditions were provided, and it was, therefore, not possible to definitively establish this issue.

The surveyor's estimate of cost was based on the bills of quantities, however, it was not possible, in the minimal time allowed by the client, to check the quantities for accuracy. The estimate was generally compiled using rates from the team's in-house cost database, or, when no historical data was available, by allowing a provisional lump sum allowance, or simply by using professional judgement. An example of this problem was for the structural steelwork section of each factory unit, where there was no information as to the extent of the works, and the surveyor's price was therefore based on a cost per square metre rate, which was then converted to a provisional lump sum allowance. A further estimating problem was that no details of any contractual conditions applicable to this project were provided within the documentation available. The surveyor could not, therefore, report in detail on this aspect, other than to add that should the works on the project be phased, then it may be prudent of the client to include an allowance in their budget to safeguard against any cost increases which may arise.

It was agreed by the facilitator and the team leader that a reasonable measure of initial success of validating the demonstration of the model would be the final client risk register produced, and the associated risk rating. These are the key deliverables to the client from the model. Table 9 summarises the client budget risk register from the step-by-step model validation exercise carried out. On this occasion, eight risks were identified, however, only one of the risks ("R/1") scored a maximum risk factor of 9. The overall project risk rating was subsequently assessed by the surveyor as being "medium". Therefore, it was reduced from being 'high', in the first pass case illustration assessment. The main reason for this was that better information was made available to the surveyor. The need for this additional information to improve the certainty of the estimate was highlighted in first case illustration of the client budget risk register (see Table 8).

At a subsequent discussion between the senior surveyor, team leader, and facilitator, it was agreed that the effectiveness of the conceptual risk management model as a systematic process was satisfactorily demonstrated. Generally, the second demonstration of the model was smoother flowing, probably because of the experience that the facilitator had gained from the first pass example. It is, however, important to note that, the final risk rating still relies upon the intuitive judgement of the surveyor from the results created. Nevertheless, because of the new information which was

CLIENT BUDGET RISK REGISTER

RISK RATING FOR TOTAL ESTIMATE = MEDIUM RIS

Ref.	Estimating problem identified	Probability of risk in the estimate	Impact on the total project estimate	Risk ranking factor	Method adopted to mitigate the estimating risk	Possible further response action to improve the certainty of the estimate
R/1	Steelwork has been measured as a lump sum in the BQ, and no drawings show details (contractor to design?).	High	High	9	Price based on cost / m2 rate and converted to provisional lump sum allowance.	Produce missing drawings and a BQ for the steelworks.
R/2	BQ is generally insufficient.	Medium	Medium	4	Obtained scope of works from drawings.	Re-measure BQ from drawings.
R/3	BQ concrete items are lumped together as "above and below ground".	Medium	Medium	4	Re-measured the concrete in Unit 1 and used the rates for other units.	Re-measure all the concrete works.
R/4	BQ not fully checked for accuracy, but quantities are wrong for Unit 1, e.g. 3 No. lifts in BQ but 2 No. on drawings.	Medium	Medium	4	Priced as BQ.	Re-measure the BQ.
R/5	No details are available for the office furniture, office equipment, and kitchen equipment.	Low	Low	1	Priced as provision lump sum allowance.	Produce full specification and details.
R/6	Items are missing from BQ, e.g. demolitions, weigh bridges, road sub-grade.	Low	Low	1	Added the cost to the estimate.	Re-measure all the BQ.
R/7	Drawings for Unit 1 only.	Low	Low	1	Assumed Units 2 to 5 are of similar construction.	Produce missing drawings for other units.
R/8	Phasing of contract will affect contract overheads and profit percentages.	Low	Low	1	Assumed let as one contract.	Produce Conditions of Contract and check phasing.

Table 9 - Client budget risk register for the model validation exercis

available in the risk register, a more informed judgement was made and the reliance on intuition was therefore reduced.

7.4 Refinements to the model

Generally, during the case illustrations, the conceptual model performed satisfactory, with no major refinements required. The most significant addition was the extensive use of standard pro forma's throughout the model, which proved to be most beneficial in recording each step, helping to facilitating the process, and also useful by leaving a documented audit trail of the information inputs and outputs. Also, the use of relevant referencing prefixes (e.g. "N" for noted, "B" for brainstormed, "F" for framed) for items was worthwhile for cross referencing of identified risks and their subsequent responses.

With respect to other tools and techniques used, brainstorming proved to be the most valuable, and perhaps the performance could be improved further if other members of the team were involved by broadening the range of experience available. Also very effective was probability-impact matrix analysis, but there is a question as to whether a more detailed grid (e.g. 5 x 5) would perform better for ranking risks in the future. This could include probability percentage numbers for the likelihood axis, and financial values for the impact axis. Although the suggested model prompt sheets did not add to the exercise with the first two case illustrations, it is perhaps worth leaving them in the model for the time being, as they may perform differently in other situation, i.e. where a sufficient number of risks cannot be identified instinctively (the surveyor might even be having an "off day"), or they could help less experienced surveyors to identify potential problems. However, in contrast, pro formas that include notes and prompts provided improved guidance and helped the users to understand the model.

Types of risks identified through demonstration of the model were mainly incomplete design, lack of information, and poor quality brief, as per the second, third, and fourth respective rankings of causing building projects to sometimes finish over budget (see Table 1 in Chapter 5). This specifically included things such as a lack of specification, incomplete drawings, no schedule of accommodation, and poor details of specialist equipment. Difficult ground conditions, ranked eighth in Table 1, with unforeseen works and site conditions, were also identified by the first surveyor. The model could maybe have failed to address the main reason for causing building projects to sometimes finish over budget, i.e. changes to the project, and perhaps this could be considered a potential weakness that needs to be reviewed in future testing.

A further potential flaw in the model was that when the first surveyor was asked to clearly define the descriptions after the brainstorming session in Step 2, items "N/1", "N/2", "N/3" (see Figure 29), and "B/10" were all merged to form "F/1" (see Figure 31). However, the resulting description probably became too generic and lost specific key words, such as "small scale drawings for only one of the five main factory buildings" ("N/2"), and "lack of detail for extensive ancillary buildings" ("B/10"). Further, the key words "link road" was lost from item "B/5" when defined for "F/5". However, generally, the clarity of other descriptions was improved and made more concise. Therefore, in refining Step 2 of the original conceptual model, the defining of each item should follow the grouping of similar items together and the elimination of any duplication, and descriptions should be as concise as possible, but without eliminating any key words.

There is also a question as to what risks should be "cut-off" from the risk registers, as, it was found that items that were originally eliminated, came back into light at a later stage, e.g. when the first surveyor was estimating for "hard rock" groundworks (see Figure 36). Response actions generally were related to producing more design information and cost data, or consulting other members of the team and external specialists, but secondary risks from proposed response actions surprisingly still had maximum risk factors following the "loop back" analysis. Again, this may be interpreted as further evidence that the probability-impact matrix needs refining. Also, a further potential addition to the model may be to use a "cost-influence" matrix, as discussed by Noor and Rye (2000) (see Chapter 3).

7.5 Feedback on the model performance

Following the two case demonstrations illustrations of the conceptual model, a presentation was held at an RICS branch meeting (Jackson, 1999), and an internal practice paper was prepared by the facilitator and copied to the client. One year after this point, the practice was contacted to obtain additional feedback in order to draw further conclusions as to the practical performance of the model. The team leader was interviewed via e-mail. However, unfortunately, "*as with most articles and the like sent to the client*", the practice received no feedback. The team leader said that the client is not in the habit of querying what the team write about, unless he sees a particular relevance, or, say, an immediate practical application or use. He had raised the matter at a recent meeting with one of the client's directors, but the only reply was, "*could the team ensure that future client copies were bound*" !

Part of the team's service is to keep the client informed of topical developments within the construction industry, and this is usually done by the preparation of articles, studies, and the like, similar to the team's paper on risk management. The process is intended to cover a broader cross section of topics than would necessarily be relevant to the client's immediate needs, or day to day duties, and, in this way, they may simply enhance and update the client's general knowledge of the industry as a whole. For example, more recent articles have covered the dangers of asbestos, the use of solar energy, and the operation of UK's Export Credit Guarantee Department. Subjects which are not of daily practical use, but a knowledge of which may assist in the future, if, and when, needed. It may also be construed that the subjects the team research are relevant in the field of continual professional development.

The team leader said that another reason for lack of feedback "*may also be down to a difficulty interpreting technical English commentary*", although, occasionally, the client has asks for the reports and articles to be translated into his own language, but only once in the past four years. Also, he said that the client may even be accused of lacking interest in matters other than specific job duties, and that the client is responsible to another body, and both are seeking definitive answers, often on previously designed and tendered projects. In other words, he believes that, "*in the eyes of the client, risk management is of academic interest only*". By way of supporting some of the team leader's own statements, he advised that several years ago the team prepared a paper on "value engineering", but, only in more recent times has the client come forward with any queries on the content, "*presumably because a specific relevance had arisen*".

The team leader also said that the team had not further developed or implemented the model internally, and said that "*risk management is not really suitable for our own work and has not been further employed*". When asked why he felt that this was so, he replied that the team normally receive a "snapshot" of the construction projects, usually around or after tender stage, and are tasked with providing a one-off cost estimate, as accurate as possible, in order for the client to determine the specific amount of money he will fund. Needless to say, there is an obvious amount of risk in preparing the evaluations, but, he correctly believes, that the true and intended process of risk management should commence at the outset of design and be applied throughout the subsequent live stages of development. He thought that to condense the process through a single, "*often hurried estimate*", requires adaptation, and, "*whilst a good practical solution was devised to suit, the team found that the final risk rating was ultimately too subjective, with little or no time available for possible mitigating action*".

It is clear, therefore, that at the stage the team receive information, they are invariably unable to exert the influence that a properly timed risk management model could achieve. Nevertheless, the team leader said that the theoretical risk management model proposed as an example "*gave the team, and, hopefully, the client, an interesting and informative insight into the theory and techniques of the process*", and the paper produced "*serves as an excellent platform for further reference and totally fulfils the objective of explaining to the client in relevant, simulated terms, how the system works*".

Concerning the apparent weakness identified in the model, this being that the team found that the final risk rating was ultimately too subjective, it was subsequently proposed by the researcher that Railtrack's (2000) "Approach to rating project progress" could be used, which is an example of a brand new cost estimation rating technique for projects, and is shown in Table 10. However, the team leader said that he was not certain how he should respond to this, because Railtrack's methodology is multi-phase over a minimum period of four to six months, whereas the team usually enter at the ultimate "Level 5", with perhaps four to six days to complete their estimate (and the possible risk report). He said that the heads listed under each level are usually noted and commented upon as necessary within the team's reports, but the team leader could not envisage any form of modified use.

During the interview the team leader added that the team do impose a form of risk management "*by qualifying each estimate relative to it's complexity and uncertainties. This is achieved by stating the basis of pricing, what assumptions have been made, the type of specialist advice requested, etc.*", and the team, therefore, cannot be held negligent if a sound explanation and approach to their pricing is described. He said that although this may also sometimes be subjective by relying on the skills of the project surveyor, the experience of the team as a whole is usually sought when difficulties are encountered. Bearing in mind that the defined team structure necessitates the employment of a widely experienced group of people, he believes that "*this alone should ensure good quality and risk control*". He is not at all against the various forms of risk management techniques available, but is not convinced that the team can find a solution to suit their own unique type of costing service, because they are basically a rapid action force with a level of staffing competence chosen to mitigate the potentially risky circumstances under which they work, and, for the time being, he believes that, "*this remains our best system*".

Level 0

Project scope is not defined and hence neither are inputs or outputs.
No understanding of technical impact of project.
Cost and programme are unknown.
The project is no more than an aspiration.

Level 1

Project has entered pre-feasibility phase.
Strategic scope has been developed. Principal inputs and outputs identified.
Initial engineering options identified.
Order of magnitude cost estimate developed.
Project contains extremely high levels of uncertainty and risk.

Level 2

Project pre-feasibility work nearing completion/completed.
Outline project scope developed and major elements of work and options identified.
Outline programme developed.
Workstream costs developing from order of magnitude estimate.
Project contains high level of uncertainty and risks.
Project developed to the point of commencing feasibility phase.

Level 3

Project is within feasibility phase.
Project scope inputs becoming detailed with engineering studies and option development well under way.
Outline programme developed.
Value and risk management workshops completed.
Works costs evolving.
Project contains moderate levels of uncertainty, known risks have been qualified.

Level 4

Feasibility phase works nearing completion/completed.
Project scope and preferred engineering solution identified.
Project programme developed and budget assessed.
Estimate developed for all work packages.
Project contains moderate levels of uncertainty, all risks have been quantified.
Project developed sufficiently to commence detailed design.

Level 5

All design development work completed.
Engineering design completed.
Programme fully costed and resource loaded.
Cost plan established and contracting strategy defined.
Approvals and consents obtained.
Project developed to the point of commencing physical implementation.

Note:

The timescale for reaching a level 5 rating is as follows:

1. Renewals type of scheme of a simple nature - 4 to 6 months.
2. Single-discipline simple enhancements - 9 to12 months.
3. Complex multi-discipline enhancements, usually simple section of route or site - 12 to 18 months.
4. Major route upgrade - in excess of 18 months. In many cases such schemes would require TWA or other planning processes.

Table 10 - Railtrack's approach to rating project progress

(Source: Railtrack, 2000)

The case illustrations of the model demonstration concentrated on the qualitative aspects to risk management, but suggestions were made how the performance of the model could further be enhanced by using quantification tools and techniques, for example, by using a computer with Monte Carlo simulation software. The team leader said, despite his continuing reservations, he did not doubt that a computerised simulation could also be used to help. Nevertheless, they have to consider the practical use, timing, cost, and ultimate, the effectiveness of such a system relative to the team's particular circumstance and need. And, whilst he compliment the enthusiasm for seeking an ideal solution, he believed that the practice's client service brief is far too restrictive to encompass any new form of scientific risk management. By the time the team's estimates are compiled, he believes that they already know, by intuitive experience, what range of price or risk is entailed, and this is explained and suitably qualified in the team's reports. He did, however, say that, he "*would be fascinated to compare the team's estimates with those of a computer simulation*".

The team has been operating with the same client for nearly twenty-five years, and the client, who should have access to the real or actual costs, still appears to be very happy with the team's results. The team leader said that they are not blinkered to improvement or change, and their IT development is witness to this, but, it has to be useful and demonstrably so. Although it was agreed that a cost estimate prepared by a multi-diciplined project team with appropriate knowledge and competency should almost ensure good quality and risk control, it was argued that the intuitive approach can be enhanced by using a more formal and systematic approach to risk management, albeit simplistic to begin with.

It was also argued that although most of the team's projects are at "Level 5" on Railtrack's scale, the quality of the design information and the availability of relevant cost data can vary somewhat. It was suggested that perhaps a similar project rating scale for the team's work could be developed with, say, "Level 1" being "No drawings, no specification, no bills of quantities, and no available cost data", and through to "Level 5" being "Full set of drawings, detailed specification, complete bills of quantities, and good cost data availability". A further form of modification to how risk could be quantified might be simply to use a plus or minus contingency percentage allowance to the scale, e.g. Level 1 = 25%, Level 2 = 20%, Level 3 = 15%, Level 4 = 10%, and Level 5 = 5%.

The team leader considered the above suggestions, and agreed that a simplistic, but not too scientific solution of contingency percentages may be appropriate. However, as they do not quote contingencies to the client, the ultimate risk test that he would still feel most comfortable with, is the knowledge and intuitive feelings of the team - whatever the degree of information received. He said, for example, in some instances the team may only receive a small percentage of the information available, but the assistance they receive from, say, specialists, may be good enough to significantly lower the pricing risk. The team leader believe that their comments on design and pricing have lead to downstream reviews and funding changes by the client, a situation which "*justifies the credibility of the team's role*".

Finally, the team leader stressed that, another simplistic way of looking at their service is that they produce independent analysis and cost guidelines that may be compared with the actual tender results. This helps to satisfy their client, the funding agent, that the service he pays for appears fair and reasonable. The team leader argued that the timing and snapshot nature of the team's service meant that the professional intuitive approach is what the client demands. He believes that "*systematic risk management is for a different set of circumstances*". Whilst these statements could be construed as the model failing, rather, what they suggest, is that the team used for demonstration of the conceptual model was perhaps not best suited to utilise it, because of the very specialist and narrow nature of their service to the client. Perhaps if they were involved throughout the design and construction process of projects, then there would be greater benefits and incentives to use the model.

Since the demonstration of case illustrations, Lewis (1999) had discussed tips for successful risk management, and states that it inevitably takes an investment of time to make it work, and there is a need to engender a learning organisation. He says that it ideally needs a champion and a good leader who needs to show that they really do believe in managing risks, with actions as well as words, and using a multi-disciplinary team-based approach is widely recognised as the most effective way that risk management can be used. However, Lewis explains that risk management is a relatively new discipline, which is still evolving, and it is therefore important that an organisation does not become insular, as there is always something more that can be learnt to improve the way that a company manages its risks.

7.6 Summary

The demonstration of a conceptual risk management model in a quantity surveying practice has been successfully presented with case illustrations. The results proved that the key risk information can be more thoroughly evaluated in terms of significant impact on a project. The model also provides the opportunity for information to be more concisely summarised, and for response action to be effectively prioritised. The model makes the actions undertaken more explicit, and provides clear guidance to the client on how further action may be taken to improve the accuracy of the estimate. The words produced from the risk management model are just as important as the numbers that may be generated from software. The qualitative framework thus provides the essential basic infrastructure within a practice, and the potential for the model to become more sophisticated in the future. Standard pro forma's are beneficial in recording each step of the model, helping to facilitate the process, and leaving a documented audit trail of the risk information.

The model may not address all the main reasons for causing buildings to sometimes finish over budget, since problems often arise where changes are unexpectedly made to projects. This issue needs to be reviewed in future testing. However, the model successfully enabled the second to fifth main causes for cost overruns to be controlled. The conceptual risk management model proposed gave the team an informative insight into the process, and served as an excellent platform for further development. The research totally fulfilled the objective of explaining to the client how the model works, and the model has fulfilled its aim of providing improved decision-making information for the client. The effectiveness of the model demonstrates the importance of the application of a model which is timely and readily available, providing the opportunity for more informed and accurate decision-making. It overcomes the mundane nature of conventional practice, encourages intelligent thinking and creativity in estimating, thereby adding value to the service provided by the quantity surveyor.

CHAPTER 8 - CONCLUSION

8.1 Conclusions

The influence of risk in building projects is becoming well recognised to all parties concerned with construction. Its identification, analysis, and management will become essential requirements in the future assessment of projects. No construction project is risk free, and the difficult challenge facing the quantity surveying profession is to establish accurate budget estimates. A primary measure of success in preparing a budget estimate is predicting the project out-turn capital cost at project inception (HM Treasury, 1999). Initial budget estimating is therefore one of the most important aspect of the work undertaken by quantity surveyors. The principal aim of this research was to develop a conceptual risk management model to be used during the establishment of an initial budget for a building construction project. This aim has been achieved by fulfilling set objectives, that included, acquiring an understanding of the concept of risk management, clarifying the methods, tools, and techniques used to estimate initial budgets for building projects, and development and demonstration of the conceptual model in a quantity surveying practice.

In the domain of risk management of building project budgets, eight key conclusions can be drawn from the research work, with relevant supporting evidence:

- **Risk means both problems and opportunities** - Risk presents both negative and positive variations in estimates. A pessimist focuses on the threats of a risk, and an optimists views risk as being opportunistic. It is impossible to eliminate risk completely, and success is the reward for choosing the correct balance of risk options available. The objectives of risk management are to identify the risks, analyse them, and then to decide and implement the optimum response actions. This means minimising the effect of problems, and enhancing the probability of opportunities.

- **Better information leads to more accurate budget estimates** - Complete information is the key that can lead to more accurate estimates. One of the most serious problems when a budget is being estimated is that little information is often available. This was proven in the case illustrations during demonstration and validation of the conceptual model. The main causes for project cost overruns include incomplete design, lack of information, and poor quality briefing. The answer is to invest ample time in the early stages of design to clearly define a project's scope and complexity.

- **Change is the biggest uncertainty** - Design variations and client driven changes are the most significant reasons for causing building projects to finish over budget. No matter how much information is produced for estimating, this can be counterbalanced by any changes that are subsequently made to the scope of a project. Changes that arise from external sources are often uncontrollable, and this is the biggest uncertainty in project estimating.

- **People can be the best or the worst risk management tools** - Systematic risk management should begin with selection of an appropriately experienced multi-disciplinary project team. Appointing the wrong people will be disastrous. People are the strongest means available to the conceptual risk management model. The model enhances the instinctive approach through a more rigorous method of managing risk, and it reduces the reliance on intuition by formalising and making explicit what is usually done instinctively and implicitly.

- **A qualitative framework is the crucial basis for successful risk management** - The qualitative conceptual model developed in this research provides the essential internal infrastructure for successful risk management practice. In contrast to other budget risk management systems, the model addresses risk issues from day one when the quantity surveying team first receive information for the project, as opposed to relying on the calculating of a baseline estimate before the risk management process begins. This proactive integrated approach ensures that a more comprehensive, auditable, procedure is adopted, and all key risks are made explicit during preparation and subsequent reporting of the budget estimate.

- **The words produced from risk management are more important than the numbers** - Risk identification is the most important stage of the conceptual risk management model. If risks are not articulated, then they cannot be analysed or controlled. Risk management is about brainstorming the perceived risks and producing meaningful words to stimulate appropriate decision-making that can lead to the best management action. Simple quantification is essential for prioritising risks, but it is a misconception to believe that a budget risk management model must include detailed analysis and simulation that is generated from software.

- **Risk registers are the key deliverable from risk management** - The risk register concisely summarises and reports the most critical decision-making information. A project must have different hierarchical levels of team risk registers that each contain information that is only appropriate to the relevant audience. It is important not to omit any risks from the register that may need reviewing at a later date.

- **It is essential to facilitate risk management** - An impartial facilitator is essential for implementation, development, and maintenance of the conceptual risk management model. The facilitator should be someone who understands the Construction Industry and has the necessary qualifications in risk management. The process of preparing a budget estimate is a stressful and isolated task. The facilitator can help by co-ordinating and guiding use of the conceptual model, and by motivating all those involved. Commitment from both senior management and the client is required in order to support the necessary change of culture.

These conclusions give a better understanding of risk management in the specific domain of initial budget estimating for building construction projects. The conceptual model provides a framework to help quantity surveyors and clients to calculate the right estimate of cost before commitment to build is made. Thus providing the opportunity for projects to be completed within initial budget estimates.

8.2 Recommendations for further research

The research work has identified five areas of further research and development work:

- **The need to understand the "cloud of uncertainty" surrounding the risk management model** - The next logical development of the conceptual model should address the "cloud of uncertainty" that surrounds the process of preparing an initial budget estimate. This includes researching the issues of both risk attitude (bias) and change (particularly client driven and design variations). The model requires additional steps for selecting the optimum multi-disciplinary project team and for managing the subsequent psychological risk the project will inherit.

- **Automation of risk management facilitation** - Some of the tasks carried out by the risk management facilitator could be supported with computer technology. This would compliment both mental and manual inputs to the conceptual model by using artificial intelligence. Bespoke software could control the production of a budget risk report by taking the quantity surveyor through the successive stages of the model - in a similar manner to that exemplified manually in the case illustrations. The proposed system should provide a graphics user interface that will enable the model to be implemented more efficiently by speeding up the process and allowing practitioners to operate more independently. Extensions could provide an extranet electronic link to the client and other project members, and incorporate the optional use of specialist risk management software through further interfaces that improve the ease of use of such tools.

- **Development of a standard risk rating scale for building construction projects** - Development of a sophisticated industry standard risk rating scale for specific types of building construction schemes would help financiers to make more confident funding decisions for projects. Similar credit rating systems are already being used in banking for customers wanting to take out mortgages or personal loans. Because complete information leads to more accurate estimates, a method of evaluating the quality level of the information available would provide a useful indication of how much risk there is in a budget figure. Such a risk rating tool could address issues like the completeness of the project brief, specifications, and drawings, including an assessment of the risk in the "cloud of uncertainty" that surrounds the processes.

- **The integration of risk and value management** - The relationship between risk management and value management must be investigated. A value management technique was successful utilised during the demonstration of the conceptual risk management model, and this exemplified the opportunity for the harmonisation of the two methodologies. Both are most effective at the early stages of a project, but both can also be applied throughout the duration of a project. It is also apparent that some major clients and consultancies within the Construction Industry are actively beginning to classify the two techniques under the same umbrella.

- **Monitoring of industrial risk trends** - Continual on-going research is required to determine the true potential of how some of the rarely used or new risk management tools and techniques perform. Improved model performance might be possible with the new systems and commercial software available. Furthermore, new classifications of risk may evolve with technological developments, environment changes, or different economic conditions. One option would be for the BCIS to maintain risk management information on their internet site. This could include cost analyses of post project reviews to gather the statistics on the reasons why projects finish over (or under) budget, together with dynamic probability density functions for each building elements.

Similar research and development work could also be aimed at clients, project managers, designers, or contractors, to enable a broader appreciation of construction risk management to be obtained. Risk management is still in its infancy and further developments are therefore required.

The conclusions and recommendations from the research have led to an overlying qualification of the thesis. A conceptual risk management model has been developed for use during the establishment of an initial budget for a building construction project. This model provides better decision-making information for quantity surveyors and their clients. While the proposed model has only been validated to a limited extent, the results are acceptable and encouraging, but the model will need to be tested further to determine if it produces the desired cost certainty that industry is demanding.

Risk management is here to stay. Everyone must realise that there is no escaping formalised risk management. In the future, all projects will need systematic risk management models to produce essential decision-making information and allow effective response to change. Change is continuous, and everyone must clearly understand the influence that they have over a project's outcome, and the part that they can therefore play in alleviating project uncertainty. To achieve this, everyone involved in the construction process must update their knowledge base of theory and applied skills in risk management.

REFERENCES

Adams, J. (1995) *Risk*, UCL Press Limited, London.

Ainsley, D. (2000), Letters - Risk is the name of the QS game, *Building*, 22 September, p.32.

Allen, P. (2000) £600k row as Edward's builder goes bust, *Daily Mail*, 4 February, p 1.

American Society for Testing and Materials (1998a) E 1946 - 98, *Standard Practice for Measuring Cost Risk of Buildings and Building Systems*, in ASTM (1999).

American Society for Testing and Materials (1998b) E 1369 - 98, *Standard Guide for Selecting Techniques for Treating Uncertainty and Risk in the Economic Evaluation of Buildings and Building Systems*, in ASTM (1999).

American Society for Testing and Materials (1999) *Annual Book of ASTM Standards*, Section 4: Construction, Volume 04.11, Building Constructions, ASTM, West Conshohocken, PA.

Ansell, J. and Wharton, F. [eds] (1992), *Risk: Analysis, Assessment and Management*, John Wiley & Sons, Chichester.

Applied Decision Analysis (2000) *DPL*, Price Waterhouse Coopers. Available at: <URL: http://www.adainc.com>

Ashworth, A. (1999) *Cost studies of building (3rd Edition)*, Addison Wesley Longman Limited, Harlow.

Association for Project Management (1998) *The Project Management Yearbook 1998/99*, APM, London.

Association for Project Management (2000) *Risk Management Special Interest Group - Software Directory*, http://www.apmgroup.co.uk/risk.htm

Baldock, H. (1999) The spin starts here, *Building,* 23 July, pp 24-25.

Barnes, M. (1989) Introducing MERA, *Chartered Quantity Surveyor*, January, p 19.

Barrick, A. (1995) Poll reveals one in three jobs late, *Building*, 28 July, p 10.

Barrie, G. (1997a) MPs' offices now £100m over budget, *Building*, 26 September, p 9.

Barrie, G. (1997b) The percentage, *Building,* 30 May, p 36.

Barrie, G. (1997c) The player, *Building*, 7 March, pp 32-33.

Barrie, G. (1999a) 'Blame MPs', says Portcullis House audit, *Building*, 19 March, p 7.

Barrie, G. (1999b) Why the new parliament building is costing £1.2m for each MP, *Building*, 26 January, pp 20-24.

Beeston, D. (1986) Combining risks in estimating, *Construction Management and Economic*, **4**, pp 75-79.

Bennett, G. (1998) *Working Together, Apart II - Web-enabling distribution teamwork.* Available at: <URL: http://www.mesavista.com>

Bernstein, P.L. (1996) *Against the gods - The remarkable story of risk*, John Wiley & Sons, Inc., Chichester.

BMT Reliability Consultants Limited (2000) *Pandora*. Available at: <URL: http://www.bmtrcl.com>

Boothroyd, C. and Emmett, J. (1996) *Risk Management - A Practical Guide for Construction Professionals*, Witherby & Co. Ltd, London.

Brandon, P.S. (1990a) *Quantity surveying techniques - New directions the challenge and the response*, in Brandon (1990b), pp 1-20.

Brandon, P.S. [ed] (1990b) *Quantity surveying techniques: New directions*, Blackwell Scientific Publications, Oxford.

Brandon, P.S. (2000) *First keynote speaker*, Bizarre Fruit Postgraduate Research Conference on the Built Environment, RICS Foundation, 9-10 March, Built and Human Environment Research Centre, University of Salford.

British Standards Institution (2000) BS 6079-3, *Project management - Part 3: Guide to the management of business related project risk*, BSI, London.

Byrne, P. and Cadman, D. (1984) *Risk, Uncertainty and Decision-making in Property Development,* E. & F.N. Spon, London.

Carma Limited (2000) *Carma Tools*. Available at: <URL: http://www.risk-reward.com>

Carter, B., Hancock, T., Morin, J., and Robins, N. (1996) *Introducing RISKMAN: The European Project Risk Management Methodology*, The Stationery Office, London.

Cavil, N. (1999) The QS: Profession on the brink, *Building,* 18 June, pp 42-45.

Chambers (1996) *Chambers 21st Century Dictionary*, Chambers, Edinburgh.

Chapman, C. and Ward, C. (1997), *Project Risk Management*, John Wiley & Sons, Chichester.

Chapman, R. (2000) Managing a risky business, *Property Week*, 16 June, pp 74-75.

Chau, K.W. (1995) The validity of the triangular distribution assumption in Monte Carlo simulation of construction costs: empirical evidence from Hong Kong, *Construction Management and Economics*, **13**, pp 15-21.

Collins (1998) *Collins English Dictionary (Millennium Edition / 4th Edition)*, Harper Collins Publishers, Glasgow.

Construction Clients Forum (1997) 60% of clients dissatisfied, *Building*, 23 May, p 8.

Construction Industry Board (2000) *The Construction Industry Best Practice Programme*. Available at: <URL: http:www.cbpp.org.uk>

Crockford, N. (1991) *Risk Management*, Witherby & Co. Ltd, London.

Croll, G. J. (1995) *Cost and schedule risk analysis in major engineering projects.* Available at: <URL: http://www.eastern-software.com/frames/cost&sch.htm>

Crosher and James (1994) Value-added cost control is best, *Building Economist Supplement, Building*, February, p 4.

DA Futura International (2000) *Uncertainty analysis using the Futura process.* Available at: <URL: http://www.futura-da.fi/method.htm>

Davis, S.D. (1996) *Construction Insurance, Bonding and Risk Management*, Chapter 1, pp 1-7 in Palmer, et al. (1996).

De Bono, E. (1992) *Serious creativity*, Harper Collins, London, pp 304-305.

Definitive Software Inc. (2000) *Definitive Scenario.* Available at: <URL: http://www.definitivesoftware.com>

Dell'Isola, A.J. (1997) *Value Engineering - Practical Applications for Design, Maintenance & Operation*, RS Means Company Inc., Kingston MA.

Department of the Environment, Transport and the Regions (2000a) Performance indicators show improvement, *Construction Monitor*, May, p 4.

Department of the Environment, Transport, and the Regions (2000b) *Rethinking Construction*, The report of the Construction Task Force to the Deputy Prime Minister, John Prescott, on the scope for improving the quality and efficiency of UK construction. Available at: <URL: http://www.construction.detr.gov.uk/ cis/rethink/index.htm>

Department of the Environment, Transport, and the Regions (2000c) *KPI Report for the Minister for Construction,* DETR. Available at: <URL: http://www. construction.detr.gov.uk>

Dependency, Risk & Decision Support (2000) *DMT.* Available at: <URL: http://www. dependency.com>

Descombe, M. (1993) *An introduction to questionnaire design*, De Montfort University, Leicester.

Edwards, L. (1995) *Practical risk management in the construction industry*, Thomas Telford Publications, London.

Edwards, P.J. and Bowen, P.A. (1998a) Risk and risk management in construction: a review and future directions for research, *Engineering, Construction and Architectural Management*, **5** (4), pp 339-349.

Edwards, P.J. and Bowen, P.A. (1998b) Note - Practices, barriers and benefits of risk management process in building services costs estimation: comment, *Construction Management and Economics*, **16**, pp 105-108.

Ferry, D.J., Brandon, P.S., and Ferry, J.D. (1999) *Cost Planning of Buildings (Seventh Edition),* Blackwell Science Limited, Oxford.

Flanagan, R., Kendell, A., Norman, G. and Robinson, G.D. (1987) Life cycle costing and risk management, *Construction Management and Economics*, **5**, Special issue, pp S53-S71.

Flanagan, R. and Norman, G. (1982) Risk analysis - an extension of price prediction techniques for building work, *Construction Papers*, **1** (3), pp 27-34.

Flanagan, R. and Norman, G. (1993) *Risk management and construction*, Blackwell Scientific Publications, Oxford.

Flanagan, R. and Tate, B. (1997) *Cost control in building design*, Blackwell Science Limited, Oxford.

Flanagan, R. and Stevens, S. (1990) *Risk Analysis*, Chapter 5, pp 121-138 in Brandon [ed] (1990b).

Fortune, C. and Lees, M. (1994) Early cost advice for client's, *Chartered Surveyor Monthly,* March, pp 18-19.

Fortune, C. and Lees, M. (1996) *The relative performance of new and traditional cost models in strategic advice for clients*, Research Paper Series, **2** (2), Royal Institution of Chartered Surveyors, London.

Godfrey, P.S. (1996) *Control of risk - A Guide to the Systematic Management of Risk from Construction*, CIRIA, London.

Gray, S. (1995) *Practical Risk Assessment for Project Management*, John Wiley & Sons Ltd, Chichester.

Harlow, J. and Syal, R. (1995) British Library not ready before 2000, *The Sunday Times*, 26 November, p 1.7.

Hawkins, M. and Solomon, M. (1989) Nothing is certain but uncertainty, *Chartered Surveyor Weekly*, 9 February, pp 72-73.

Hayes, R.W., Perry, J.G., Thompson, P.A., and Willmer, G. (1986) *Risk management in engineering construction - Implications for project managers*, A SERC Report, Thomas Telford Limited, London.

Heather, P. and Stone, S. (1991) *Questionnaire design*, Sheffield Hallam University, Sheffield.

HM Treasury (undated) *Central Unit on Purchasing, Guidance No.15 - Estimating for Works Projects*, HM Treasury, London.

HM Treasury, (1993) *Central Unit on Procurement, Guidance No.41 - Managing Risk and Contingency for Works Projects*, HM Treasury, London.

HM Treasury (1995) *Setting new standards: a strategy for government procurement*, HMSO, London.

HM Treasury (1997) *Procurement Group - Government Construction Procurement Guidance*, Treasury's Public Enquiry Unit, London. Available at: <URL: http://wood.ccta.gov.uk/treasury/reports.nsf>

HM Treasury (1999) *Procurement Group - Government Construction Procurement, Guidance No. 6, Financial Aspects of Projects* , Treasury's Public Enquiry Unit, London. Available at: <URL: http://wood.ccta.gov.uk/treasury/reports.nsf>

Institute of Chartered Accountants in England & Wales (1999), Internal Control, Guidance for Directors in the Combined Code, The Institute of Chartered Accountants in England & Wales, London.

Institute of Civil Engineers and the Faculty and Institute of Actuaries (1998) *Risk Analysis and Management for Projects (RAMP),* Thomas Telford Limited, London.

Institute of Risk Management (1994) *An Introduction to Risk Management,* Institute of Risk Management, London.

Jackson, S.H. (1999) *Risk management of building project budgets,* Presentation at the Extraordinary General Meeting of the Royal Institution of Chartered Surveyors (Saudi Arabia Group), 8 June, Al Mena Compound, Oleya, Riyadh, Saudi Arabia.

Jackson, S.H., Griffith, A., Stephenson, P., and Smith, J. (1997) *Risk management tools and techniques used when estimating initial budgets for building projects,* In Stephenson, P. [ed] (1997), Proceedings of 13th Annual Conference of the Association of Researchers in Construction Management, King's College, Cambridge, September, pp 123-132, Sheffield Hallam University, Sheffield.

Jones, M. (2000) Banks blamed for pulling the plug too soon, *Building*, 11 February.

Katmar Software (1999) *PRA*. Available at: <URL: http://users.lia.net/katmar>

King, D. (1999) Firms hit by tough tax and risk rules, *Building,* 15 January, p 16.

Kliem, R.L. and Ludin, I.S. (1997) *Reducing Project Risk*, Gower Publishing Limited, Aldershot.

Kloman, F. (2000) A personal view of the risk management milestones that helped shaped our discipline in the last century, *InfoRM*, January / February, pp 14-17.

Latham, Sir Michael (1994) *Constructing the team*, HMSO, London.

Lewis, A. (1999) *10 Tips for Successful Risk Management*, Project Manager Today, October.

Lichtenberg, S. (2000) *The Lichtenberg method.* Available at: <URL: http://www. futura-da.fi/method.htm>

Line International Limited (2000) *Ris*^{3}. Available at: <URL: http://www.ris3.com>

Mak, S. and Picken, D. (2000) Using Risk Analysis to Determine Construction Project Contingencies, *Journal of Construction Engineering and Management*, March / April, pp 130-136.

Mak, S., Wong, J. and Picken, D. (1998), Note - The effect on contingency allowances of using risk analysis in capital cost estimating: a Hong Kong case study, *Construction Management and Economics*, **16**, pp 615-619.

Makin, C. (1996) What do surveyors know about risk, *InfoRM*, November, p 6.

Martin, J. (2000a) Chartered surveyors provide benchmarking data for construction, *Chartered Surveyor Monthly*, February, p 19.

Martin. J. (2000b) How to provide the best early cost advice to clients, *Chartered Surveyor Monthly*, October, pp. 32-33.

Mok, C.K., Tummala, V.M.R., and Leung, HM (1997) Practices, barriers and benefits of risk management process in building services cost estimation, *Construction Management and Economics*, **15**, pp 161-175.

National Audit Office (1998) *Cost Over-runs, Funding Problems and Delays on Guy's Hospital Phase III Development*, Reported by the Comptroller and Auditor General, 10 June, NAO, London.

Newton, S. (1992) Methods of analysing risk exposure in the cost estimates of high quality offices, *Construction Management and Economics*, **10**, pp 431-449.

Noor, I. and Rye, T.J. (2000) Guidelines for Successful Risk Facilitation and Analysis, *Cost Engineering*, **42** (4), April, pp 32-37.

Norris, C., Perry, J. and Simon, P. (1993) *Project Risk Analysis and Management - A Guide by the Association of Project Managers*, The Association of Project Managers, High Wycombe.

Osborne, John (2000) Top 250 consultants, Building, 6 October, pp 50-81.

Oxford (1998) *Dictionary for International Business*, Oxford University Press, Oxford.

Oxford (1999) *Concise Oxford Dictionary (Tenth Edition)*, Oxford University Press, Oxford.

Palisade (2000) *@Risk*. Available at: <URL: http://www.palisade-europe.com>

Palmer, W.J., Maloney, J.M., and Heffron, J.L. (1996) *Construction Insurance, Bonding and Risk Management*, McGraw-Hill, London.

Papageorge, T.E. (1988) *Risk management for Building Professionals*, RS Means Company Inc., Kingston, Ma.

Primavera Systems Inc (2000) *Monte Carlo*. Available at: <URL: http://www. primavera.com>

Project Management Institute (1996) *A Guide to the Project Management Body of Knowledge*, PMI Publishing Division, Sylva, North Carolina.

Raftery, J. (1994) *Risk analysis in project management*, E & FN Spon, London.

Railtrack (2000) *Cost estimation*. Available at: <URL: http://www.railtrack.co.uk/ corporate/2000nms/vol1/developing_network/cost_estimation.html>

Rayner, J. (2000) Turnbull: Emperor's new clothes or a means of creating real competitive advantage?, *InfoRM*, January/February, pp 18-20.

Raz, T. and Michael, E. (2001) Use and benefits of tools for project risk management, *International Journal of Project Management*, **19 (1)**, pp 9-17 (Available online 27 October 2000).

Risk Decisions Limited (2000) *The Construction Industry Research and Information Association's report into risk management in the construction industry.* Available at: <URL: http://www.riskdecisions.com/ciria.htm>

Riskdriver (2000) *Riskman.* Available at: <URL: http://www.riskdriver.com/riskmantool>

Royal Institute of British Architects (1973) *Handbook of Architectural Practice and Management,* in Seeley (1996).

Royal Institution of Chartered Surveyors (1991) *QS2000 - The future role of the Chartered quantity surveyor*, RICS, London.

Royal Institution of Chartered Surveyors (1995) *Directory of members 1996*, RICS, London.

Royal Institution of Chartered Surveyors (1998a) Towards a sustainable profession, *Chartered Surveyor Monthly,* June, pp 56-65.

Royal Institution of Chartered Surveyors (1998b) Construction Admin and Management panel, *Pre-contract cost planning and cost management*, The Surveyors Construction Handbook, Part 2, Section 1, Bulletin Update, April, RICS, Coventry.

Royal Institution of Chartered Surveyors (1999) Construction Admin and Management panel, *The management of risk*, The Surveyors Construction Handbook, Part 4, Section 3, Bulletin Update, December, RICS, Coventry.

Scottish Parliamentary Corporate Body (2000) *Report on the Holyrood Project,* SP Paper 99, Session 1. Available at: <URL: http://www.scottish.parliament.uk/agenda_and_decisions/bb-00/holy-01.htm>

Seeley, I.H. (1996) *Building Economics (4th Edition)*, Macmillan Press Limited, London.

Simon, P, Hillson, D., and Newland, K. [eds] (1997), Project Risk Analysis and Management Guide, The APM Group Limited, Norwich.

Smallman, C. (1997) Read all about it - risk trends in the media: a research note, *Disaster Prevention and Management*, **6** (3), pp 160-164.

Smith, N.J. (1999) *Managing Risk in Construction Projects*, Blackwell Science Limited, Oxford.

Spring, M. (1997) Gentle giant, *Building*, 31 October, pp 40-45.

Standards Australia (1999) AS/NZS 4360:1999, *Risk Management*, Standards Association of Australia, Strathfield, NSW.

Standards Council of Canada (1997) CAN/CSA-Q850-97, *Risk Management: Guidelines for Decision-Makers*, Canadian Standards Association, Ontario.

Stephenson, P. and Oxley, R. (1985) *The requirements of a management information system for the planning and control on construction projects*, in Barton [ed] (1985), *Information Systems in Construction Management*, Batsford Academic and Educational, London.

Strategic Thought Limited (2000) *Active Risk Manager*. Available at: <URL: http:// www.arm-risk.com>

Taylor, M. (2000) *Avoiding Claims in Building Design: Risk Management in Practice*, Blackwell Science Limited, Oxford.

Thompson, P. and Perry, J. [eds] (1992) *Engineering construction risks - A guide to project risk analysis and risk management*, Thomas Telford, London.

Turner, A. (1990) *Building procurement*, Macmillan Education Limited, London.

Tweeds [eds] (1996) *Laxton's Guide to Risk Analysis and Management*, Laxton's / Butterworth-Heinemann, Oxford.

US Department of the Navy (1999) Risk Radar - The essential software tool for project risks, *NetFocus*, No.216, April. Available at: <URL: http://www.spmn.com/rsktrkr.html>

Valentine, C. (1999) IRM Annual Conference - The skills required for the new risk manager, *InfoRM*, November/December, p 8.

Wall, D.M. (1997) Distribution and correlation in Monte Carlo simulation, *Construction Management and Economics*, **15**, pp 241-258.

Webb, A. (1997) Risk analysis for business decisions, *Engineering Management Journal*, February. Available at: <URL: http://www.dependency.com/alanwebb1.htm>

Wharton, F. (1992) *Risk Management: Basic Concepts and General Principles*, in Ansell and Wharton (1992).

Wheeler, C. (1998) Thanks for the insight, *Building*, 9 January, p 17.

White, D. (2000a) Costain turns to KPMG to cut risk - Contractor's review of project risk may lead to a spend-earlier-to-save-later approach, *Building*, 4 February, p 17.

White, D. (2000b) Balfour to spend £5m on project database, *Building,* 31 March, p 19.

Wideman, R.M. (1995) *Cost Control of Capital Projects and the Project Cost Management System Requirements* (2nd edition), BiTech Publishes Limited, Richmond, British Columbia.

Williams, T.M. (1993) Risk-management infrastructures, *International Journal of Project Management*, **11** (1), February, pp 5-10.

Wilson, A. (1985) *Risk Analysis,* Quantity Surveyors' Research & Development Forum, 13 March, Royal Institution of Chartered Surveyors, London.

Wilson, N. and McClean, S. (1994) *Questionnaire design - A practical introduction.* University of Ulster, Newtownabbey.

Wong, E.T.T, Norman, G. and Flanagan, R. (2000) A fuzzy stochastic technique for project selection, *Construction Management and Economics*, **18**, pp 407-414.

Yates, A. (1986) Assessing uncertainty, *Chartered Quantity Surveyor*, November, p 27.

BIBLIOGRAPHY

AACE International (Association for the Advancement of Cost Engineering through total cost management) (2000) AACE International's Risk Management Dictionary, *Cost Engineering*, **42** (4), pp 28-31.

Akilade, A. (2000) SNP slams Scots parliament as cost estimates hit £230m, *Building*, 3 March, p 10.

Association for Project Management (1998) *Risk Management Lexicon Version 1.0*, Association for Project Management Risk Management Special Interest Group. Available at: <URL: http://www.risksig.com/lexicon.htm>

Barrie, G. (1998) £8m British Library claim launched, *Building*, 29 May, p 8.

Beeston, D.T. (1974) *One statistician's view of estimating*, Cost Study F3, BCIS 1974/75-123-9 to 16, Royal Institution of Chartered Surveyors, London, pp 398-411 in Skitmore and Marston [eds] (1999).

Birnie, J. and Yates, A. (1991) Cost prediction using decision / risk analysis methodologies, *Construction Management and Economics*, **9**, pp 171-186.

Building (2000) Wembley price soars towards £660m, *Building*, 27 October, p11.

Chapman, C. and Ward, C. (2000) Estimation and evaluation of uncertainty: a minimal first pass approach, *International Journal of Project Management*, **18**, pp 369-383.

Construction Industry Research and Information Association (2000) *Risk management in construction - the practical benefits*, Construction Productivity Network, Workshop Report Ref. CPN E0141C, CIRIA, London.

Elkjaer, M. (2000) Stochastic Budget Simulation, *International Journal of Project Management*, **18**, pp 139-147.

Gorman, E. (1995) Fellow climbers pay tribute to one of the greats, *The Times*, 18 August, p 3.

Kahkonen, K. and Artto, K.A. [eds] (1997) *Managing Risks in Projects*, Proceedings of the IPMA Symposium on Project Management, Helsinki, Finland, 17-19 September.

Norris, C. (1992) *The management of risk on engineering projects*, M.Sc. Thesis, Manchester.

Pelham, J. (2000) *Risk - why bother?*, Association for Project Management Yorkshire and North Lincolnshire Branch Meeting, 14 March, Leeds Metropolitan University, APM.

Project Management Institute (1997), *The PMI book of project management forms*, PMI Publishing Division, Sylva, North Carolina.

Raftery, J. (1991) *Principles of Building Economics*, BSP Professional Books, Oxford.

Royal Institution of Chartered Surveyors (1998) *Your Liability: Are You Aware of Your Business and Personal Risks?*, An information paper, RICS, London.

Skitmore, M. and Marston, V. [eds] (1999) *Cost Modelling*, E & F.N. Spon, London.

Smit, J. (1997) Working in oils, Procurement supplement, *Building*, April, pp 6-8.

Yates, A. (1985) *Risk Analysis - An example of its application in the forecasting of construction costs,* Quantity Surveyors' Research & Development Forum, 13 March, Royal Institution of Chartered Surveyors, London.

APPENDIX "A" - DEFINITIONS OF RISK

English dictionary definitions of risk

"1. the chance or possibility of suffering loss, injury, damage, etc; danger

2. someone or something likely to cause loss, injury, damage, etc.

3. insurance

a. the chance of some loss, damage, etc. for which insurance could be claimed

b. the type, usually specified, of such loss, damage, etc

c. someone or something thought of as likely (a bad risk) or unlikely (a good risk) to suffer loss, injury, damage, etc.."

Chambers, 1996.

"1. the possibility of incurring misfortune or loss; hazard

2. insurance

a. chance of a loss or other events on which a claim may be filed

b. the type of such an event, such as fire or theft

c. the amount of a claim should such an event occur

3. vulnerability; likely to be lost or damaged."

Collins, 1998.

"1. chance or possibility of danger, loss, injury, etc. If it can be described sufficiently accurate for a calculation to be made of the probability of it happening , on the basis of past records, it is called an insurable risk. If the

risk is met so infrequently that no way of calculating the probability of the event exists, no underwriter will insure against it and it is therefore an uninsurable risk.

2. possibility of suffering a loss in trading

3. person or thing causing a risk or regarded in relation to risk."

Oxford, 1998.

"*1. a situation involving exposure to danger; the possibility that something unpleasant will happen*

2. a person or thing causing a risk or regarded in relation to risk: a fire risk."

Oxford, 1999.

International standard definitions of risk

"The chance of injury or loss as defined as a measure of the probability and severity of an adverse effect to health, property, the environment, or other things of value."

Standards Council of Canada, 1997.

"*The chance of something happening that will have an impact upon objectives. It is measured in terms of consequences and likelihood.*"

Standards Australia, 1999.

"Uncertainty inherent in plans and the possibility of something happening (i.e. a contingency) that can affect the prospects of achieving business or project goals. Note - Such contingencies could make the results more or less satisfactory."

British Standard Institute, 2000.

Construction management definitions of risk

"A risk is any exposure to the possibility of loss or damage to people, property, or other interest."

Papageorge, 1988.

"Risk, defined as the chance of an adverse event, depends on circumstances."

Godfrey, 1996.

"A risk involves uncertainty and has an impact."

Carter et al, 1996.

"The implications of the existence of significant uncertainty about the level of project performance achievable."

Chapman and Ward, 1997.

"Risk is the occurrence of an event that has consequences for, or impacts on, projects."

Kliem and Ludin, 1997.

"The potential impact of all the threats (and opportunities) which can affect the achievement of the objectives for an investment."

Institute of Civil Engineers et al, 1998.

"Risk exists when a decision is expressed in terms of a range of possible outcomes and when probability can be attached to the outcomes; uncertainty exists when there is more than one possible outcome of a course of action but the probability of each outcome is not known."

Smith, 1999.

"An uncertain event which, should it occur, will have an effect on the achievement of the project's objectives."

Royal Institution of Chartered Surveyors, 1999.

"Hazard: chance of loss or injury resulting from the threat of, or an actual claim against the practice, arising from alleged breach of contract or negligence."

Taylor, 2000.

APPENDIX "B" - DEFINITIONS OF RISK MANAGEMENT

English dictionary definitions of risk management

(Risk analysis) "A methodical investigation undertaken to assess the financial and physical risks that may affect a business venture."

Chambers, 1996.

"Control of the chances of losing on an investment. It can involve taking out an insurance against loss, hedging a loan against a rise in interest rates, and using financial futures to protect an investment against a fall in interest rates."

Oxford, 1998.

International standard definitions of risk management

"The systematic application of management policies, procedures, and practices to the tasks of analysing, evaluating, controlling, and communicating about risk issues."

Standards Council of Canada, 1997.

"The culture, processes and structures that are directed towards the effective management of potential opportunities and adverse effects."

Standards Australia, 1999.

"Systematic application of management policies, procedures and practices to the tasks of analysing, evaluating and controlling risk."

British Standard Institute, 2000.

Construction management definitions of risk management

"Risk management is not a simple list of do's or don'ts, a formula, or a single approach to problem solving. Risk management is a control system similar to a time or cost control system which must be integrated into every aspect of doing business and offering services."

Papageorge, 1988.

"Risk analysis enables decision makers to improve the quality of their judgements by providing more realistic information on which to base decisions."

Raftery, 1994.

"The identification, measurement and control at most economic cost of the hazards which can threaten life, property and the assets and earnings of an organisation."

Edwards, 1995.

"The systematic approach makes your risks explicit, formally describing them and making them easier to manage. In other words, systematic risk management is a management tool, which for best results requires practical experience and training in the use of techniques. Once learnt, it supports you in your decision-making and informs your instinctive judgement."

Godfrey, 1996.

"Risk management is a planned and structured process aimed at helping the project team make the right decision at the right time to identify, classify and quantify the risks and then to manage and control them. The aim is to ensure best value for the project in terms of cost, time and quality by balancing the input to manage the risk with the benefits from doing so."

Boothroyd and Emmett, 1996.

"The essential purpose of risk management is to improve project performance via systematic identification, appraisal and management of project-related risk."

Chapman and Ward, 1997.

"Risk management is the continual process of identifying, assessing, recording and responding to all risks associated with the project in a controlled framework."

HM Treasury, 1997.

"A process for identifying, assessing and responding to risks associated with delivering an objective, for example, a construction project, and the focus is on commercial type risks. Health and safety related risks are likely to need separate consideration and the Health and Safety Executive (HSE) provide specialist guidance in this area."

Royal Institution of Chartered Surveyors, 1999.

APPENDIX "C" - PILOT QUESTIONNAIRE AND COVER LETTER

«NAME»
«COMPANY»
«ADDRESS1»
«ADDRESS2»
«ADDRESS3»
«ADDRESS4»
«POSTCODE»

Our ref: «references»

28 April 1995

Dear «SALUTATION»

RISK IN BUILDING DESIGN AND CONSTRUCTION

Some academics have suggested that risk management could assist in improving the reputation of the Construction Industry.

I am developing my research in the area of risk management, and aim to model a risk management system which will help minimise risk by improving the awareness of uncertainty inherent in the design and construction process.

I would be most grateful if you would take 15 - 20 minutes to complete the enclosed questionnaire and return it to me in the next two months.

The identity of your reply will remain confidential, and your help will be much appreciated.

Yours sincerely

Simon Jackson
Research Section

Encl.

Sheffield Hallam University

RISK IN BUILDING DESIGN AND CONSTRUCTION

QUESTIONNAIRE: APRIL 1995
CONFIDENTIAL

Please return to: Simon Jackson, Research Student, Sheffield Hallam University, School of Construction, City Campus, Pond Street, Sheffield, S1 1WB.

BACKGROUND

The building industry has a reputation of delivering buildings late, over budget, and not to specification requirements (Raftery, 1994).

The process of taking a project from initial investment appraisal, to completion, and into use is complex, generally bespoke, and entails time consuming design and construction processes. It requires a multitude of people with different skills and interests and the co-ordination of a wide range of disparate, yet interrelated, activities. Such complexity is compounded by many external uncontrollable factors.

Risk management is appropriate primarily at strategic level. Intuition, expert skill, and judgement will always influence decision making, but a set of tools is now needed which will enable risk management to be put into practice in the construction industry (Flanagan and Norman, 1993).

SECTION A: GENERAL

Name of organisation: ______________________________

Contact name: ______________________________

Contact's position: ______________________________

Contact telephone number: ______________________________

Type of organisation: ______________________________

Size of organisation:

- **Small (1 to 10 professionals):** ____
- **Medium (11 to 30 professionals):** ____
- **Large (Over 30 professionals):** ____

Description of workload type:

SECTION B: YOUR INITIAL THOUGHTS

(B.1) What aspects of the building design and construction process do you perceive as being main areas of risk?

N.B. If there is insufficient space to answer any of the questions please attach additional paper as needed. Also, any supporting documentation that you think may be relevant would be much appreciated.

SECTION C: RISK MANAGEMENT STRATEGIES, PROCEDURES, TOOLS, AND TECHNIQUES

(C.1) What strategies, procedures, tools, or techniques do you use for risk management of projects? How do these perform?

(C.2) Are there any strategies, procedures, tools, or techniques you are aware of but do not use? If so, why don't you use them?

(C.3) Are there any areas where you feel that current risk management practice could be improved?

SECTION D: RISK IN PROCUREMENT ROUTES

(D.1) How do you feel different procurement routes and contracts (e.g. Traditional, Design & Build, Management) cope with risk?

SECTION E: RISK IN TYPES OF CONSTRUCTION WORK

(E.1) What types of construction work (e.g. New Build, Refurbishment, Repairs, Demolition) do you think has the greatest risk? Please explain your answer.

SECTION F: RISK IN TYPES OF BUILDINGS

(F.1) What types of buildings (e.g. Offices, Housing, Retail, Industrial, Hospitals) do you think have the greatest risk? Please explain your answer.

SECTION G: RISK IN BUILDING ELEMENTS

(G.1) Which elements (e.g. Substructure, External Walls, Frame, Services) do you think have the greatest risk? Please explain your answer.

SECTION H: OTHER PEOPLE

(H.1) Do you know any clients, consultants, contractors, or academics who may be interested in discussing this area of research? Please give name, position, organisation, address, and telephone number.

Thank you for taking the time to complete this questionnaire.

APPENDIX "D" - POSTAL QUESTIONNAIRE AND COVER LETTER

«NAME»
«COMPANY»
«ADDRESS1»
«ADDRESS2»
«ADDRESS3»
«ADDRESS4»
«POSTCODE»

Our ref: «references»

23 May 1996

Dear «SALUTATION»

QS RISK MANAGEMENT TOOLS AND TECHNIQUES

Some academics have suggested that risk management tools and techniques could assist quantity surveyors when estimating initial budgets for building projects.

I am developing my research in the area of risk management to determine if this statement is true, and I will be grateful if you would take 5 to 10 minutes to complete the enclosed questionnaire and return it in the freepost envelope by **14 June**.

The identity of your reply will remain confidential, and I will be pleased to inform you of any conclusions that are made.

Yours sincerely

Simon Jackson
Research Section

Encl.

Sheffield Hallam University

A survey of Risk Management tools and techniques used by Quantity Surveyors when estimating the initial budgets for building projects

Prepared by:
Simon Jackson, School of Construction, Sheffield Hallam University, Pond Street, Sheffield, S1 1WB. E-Mail: S.H.Jackson@SHU.AC.UK Telephone: 0114 275 7330

CONFIDENTIAL

Our reference: ______________

Q1. What is the size of your regional office?

________No. Chartered Quantity Surveyors ________No. Other staff

Q2. What base method(s) do you use to estimate initial budgets for building projects? (If you use more than one method please indicate which you use most often, i.e. 1st, 2nd, 3rd).

________ Cost per m2 floor area

________ Functional unit method (i.e. per bed, per seat, per vehicle)

________ ELSIE

Others not above?:

________ ____

________ ____

Q3. What do you perceive as being the main causes for making building projects sometimes finishing over budget?

- ____
- ____
- ____
- ____
- ____

Q4 Some academics have suggested that the following list of Risk Management tools and techniques could assist quantity surveyors when estimating initial budgets for building construction projects. Have you heard of any of these?

Please tick:

		No, not familiar with	Yes but 'never' use	Yes 'always' use	Yes 'sometimes' use - please state when	Please state software used if applicable	
a	Professional judgement and intuition						a
b	Contingency % allowance						b
c	Risk-adjusted discount rate						c
d	Subjective probability						d
	Decision analysis:						
e	- algorithms						e
f	- means-end chain						f
g	- decision matrix						g
h	- decision tree						h
i	- stochastic decision tree						i
j	- Bayesian theory						j
k	Sensitivity analysis						k
l	Monte carlo simulation						l
m	Portfolio theory						m
n	Stochastic dominance						n
o	Utility theory						o
p	Expected monetary value						p
q	Delphi peer group						q
r	ELSIE						r
s	Brainstorming						s
t	Prompts / checklists						t
u	MERA						u
v	Own system (please specify details:) ______						v
	Others? (please list)						
w	______						w
x	______						x
y	______						y
z	______						z

Q5 Of those you have heard of, how do you feel they perform?

		Please tick: Don't know	Poor	Fair	Good	Excellent	Your comments:	
a	Professional judgement and intuition							a
b	Contingency % allowance							b
c	Risk-adjusted discount rate							c
d	Subjective probability							d
	Decision analysis:							
e	- algorithms							e
f	- means-end chain							f
g	- decision matrix							g
h	- decision tree							h
i	- stochastic decision tree							i
j	- Bayesian theory							j
k	Sensitivity analysis							k
l	Monte carlo simulation							l
m	Portfolio theory							m
n	Stochastic dominance							n
o	Utility theory							o
p	Expected monetary value							p
q	Delphi peer group							q
r	ELSIE							r
s	Brainstorming							s
t	Prompts / checklists							t
u	MERA							u
v	Own system ______________							v
	Others? (please repeat your list)							
w	______________							w
x	______________							x
y	______________							y
z	______________							z

Q6 Of those you have heard of but 'never' use, what are your reason(s) for not using them?

Please tick:

		Lack of understanding	Reliability / accuracy	Cost	Lack of clear benefit	Lack of IT facilities	Your reasons / comments:	
a	Professional judgement and intuition							a
b	Contingency % allowance							b
c	Risk-adjusted discount rate							c
d	Subjective probability							d
	Decision analysis:							
e	- algorithms							e
f	- means-end chain							f
g	- decision matrix							g
h	- decision tree							h
i	- stochastic decision tree							i
j	- Bayesian theory							j
k	Sensitivity analysis							k
l	Monte carlo simulation							l
m	Portfolio theory							m
n	Stochastic dominance							n
o	Utility theory							o
p	Expected monetary value							p
q	Delphi peer group							q
r	ELSIE							r
s	Brainstorming							s
t	Prompts / checklists							t
u	MERA							u
v	Own system ______							v

Others? (please repeat your list)

w	______							w
x	______							x
y	______							y
z	______							z

Thank you for taking the time to complete this questionnaire.

APPENDIX "E" - INTERVIEW QUESTIONS

Question One

"Cost per m^2 floor area" is the most commonly used method to estimate initial budgets for building projects. How do you estimate an initial budget using this method?

Question Two

The perceived main causes for making building projects sometimes finish over the initial budget are:

- changes to project
- incomplete design
- lack of information
- poor quality brief

2.1 Do you try to <u>identify</u> the risks in each of these causes when determining a cost per m^2 budget estimate?

2.2 Do you <u>analyse</u> or <u>quantify</u> these risks?

2.3 How do you <u>manage</u> these risks after the initial budget estimate?

Question Three

The main techniques used for risk management of budget estimates are a combination of:

- professional judgement and intuition
- prompts and checklists
- brainstorming
- contingency percentage allowance

3.1 Do you use these techniques for determining initial budget estimates based on the cost per m^2 floor area method?

3.2 Our survey shows that these techniques perform as follows:

	Excellent	Good	Fair	Poor
Professional judgement /intuition	29%	63%	8%	0%
Prompts and checklists	25%	53%	20%	1%
Brainstorming	18%	51%	23%	7%
Contingency percentage allowance	14%	51%	27%	4%

Therefore, on average, most perform "good" - do you agree?

Question Four

Do you use any other techniques for risk management when determining cost per m^2 budget estimates?

Question Five

Are there any other risk management techniques you are aware of but don't use (if so, then why don't you use them)?

APPENDIX F - RISK MANAGEMENT TOOLS AND TECHNIQUES SURVEY

SUMMARY SHEETS

RISK MANAGEMENT TOOL / TECHNIQUE SUMMARY SHEET

(a) Professional judgement and intuition

	%	% of other sample size shown	No.
SAMPLE SIZE:	100%		125
AWARENESS:			
not familiar with	1%		1
Total who have heard of =	99%		124
USE:			
heard of but don't use	0%		0
always use	93%	94%	116
sometimes use	6%	6%	8
Total who use =	99%	100%	124
when sometimes: smaller schemes and repeat work; most estimates; absence of data / general; by partner; where buildings are of similar construction to previous projects			
software: guti; Gleeds			
PERFORMANCE:			
Sample size (ie total who have heard of)	99%	100%	124
don't know	0%	0%	0
poor	0%	0%	0
fair	8%	8%	11
good	61%	62%	77
excellent	29%	29%	36
not stated	1%	1%	1
comments: essential; needs to be used with care; dependant on person; experience is the key; knowledge; all other t&t rely on this; not auditable; sometimes all that's available; no substitute			
REASON FOR NON USE:			
Sample size (ie those who have 'heard of but don't use')	0%		0
lack of understanding	0%		0
reliability / accuracy	0%		0
cost	0%		0
lack of clear benefit	0%		0
lack of IT facilities	0%		0
other reasons	0%		0
not stated	0%		0
comments:			

RISK MANAGEMENT TOOL / TECHNIQUE SUMMARY SHEET

(b) Contingency % allowance

	%	% of other sample size shown	No.
SAMPLE SIZE:	100%		125
AWARENESS:			
not familiar with	0%		0
Total who have heard of =	100%		125
USE:			
heard of but don't use	2%		2
always use	82%	83%	102
sometimes use	17%	17%	21
Total who use =	98%	100%	123
when sometimes: feasibility stage; commercial projects; when not using other methods; when poor info/brief available; as check on risk study output; low risk; poor info base; the norm; for simplicity; when clients / architects request; 90% used; based on assessment of id			
software: Everest; Excel; Gleeds			
PERFORMANCE:			
Sample size (ie total who have heard of)	100%	100%	125
don't know	0%	0%	0
poor	4%	4%	5
fair	26%	26%	33
good	54%	54%	68
excellent	14%	14%	17
not stated	2%	2%	2
comments: always required; depends on control / adjusting; does not facilitate informed decision making; too subjective without risk analysis; simple; everybody knows where they stand; historically used			
REASON FOR NON USE:			
Sample size (ie those who have 'heard of but don't use')	2%	100%	2
lack of understanding	0%	0%	0
reliability / accuracy	1%	50%	1
cost	0%	0%	0
lack of clear benefit	0%	0%	0
lack of IT facilities	0%	0%	0
other reasons	1%	50%	1
not stated	0%	0%	0
comments:			

RISK MANAGEMENT TOOL / TECHNIQUE SUMMARY SHEET

(c) Risk-adjusted discount rate

	%	% of other sample size shown	No.
SAMPLE SIZE:	100%		125
AWARENESS:			
not familiar with	54%		68
Total who have heard of =	46%		57
USE:			
heard of but don't use	23%		29
always use	6%	25%	7
sometimes use	17%	75%	21
Total who use =	22%	100%	28

when sometimes:

when risks are definable; initial cost advice; government projects; educated clients; MOD projects; tender decisions; life cycle estimate; client request; when paid for by client; more aware clients; public sector projects (MERA); when suitable

software:

Bespoke; Predict; Spreadsheet

	%	% of other sample size shown	No.
PERFORMANCE:			
Sample size (ie total who have heard of)	46%	100%	57
don't know	14%	32%	18
poor	2%	5%	3
fair	18%	39%	22
good	10%	23%	13
excellent	1%	2%	1
not stated	0%	0%	0
comments:			

	%	% of other sample size shown	No.
REASON FOR NON USE:			
Sample size (ie those who have 'heard of but don't use')	23%	100%	29
lack of understanding	15%	66%	19
reliability / accuracy	2%	7%	2
cost	0%	0%	0
lack of clear benefit	4%	17%	5
lack of IT facilities	0%	0%	0
not considered appropriate	1%	3%	1
not stated	2%	7%	2
comments:			

RISK MANAGEMENT TOOL / TECHNIQUE SUMMARY SHEET

(d) Subjective probability

	%	% of other sample size shown	No.
SAMPLE SIZE:	100%		125
AWARENESS:			
not familiar with	46%		58
Total who have heard of =	54%		67
USE:			
heard of but don't use	17%		21
always use	13%	35%	16
sometimes use	24%	65%	30
Total who use =	37%	100%	46

when sometimes:

when suitable; on large schemes; public sector projects; in majority of cases; client request; detailed cost plan stage; complex projects; MOD projects; first simple risk assessment; high risk; exceptional risk identified; 10% used; government projects; I

software:

Excel; @RISK; in house

PERFORMANCE:	%	% of other sample size shown	No.
Sample size (ie total who have heard of)	54%	100%	67
don't know	14%	25%	17
poor	2%	4%	3
fair	19%	36%	24
good	16%	30%	20
excellent	2%	4%	3
not stated	0%	0%	0

comments:

depends on team vision; allows combination of a range of variables to be assessed; who decides?

REASON FOR NON USE:	%	% of other sample size shown	No.
Sample size (ie those who have 'heard of but don't use')	17%	100%	21
lack of understanding	11%	67%	14
reliability / accuracy	2%	10%	2
cost	0%	0%	0
lack of clear benefit	3%	19%	4
lack of IT facilities	0%	0%	0
other reasons	0%	0%	0
not stated	1%	5%	1

comments:

RISK MANAGEMENT TOOL / TECHNIQUE SUMMARY SHEET

(e) Decision analysis - Algorithms

	%	% of other sample size shown	No.
SAMPLE SIZE:	100%		125
AWARENESS:			
not familiar with	74%		92
Total who have heard of =	26%		33
USE:			
heard of but don't use	21%		26
always use	1%	14%	1
sometimes use	5%	86%	6
Total who use =	6%	100%	7
when sometimes:			
as part of client system			
software:			
ProAct; @RISK			
PERFORMANCE:			
Sample size (ie total who have heard of)	26%	100%	33
don't know	15%	58%	19
poor	2%	9%	3
fair	6%	21%	7
good	2%	6%	2
excellent	0%	0%	0
not stated	2%	6%	2
comments:			
REASON FOR NON USE:			
Sample size (ie those who have 'heard of but don't use')	21%	100%	26
lack of understanding	12%	58%	15
reliability / accuracy	2%	8%	2
cost	1%	4%	1
lack of clear benefit	5%	23%	6
lack of IT facilities	0%	0%	0
not client driven	1%	4%	1
not stated	1%	4%	1
comments:			

RISK MANAGEMENT TOOL / TECHNIQUE SUMMARY SHEET

(f) Decision analysis - Means-end chain

	%	% of other sample size shown	No.
SAMPLE SIZE:	100%		125
AWARENESS:			
not familiar with	83%		104
Total who have heard of =	17%		21
USE:			
heard of but don't use	14%		18
always use	0%	0%	0
sometimes use	2%	100%	3
Total who use =	2%	100%	3
when sometimes:			
where critical path is very important; dependent on project type			
software:			
PERFORMANCE:			
Sample size (ie total who have heard of)	17%	100%	21
don't know	6%	38%	8
poor	2%	14%	3
fair	4%	24%	5
good	1%	5%	1
excellent	0%	0%	0
not stated	3%	19%	4
comments:			
requires continual review			
REASON FOR NON USE:			
Sample size (ie those who have 'heard of but don't use')	14%	100%	18
lack of understanding	6%	44%	8
reliability / accuracy	3%	22%	4
cost	1%	6%	1
lack of clear benefit	3%	22%	4
lack of IT facilities	0%	0%	0
too strategic / not suitable	1%	6%	1
not stated	0%	0%	0
comments:			

RISK MANAGEMENT TOOL / TECHNIQUE SUMMARY SHEET

(g) Decision analysis - Decision matrix

	%	% of other sample size shown	No.
SAMPLE SIZE:	100%		125
AWARENESS:			
not familiar with	58%		73
Total who have heard of =	42%		52
USE:			
heard of but don't use	27%		34
always use	3%	22%	4
sometimes use	11%	78%	14
Total who use =	14%	100%	18
when sometimes:			
government work; in conjunction with PM; depending on complexity of project			
software:			
in house			
PERFORMANCE:			
Sample size (ie total who have heard of)	42%	100%	52
don't know	14%	33%	17
poor	4%	10%	5
fair	15%	37%	19
good	6%	13%	7
excellent	1%	2%	1
not stated	2%	6%	3
comments:			
when suitable;			
REASON FOR NON USE:			
Sample size (ie those who have 'heard of but don't use')	27%	100%	34
lack of understanding	11%	41%	14
reliability / accuracy	2%	9%	3
cost	1%	3%	1
lack of clear benefit	9%	32%	11
lack of IT facilities	0%	0%	0
other reasons	2%	6%	2
not stated	2%	9%	3
comments:			

RISK MANAGEMENT TOOL / TECHNIQUE SUMMARY SHEET

(h) Decision analysis - Decision tree

	%	% of other sample size shown	No.
SAMPLE SIZE:	100%		125
AWARENESS:			
not familiar with	58%		73
Total who have heard of =	42%		52
USE:			
heard of but don't use	29%		36
always use	3%	25%	4
sometimes use	10%	75%	12
Total who use =	13%	100%	16

when sometimes:
when suitable; in conjunction with PM; where working with unknown members of design team; depending on complexity of project

software:

	%	% of other sample size shown	No.
PERFORMANCE:			
Sample size (ie total who have heard of)	42%	100%	52
don't know	18%	42%	22
poor	3%	8%	4
fair	11%	27%	14
good	6%	15%	8
excellent	1%	2%	1
not stated	2%	6%	3

comments:
only a 2-D representation; scientific guessing; appropriate weightings are essential

	%	% of other sample size shown	No.
REASON FOR NON USE:			
Sample size (ie those who have 'heard of but don't use')	29%	100%	36
lack of understanding	14%	50%	18
reliability / accuracy	4%	14%	5
cost	1%	3%	1
lack of clear benefit	6%	22%	8
lack of IT facilities	0%	0%	0
*other reasons**	1%	3%	1
not stated	2%	8%	3

comments:
* too strategic / not suitable (1); not client driven (1)

RISK MANAGEMENT TOOL / TECHNIQUE SUMMARY SHEET

(i) Decision analysis - Stochastic decision tree

	%	% of other sample size shown	No.
SAMPLE SIZE:	100%		125
AWARENESS:			
not familiar with	82%		103
Total who have heard of =	18%		22
USE:			
heard of but don't use	14%		18
always use	0%	0%	0
sometimes use	3%	100%	4
Total who use =	3%	100%	4
when sometimes:			
where appropriate; major projects only			
software:			
PERFORMANCE:			
Sample size (ie total who have heard of)	18%	100%	22
don't know	10%	59%	13
poor	2%	14%	3
fair	3%	18%	4
good	2%	9%	2
excellent	0%	0%	0
not stated	0%	0%	0
comments:			
REASON FOR NON USE:			
Sample size (ie those who have 'heard of but don't use')	14%	100%	18
lack of understanding	10%	67%	12
reliability / accuracy	2%	11%	2
cost	0%	0%	0
lack of clear benefit	3%	22%	4
lack of IT facilities	0%	0%	0
other reasons	0%	0%	0
not stated	0%	0%	0
comments:			

RISK MANAGEMENT TOOL / TECHNIQUE SUMMARY SHEET

(j) Decision analysis - Bayesian theory

	%	% of other sample size shown	No.
SAMPLE SIZE:	100%		125
AWARENESS:			
not familiar with	87%		109
Total who have heard of =	13%		16
USE:			
heard of but don't use	11%		14
always use	0%	0%	0
sometimes use	2%	100%	2
Total who use =	2%	100%	2
when sometimes:			
where appropriate			
software:			
PERFORMANCE:			
Sample size (ie total who have heard of)	13%	100%	16
don't know	9%	69%	11
poor	1%	6%	1
fair	3%	25%	4
good	0%	0%	0
excellent	0%	0%	0
not stated	0%	0%	0
comments:			
REASON FOR NON USE:			
Sample size (ie those who have 'heard of but don't use')	11%	100%	14
lack of understanding	8%	71%	10
reliability / accuracy	1%	7%	1
cost	0%	0%	0
lack of clear benefit	2%	21%	3
lack of IT facilities	0%	0%	0
other reasons	0%	0%	0
not stated	0%	0%	0
comments:			

RISK MANAGEMENT TOOL / TECHNIQUE SUMMARY SHEET

(k) Sensitivity analysis

	%	% of other sample size shown	No.
SAMPLE SIZE:	100%		125
AWARENESS:			
not familiar with	39%		49
Total who have heard of =	61%		76
USE:			
heard of but don't use	27%		34
always use	6%	19%	8
sometimes use	27%	81%	34
Total who use =	34%	100%	42

when sometimes:

when suitable; public sector projects; detailed cost plan stage; not often enough; in conjunction with PM; client request; standard; to give a range when doing early estimates; if major variance in possible brief; commercial projects; major schemes

software:

Excel; In house; Lotus 123

PERFORMANCE:	%	% of other sample size shown	No.
Sample size (ie total who have heard of)	61%	100%	76
don't know	17%	28%	21
poor	5%	8%	6
fair	18%	30%	23
good	18%	29%	22
excellent	2%	3%	2
not stated	2%	3%	2

comments:

usually gives good substance to (b); useful for identified potential effect of change in key variable

REASON FOR NON USE:	%	% of other sample size shown	No.
Sample size (ie those who have 'heard of but don't use')	27%	100%	34
lack of understanding	15%	56%	19
reliability / accuracy	3%	12%	4
cost	2%	6%	2
lack of clear benefit	2%	9%	3
lack of IT facilities	2%	9%	3
too theoretical re: actual reason for change / risk	1%	3%	1
not stated	2%	6%	2

comments:

RISK MANAGEMENT TOOL / TECHNIQUE SUMMARY SHEET

(I) Monte Carlo simulation

	%	% of other sample size shown	No.
SAMPLE SIZE:	100%		125
AWARENESS:			
not familiar with	48%		60
Total who have heard of =	52%		65
USE:			
heard of but don't use	34%		43
always use	2%	9%	2
sometimes use	16%	91%	20
Total who use =	18%	100%	22

when sometimes:

when suitable; major schemes; too complicated; where appropriate; in conjunction with PM; client request; time analysis; 1 in 100 jobs; risk cost planning; rarely use

software:

Crystal ball; @ RISK

	%	% of other sample size shown	No.
PERFORMANCE:			
Sample size (ie total who have heard of)	52%	100%	65
don't know	24%	46%	30
poor	8%	15%	10
fair	14%	26%	17
good	5%	9%	6
excellent	0%	0%	0
not stated	2%	3%	2

comments:

not convinced; complicated; 'dislike 'black box' system'; dependant upon probability selected

	%	% of other sample size shown	No.
REASON FOR NON USE:			
Sample size (ie those who have 'heard of but don't use')	34%	100%	43
lack of understanding	18%	51%	22
reliability / accuracy	5%	14%	6
cost	2%	6%	3
lack of clear benefit	6%	16%	7
lack of IT facilities	3%	8%	4
not client driven	1%	2%	1
not stated	1%	2%	1

comments:

too theoretical; dislike single figure output

RISK MANAGEMENT TOOL / TECHNIQUE SUMMARY SHEET

(m) Portfolio theory

	%	% of other sample size shown	No.
SAMPLE SIZE:	100%		125
AWARENESS:			
not familiar with	89%		111
Total who have heard of =	11%		14
USE:			
heard of but don't use	11%		14
always use	0%		0
sometimes use	0%		0
Total who use =	0%		0
when sometimes:			
software:			
PERFORMANCE:			
Sample size (ie total who have heard of)	11%	100%	14
don't know	8%	71%	10
poor	1%	7%	1
fair	0%	0%	0
good	0%	0%	0
excellent	0%	0%	0
not stated	2%	21%	3
comments:			
REASON FOR NON USE:			
Sample size (ie those who have 'heard of but don't use')	11%	100%	14
lack of understanding	6%	57%	8
reliability / accuracy	2%	14%	2
cost	0%	0%	0
lack of clear benefit	2%	21%	3
lack of IT facilities	0%	0%	0
too strategic / not suitable	1%	7%	1
not stated	0%	0%	0
comments:			

RISK MANAGEMENT TOOL / TECHNIQUE SUMMARY SHEET

(n) Stochatic dominance

	%	% of other sample size shown	No.
SAMPLE SIZE:	100%		125
AWARENESS:			
not familiar with	91%		114
Total who have heard of =	9%		11
USE:			
heard of but don't use	9%		11
always use	0%		0
sometimes use	0%		0
Total who use =	0%		0
when sometimes:			
software:			
PERFORMANCE:			
Sample size (ie total who have heard of)	9%	100%	11
don't know	6%	73%	8
poor	1%	9%	1
fair	1%	9%	1
good	0%	0%	0
excellent	0%	0%	0
not stated	1%	9%	1
comments:			
REASON FOR NON USE:			
Sample size (ie those who have 'heard of but don't use')	9%	100%	11
lack of understanding	6%	64%	7
reliability / accuracy	2%	18%	2
cost	0%	0%	0
lack of clear benefit	1%	9%	1
lack of IT facilities	0%	0%	0
too strategic / not suitable	1%	9%	1
not stated	0%	0%	0
comments:			

RISK MANAGEMENT TOOL / TECHNIQUE SUMMARY SHEET

(o) Utility theory

	%	% of other sample size shown	No.
SAMPLE SIZE:	100%		125
AWARENESS:			
not familiar with	85%		106
Total who have heard of =	15%		19
USE:			
heard of but don't use	13%		16
always use	0%	0%	0
sometimes use	2%	100%	3
Total who use =	2%	100%	3
when sometimes:			
client request			
software:			
PERFORMANCE:			
Sample size (ie total who have heard of)	15%	100%	19
don't know	7%	47%	9
poor	2%	11%	2
fair	6%	37%	7
good	0%	0%	0
excellent	0%	0%	0
not stated	1%	5%	1
comments:			
difficult to assess utilities; blunt instrument; if you're looking at peoples attitudes			
REASON FOR NON USE:			
Sample size (ie those who have 'heard of but don't use')	13%	100%	16
lack of understanding	5%	38%	6
reliability / accuracy	2%	13%	2
cost	1%	6%	1
lack of clear benefit	4%	31%	5
lack of IT facilities	0%	0%	0
too strategic / not suitable	1%	6%	1
not stated	1%	6%	1
comments:			

RISK MANAGEMENT TOOL / TECHNIQUE SUMMARY SHEET

(p) Expected monetary value

	%	% of other sample size shown	No.
SAMPLE SIZE:	100%		125
AWARENESS:			
not familiar with	67%		84
Total who have heard of =	33%		41
USE:			
heard of but don't use	20%		25
always use	4%	31%	5
sometimes use	9%	69%	11
Total who use =	13%	100%	16
when sometimes: as an indicator; most usual form of calculating consequences; on commercial projects; spec developments; client request			
software:			
PERFORMANCE:			
Sample size (ie total who have heard of)	33%	100%	41
don't know	14%	41%	17
poor	2%	5%	2
fair	10%	32%	13
good	6%	20%	8
excellent	0%	0%	0
not stated	1%	2%	1
comments: good if combined with (k); one point estimate			
REASON FOR NON USE:			
Sample size (ie those who have 'heard of but don't use')	20%	100%	25
lack of understanding	11%	56%	14
reliability / accuracy	2%	12%	3
cost	2%	8%	2
lack of clear benefit	3%	16%	4
lack of IT facilities	0%	0%	0
other reasons	0%	0%	0
not stated	2%	8%	2
comments:			

RISK MANAGEMENT TOOL / TECHNIQUE SUMMARY SHEET

(q) Delphi peer group

	%	% of other sample size shown	No.
SAMPLE SIZE:	100%		125
AWARENESS:			
not familiar with	91%		114
Total who have heard of =	9%		11
USE:			
heard of but don't use	9%		11
always use	0%		0
sometimes use	0%		0
Total who use =	0%		0
when sometimes:			
software:			
PERFORMANCE:			
Sample size (ie total who have heard of)	9%	100%	11
don't know	6%	64%	7
poor	0%	5%	1
fair	2%	23%	3
good	0%	0%	0
excellent	0%	0%	0
not stated	1%	9%	1
comments:			
no cross fertilisation of ideas			
REASON FOR NON USE:			
Sample size (ie those who have 'heard of but don't use')	9%	100%	11
lack of understanding	4%	45%	5
reliability / accuracy	1%	14%	2
cost	1%	14%	2
lack of clear benefit	1%	9%	1
lack of IT facilities	0%	0%	0
other reasons	1%	9%	1
not stated	1%	9%	1
comments:			

RISK MANAGEMENT TOOL / TECHNIQUE SUMMARY SHEET

(r) ELSIE

	%	% of other sample size shown	No.
SAMPLE SIZE:	100%		125
AWARENESS:			
not familiar with	27%		34
Total who have heard of =	73%		91
USE:			
heard of but don't use	58%		73
always use	2%	11%	2
sometimes use	13%	89%	16
Total who use =	14%	100%	18

when sometimes:

offices; very rarely; if appropriate to type of building; 2 in 100 jobs; to check other methods; initial enquiry; early budget for commercial; industrial / commercial feasibility studies

software:

ELSIE

	%	% of other sample size shown	No.
PERFORMANCE:			
Sample size (ie total who have heard of)	73%	100%	91
don't know	30%	41%	37
poor	4%	5%	5
fair	18%	25%	23
good	10%	14%	13
excellent	1%	1%	1
not stated	10%	14%	13

comments:

depends on experience of user; limited to specific types of development

	%	% of other sample size shown	No.
REASON FOR NON USE:			
Sample size (ie those who have 'heard of but don't use')	58%	100%	73
lack of understanding	14%	25%	18
reliability / accuracy	7%	12%	9
cost	11%	19%	14
lack of clear benefit	7%	12%	9
lack of IT facilities	8%	14%	10
*other reasons**	2%	4%	3
not stated	8%	14%	10

comments:

consider own system better; assumes standard building all the time; needs more development; OK for large practice with lots of projects

RISK MANAGEMENT TOOL / TECHNIQUE SUMMARY SHEET

(s) Brainstorming

	%	% of other sample size shown	No.
SAMPLE SIZE:	100%		125
AWARENESS:			
not familiar with	18%		23
Total who have heard of =	82%		102
USE:			
heard of but don't use	22%		28
always use	26%	45%	33
sometimes use	33%	55%	41
Total who use =	59%	100%	74

when sometimes:
when suitable; as team leader; detailed cost plan stage; mostly in conjunction with others; just prior to finishing robust estimate; when info is scarce; as the occasion demands; hospital contracts; when others can contribute; seldom; on unfamiliar constr

software:

	%	% of other sample size shown	No.
PERFORMANCE:			
Sample size (ie total who have heard of)	82%	100%	102
don't know	8%	10%	10
poor	5%	6%	6
fair	15%	19%	19
good	34%	42%	43
excellent	12%	15%	15
not stated	6%	8%	8

comments:
essential to all projects; with designers to compile list of core probabilities; cross fertilisation of ideas; requires pro active design team; other consultants protect their interests; helps generate info for other systems; depends who leads; based on r

	%	% of other sample size shown	No.
REASON FOR NON USE:			
Sample size (ie those who have 'heard of but don't use')	22%	100%	28
lack of understanding	6%	25%	7
reliability / accuracy	6%	25%	7
cost	2%	7%	2
lack of clear benefit	3%	14%	4
lack of IT facilities	0%	0%	0
*other reasons**	2%	7%	2
not stated	5%	21%	6

comments:
* unstructured (1) ; timescale prohibits learning curve (1)

RISK MANAGEMENT TOOL / TECHNIQUE SUMMARY SHEET

(t) Prompts / checklists

	%	% of other sample size shown	No.
SAMPLE SIZE:	100%		125
AWARENESS:			
not familiar with	11%		14
Total who have heard of =	89%		111
USE:			
heard of but don't use	10%		12
always use	66%	83%	82
sometimes use	14%	17%	17
Total who use =	79%	100%	99

when sometimes:

when suitable; as team leader; detailed cost plan stage; part of quality management system; most estimates; use as a support to other techniques; omission is the main reason for failure

software:

	%	% of other sample size shown	No.
PERFORMANCE:			
Sample size (ie total who have heard of)	89%	100%	111
don't know	6%	6%	7
poor	1%	1%	1
fair	16%	18%	20
good	42%	47%	52
excellent	19%	22%	24
not stated	6%	7%	8

comments:

essential on all projects; helps; cross checking always pays dividends; good starting point; hopefully you do not forget anything

	%	% of other sample size shown	No.
REASON FOR NON USE:			
Sample size (ie those who have 'heard of but don't use')	10%	100%	12
lack of understanding	2%	25%	3
reliability / accuracy	2%	25%	3
cost	0%	0%	0
lack of clear benefit	2%	17%	2
lack of IT facilities	0%	0%	0
*other reasons**	2%	17%	2
not stated	2%	17%	2

comments:

*part of professional function (1); variable results / variable benefits (1)

RISK MANAGEMENT TOOL / TECHNIQUE SUMMARY SHEET

(u) MERA

	%	% of other sample size shown	No.
SAMPLE SIZE:	100%		125
AWARENESS:			
not familiar with	75%		94
Total who have heard of =	25%		31
USE:			
heard of but don't use	7%		9
always use	2%	9%	2
sometimes use	16%	91%	20
Total who use =	18%	100%	22

when sometimes:

MOD projects; client request; government projects; educated clients; in majority of cases; dependant on project; covers your back when you do not know; 8% used; ex PSA projects; public sector projects

software:

Excel; in house; Root Mean Squared

	%	% of other sample size shown	No.
PERFORMANCE:			
Sample size (ie total who have heard of)	25%	100%	31
don't know	7%	29%	9
poor	1%	3%	1
fair	7%	29%	9
good	8%	32%	10
excellent	2%	6%	2
not stated	0%	0%	0

comments:

itemised contingency (better); slightly outdated; nice big contingency

	%	% of other sample size shown	No.
REASON FOR NON USE:			
Sample size (ie those who have 'heard of but don't use')	7%	100%	9
lack of understanding	5%	67%	6
reliability / accuracy	0%	0%	0
cost	1%	11%	1
lack of clear benefit	1%	11%	1
lack of IT facilities	0%	0%	0
other reasons	0%	0%	0
not stated	1%	11%	1

comments:

software: