PROJECT RISK MANAGEMENT AND ITS APPLICATION INTO THE AUTOMOTIVE MANUFACTURING INDUSTRY.

EXECUTIVE SUMMARY.

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ABSTRACT.

In today's competitive environment, there is a continual need for organisations to invest substantial amounts of resource into the development and manufacture of products and processes, and Automotive Manufacturing Organisations are no exception to this. However, if the success rate of the projects undertaken by these organisations could be increased, then the level of resources invested in these projects could potentially be reduced. The management of risk offers a method through which the success rate of projects can be increased. However, as yet, many organisations within the Automotive Manufacturing Sector have not undertaken to integrate a rigorous method of managing the risks to their projects.

This work focuses on the development and implementation of a project Risk Management Methodology into the Automotive Manufacturing Industry. The methodology was developed from a rigorous examination into the use of project and risk management into the Automotive Manufacturing Industry, as well as an investigation of risk management and project risk management processes within both the industrial and academic domains. Therefore, the Risk Management Methodology was designed to fit the needs of the users within the Automotive Manufacturing Industry, and as such, is compatible with the project management methods used within this industrial sector. The deliverables of the Risk Management Methodology were compared to 9 risk management processes and were found to give additional benefits to these processes. These were identified as the realisation of quality benefits, improvements to the technology and changes to working practices from reactive to pro-active management, which indicate that the Risk Management Methodology is more suited to Automotive Manufacturing Organisations than the other risk management processes.

The Risk Management Methodology is a cyclic process, consisting of 5 stages; identification, assessment, analysis, reduction and/or mitigation and monitoring of the risks. Various tools have been developed as part of the Risk Management Methodology. They are the Front-End Assessment Tool to determine if there is a potential need to use the Risk Management Methodology, a Risk Register Database System to document the identified risks irrespective of geographical location, and the Risk Assessment Tool to enable the level of risk within the project to be reported. In addition to this, a Tracking Tool for Research and Technology Projects, based on the requirements of Rover's Technology Strategy Team, was developed to enable the probability of success of technology projects to be determined and tracked throughout their lifespan.

The application of the Risk Management Methodology into 7 projects within the Rover/BMW group enabled the methods through which the assessment of the risks as well as the use of numbers within the tools themselves to be critiqued, as well as benefits of the use of the methodology and the tools to be ascertained. What was determined from its implementation was that it enabled the risks to be made visible through their identification, assessment, analysis and management. Deviations from the proposed plan could be identified, and an effort made to reduce and/or mitigate against the effects of the risks. In addition, the decision making process was improved, through increasing the amount of relevant information within the project and that there was identified a change in the working practices of the individuals and teams, from reactive, firefighting to pro-active management of the project.

In conclusion, the Risk Management Methodology and its associated tools and techniques provides the means by which the risks and potential problems within projects in the Automotive Manufacturing Sector can be actively managed and as such, enables the projects to be completed successfully.

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GLOSSARY OF TERMS.

ACRONYM	MEANING
→	To
ALARP	As Low As Reasonably Possible
ALM	Asset/Liability Method
ARR	Accounting Rate of Return
BMW	
CAPM	Capital Asset and Pricing Model
CASPAR	Computer Aided Simulation for Project Appraisal and Review
CB40	CB40 Fender Project in which the initial test of the Risk Management Methodology was performed
CBoM	Convergence Bill Of Materials programme, consisting of 6 projects in which the final form of the Risk Management Methodology was implemented
CCTA	Central Computer and Telecommunications Agency
CPA	Critical Path Analysis
FMEA	Failure Modes and Effects Analysis
FMECA	Failure Modes, Effects and Criticality Analysis
GIPT	Granular Injected Paint Technology
H	High
HAZID	HAZard IDentification (as HAZOP but also identified external processes and interactions between systems in operation)
HAZOP	HAZard Operable study
HSE	Health and Safety Executive
I	Impact
IRR	Internal Rate of Return
L	Low
M	Medium
MOD	Ministry of Defence
MS®	Microsoft®
No	Number
NPD	New Product Development
NPV	Net Present Value
OEM	Original Engineering Manufacturer
P	Probability
PERT	Project Evaluation and Review Technique
PM	Project Management
PRAM	Project Risk Analysis and Management
PSA	Probabilistic Safety Analysis
QFD	Quality Function Deployment
QRA	Quantitative Risk Assessment
R&T	Research and Technology, more commonly known as Research and Development

RDM	Risk Diagnostic and Management
Risk Analysis	Use of computational simulation techniques to analyse the risks within the entire project
Risk Assessment	Assessment of the identified risks for their probability and impact values
Risk Identification	The identification of the risks within the project
Risk Monitoring	Monitoring the risks on a continual basis and the continuation of the cyclic process of the Risk Management Methodology
Risk Reduction and/or Mitigation	Production of reduction plans to reduce the impact of the risk and/or mitigation plans to mitigate against its affect
RF	Risk Factor
RISKAT	Risk Assessment Tool
RMC	Results Management Committee
RMM	Risk Management Methodology
ROCE	Return on Capital Employed
ROI	Return on Investment
RV	Risk Value
SAP	Safety Assessment Principles
TOPM	Target Optimum Portfolio Management
TOR	Tolerability of Risks
VH	Very High
VL	Very Low
VL $\rightarrow$ VH	Very Low to Very High
Wt.	Weight

1.0 INTRODUCTION.

In today's competitive environment, there is a continual need for organisations to invest substantial resources into the development and manufacture of products and processes. However, as risk is an integral part of many projects, this can sometimes be a highly uncertain path for organisations to follow. Organisations need to look to new and innovative methods to ensure that their products and processes are developed in shorter lead times and that resources are not wasted. Therefore, if a proportion of the risk and uncertainty could be controlled or reduced through effective project risk management, then resources could possibly be saved and the organisation would be able to focus on activities which potentially give the greatest chance of success.

This work initially identifies why the majority of manufacturing organisations do not manage the risks to their projects, why risk management is important for organisations to undertake and how it is relevant to projects within the Automotive Manufacturing Industry. From this, a Risk Management Methodology (RMM), which will enable the inherent risks to projects within the automotive sector to be managed, is developed. The implementation of the Risk Management Methodology and its associated tools and techniques into 7 projects in the Automotive Manufacturing Industry are discussed and the benefits of its use within these projects are presented. Conclusions from the dissemination of the methodology in relation to its acceptability and applicability to the Automotive Manufacturing Industry are given.

This research was initiated by the Rover Group as a means of determining if the success rate of projects could be potentially increased as well as to ascertain which projects should be continued in the long term as a means of decreasing the amount of resources invested into projects which do not deliver to their initial objectives.

1.1 Objectives and Methodology of the Research.

The main objective of this work was to develop an overall methodology which can be used to enable the risks, uncertainty and potential problems within a project in the Automotive Manufacturing Sector to be effectively, efficiently and actively managed as a means of increasing the overall probability of success of the project.

The methodology was designed for those types of projects which enable the Automotive Manufacturing Organisations to design, develop and manufacture their products. In addition, the process would have to both integrate with and enhance the project management processes and techniques already in existence within the organisation.

Within this, the initial aim was to construct and test a project risk management process for use within the Automotive Manufacturing Industry, based on the specific needs and requirements of the industry and the users of the process. The goal was to develop the process, test its design and provide a generic risk management method which could be used, applied and implemented throughout the Rover/BMW group and the industry as a whole. As the work progressed there was a need to investigate and research various areas;

- A comprehensive literature review was carried out to investigate 'risk management'. This review explored many areas, including project management, financial and project risk management, the use of risk management in various industrial sectors as well as people issues and the perception of risk.
- An investigation of the use of project management within the Automotive Manufacturing Industry, which included a review of the literature and the processes used within the Automotive Manufacturing Industry, a post-audit review of the GIPT project, and the views of individuals within the Rover/BMW group, some of whom had worked at various other Automotive Manufacturing Organisations within the UK, Europe and the Pacific Rim.
- Various existing risk management processes were investigated with respect to their objectives, the stages and tasks contained within and the deliverables of each of those stages.
- Evidence of the applicability and use of the methodology within the Automotive Manufacturing Industry, which will be achieved through the investigation of the use and benefits of the process.

From this investigation, the initial form of the Risk Management Methodology was developed and tested on the CB40 Fender Project within the Rover/BM group. From the initial implementation, it was determined that changes to the methodology as well as the development of additional tools and techniques were required. The latter took the form of the computerised Risk Register database system and Risk Assessment Tool, the Front-End Assessment tool and the Tracking Tool for R&T Projects.

The Risk Management Methodology was then applied to 6 projects within the CBoM programme from which a variety of information on its use, benefits and performance were gained. From its application, overall benefits of its use were determined and procedures for its use, which were based on the learning and knowledge developed through the implementation into the projects, were written. These procedures have since been introduced into the IT and R&T divisions of the Rover/BMW group. The innovation of this research can therefore be described as the development of the overall methodology and its implementation into an industry which has previously not tended to use a formal process of project risk management.[1]

A diagram of the research methodology can be seen in figure 1.

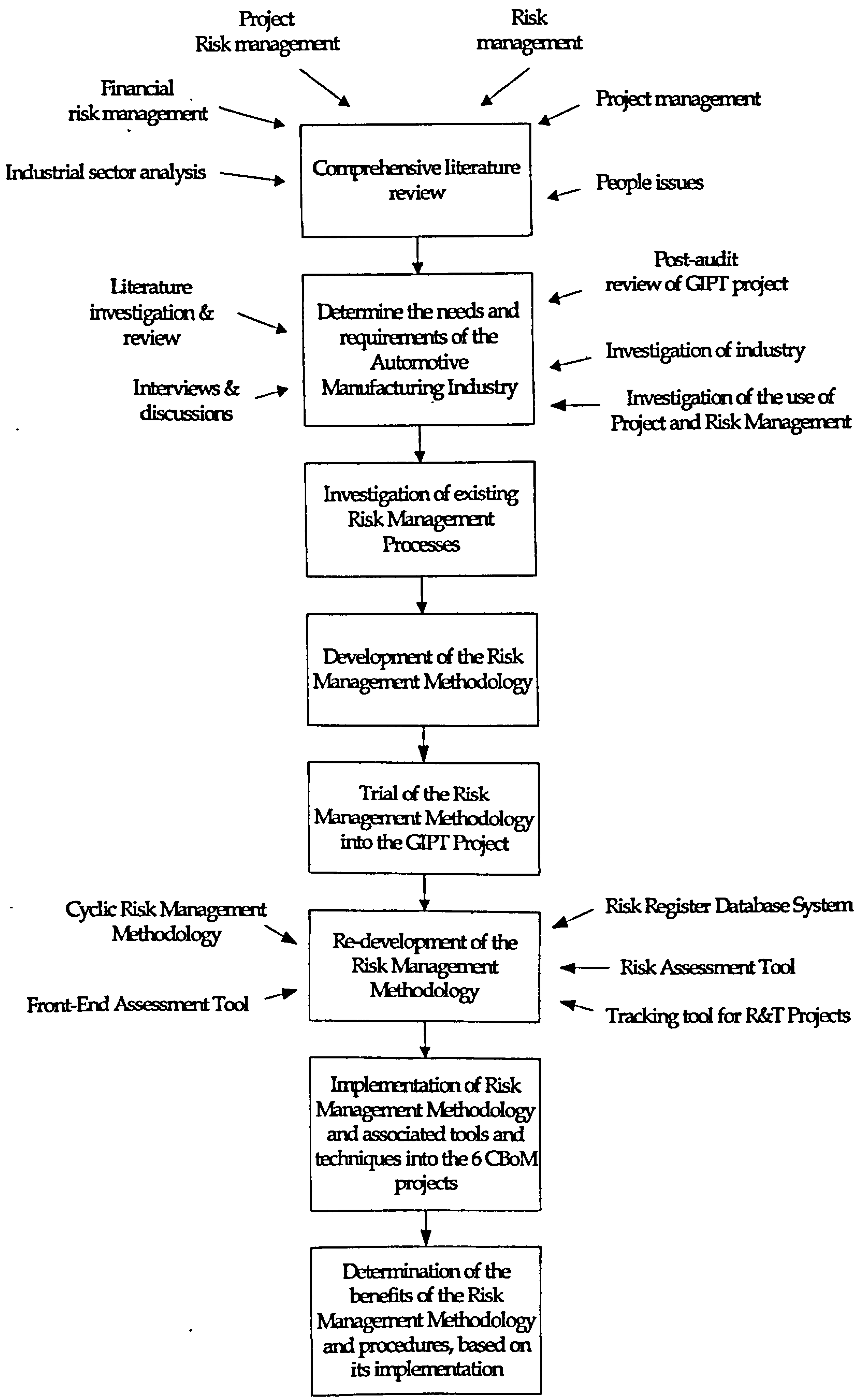

Figure 1 - The Research Methodology.

1.2 Reading Order of the Portfolio.

The portfolio consists of 13 pieces of work (submissions), which can be identified through their titles and numerical order in which they were submitted, figure 2. It can be seen that the pieces of work were submitted in a different order to which they should be read. The main reason for this is that the numerical order of the submissions is based on the development of the research. It is felt that to aid the reader to understand the flow and consistency of the work, the submissions should be read in the order shown in figure 1.

Hence, the investigation of the literature as well as the post-audit review of the GIPT project enabled the needs and requirements of the Automotive Manufacturing Industry to be determined (submission 1a). From this, the Risk Management Methodology, based on these investigations was initially designed and tested (submission 1b). This initial test resulted in a re-design of the Risk Management Methodology (submission 2), as well as the identification of the need for a computer based Risk Register (submission 6). Further application of the methodology detected the need for a 'Risk Assessment Tool' (submission 3), and the Front-End Assessment Tool (submission 9). From these applications, the 'Implementation of the Risk Management Methodology - Problems and Solutions' (submission 7), 'Procedures for the Use of the Risk Management Methodology' (submission 11), and 'Benefits of the Risk Management Methodology' (submission 10) were then written. In addition to these a 'Tracking Tool for R&T Projects' was developed (submission 8) and both a Journal and Conference paper written and presented (submissions 4 and 5). This Executive Summary (submission 12) presents an overview of the research, development and implementation of the Risk Management Methodology, its associated tools and techniques as well as the supporting evidence and documentation developed within the work. The Personal Profile (submission 13) illustrates how the author has developed during the period of this work.

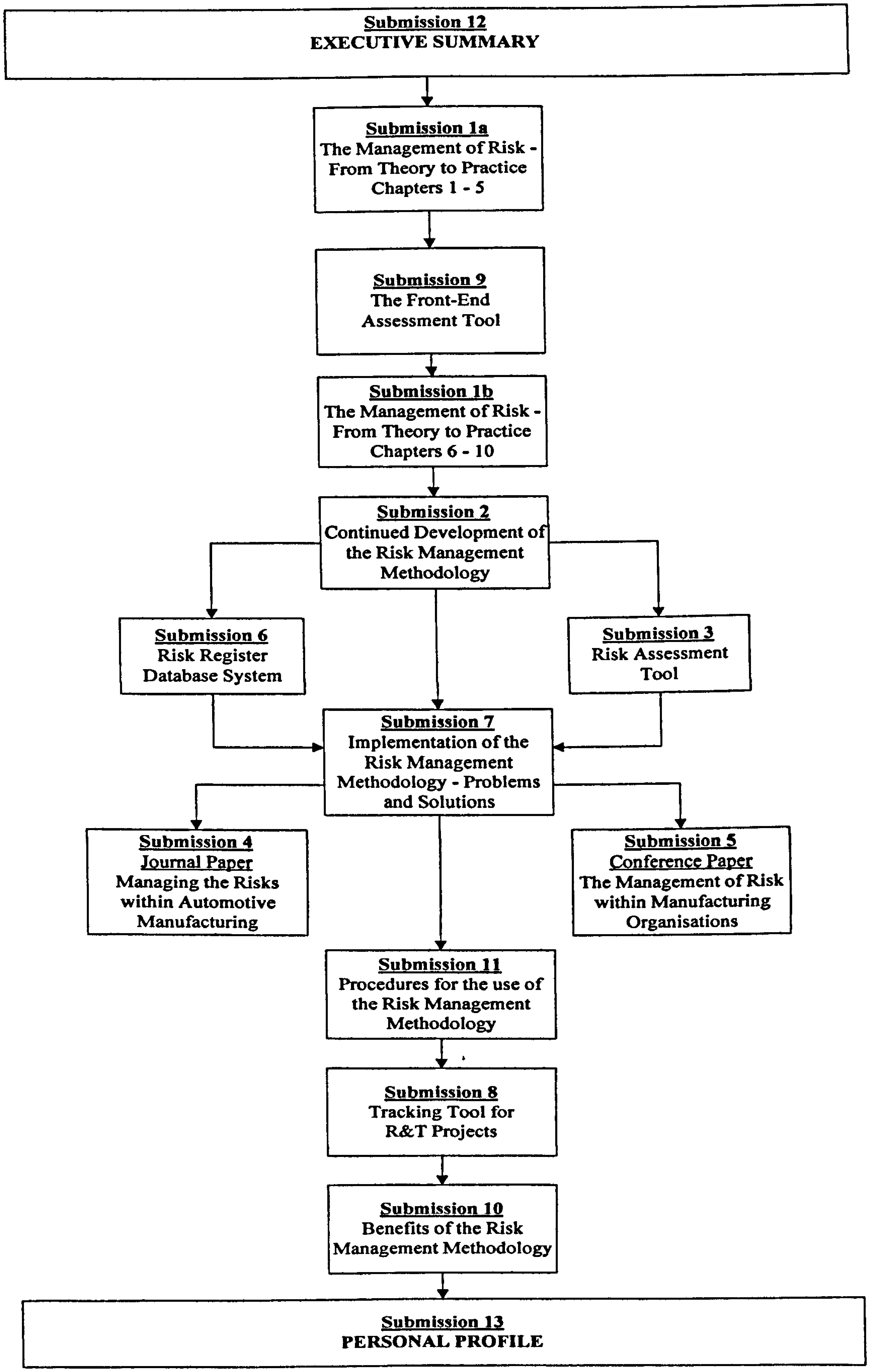

Figure 2 – Suggested Reading Order of the Portfolio.

2.0 RISK MANAGEMENT AND ITS USE IN INDUSTRY.

This section will give a brief definition of both risk and project risk management, as well as introduce the means by which various industries utilise risk management. It is intended to show the wide variety of risk management practices used throughout the many industrial sectors and as such, will provide both a foundation and insights into the use of project management tools and techniques.

2.1 Definition of Risk and Project Risk Management.

There are numerous ways of defining both risk and project risk management. In its most basic form, risk can be defined as *'the possibility of incurring misfortune or loss, a person or thing considered as a potential hazard'*[2], which takes into consideration uncertainty and chance. However, texts on the subject of risk have tended to remove uncertainty from their definition, through focusing on the use of quantifiable, probable events within a specific time period. Thus, the Royal Society defines risk as *'the probability that a particular adverse event occurs during a stated period of time, or results from a particular challenge'*.[3] A similar description defines risk as *'the likelihood of a specific undesirable event occurring within a specified period or in specified circumstances'*.[4] Wharton, on the other hand, presents a concise meaning of risk which is *'any unintended or unexpected outcome of a decision or course of action'*.[5] These definitions of risk tend to focus on the negative aspects of its occurrence. However, risk can also be equated to a positive outcome or event. This is backed up by Cooper and Chapman who state that *'risk is exposure to the possibility of economic or financial loss or gain, physical damage or injury, or delay, as consequence of the uncertainty associated with pursuing a particular course of action'*.[6]

There are also many definitions of 'project risk' and 'project risk management'. Carter et al define project risk as *'the function of both the likelihood (probability) of an event ....occurring and its impact'*.[7] This therefore takes into account the empirical method of calculating the magnitude of a risk. Chapman and Ward define project risk as *'the implications of the existence of significant uncertainty about the level or project performance achievable'*, whereas the role of risk management is *'to improve project performance via systematic identification, appraisal and management of project-related risk'*.[8]

It can therefore be seen that there are many different definitions of risk and project risk within the literature, and that the role of risk management is to increase the success of a project. Using these definitions and the understanding that the author has, a risk will be defined within this work as *'any aspect of the project which may have a detrimental effect on the project itself.'*[9] Risk management will therefore be defined as managing the risks within the project, with the overall objectives of completing risk management being to *'actively manage the risks within a project and as such, potentially increase the likelihood that the project will be successfully completed'*.

2.2 The Application of Risk Analysis and Management into Various Industries.

Project and risk management are processes which have been used in many industrial sectors as a means of both improving the business practices and being able to effectively control projects, processes and product developments. As Williams states, *'the need to identify a project's uncertainty, estimate their impact, analyse their interdependencies and control them within a risk management structure has only in recent years been realised, mainly within the defence, construction and oil industries'*.[10] The finance, software and information technology, the UK government agencies and its contractors - which include the Health and Safety Executive (HSE) - the offshore oil and gas industry, and the nuclear, defence and construction industries were investigated during this research. Figure 3 shows the various techniques which are utilised within these industrial sectors. From this it can be seen that in the majority of industries, both quantitative and qualitative techniques play an extremely important role in managing and simulating the effects of risks.

Industrial Area	*Description of Techniques and Tools*	*Techniques and Tools Used*	*Methodologies • Used*
Finance Industry	Primarily numerical quantitative simulation techniques	• NPV, IRR, ROCE, ARR[11] • Sensitivity Analysis[12] • Portfolio Theory[13] • CAPM[12] • Monté Carlo Simulation[14] • Asset/Liability Method (ALM)[15] • Risk Neutral Valuation[16]	
Software and IT Industry	Qualitative and quantitative techniques based on reliability and failure analysis	• Fault Tree Analysis[17] • FMEA / FMECA[17] • Reliability Growth Models[17] • Fault Tolerance Techniques[17]	• Project Risk Analysis and Management (PRAM)[18] • Project Scoping[19] • Eloff et al's Comparative Framework for Risk Analysis Methods[20]
Government	Provider of legislation on health and safety issues, and the mandatory use of risk management for its contractors and suppliers		
Health and Safety Executive (HSE)	Primarily quantitative methods, as well as ensuring that government legislation is carried out by organisations	• Quantitative Risk Assessment (QRA)[21] • ALARP Principle[4] • Risk Assessment Tool, RISKAT[22]	
Offshore Oil and Gas	Primarily quantitative methods, using numerical and computational simulation techniques	• ALARP Principle[4] • QRA[21] • Event Tree[21] • Spreadsheet Analysis Methods[21] • Computerised Simulation (Event Tree)[21] • Monté Carlo Simulation[23] • HAZOP[24] • HAZID[25]	
Nuclear Industry	Primarily quantitative techniques	• ALARP Principle[4] • QRA[21]	

		• Probabilistic Safety Analysis (PSA) • Tolerability of Risks (TOR) • Safety Assessment Principles (SAP)	
Defence	As a mandatory requirement by government, using mainly qualitative techniques[26]		• Project Risk Management Methodologies
Construction Industry	Both qualitative and quantitative techniques	• Intuition, judgement, experience[27-28] • Applying a Risk Premium[27] • Subjective Probability[27] • Decision Trees[27] • Decision Analysis[27] • CASPAR[27] (Computer Aided Simulation for Project Appraisal and Reviews) • Monté Carlo Simulation[27] • Probabilistic Analysis[29] • Fuzzy Set Theory[29]	• Project Risk Management Methodologies • Analytical • Hierarchy Process (AHP)[30, 31, 32, 33]

Figure 3 - Types of Tools, Techniques and Methodologies used within the Investigated Industrial Sectors.

It has been argued that the need for safety, whether it be in terms of financial security, that of the organisation's operations or in the reduction of hazards to employees, the public and the environment, has been a major force behind the use of risk management tools and techniques within these industries.[34] However, these organisations also need to satisfy both government and self-imposed regulation. The UK Government has been pivotal in the requirement for organisations to use risk management techniques. This has primarily been through defining legislation to control the use of hazardous and risky material, the practices adopted within each organisation as well as in the deliverables of contracts, such as within defence procurement. Starr states that the regulations fall into two categories: the *'imposition of technical and operating criteria'* and the *'encouragement of operating system self-management'*.[35] The key development in the legislation has been the progression from prescriptive legislation, in which orders were given as to what should be done, to a goal-orientated and flexible *'safety contract'* between the organisation and the government.[36] Providing an organisation meets its self-imposed safety standards, the government should allow the organisation to continue its operations.

Even though this path of self-regulation requires greater commitment by management, it has been used within many large UK companies with encouraging results.[37] However, the theory that self-regulation will work is contradicted by Smith and Tombs, who cite a number of incidents where organisations have not effectively regulated their operations.[38] Even so, the UK Government still retains its policing role by ensuring that self-imposed rules and regulations are carried out by those who created them. This is achieved through the use of fines, limitations on operations and *'enforcement tools'*.[38] Kharbanda and Stallworthy state that in the UK, *'the company is held completely responsible for its actions and the consequences; neglect of duty on the part of the company has to be established in order that claims for damages may be sustained'*.[37]

Ultimately, the industrial sectors stated in figure 3 would not continue to use risk management tools and techniques if there was no benefit, monetary, contractually or otherwise, gained from their use. In government contracts, the use of risk management is mandatory as a requirement of the procurement contracts. Also legislative requirements have meant that organisations have utilised risk management techniques as a means of increasing safety and reducing hazards. These aspects can have wider implications, through increasing the public's acceptance of the organisation's products and processes and of the industry as a whole. In addition, these aspects may also enable the organisation to increase the quality of its products and processes, as well as decrease the time and cost of product development.[39] All of these aspects can hence benefit the organisation and as such, enable it to remain competitive and in business.

3.0 NEEDS AND REQUIREMENTS FOR PROJECT RISK MANAGEMENT WITHIN THE AUTOMOTIVE MANUFACTURING INDUSTRY.

In chapter 2 it was identified that risk management is currently used in different forms within various industrial sectors. However, what became evident was that, as a whole, project risk management is not used throughout the Automotive Manufacturing Industry. The reasons why this is so, whether this industrial sector would benefit from the use of project risk management and also what form it should take will be discussed in this chapter. Starting with the diffusion and use of project management within the Automotive Manufacturing Industry, the reasons why project risk management is not used throughout the industry are then examined. A post-audit review of the GIPT project within the Rover group was also completed, to determine how innovative, product development projects are managed within the organisation. From this, a discussion of the potential benefits to be gained from the use of a project risk management process within an Automotive Manufacturing Organisation will be given.

3.1 The Use of Project Management within the Automotive Manufacturing Industry.

Project risk management can be considered a subset and a tool within a project managers' toolbox. This section will therefore critique the development, use and need for modern-day project management within the automotive manufacturing sector, and demonstrate how it contrasts and differs with project management used within other industrial sectors.

3.1.1 The Development of the Use of Project Management within the World Automotive Manufacturing Industry.

Project management was initially developed at the beginning of the 20th century to help cope with the continual and increasingly faster development of technology.[34] However, the development and use of 'modern-day project management techniques', such as PERT and CPA, have only been prevalent in various industries over the last 40 years.[40] Greek therefore concludes that the usage of project management is new to many industrial sectors, including the Automotive Manufacturing Industry.[41]

3.1.1.1 The Need for Effective Project Management Techniques.

There is no doubt that within the USA and Europe, the increase in competition from the Asia/Pacific rim has caused the Automotive Manufacturing Industry to re-think the ways in which new vehicles are designed and developed. By the early 1990's, the time to market of a new vehicle in Honda was 3 years, whereas in Chrysler it was closer to 6 years.[42]

Clark et al found that the time to develop new vehicles significantly reduced as projects changed from functional → lightweight → heavyweight project management.[43] A lightweight project manager is generally part of a functional organisation, where the project manager co-ordinates but has little influence over the content of the project and has a low status within the organisation. This is in contrast to a heavyweight project manager, who has direct responsibility for the project, has influence both inside and outside of the project boundaries and has a high status within the organisation. Within Japanese Automotive Manufacturing Organisations, 'heavyweight' project managers were prevalent, whereas within their American and European counterparts, 'lightweight' and 'functional' project managers were usually responsible for the projects.[43]

A number of authors[44, 45, 46] maintain that although many organisations successfully use project management techniques within their projects, as a whole, manufactures, such as those within the Automotive Manufacturing Industry, have only recently started to use modern-day project management as a means of improving their product development process. This is backed up by Sprague et al who state that *'PM (project management) usage has been somewhat restricted and limited in manufacturing'*.[44] Curley and Ryder argue that traditional methods of project management are arbitrary and rely on the ability of the scheduler instead of the actual time.[46] These methods worked well in projects lasting over 5 years, but are not suited to the much shorter periods now required by world-class automotive product development processes. However, those project management tools and techniques for use within the Automotive Manufacturing Industry need to be different from those used within, say, the defence or construction industries, as the way in which the organisations operate is ultimately different, and this will be discussed further in section 3.1.1.3.

3.1.1.2 The Diffusion of Project Management Techniques in Western Automotive Manufacturing Organisations.

It was only by 1985 that the Ford Motor Company realised that the existing over-the-wall methods of managing projects used within their operations were inappropriate, due to the fact that it took too long to develop new products.[47] Therefore, they looked towards project management tools and techniques for a solution. Ferguson gives a chronological account of the use of project management techniques used within the Body Engineering Division of the Ford Motor Company.[48] By the early 1990's, the focus of project management had shifted from manual schedule development to more sophisticated computer based Critical Path Methods (CPM). However, Ferguson does maintain that, such sophisticated computer based scheduling packages appeared to have been irregular in their application.[48] Therefore, even though modern day project management techniques were being used effectively within the Ford Motor Company from the mid 1980's, they were still not properly integrated throughout the organisation in 1993, some 8 years later.

This focus on modern project management techniques within the 1980's seems to have been prevalent within the Automotive Manufacturing Industry throughout the west. Chrysler used platform teams and their suppliers also looked to develop project management skills and techniques during the late 1980's.[47] However, it was only in 1996 that Toyota Motor Sales USA created a project management office for their Information System (IS) projects.[49] Therefore, the use of project management within the US Automotive Manufacturing Industry was seen to improve drastically throughout the 1990's. By 1997, the Detroit Diesel Corporation was using project management techniques to its advantage and these were cited as part of the success of completing a new development project in a record 7.5 months.[50]

This use of project management techniques was not limited purely to the US auto industry, as the UK and Europe were also finding success from the use of similar techniques. However, this seemed to be at a slightly later date than their American counterparts. It was only in 1992 that Jaguar implemented a new 'heavyweight' project management model, which was based on full-time cross-functional teams integrated into the project.[51] Also, up until the mid 1980's, the focus had been detracted away from the use of good project management tools and techniques within the design stage of Rover vehicles.[52] To counteract this, new methods and techniques for project management have since been introduced into the company, as a means of improving the product development process.[53] Within this, the design and development engineers became responsible for costs within the design phase. Nevertheless, the focus was on the cost and budgets within the project and it is predominantly the effects of new ideas on the cost of the project which are evaluated. This 'routemap' process does however have many similarities to that described by Curley and Ryder, and hence may not be the most appropriate method to use for projects with duration less than 5 years.[46] Nevertheless, the Rover/BMW group have recognised that they require additional tools to those provided within the Project Management Guidelines if the risks and uncertainty within their projects are to be effectively managed.

3.1.1.3 *The Difference in the Use of Project Management Techniques.*

In many project-oriented companies, such as construction and aerospace, profits are made *'by planning and managing "one-of-a-kind " products, such as buildings, bridges and space labs'*[54] (i.e. by the project itself). Within the Automotive Manufacturing Industry, however, project management is seen as a non-profit making activity and an additional expense for the organisation. As such, it is not always seen as both a benefit and vehicle to potentially decrease the uncertainty within the project and product development itself.

Gill and Whitman have focused on the project manager to explain the differences between the use of project management in the Automotive Manufacturing Industry and other industrial sectors. They assert that within the Automotive Manufacturing Industry, although existing managers are given the title of *'project manager'*, they retain many of their existing responsibilities, to the detriment of their new role.[55] Telaro argues that many organisations assign the role of a project manager to an unqualified and already overly burdened team member.[56] In addition, as project teams decrease in size, many more tasks are placed on existing team members, thereby increasing their individual responsibilities and diluting the time available to spend on gaining and applying new skills.[57]

Wirth points out that the average project manager in manufacturing has 6 years of experience, which is relatively short.[58] Thus, in general, project managers within the manufacturing sector are not as experienced as other industrial counterparts within sectors such as the pharmaceutical, IT and construction industries.[58] Clark et al also identified that within Europe, functional project management, in which the product development is organised into functional departments, was prevalent and within this, there was a lack of project managers.[43] This lack of acquiring and building skills could have therefore resulted in the deficiency of manufacturing employees with long-term project management skills. This again is backed up by the observations made within the Rover/BMW group. Also Curley and Ryder state that *'most US automotive companies do not appoint a project manager for their car programs with the same type of authority and responsibility as do other industries, particularly those that are project focused'*.[46] The types of projects undertaken by automotive OEM's have, in Gould's opinion, changed towards large autonomous projects.[59] Project management was focused on *'helping planners make decisions for the projects own good, without worrying about whether the decisions were good for the entire enterprise'*.[59] Hence, project managers need to develop skills and experience within the bounds of project management to enable them to successfully manage the projects with which they are entrusted. One method by which the Automotive Manufacturing Industry could increase the number of project managers within its ranks can be to hire in experienced professionals. However, *'most midsized business lack the finances to afford a professional project manager whose sole duty is to oversee the entire project'*.[56] Therefore the route that many organisations take is to train their existing staff in the tools and techniques of project management.

3.1.2 *Improving the Management of the Project.*

Although Automotive Manufacturing Organisations have used and improved project management systems, there is still more scope for improvement. Curley and Ryder found that a *'substantial majority of engineering changes fell into the "correction" category'*[46], meaning that much of the re-work done was to correct faults previously caused by mistakes and lack of communication within the overall vehicle project, and as such, many of these could be considered as avoidable. This is backed up by Soderberg, who maintains that the difference in the cost of American manufactured components in comparison to those designed and manufactured in Japan were down to the design of the product and the amount of 'scrap' designed into American goods.[60]

There have been various solutions put forward to assist organisations to build upon and improve their use and application of project management activities. Urbaniak puts forward a solution of project management support systems - an integration of procedures, tools and techniques and people with experience.[61] Gill and Whitman focus on two aspects; communication and commitment to project management culture change.[55] Communication is by no doubt an important aspect within the management of a project, as through communication, problems can be identified, timely proactive management can take place and hence there is little need to perform crisis management. However, having open, informal communication within an organisation often requires a change to the culture of individuals within that organisation, especially within middle management.[55]

Nevertheless, the success of a project does not only rely solely on effective systems, communication and an appropriate culture. Other factors such as the definition of the project, the project manager and team and their roles and responsibilities, external market factors and manufacturing capability are all aspects of the project which can aid in its success.[62] Therefore, organisations need to look at enhancing their planning and management activities to keep ahead of the competition. Shea stresses that operational barriers to the project management discipline have caused many organisations to shy away from using the tools and techniques, often due to the difficulty to understand and use the terminology and concepts within the discipline of project management.[63] Nevertheless, with the functionality and usability of many project management systems currently in operation, project management as a technique has improved considerably in usage.[63]

There are however, tremendous risks when developing a new vehicle program, as many thousands of decisions need to be made, ranging from the design, engineering and manufacturing functions, to ensuring that the time to market, government regulations and customer satisfaction can be achieved. Within Urbaniak's concept of project management support system comes risk control,[61] and although Rover/BMW have used a concept of project management within their operations, an effective strategy for risk control and management has been missing.

3.2 Reasons for the Omission of Risk Management within the Automotive Manufacturing Industry.

The reasons for the omission of risk management tools and techniques within the majority of the manufacturing industry, had not been specifically identified before this work, and can be attributed to a number of issues. Firstly, manufacturing organisations have, over the last 25 years, tended to focus on Japanese imported management, operational and production activities and techniques. This has likely to have been in response to the increase in competition from the Asia/Pacific rim in relation to quality and delivery issues. Risk management has, on the other hand, been developed and utilised within other industrial sectors in the Western world and has tended to have been ignored within manufacturing in favour of the Japanese techniques. Secondly, there is no stipulated requirement for risk management to be used within the automotive manufacturing sector, as is mandatory with UK government and defence contracts.[64] However, the learning and practices established within the defence manufacturing industry have recently been translated into the civil sector of an organisation's operations.* The manufacturing industry as a whole is not self-regulating and predominantly relies on government and environmentally led legislation. Therefore, there is little need for it to develop and use techniques to enable forward planning to reduce hazards and risks, and as such increase its safety limits. Finally, the majority of manufacturing industry tends to produce components for larger industries, many of which are given in figure 3. Because of this, and the fact that there is no stipulated requirement from their customers to use risk management as part of their project management procedures, the mitigation of risks, the ensurance of compatibility of components and the overall safety of the product or process is left to the end-user. This is backed up by a survey by Simister, who, in late 1992, surveyed practitioners of PRAM, through the Association of Project Managers.[65] In this he identified that, apart from within the defence industry, none of the users of project risk management were from within the manufacturing

* Established through interviews with British Aerospace Employees, 1997.

area. Simister also identified that many different organisations and industries which actively used project risk management did so because of client demand. Within OEM's in the Automotive Manufacturing Industry, there has been no specific client demand for the use of project risk management techniques, and hence the incentives for its use have had to be generated internally.

3.3 The Need for Project Risk Management within the Automotive Manufacturing Industry.

In automotive manufacturing organisations, compatibility problems tend to be identified through the construction of prototypes at the development stage and through the manufacture of full-scale vehicles.[66] However, as the need to reduce lead times, increase quality and reduce the cost and time required to develop and manufacture new products all increase, the use of purely these methods becomes questionable as a means of solving the many problems experienced in the development and manufacture of new and existing vehicles. The increase in technological advances has also meant that more intricate products are being developed, and there is a need for the research and development of these products to be carried out at an ever-increasing rate within even tighter budgets.[66] However, as the business and operational environment rapidly changes, these organisations must now look to new methods of ensuring that the problems are solved before their products and processes are fully developed. The GIPT project was therefore investigated to determine how innovative, product development projects are managed within the Rover/BMW group and whether they could benefit from a project risk management process as a tool to use alongside existing project management processes.

3.3.1 *A Review of the GIPT Project.*

The GIPT project was designed to investigate and develop a system to enable plastic components to be pre-painted in-mould, as a means of reducing the cost, environmental and colour matching problems experienced when painting the surface of a plastic component within a paint shop. Therefore, due to its innovative nature, the project itself had encountered various problems, predominantly the effect of diversions inherent within research. The result of this was that the project did not meet the original objectives, and delays in the project schedule and overspend of resources occurred. It was felt by senior management that many of the problems and diversions experienced could have been avoided if adequate and appropriate project planning and management activities had taken place, and that the potential problems could have been managed at the outset. It was also thought by some that if appropriate tools to effectively assess the technological viability of the project had been used, then the project may have been deemed too risky as well as not strategically important enough for the organisation to invest in. It was therefore deemed appropriate to perform a post-audit review to determine if effective project management took place and also if risk management could have enabled the problems to be identified. The post-audit review investigated the GIPT objectives and project plans, including its resource and funding allocation. In-depth interviews and discussions with the project and management team, both individually and in groups on the deviations from the plans, problems which occurred, took place. Finally, a plan of what occurred within the project was assembled and compared to the initial objectives and plans. It was from this, as well as the interviews and discussions with the project and management team that the conclusions were initially obtained, further discussed with the team and finally clarified. In addition to determining if effective project management could have enabled the problems to be identified, the GIPT project also provided the basis of a risk management process for use within the Automotive Manufacturing Industry to be determined.

The project itself will not be discussed here, due to the sensitive nature of the issues within. However, a full description can be seen in chapter 4 of the submission '*The Management of Risk – From Theory to Practice*'.[34]

3.3.2 *Conclusions of the GIPT Post-Audit Review.*

There was scope for the project to be managed more effectively from the outset, through both better planning and the development of contingencies. Very little planning had taken place during the first stage of the project. The planning of the second stage was however, more in-depth. This may have been that, as the project proceeded, more information as to the direction of the project became available, and hence the planning of the project could be carried out more effectively. However, new company regulations as to the continued funding of resources into R&T projects also came into place at this time. These regulations required more information and planning at each phase to take place before funding was released into the project. It is the author's belief that this was the major thrust behind the increase in planning activity at the second phase. There is however, no evidence that this improved planning activity was used to aid the management of the project as a whole.

The learning points which were identified through the analysis of this project were;

- Ensure that project management tools and techniques are used effectively and efficiently.
- Ensure that all of the available information on the project, e.g. technology, legislation and future plans are made available at the beginning as well as throughout the project lifespan.
- Use both internal and external knowledge. This can be through employing the most appropriate people within the team, undertaking collaborative projects with the right partners, purchasing information or employing an experienced and/or knowledgeable person.
- Investigate fully both existing and future legislation.
- Ensure that the project fits in with the existing and future corporate strategy.
- Ensure buy-in and involvement of all team members, suppliers, customers and collaborators as to the product and process.

It was concluded that a means of identifying, assessing, reducing and mitigating against risks and potential problems would have aided in ensuring that the project delivered its objectives on time and within cost and would have increased the success of the project as a whole. There was thus a need to manage the level of risk and uncertainty within projects in the Automotive Manufacturing Industry.[34] However, a review of the industry as a whole identified that there were other factors affecting its business. The reduction in the time that customers are willing to wait for both new products and delivery of their specified orders, the increasing quality requirements and the reduction in the amount of resources for projects, especially new product developments (NPD), all indicate the need to reduce the level of risk within manufacturing projects.[67, 68, 69, 70, 71]

3.4 The Requirements of a Project Risk Management Process for the Automotive Manufacturing Industry.

Using the findings of the GIPT project, interviews with senior and middle management within the Rover/BMW group and the literature,[5, 6, 7, 8, 18, 34, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77] it was determined that the risk management methodology should;

- be able to be implemented into a project at any time, although to get the greatest benefit, it would be best implemented at the project initiation stage.
- be simple to use, requiring few new and complicated techniques for an individual to acquire, and be easy to understand.
- add to the project management knowledge of an individual. It should therefore be able to be used by anyone within the organisation and should not need to be carried out by a professional or highly experienced project manager.
- be flexible, so that it can be used on within different types of projects that could occur within an Automotive Manufacturing Organisation (for example, from IT integration or engine design to the development of a new site).
- be iterative to enable continual use, application and cross-fertilisation of ideas from different projects.
- enable the risks to be actively managed throughout the lifespan of the project.

What was therefore required was a flexible, easy to use, iterative methodology of project risk management. The most appropriate method to describe the methodology would be in diagram form, so that there could be ease of understanding as to the processes, tools and techniques underlying it.

It was known by the author that various project risk management methodologies already existed. Therefore, to determine if any existing methodologies fitted the requirements of the Automotive Manufacturing Industry, especially the Rover/BMW group, these existing processes were investigated further, with respect to their objectives, the stages and tasks contained within, and the deliverables of each of these stages.

4.0 EXISTING RISK MANAGEMENT PROCESSES.

There are various risk management methodologies discussed within the literature, and the objective of this chapter is to review some of these. The methodologies which will be discussed are;

- The PRAM Process[8, 18]
- The SCERT Approach [78, 79, 80]
- Coppendale's Process for Managing Risk[81]
- Risk Diagnostic and Management Method[82]
- Nocharli and Hayes' Applied Project Risk Management[33]
- Pre-Emptive Risk Management[83]
- Software Engineering Risk Analysis and Management[84]
- The RISKMAN Methodology[6]
- Risk Management in Defence Procurement[64, 85]

These processes offer a variety of project risk management processes which are used within the various industries discussed in chapter 3.0. The main focus of this review will be on the objectives of each methodology, its stages and tasks, as well as the deliverables of each of these stages.

4.1 Project Risk Analysis and Management (PRAM).[8, 18]

Chapman and Ward describe a nine phase Risk Management Process (RMP), figure 4, which has been designed for generic projects. The RMP is that of the Project Risk Analysis and Management (PRAM) methodology, which was developed alongside and specifically for the Association for Project Management (APM).[18] It therefore uses the knowledge and experience of professional project managers from a wide variety of organisations and backgrounds in its design and development, resulting in it being a standard risk management process for professional project managers.

Chapman states the most useful point to implement the PRAM process is at the initial stage of a project. However, this *'can be like attempting to nail jelly to the wall'*[18] as in many cases, the project is not fully defined and its objectives and deliverables can even change. Even so, the plans and/or the initial design of the product can be improved by its use. Each phase within the PRAM process has broadly defined deliverables which are described by their purpose and tasks required to produce that deliverable. Chapman states that all of the stages should be completed in parallel, and that although it is a detailed comprehensive process, both the use of shortcuts and expansion of the process are possible. The process itself is also iterative in nature.

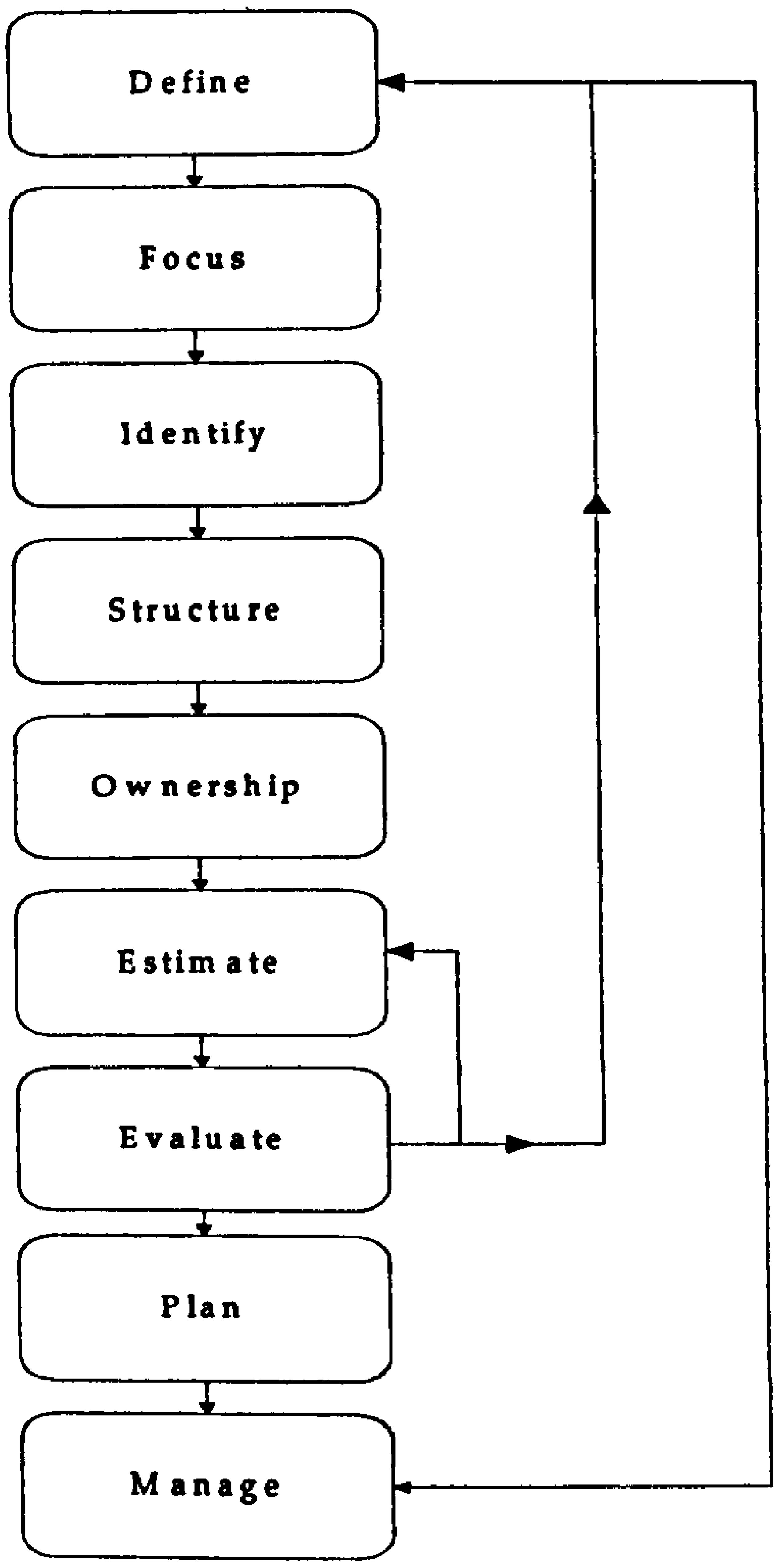

Figure 4 – The PRAM Process.[18]

The PRAM Methodology can be considered as a comprehensive and in-depth process through which professional project managers from a variety of industrial sectors can analyse and manage the risks to their projects. Hence, because of this wide scope, the PRAM process is described in much more detail than the other project risk management methods. Chapman presents the phases and the deliverables from the use of the PRAM process in tabular form. Within this table, the objectives of the phases and the tasks performed in each phase have been added by the author (figure 5), to provide a consensus for comparison with the remainder of the chapter. Also, additional deliverables have been given, based on the actual deliverables of each of the phases.

Phase	Objectives	Tasks	Deliverables
Define	Determine the effort which has gone into the project at the time when the PRAM process is implemented into the project	♦ Gather and summarise existing information within the project ♦ Ensure gaps are filled and recorded ♦ Gain agreement and highlight unresolved issues ♦ Review and release the information generated to the relevant people	♦ A clear, unambiguous, shared understanding of all relevant key aspects of the project documented, verified and reported ♦ One or several documents to enable classification of the relevant aspects of the project

Focus	Define the scope, strategy and operational plan of the project	• Review the use of risk management within the project • Determine techniques to be used and plan for the use of risk management within the project • Record the information and gain agreement • Highlight unresolved issues • Review and release the information generated to the relevant people	• Clear, unambiguous, shared understanding of all relevant key aspects of the RMP, documented, verified and reported • Ensure key issues within the project have not been missed out, and that the Risk Management Process (RMP) is defined, updated and verified within the process as a whole
Identify	Identify the risks within the project and classify their order in a suitable structure	• Identify sources of risks and their responses • Order risks in a structure • Record information and gain agreement • Highlight unresolved issues • Review and release the information generated to the relevant people	• All key risks and responses identified, both threats and opportunities, classified, characterised, documented, verified and reported • Development of a risk log or register
Structure	Test simplifying assumptions made in the project	• Develop order and classification of the risks • Identify interdependencies between the risks • Develop priorities for the project and risk responses	• Clear understanding of the implications of any important simplifying assumptions about relationships between risks, responses and base plan activities
Ownership	Determine who is to own, manage and accept responsibility of the risks and their associated responses	• Determine ownership of the risks and how the ownership is to be managed within the project	• Clear ownership and management allocations, effectively and efficiently defined, legally enforceable in practice where appropriate
Estimate	Identify where within the project there is either a possibility or a definite level of uncertainty	• Determine probability estimates • Refine estimates	• Basis for understanding which risks and responses are appropriate • Determination of the likelihood and impact (in terms of cost, duration or other criteria)
Evaluate	Assess and combine the results of the estimate phase	• Combine the effects of the risks through simulation techniques • Present the information in an easy to understand method • Investigate the implications of the risks and their management plans	• Diagnostics of all important difficulties and comparative analysis of the implications of responses to these difficulties, with specific deliverables like a prioritised list of risks, a comparison of base plan and contingency plans with possible difficulties and revised plans • Comprehensive record of the problems within the project, and how they can be overcome
Plan	Ensure that the project plan and risk management plan are constructed and prepared for	• Develop the project plan with respect to risk management	• Base plan in activity terms at the detailed level required for

	implementation	• Determine the opportunities, threats and assess their impact on the project if the risks occur • Determine responses to the opportunities and threats • Develop contingency plans for the project	implementation with timing, precedence, ownership and associated resource usage - contractual terms where appropriate clearly specified, including milestones initiating payments, other events or processes defining expenditure, and an associated base plan expenditure profile • Risk Assessment in terms of threats and opportunities, prioritised, assessed in terms of impact given no response is feasible and potentially desirable, along with assessment of alternative potential reactive and proactive responses • Recommended proactive and reactive contingency plans in activity terms, with timing, precedence, ownership and associated resource usage - contractual terms where appropriate clearly specified, including trigger points initiating reactive contingency responses and impact assessment
Manage	Ensurance that the identified risks are managed and that the project team members have knowledge of the further steps to be taken in the project	• Manage the project and the risks • Forward plan the project and the risks attached to it	• Diagnosis of a need to revisit earlier plans, and initiation of re-planning as appropriate, including on a regular basis specific deliverables like the monitoring of achieved performance in relation to planned progress, and prioritised lists of risk-response issues • Exception (change) reporting after significant events, and associated re-planning • A rolling horizon of detailed plans for implementation (base and contingency)

Figure 5 - The PRAM Process; Phases, Objectives, Tasks and Deliverables.

The PRAM process not only focuses on the identification, analysis and management of the risks within the project, but also on the management of the project as a whole. This is made explicit in the define phase, in which the information within the project is gathered and summarised, and where gaps in the project, the plan and the knowledge and skills of the team members are filled. Within the focus phase, the process of how the risk management process is to be used is clarified and defined. The actual start of using true risk, and not project management does not begin until the identification of the risks. The risks, interdependencies and responses are developed throughout the remainder of the process. Hence, Chapman and Ward show that the management of the risks is an integral and not additional part of the project management process.

Chapman states that other risk management processes can be 'mapped' into the nine phases of the PRAM process.[18] Section 4.10 uses the outline of the PRAM deliverables to determine and discuss the general objectives of each of the discussed processes and more importantly their deliverables.

4.2 The SCERT Approach.[86, 87, 88]

The SCERT (Synergistic Contingency Evaluation and Review Techniques) approach uses techniques such as risk identification, analysis and mitigation of risks within a project as part of the overall methodology of risk management. It was developed to enable time (scheduling or programme) risk analysis to take place in conjunction with cost risk analysis on offshore oil projects. The SCERT Approach comprises of the '*systematic identification and articulation of the risks to which a project is subject and the uncertainties and contingencies which might significantly affect the outcome of the project*'.[79] The process is a flexible, iterative approach to risk analysis which can be tailored to suit the needs of the available time within the project.[80]

Like many processes, the SCERT approach has been developed over a period of time. Initially there were two main phases which focused on the qualitative and quantitative aspects respectively.[79] More recently, Klein et al describe the process as having four distinct stages;[80]

1. Identify the activities of the project and risks
2. Structure the material
3. Determine numerical estimates of the uncertainty and the risks
4. Develop an overall project plan

When examining the two slightly different processes developed for the SCERT method, what can be seen is that the qualitative phase consists of the first two stages from that of Klein et al, and the quantitative the latter two, figure 6.

The SCERT method deals with both qualitative and quantitative analysis of the risks, their interdependencies as well as how each risk can affect the overall risk to the project. Its main focus is on the time and cost risk analysis, and not other factors within the project as a means of saving both time and cost within the project as a whole. Its main application has been within the offshore oil industry.[89]

The process consists of four stages, each with activities and deliverables as given in figure 6.

Phase	Objectives	Tasks	Deliverables
Qualitative	Identify activities of project and risks	• Identify and describe in detail the activities within the project • List and describe the risks attached to each of these activities • List and describe the responses to enable the risks to be mitigated • Identify, list and describe further risks attached to the responses	• Partially Structure collection of element of analysis, expressed in 'natural language'
	Structure the material	• Identify the interdependencies between risks and responses • Qualitatively determine the size of the risks • Classify the responses with respect to specific or general	• Summary of results, in diagram form
Quantitative	Numerical estimates	• Assess the probability of the risks occurring and its consequence • Compute the cumulative effects of the risks to give a picture of the role of each risk within the project and its relative contribution to the total project risk	• Computer simulation of the uncertainty and risks within the project
	Develop overall plan	• Develop strategy as to how the risk exposure within the project can be effectively managed	• Management plan to effectively and efficiently deal with the risk exposure to the project

Figure 6 - The SCERT Process; Phases, Objectives, Tasks and Deliverables.

The SCERT process is in-fact similar to the PRAM process in that it is not purely focused on the management of the risks, but also on the project as a whole. Its initial stage looks to ensure that all elements of the project are considered before proceeding onto the identification of the risks themselves. The process itself uses the best judgement of individuals within the project and then computational techniques with which to quantify the information. Hence from this, a picture of the most important risks to the project can be generated and a strategy evolved to deal with them. In the second stage, the likelihood and impact of each of the risks are determined qualitatively in terms of high (H), medium (M) and low (L). Therefore, judgements must be used in determining these values, and the resultant effects caused due to the risks are then identified and mapped out. From this, the most detrimentally affected area of the project can be determined. As such, SCERT takes into consideration the effect that the responses to the risks will have on the overall project, and attempts to integrate these aspects into the overall solution.

The third stage is the start of the quantitative phase within the SCERT process. Computer-based models are used to create a quantitative analysis of the risks to the entire project as well as to determine how the levels of uncertainty affect the overall level of risk. Feedback should then occur until everybody involved in the project is satisfied with the assumed probability and decision rules. From this, the fourth and final phase uses the information generated in the three proceeding phases to develop a strategy as to how the risk exposure to the project can be most effectively dealt with. Therefore, an iterative approach is given, with the emphasis being on computational modelling and simulation using best judgement of all people involved in the project.

As the process focuses on computational simulation of the risks, based on their probability and consequence, it relies on qualitative assumptions. Hence it is only as accurate and as non-subjective as that initial information. The feedback loop also enables bias to be included, irrespective of the mathematical basis of the simulation and hence users should be aware of this when developing a strategy to reduce the exposure of the project to the risks.

The authors themselves have determined disadvantages of this method, these being the need for experienced engineers in risk analysis and the time and cost of performing such an investigation.[80] These are general problems with risk management processes, and experience in the use of the tools and techniques is required due to the intricate nature of the processes themselves. However, they do go on to explain a less detailed, and hence less time consuming and costly approach to the SCERT methodology, which could be picked up more quickly by engineers.[80]

4.3 Coppendale's Process for Managing Risks.[81]

Coppendale's process of managing risks was developed after a survey of UK based companies showed that more than 60% considered themselves to be '*inadequate or poor*' at managing project risk.[81] The focus of Coppendale's process is on the development process for both product and processes. It has been used successfully in the aerospace defence, material manufacturing and consumer durable industries.[81]

The process comprises of three main phases;

- Identify the risks
- Assess the likelihood and the impact of potential risks
- Develop risk management plans

Figure 7 gives the phases and objectives of the project, alongside the tasks and delivery of each phase.

Phase	Objectives	Tasks	Deliverables
Identify the Risks	Identify the aspects within the project that either threaten its success or could go wrong	• Identify aspects which threaten a project's success or could go wrong • Organise risks into categories	• Structured list of risks within the project
Assess the Risks	Assess the identified risks for their likelihood of occurrence and impact on the project	• Assess risks for likelihood and impact • Plot risks on the Matrix	• Gain consensus on the likelihood and impact of the risks within the project
Develop Risk Management Plans	Develop and put into action risk management plans for those risks with the highest likelihood and impact	• For the highest likelihood and impact risks, develop a risk management plan • Put the plans into action for those risks for which it is reasonable to do so	• Reduce the likelihood and impact of the identified risks through action plans, for those it is reasonable to do so

Figure 7 - Coppendale's Process; Phases, Objectives, Tasks and Deliverables.

Like many of the processes described in this chapter, Coppendale's process is practical in nature, simple to use and apply and delivers a risk management plan to be used throughout the project. The process itself however, lacks any in-depth detail of how it should be used or implemented into an organisation or project.

Within the second phase, the impact and likelihood are determined through assessing the risks and assigning values from 0 to 10, which are then translated into percentage values. Although the impact and likelihood values are not combined explicitly, they are combined on the impact/likelihood matrix, in which the 'largest' risks (i.e. those with high impact and probability) are identified in isolation from their combined effects. Coppendale does not delve into deciding which risks should be managed, but states that the management of the risks should be based on the level of likelihood of occurrence and impact within the project, taking into consideration the limited time and resources available.

Even though Coppendale states that the process should be re-run at regular intervals, this does not lead the reader to believe it is an ongoing, iterative process, which is run continually throughout the project as a means of identifying risks along with the decisions and developments within the project as a whole. It is also focused at the development process and not on the overall potential lifespan of the project or process being developed.

4.4 Risk Diagnostic and Management Method.[82]

The Risk Diagnostic and Management (RDM) method was initiated to assist in improving the product-innovation process within a multi-national organisation. The process itself is designed to be implemented into a project by a project consultant who works alongside the risk team in utilising the method. The Risk Diagnostic Method consists of 4 stages, as shown in figure 8.

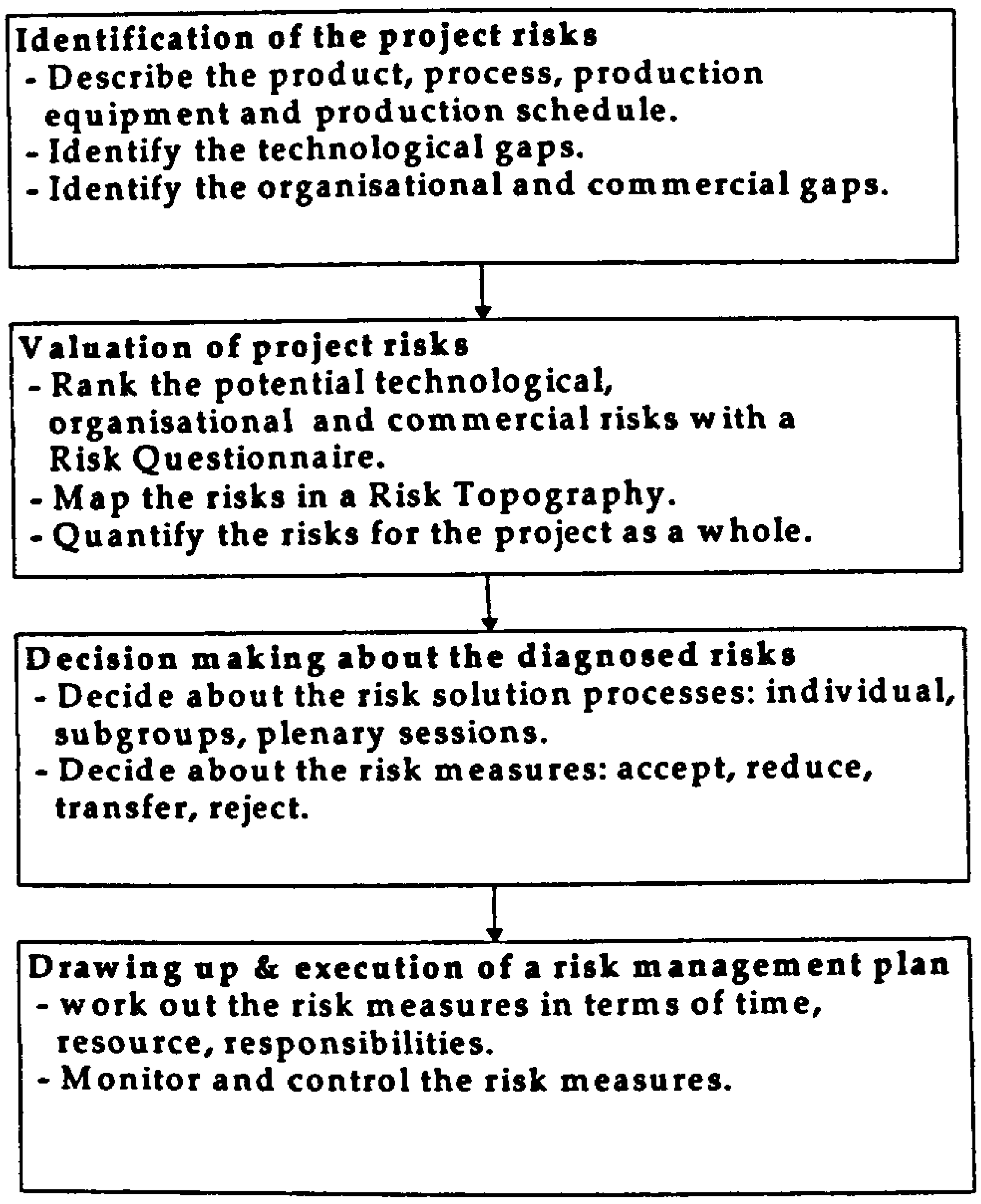

Figure 8 - The Risk Diagnostic and Management Method.[82]

The Risk Diagnostic and Management (RDM) method was developed through a company case study of the product innovation process. The process was found to be of most benefit at the end of the feasibility phase of the product-creation process, and as such, can assist in the decision making process as to whether the product can be developed for commercial means.[82] The process also investigates interdependencies relating to the technical aspects of the project, as well as the relationship between the organisational and commercial gaps in knowledge, experience and skills, and risks.

Figure 9 gives the phases, objectives, tasks and deliverables of the process.

Phase	Objectives	Tasks	Deliverables
Identification of the Project Risks	Enable the risks to the product innovation project to be identified in a structured manner	• Description of the product, process, production equipment and production schedule • Identification of the technological gaps • Identification of the organisational and commercial gaps	• List of relative risks and identification of technological and organisational gaps

Valuation of Project Risks	Determine the likelihood of the risk occurring, the ability to create a solution for the risk within the resource and timescale available and the potential consequences for the success of the project	• Ranking of the potential technological, organisation and commercial risks with a risk questionnaire • Mapping of the risks in a risk topography • Quantification of the risks for the project as a whole	• Overall score of the risks within the project
Decision Making About the Diagnosed Risks	Analyse the causes and consequences of the risks and determine risk measures to accept, reduce, transfer or reject the risks	• Deciding upon the risk solution process • Deciding about the risk measures (accept, reduce, transfer or reject)	• Consensus as to whether to accept, reduce, transfer or reject the risks
Drawing up & Execution of a Risk Management Plan	Decide if the project is achievable in practice, as well as change the scope of the project objectives and resource allocations, based on the identified risk factors and their influences on the project	• Working out the risk measures, in terms of time, resource and responsibilities • Monitoring and controlling the risk measures	• Decision as to whether the project is feasible

Figure 9 - The Risk Diagnostic and Management Method; Phases, Objectives, Tasks and Deliverables.

As the process is designed to focus on product innovation, the main reason for its use is to determine if a project is feasible, and as such, whether investment should be given. It is carried out at the beginning of a project, and hence it is not iterative in nature. Nevertheless, the information generated as part of the process is used to monitor the risks within the project over its lifespan. Hence, once the Risk Diagnostic and Management method has completed a first pass, the process of identifying and assessing the risks is completed. Thus, its focus is not predominantly on the management of the risks throughout the lifespan of the project. Halman and Keizer state that the Risk Diagnostic and Management method should be undertaken by a *'project consultant on the request of the project management'*.[82] This therefore leads the author to believe that although the Risk Diagnostic and Management method is carried out by a 'risk team', it is implemented through the use of experts in the method itself.

4.5 Nocharli and Haynes' Applied Project Risk Management.[33]

The reporting of the applications of risk management processes is one method which has been utilised within the literature to describe the development of a risk management process. Nocharli and Haynes used this method within a Pumped Storage Project (i.e. within the construction industry). The Applied Project Risk Management process is reportedly that of identification, assessment (in terms of probability, inter-relationships, consequences and impacts in terms of cost and schedules) and contingency or mitigation planning. The process itself is described in terms of the phases within the project; the planning phase and the development phase.

The Applied Project Risk Management Process tends to focus on the safety of the project, more so than on general project issues. The process itself also does not tend to focus on the actual management of the risks, but more on their identification and assessment within the context of the project as a whole. Generic risk management is predominantly carried out at a very high level, with the focus being on the identification and assessment of technical risks within the project, which have time, cost and safety issues.

Figure 10 identifies the phases, tasks and deliverables of the process.

Phase	Objectives	Tasks	Deliverables
Planning	Identify, assess and determine which risks should be mitigated against, transferred to another party, or contingency planning put into place to deal with them if they occur	• Identify risks in the following areas; • Geotechnical • Hydraulic • Regulatory • Economic • Market • Force majeure • Assess probability of occurrence • Determine interrelationships • Determine consequences • Estimate cost & schedule impact if risk arises	• List of risks with their probability, interrelationships and impacts, as well as contingency/mitigation / transfer proposals
Development	Ensure that adequate levels of quality and safety are reached within a reasonable cost and schedule	• Define the risks • Develop mitigation responses • Assess planned versus actual factors within the project	• Identify variations between planned and actual factors to determine how well the project is being managed

Figure 10 - The Applied Project Risk Management Process; Phases, Objectives, Tasks and Deliverables.

The overall objective of performing the Applied Project Risk Management process is to ensure that adequate quality and safety is attained within the time allocated for the project. The process uses a probabilistic approach to quantify the risk in terms of cost and schedule. The results of the assessment are defined to enable the impacts of the risks to be reduced or eliminated. From this, the risks that can be mitigated, diverted or dealt with through contingency planning, are identified. The deliverables of the planning phase are the development of the contingency, mitigation or transfer proposals for each of the identified risks whereas the development phase deliverables are the planned and implemented mitigation responses. However, the actual management of the risks throughout the project does not seem to take place. The focus seems to be on the identification of the variations in the planned versus the actual factors within the project. There is reporting of the continuation of the methodology throughout the life span of the project. However this is not discussed in detail, and one is unsure of the format that the tool takes.

Hence, although identification and assessment of the risks takes place, no real management of the risks is reported or evident. Nevertheless, this cannot be ruled out. Also, even though mitigation responses are developed within the development phase, no information on how this is performed in the project is given. Comparisons of planned versus actual events enable the effects of the mitigation and contingency planning to be determined, although they are more of an 'after the fact' than pro-active process.

4.6 Pre-Emptive Risk Management.[83]

Utilising past projects, Stump determined that the main cause of failure was due to visible risks.[83] These are described as being those risks which were visible at the beginning of the project or those which could be made visible through a 'modest review' process.[83] However, even though past projects are a good source of information and enable possible risk areas to be determined, care must be taken when looking in retrospect, as all problems which are highlighted at the end may not have been foreseeable at the outset of the project.

Stump therefore designed Pre-Emptive Risk Management from this investigation as a means of identifying and assessing the visible aspects within the project which could potentially cause it to deviate from its original plan. These visible aspects are called 'Risk Drivers' and are determined and managed through either limiting or eliminating their effects on the project. Stump therefore describes Pre-Emptive Risk Management as *'a systematic attempt to identify and assess risks before they happen, and to trade off mitigation efforts against accepting the risk'*.[83] However, as not all aspects within the project are 'visible', Stump suggests contingency and mitigation plans should be developed for the invisible risks.[83]

The process can be broken down into its phases, given in figure 11.

Phase	Objectives	Tasks	Deliverables
Risk Identification	Identify the risk drivers within the project	• Create well structured project plan • Identify the visible risk drivers within the project (performance, schedule and cash flow)	• Developed project plans • Identification of the risk drivers within the project
Risk Assessment	Assess and quantify the magnitude and likelihood of the risks	• Quantify the risks through determining their magnitude and likelihood • Determine the overall project risk, through exact or approximate calculation of schedule and cash flow	• Magnitude and likelihood of the risks determined • Level of risk within the project ascertained
Risk Mitigation	Mitigate selected risk drivers based on the descending order of the net risk	• Rank the risks in descending order of the net risk • Mitigate the risks until all of the resources are used up	• Development and actioning of mitigation plans for the highest ranked risks until all of the available resources are exhausted
Mitigation Performance Tracking	Track the efforts of mitigation to ensure that they are performed to an adequate level	• Record the magnitude, probability or distributions of the risks • Record how the risks should look after they are mitigated • Track the risk with relation to actual vs. planned risk distributions	• Increased confidence within the team that the risks are being effectively mitigated

Figure 11 - The Pre-Emptive Risk Management; Phases, Objectives, Tasks and Deliverables.

Within the Pre-Emptive Risk Management process, the assessment of the risks relies purely on quantitative methods and the developed mitigation plans are based on the expected value; the monetary amount it will take to reduce the risk multiplied by the probability value of the risk. A checklist also requires professionals which have taken part in similar projects to have kept a list of the information needed for those past projects. However, in new projects or industries where risk management is first being applied, these lists will not necessarily be available, resulting in professionals having to utilise their memory as a means of checking what they require against the information they currently have in the project. Hence, the major criticism of this process is that when using quantified risk information, it is often difficult to change the minds of the people who have taken part within the assessment and/or are using the information generated without full knowledge of its origins. In Stump's own words *'quantitative assessment can carry an element of personal commitment'*.[83] These personal issues can result in people being un-willing to change their estimates. Furthermore, estimating values greater than those which are truly expected gives a method of reducing the impact of a poor decision.

Within the mitigation stage of the Pre-Emptive Risk Management process, the mitigation of the risks is based on their ordering, until all of the resources are used up. This relies on the mitigation actions being effective within the project and that if there are any additional problems, there would be no resources with which to deal with them, apart from that scheduled for use within the project. Using monetary values as a means of determining which risks to develop mitigation plans for is not always appropriate as there can often be more issues than purely financial incentives for mitigating and managing risks. Hence, mitigation cannot only be decided on by numbers as other aspects come into effect, such as the urgency of the risk due to the phase at which it may materialise within the project.

Pre-Emptive Risk Management is, as Stump states, designed for those risks which are visible within the project, and hence the non-visible risks should be dealt with through the use of contingency and mitigation plans. However, for contingency and mitigation plans to be developed, these 'invisible' risk drivers would have to be considered and as such, may become 'visible' as a result. Also, invisible risk drivers can also become visible as the project proceeds, and therefore it is deemed by the author inappropriate to divide the visible and invisible risk drivers and deal with the invisible risk drivers through contingency and mitigation planning. Therefore, more effort should be given to the continual identification of these initially invisible risk drivers within the project. For those risk drivers which remain invisible, contingency funds and time should be in place.

Stump highlights the need for Mitigation Performance Tracking, as a means of measuring and tracking the effectiveness of the mitigation plans of the identified risks. The measure of the effectiveness of the developed plans versus the actual within the project is very similar to that developed by Nocharli and Haynes, as a means of identifying the variations within the project.

4.7 Software Engineering Risk Analysis and Management.[84]

Software Engineering Risk Analysis and Management is a comprehensive guide to how risk analysis and management can be used in the field of software engineering, and presents broad examples of the tools, techniques and processes that can be used within this field. The process is split into two distinct areas; Risk Analysis, which includes risk identification, estimation and evaluation, and Risk Management, which includes risk planning, control and monitoring.[84] Within this process, Charette asserts that the risk analysis stage is designed to identify the potential problems within the project, quantify their associated risks and develop options, whereas the risk management stage is designed to take place after the analysis as a means of developing decisions about the risks.[84]

Figure 12 gives the objectives, tasks and deliverables of each of the phases within the process.

Phase		Objectives	Tasks	Deliverables
Risk Analysis	Risk Identification	Reduce the uncertainty within the project and increase the understanding of the team	• Determine if the process should be implemented into the project • Identification of the root cause of the risks, facts and data • Categorise the risks into known, predictable and unpredictable	• Battle plan of the project, to reduce the uncertainty within the project and increase the knowledge and understanding of the team
	Estimation	Estimation of the risks in terms of likelihood and consequence	• Determine value of variables • Identify the consequences • Determine magnitude of risks • Elimination of surprises	• Estimation of the likelihood and consequence of the identified risks
	Evaluation	Investigation of the interactions of the risks	• Determine the criteria against which the risk consequences are measured • Determine the level of risk used to evaluate the entire project • Determine the interaction of the risks • Compare the aggregated risks for the project vs. the system level and the individual risk levels • Prioritise the risks	• Prioritisation of the risks to determine which are most dangerous to the project
• A decision whether to continue and manage the risks, or revise, cancel or salvage the project is now made				

Risk Management	Planning and Controlling	Determination if the risk management strategy is feasible and whether the tactics and means to implement the strategy fit in with the overall objective of the project	• Develop risk management plan and risk aversion plan	• Determine if the risk management plan is feasible and whether it fits in with the project plan (RMP/RAP)
	Monitoring	Reassessment of the decisions, identification of new opportunities and feedback on the project and the risk aversion plans	• Monitor the risks to reassess, and identify new opportunities	• Continual monitoring of the project and the developed plans

Figure 12 - Charette's Software Engineering Risk Analysis and Management Process; Phases, Objectives, Tasks and Deliverables.

Charette uses a process of determining if the risk management process should be employed within a project, as well as how it should be used and implemented. After this, the risks are identified, estimated and evaluated through various means and then prioritised to enable those risks which have the most detrimental affect on the project to be determined. It is only at this point that the decision as to whether the project should be continued, changed to reduce the risks or cancelled is made. Hence, the initial stages of risk analysis can be seen as an investigation of the suitability of the project, with the risk management initially being an investigation of the suitability of the risks management plan for the project, before it is used as a means of managing the risks and the project as a whole.

Even though the Software Engineering Risk Analysis and Management process is designed for the software field, it tends to fit into the generic risk management process field, as it enables the identification, assessment and management of the risks within the project to take place, as a means of reducing the risks to the overall project. However, the main failing of this process is the lack of real life examples in how the many given techniques can be used in practice as well as leaving their choice to the user. For experienced risk analysis and management users, this may prove to be of little problem. However, to the uninitiated, this may prove to be daunting.

4.8 The RISKMAN Methodology.[7]

The RISKMAN Methodology overall objective is stated as '*to provide a general framework for professional project risk analysis and control, and guidance for its implementation*'.[7] However, the major focus is contract management, as a means of decreasing the likelihood that contracts will cause problems or if they do, to ensure that a process is in place to deal with the problems.[7]

The methodology consists of eight steps, of which only six form the risk management process. These six steps are;

- *'Identification*
- *Assessment*
- *Evaluation*
- *Mitigation*
- *Budget provisioning*
- *Monitoring and control'*

The last two activities, are *'risk audits'* and *'ensuring continuous improvement in the management of risk'*, which focuses on the entire process and improving its use in practice. The interactions between the steps are shown in figure 13.

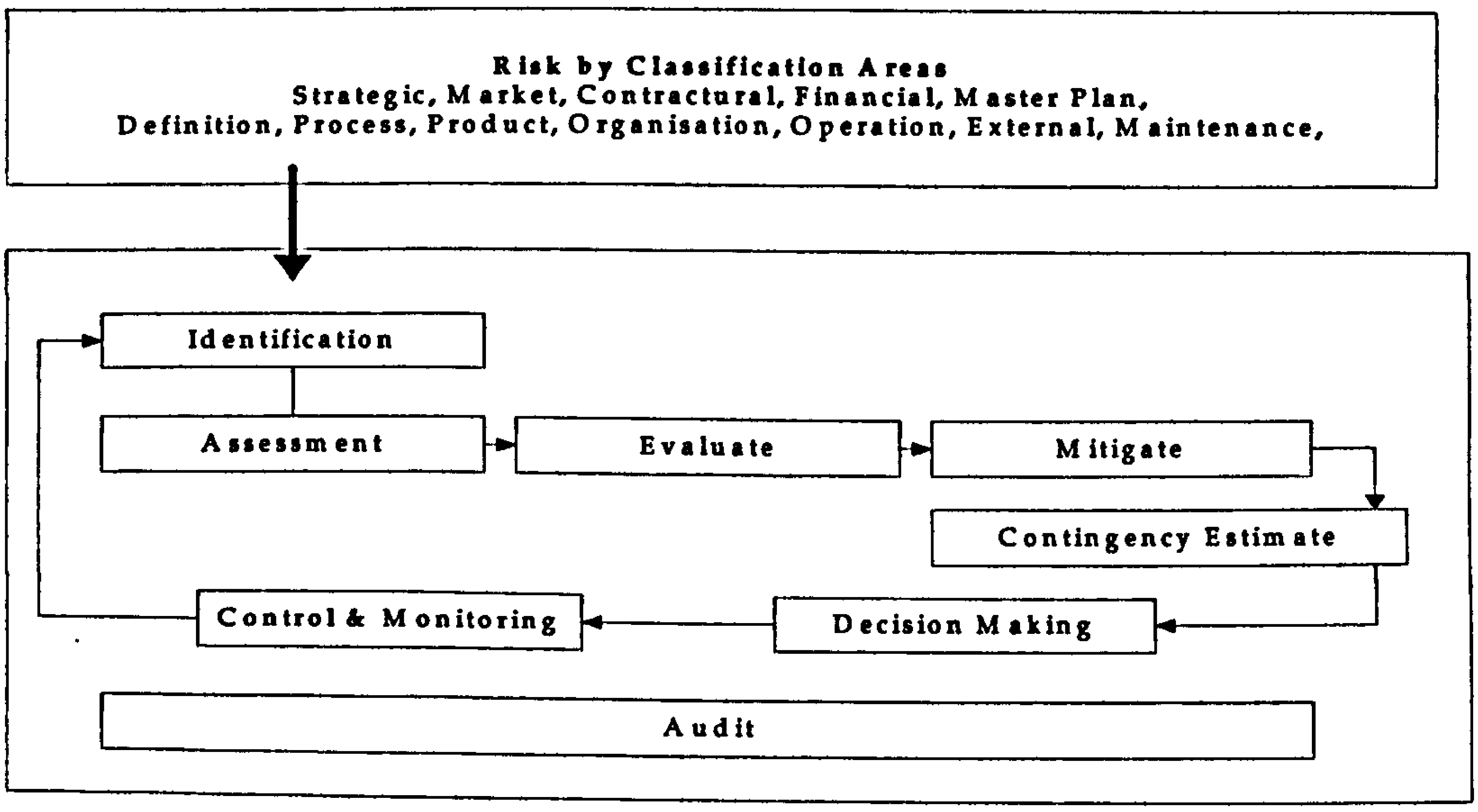

Figure 13 - Steps in the RISKMAN Methodology.[7]

There are also three levels of implementation of the RISKMAN methodology; basic, intermediate and comprehensive, depending on the level of risk management required within the project and the experience of the users.

The phases, tasks, objectives and deliverables can be seen in figure 14.

Phase	Objectives	Tasks	Deliverables
Risk Identification and Documentation	To Identify and document the risks within the project	• Identify the risks • Classify the risks into one of the 12 classes • Add the description of the risks, their identifier, ownership and consequence to the form for documentation	• Identify and document the risks within the project on a specific form

Risk Quantification	To determine the risk factor for the identified risks	• Determine the probability and impact of the risks, in terms of timescales, cost and performance estimates • Determine the effects of the risk estimates on the overall timescales and costs of the project	• Estimate the risks in terms of probability and impact • The risk factor for each of the risks is determined
Risk Prioritising and Filtering	Prioritise and filter the risks into an order of importance by their classification, weighting, risk category and imminence in time	• Prioritise each of the risks within their 12 classes • Document the risks onto a database, log or form	• List of prioritised risks
Risk Mitigation Strategies	Identify and act upon the risks which require mitigation	• For High or Medium impact or likelihood risks, or those classed as unacceptable within the project, develop mitigation paths to avoid, transfer, reduce, manage or allocate contingency funds	• Risks within a high or medium or unacceptable level of risk are mitigated against
Risk Monitoring, Reporting and Control	Re-assessment of the risks until the risk is 'managed out'	• Risks within the database are reassessed continuously throughout the project	• Completion of numerous different forms, to ensure that the project risks are mitigated and reassessed throughout the project

Figure 14 - The RISKMAN Methodology; Phases, Objectives, Tasks and Deliverables.

Within the RISKMAN Methodology, the impact and probability are determined through the expert judgement or intuition of the owner of the risk; the risk owner being the individual who should know the risk and can appropriately evaluate its consequences. Therefore, there is only one probability and impact estimate for each given risk. The probability is estimated in terms of low/medium./high, 0 – 100% or scales of 0 – 10, and the impact in terms of scales based on timescales, cost and quality issues. From this, the probability and impacts can be combined through using a probability/impact grid, or though the equation for the scale of 0 - 1;

$$RF = P + I - (P \times I)$$

Where RF - Risk Factor

P - Probability

I - Impact

This risk factor is given as a non-linear distribution. From this, the interactions of the risks can be made explicit through the use of a form, based on the 'roof' of the house of quality (quality function deployment (QFD)) method.[90, 91, 92]

What was evident from the description of the RISKMAN Methodology was that the explanation does not follow the process shown in figure 13.[7] This is due to the fact that the RISKMAN Methodology is presented by Carter et al in a dissimilar form throughout the book, and the focus of the descriptive work is on the identification and mitigation of the risks. Many of the statements, diagrams and equations given are unsubstantiated and as such, leave the reader with many questions about the origins of the material. The methodology also focuses on the use of forms, some of which are computer based, as a means of documenting the entire process, its deliverables within the project and the action taken to enable the risks to be mitigated against. The fact that the RISKMAN methodology is focused on contract management may explain the reasons why there is a large document trail from the use of this method. The documents themselves would provide an audit trail of decisions and owners of the risks as well as who is contractually responsible to reduce and/or mitigate the risks within the project. There is also no overall consensus of what the RISKMAN methodology is within the book, but much more of descriptions of interrelated methods of project risk analysis and management, focusing on cost, timescales and the bid process of a project.

The RISKMAN Methodology itself is similar to risk management processes used within the defence industry, and in particular that of British Aerospace and the American Department of Defence. There is a high focus on the bidding process as well as contract work that is carried out for customers. Therefore, the focus is primarily on these areas and not on the overall project management process for organisations who do not take part in such activities.

4.9 Risk Management in Defence Procurement.[64, 85]

Various papers previously discussed in this chapter focus on defence contracts. However what has not been discussed are the requirements of the defence industry within the risk analysis and management domain. The UK Ministry of Defence (MOD) has a risk management process that gives the basis to which all contractors to the MOD must follow. The major force behind introducing a formalised approach to risk management came from the Jordon-Lee-Cawsey report, which stated that there was a definite need to introduce a more disciplined and formalised approach to risk assessment within MOD procurement.[64]

The MOD's risk management process consists of;

- Risk identification and analysis within the technical management (performance), financial management (cost), program management (timescale), reliability management (reliability) and contract management (contract) functional areas
- Preparation of the plans to contain the level of the risk '*within reasonable and acceptable limits*'
- Ensuring that the plans are implemented efficiently and effectively, through management activities

The strategy of how the process should be used should become an integral part of the management of the project, and continued throughout its lifespan. This constitutes the risk management strategy which, although is not an integral part of the risk management process, is valuable to develop prior to implementing the stages of the process.

Figure 15 gives the phases, tasks and deliverables of the process.

Phase	Objectives	Tasks	Deliverables
Identification	Identify the risks associated with the phase of the project and the project as a whole, and possible countermeasures to these	• Identify the risks associated with the project or phase of the project being investigated • Develop mitigation or reduction plans to counteract the effects of the identified risks	• Documentation of the risks associated with the entire phase or project • Countermeasures to reduce or mitigate the identified risks • Interdependencies between the risks identified
Analysis	Document the analysis efforts for the identified risks	• Analyse the identified risks for probability of occurrence and impact through the use of both qualitative and quantitative techniques	• Documentation of the analysis methods of the identified risks
Planning	Develop plans for managing the risks identified within the project	• Development of the plans for managing the risks identified within the project • Determine which risks are acceptable and which should be managed, reduced or transferred	• A risk management plan which contains all of the information on how the risks should be managed throughout the lifespan of the project
Management	Manage the risks which have been identified, analysed and written into the Risk Management Plan, developed in the planning phase	• Monitoring, controlling and reporting of the risks and resultant decisions	• Documentation of the tasks within the phase

Figure 15 - Risk Management Process in Defence Procurement; Phases, Objectives, Tasks and Deliverables.

The MOD's risk management process gives a very basic outline of the tools, techniques and process and gives an indication to the user of the steps that they must take when contracting to the MOD. The process does not delve into the practicalities of using the tools and techniques, nor give any examples of how it has been used in practice. This is different to the other tools which have been discussed here, as they tend to give examples of the uses of the tools and techniques, and also in some cases, their use in practice. The process is owned by the project manager or, in large projects, the risk manager. Hence, as the process only outlines the tools and techniques, it can be assumed that these individuals will have prior exposure or knowledge of the risks management techniques presented. As with the RISKMAN methodology, documentation is also important. Hence, as an audit trail to the contractor's methods used, risk identification, management and ownership issues are extremely important.

The risk management process defined by the MOD can be seen to be a very generic project risk management process, from which contractors to the defence industry can build a basis on which to manage the risks within their projects.

4.10 Discussion of the Described Risk Management Processes.

The analysis of the project risk management processes described in this chapter will focus on the planned audience of the described methodologies, as well as the general objectives, tasks and deliverables of each stage of the methodologies as a whole.

4.10.1 Industrial Focus of the Risk Management Processes.

Although the risk management processes described here are not exhaustive, they do represent a broad sample of the processes in existence and being utilised within projects. While they are primarily intended for use within the project management domain, many of them have been directed towards use within a specific industrial sector (figure 16).

Project Risk Management Process	Stated Industrial Focus
Project Risk Analysis and Management (PRAM)	• Generic project risk management process, designed for use with and for the Association of Project Managers
The SCERT Approach	• Projects within the offshore oil projects/industry
Coppendale's Process for Managing Risks	• Projects within; • Aerospace defence • Materials manufacturing • Consumer durables
Applied Project Risk Management	• Construction, focusing on identification and assessment of safety risks
Risk Diagnostic and Management Method	• Product innovation
Pre-Emptive Risk Management	• Visible risk drivers for Project Risk Management
Software Engineering Risk Analysis and Management	• Software engineering projects
The RISKMAN Methodology	• Project risk management with a focus on contract management, especially in the defence industry
Risk Management in Defence Procurement	• Defence with a focus on procurement contracts

Figure 16 - Risk Management Processes and their Industrial Focus.

The investigated project risk management processes have tended towards use within the defence (contracts), construction and oil industrial sectors. Product innovation and the use of risk management to determine if a project is feasible also rate highly. Although the majority of the research and implementation carried out has been within these areas, it is not to say that these are the sole respondents of these methods. However, none have been explicitly applied or used within the Automotive Manufacturing Industry. Nevertheless, aspects such as project risk management, product innovation and materials manufacturing could be applicable to the Automotive Manufacturing Industry as a means of managing the risks within those areas.

4.10.2 Deliverables of the Risk Management Processes.

The deliverables of the risk management processes can be seen in figure 17. All of the processes meet the deliverables to 'identify and list the risks in a clear, concise and unambiguous way' (deliverable 2) and 'consensus on the assessment of the risks through either qualification or quantification' (deliverable 4). Only the Applied Project Risk Management does not perform the 'development of risk management plans to effectively manage, reduce, transfer or reject the risks' (deliverable 9). This anomaly can be explored through looking at the tasks within the process, and as such, the Applied Project Risk Management focuses on the identification and assessment of the risks within the project as well as more predominantly on safety issues attached to the construction project as a whole. This is an exception within the remainder of the processes described in this chapter, as their main focus is on the identification, and assessment as well as overall management of the risks within the project.

What will therefore be discussed are those deliverables not provided by all of the risk management processes, as a means of explaining the differences and similarities between the processes themselves.

Deliverable	PRAM	SCERT Approach	Coppendale Process for Managing Risks	Applied Project Risk Mgt	RDM Method	Pre-Emptive Risk Mgt	Software Eng. Risk Analysis & Mgt	RISKMAN Method	Risk Mgt. in Defence Proc.
1) Clear identification and understanding of the project and its plans, objectives, key tasks and how risk management fits into this	✓	✓	X	X	X	✓	✓	X	✓
2) Identify and list the risks in a clear, concise and unambiguous way	✓	✓	✓	✓	✓	✓	✓	✓	✓
3) Classification of the risks identified within the project	✓	✓	✓	✓	X	X	X	✓	X
4) Consensus on the assessment of the risks through either qualification or quantification	✓	✓	✓	✓	✓	✓	✓	✓	✓
5) Prioritisation of the risks within the project	✓ (within structure phase)	X	✓	X	✓	✓	✓	✓	✓ (determines which risks are/are not acceptable)
6) Interdependencies/inter-relationship between the risks understood	✓	✓	X	✓	X	X	✓	✓	✓
7) Ownership of the risks allocated	✓	X	X	X	X	X	X	✓	X
8) Go/no go decision on the feasibility of the project and use of risk management, based on the risk management activities	X	X	X	X	✓	X	✓	X	X
9) Development of risk management plans to effectively manage, reduce, transfer or reject the risks	✓	✓	✓	X	✓	✓	✓	✓	✓
10) Identification of the variations in the actual vs. planned project	X	X	X	✓	X	✓	X	X	X
11) Iterative process, to be used throughout the lifespan of the project	✓	✓	X (re-run at intervals)	X	X	X	✓	✓	✓

Figure 17 - Deliverables of the Risk Management Processes.

4.10.2.1 Project Plans within the Risk Management Process.

Many of the described risk management processes look initially at the project and the developed plans before initiating the identification of the risks. The reasons for this seem to be to ensure that the project plans, objectives and tasks are developed, and that the teams have all of the knowledge currently available within the project accessible to them. Hence, project risk management does not purely start with the identification of the risks; it should be an integral part of the project management process. This fits in with the development plan of project and risk management in which risk management is a subsequent development within the project management discipline.[93]

4.10.2.2 Classification of the Risks.

Classifying the risks which have been identified within a project can enable them to be ordered in a way which is understandable to the team as well as to external bodies. Therefore, it is surprising that 4 of the 9 discussed risk management processes do not state that the identified risks should be ordered into any particular classification. Those processes which state that the risks should be classified can be considered as the most generic project risk management processes, and include the PRAM, SCERT, Coppendale's Process for Managing Risks and the RISKMAN Methodology. The Applied Project Risk Management also looks at classifying the risks. However these tend to be within the engineering scope of the project (geotechnical, hydraulic and force majeure), and external risks (regulatory, market and economic). Hence, there is a lack of focus on the project risks within the Applied Project Risk Management process, which can be seen to tie in with the omitance of the development of risk management plans which are performed and delivered within all the other risk management processes in which classification takes place.

4.10.2.3 Prioritisation of the Risks within the Project.

Prioritisation enables the user to determine which risks have the potential to be the most problematic within the project. However, two project risk management processes do not state that the identified risks within the project should be prioritised. The Applied Project Risk Management process does not prioritise the risks but states that the risks for which contingency planning, mitigation or diversion efforts are to take place, should be identified within the project. From this, comparisons of the planned and the actual occurrences in the project are monitored. However, the actual management of the risks does not take place. Within the SCERT method, the reasons for the omitance of prioritisation seems to be that, while it focuses on the area of the project which is most affected by the identified risks and looks at the relative role of each source of risk within an activity within the project it does not focus on the individual risks themselves.

4.10.2.4 *Interdependencies/Interrelationships Between the Risks.*

Identifying interrelationships between the risks and their mitigation and/or contingency plans allows for the effects that these risks and activities might have on other aspects of the project and as such, the effect that they have on the level of risk within the project to be made explicit. Again however, not all of the reported risk management processes explicitly state that interdependencies or interrelationships should be identified and documented; these being Coppendale's Process for Managing Risks, the Risk Diagnostic Method and the Pre-Emptive Risk Management method. For those which do state that the interdependencies should be considered, the RISKMAN methodology provides an easy to visualise method, using a system similar to the 'roof' of the 'house of quality' (QFD). Within the remainder, it is simply stated that interdependencies/interrelationships should be identified, assessed and documented alongside the previously identified risks.

4.10.2.5 *Ownership of the Risks.*

When the risks have been identified, assessed and in some cases prioritised, there should be a clear line of communication of who is responsible for the mitigation and/or contingency planning of the risks. This increases the probability that action will be taken to reduce or mitigate against as appropriate. It is therefore surprising that only two of the discussed processes explicitly state that allocation of ownership of the risks should take place. Some of the remainder do state that the strategy for managing the risks should take place, but there is no explicit mention of ownership. More information on what to include within the risk management strategy should be included within the processes, and within this, the allocation issue should be addressed.

4.10.2.6 *Feasibility of the Project.*

The risk management processes can not only enable the risks to be effectively identified, assessed and potentially managed, they can also act as a means of determining which projects are feasible, and whether the project should be continued in its existing form, changed or even cancelled. The Risk Diagnostic Method and Charette's Software Engineering Risk Analysis and Management method assist with this decision point. Unlike Charette's process, the Risk Diagnostic Method was designed to assist in improving the product-innovation process and hence the reasons why this go/no go decision within the project takes place is to aid the process as to whether to invest in a new innovation. Hence, the process is designed to assist the feasibility of the project's objectives and not the project as a whole. Charette's process however uses the project information to aid the go/no go decision on the project. This is important due to the complexity of engineering software development projects. Within this, the initial project is examined and assessed for the level of risk, so that confidence in the actual feasibility of the project can take place. If there is a lack of confidence in the feasibility of the project, then either the objectives or activities can be changed or the project cancelled. Hence, the remainder of Charette's process only takes place when the level of risk is of a low enough value to ensure that there is confidence that the project is practical. However, the author disagrees with Coppendale when it is stated that the risk management process should be mandatory within a project.[81] The use of risk management should be left up to the project team, and should be based on the level of risk within the project, and the overall importance to the success of the organisation as a whole.

4.10.2.8 *Actual vs. Planned Activities/Risks.*

Although investigating the actual vs. the planned activities or risks within a project may constitute monitoring of the project, only two methodologies explicitly state that this should take place. When the project is investigated in retrospect, comparing the actual vs. the planned can enable a passive role to be made explicit. Monitoring the actual vs. the planned activity within the project can be considered a useful activity to take place, as it enables aspects such as how well the project has been managed or the effectiveness of the risk management effort to be determined. However, the monitoring process itself does not aid in the active management of the risks, and hence, is probably the reason why only two of the processes examined in this chapter use it as a means of monitoring the project as a whole.

4.10.2.9 *An Iterative Risk Management Process.*

As a project is an ongoing and changing process, it is important that the risk management process takes place throughout the lifespan of the project. Therefore, the use of the risk management process should be repeated as necessary to encapsulate these changes and developments. However, as can be seen in figure 17, nearly half of the risk management processes discussed within this chapter; Applied Project Risk Management, the Risk Diagnostic Method and Pre-Emptive Risk Management; are not iterative in nature. In addition, Coppendale's Risk Management Process should only be re-run at regular intervals.

The Applied Project Risk Management Process can be considered to be not as generic as the other processes described within this chapter, as it focuses on safety issues alongside more general project issues and does not tend to centre on the management of the risks, but predominantly on their identification and assessment. The Risk Diagnostic Method focuses on the product-innovation process, in which the risks attached to these are identified and considered. Hence, the focus of this process is on the up-front development and decisions on the feasibility of the project, not on the actual development of the product through the use of project management.

Even though Pre-Emptive Risk Management is much more 'generic' than the other three and it focuses on the risks and the management of the risks as a whole, it is also not iterative. This process was developed from research that identified that projects fail mainly due to the risks which are visible within the project. Therefore, if all risks are visible, these should be able to be identified at the beginning of the project and hence, the process would not need to be repeated. This is, in the authors opinion, not an appropriate approach to take, as even though most risks are able to be identified at the beginning of a project, projects do not always stick to their initial plan, and deviations take place as a matter of course. When these deviations take place, existing identified risks may not occur as the activity through which they may materialise is not due to take place (for example, the development of a part or expansion into uncharted territory). Also, new risks will be identifiable within this new path, and hence should be identified, assessed and managed as appropriate within the project.

4.10.2.10 *The Need for Experienced Risk Management Professionals.*

Although the need for experienced risk or project management professionals has not been explicitly added to figure 17, this is an important aspect in the use of project risk management processes within industry. Klein et al point out that a major disadvantage of risk management processes such as the SCERT approach is that they require experienced professionals in risk analysis and management to carry out and use the techniques presented within the methodology.[80] Although both shorter, less in-depth processes and methods to reduce the complexity of some processes are described, this can be considered as a potential problem for individuals, organisations and industries who are not familiar with project risk management processes. Coppendale backs up the theory of having an easy to use and understand project risk management methodology in place within an organisation.[81]

Various methods can be employed to overcome this; including hiring trained and experienced professionals, training existing staff or using less complicated methods and techniques to manage the risks within the projects. Both Rover and BMW used a mixture of these three aspects when looking at implementing project risk management within its project management practices.

4.11 Conclusions.

Nine different project risk management processes have been discussed within this chapter and comparisons made on the deliverables of each of the processes. Each of the project risk management processes have been developed for specific reasons, whether it be as a generic process, from experience of its application into a specific industry, or research into a specific area. What can be said about these processes is that, although they have all been designed to manage project risk, they are all different in their approach to project risk management and their usage in practice. None offer the same depth or application into industrial sectors, and although they all sit within the project risk management domain, they are all dissimilar in many ways. However, similarities do exist between them, such as the identification and assessment of the risks, and the development of risk management plans (with the exception of the Applied Project Risk Management Process). Also, when looking at the application into the Automotive Manufacturing Industry, it can be seen that;

- None of the discussed project risk management processes have been explicitly designed for or applied within this sector.
- There is a need to condense existing processes and develop a generic Risk Management Methodology, for use within this area.

These factors will be considered within the following chapters.

5.0 THE RISK MANAGEMENT METHODOLOGY AND ITS ASSOCIATED TOOLS AND TECHNIQUES.

The Risk Management Methodology and its associated tools and techniques were designed to enable risks within projects which are strategically important and will enable the Automotive Manufacturing Industry to design, develop and manufacture their products. It first determines whether any benefit can be possibly attained through implementing project risk management into a project and then enables the inherent risks and potential problems to be effectively identified and managed throughout the lifespan of the project. The flowchart, figure 18, shows the overall Risk Management Methodology in its final form.

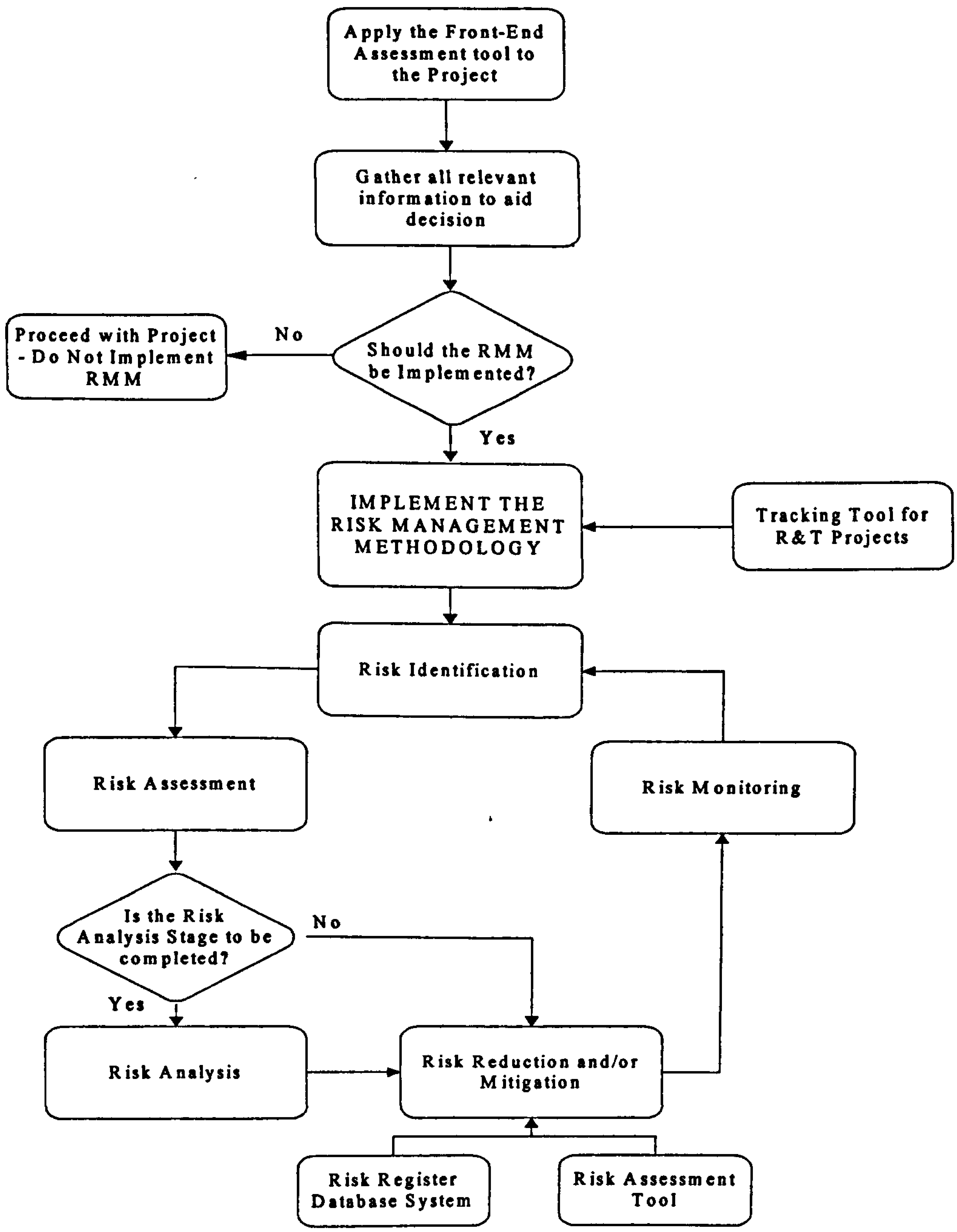

Figure 18 - Process of the Risk Management Methodology.

As was stated in section 1.0, the Risk Management Methodology was developed in various iterations, based on information determined through its implementation into the CB40 Fender and CBoM projects. Hence, both the Front-End Assessment Tool and the Tracking Tool for R&T Projects were developed *after* the Risk Management Methodology had been implemented into the projects. The reason for the Front-End Assessment Tool being developed after the implementation was that its need was determined through an investigation of existing risk management processes and the post-audit review of the CBoM projects, as a means of determining whether the Risk Management Methodology should be implemented into a project. The Tracking Tool for R&T Projects was developed as a separate process, based on a requirement from Rover's Technology Strategy team and, although complementary in nature to the Risk Management Methodology, is not an integral tool.

The most appropriate place to implement the Risk Management Methodology and its associated tools and techniques is at the beginning of a project. The reason for this is that the concept, direction and risks are more able to be determined and understood by all members of the team at this time. As such, the process itself can aid the development of project objectives and management plans. Through doing this, risks can be reduced and removed at the initial stages through the development of appropriate objectives and directions for the project based on this initial understanding of project risk management. Nevertheless, benefit can still be gained through implementing the methodology at a later stage within the project.

It was stated in the submission *'Implementation of the Risk Management Methodology - Problems and Solutions'* that the Risk Management Methodology should be part of the project management procedures within the organisation, as well as on the agenda of project and programme meetings and external audits.[9] It should also be implemented at the highest level within a programme of project, and as such, be cascaded downwards.

It is also important to state that the Risk Management Methodology is not a prescriptive method of managing risks within a project. It merely provides tools, techniques and methods through which the project team can effectively identify, assess, analyse, reduce and/or mitigate against and ultimately manage the risks to a project.

Chapters 6.0 to 9.0 will discuss the Risk Management Methodology and its associated tools and techniques, as well as its implementation into the CB40 and CBoM projects. The methodology and tools will be discussed in relation to their use of numeric and non-numeric values, their justification and the similarities and complementary nature of the tools themselves.

6.0 THE FRONT-END ASSESSMENT TOOL.[94]

The Risk Management Methodology was designed to enable project managers and teams to increase the potential success of their projects. However, as the methodology itself requires resources to be used in its implementation and continual use throughout the lifespan of the project, there is little advantage in using it if the project is of a low risk or if there is no significant benefit in doing so. Therefore, the Front-End Assessment Tool was designed to provide a comprehensive view as to whether the project is likely to be a success or failure, and from this, if any benefit can be obtained through implementing the Risk Management Methodology. A full description of this tool can be seen in the submission *'Tool to Ascertain if the Risk Management Methodology should be Implemented into a Project'*,[94] whereas a paper-based copy of the tool can be seen in appendix 1.

The tool uses *'statements of success'*. The statements were grouped into four generic areas; technical, project, organisational and external, and were worded so as not to detract from or unduly compromise the assessment. The 33 *'statements of success'* were then ranked to enable a weighted assessment tool to be developed. These weightings were derived by determining the importance that the academic community attached to attributes of success and failure within projects, as well as from the previous implementations of the Risk Management Methodology into the projects within the Rover/BMW Group. When investigating the academic research, as the tool required actual rankings to be determined, only existing research where the critical success and failure factors were ordered into priorities were used.[144, 145, 146, 147, 148] Therefore, from the average rankings of each statement, the weightings of 1 - 10 were obtained through identifying the lowest average ranking value and determining the spread between the lowest and highest value. Although the statements of success and their corresponding weightings have been set within the assessment tool, they should be revisited at intervals, firstly to ensure that they are still applicable to the type of projects, business units and organisations being assessed, and also to incorporate new research into the area of critical success and failure factors into the Risk Assessment Tool. .

The tool itself was developed in MS® Excel® and is shown in appendix 1. The *'area of the project'* relates to the 'Generic Risk Areas' which will be discussed in section 7.1, to ensure that the terminology used within the Front-End Assessment Tool fits in with that of the Risk Management Methodology. The *'identification number'* of the *'statement of success'* ensures ease of identification of the statement when the assessment is carried out in a group situation. The *'statements of success'* are the statements within the tool which have been identified from the critical success and failure factors, the projects in which the Risk Management Methodology had previously been implemented as well as the previous experience of the author in working in and applying risk management techniques to projects within the Automotive Manufacturing Industry.

6.1 Using the Front-End Assessment Tool.

The understanding of how important each statement is to the success of the project should be inserted into the column at the relevant place within in the tool (appendix 1). The assessment itself should be performed by people involved in all aspects of the project, and the assessment is based on the judgement and experience of these individuals. These individuals should have a clear understanding of the project and the statements, and the determination of how important an issue is needs to be performed in isolation from the level which has been achieved, to ensure that objectivity and accuracy are maintained. From this, the tool automatically calculates the value of the 'Normalised Importance to Project Success' for each of the statements of success.

The declarations in figure 19, provide clarification of the importance to the success of the project.

Importance to Project Success	*Clarifying Declaration*
1	Of very little importance to the success of the project.
2	Of little importance to the success of the project.
3	Of medium importance to the success of the project.
4	Of importance to the success of the project.
5	Of very high importance to the success of the project.

Figure 19 - Table of the Importance to Project Success Clarifying Statements.

The 'Level Achieved to Date' is the level at which the project has achieved the statement up to the date at which the assessment has been undertaken. For example, if the goals are not stable at the beginning of the project, then a value of 1 should be inserted into the relevant place on the column. A list of clarifying declarations can be seen in figure 20, below.

Level Achieved to Date	*Clarifying Declaration*
1	The statement has not been achieved.
2	There is evidence that the statement has been started.
3	There is evidence that the statement could be completed soon.
4	There is evidence that the statement is very nearly achieved and that there is nothing expected to happen to deter from this.
5	There is evidence that the statement has been fully achieved.

Figure 20 - Table of the Level Achieved to Date Clarifying Statement.

It is important to note that evidence needs to be provided to ensure that the appropriate value is inserted in the relevant place. The evidence can and should be asked for within the team meetings or within the audit process. From this, the 'Level of Risk Value' is automatically calculated within the tool. This value enables each of the statements to be assessed for the level of risk that the statement poses for the project.

6.1.1 The Assessment.

The assessment consists of three aspects; the 'Risk Value' within the project, the 'Classification of the Risk' and whether the Risk Management Methodology should be implemented into the project.

The 'Risk Value' is the average of the level of risk value within the project, through the summation of the level of risk values divided by the number of statements (in this case 33). The 'Risk Value' gives an arbitrary value as to the perceived level of risk in the project. This value comes into effect when projects are being evaluated, as a means of determining which ones present the most risk to an organisation, and thereby require more attention. The 'Classification of the Project' classes the riskiness of the project as between VL (very low) to VH (very high), based on the values given in the Risk Management Methodology, as will be introduced in section 7.2. These bandings were used as a method of creating greater understanding as to the significance of the classes of riskiness within a project. The bandings of 0 - 5, 6 - 20, 21 - 50, 51 - 90 and 91 - 100 are skewed towards there being a greater number of high priority risks within the project. The reason for this is due to research that people tend to overestimate their ability to manage risk, and will be further discussed in section 10.1.1 Hence, this non-linearity of the bandings tends to the fact that more risks are identified as being of a higher risk value than had the bandings been linear. Through making the bandings smaller within the higher level (i.e. from 50% upwards), the values could be classified more specifically and greater emphasis placed on determining the ranking the risks in an order of priority. However, it is the authors belief that this would have created more variability in the rankings of the risks, through there being greater emphasis on not only the specific rankings of the risks, but also the belief that the users have in the assessments and the priority of the risks. This could result in risks, say between a 95 - 100% banding, being given the most amount of attention by the users, however one which is say classed as 94% being given much less attention. The difference in the values is arbitrary, due to the very subjective nature of the assessment methods, and can be limiting to the use of the assessment within the project. Therefore, by increasing the width of the bandings in the higher level, the users are less focused on the priority of the risks themselves, and more aware of the risks in the project which may have the most impact on the project and probability of occurring. From this, they can focus their efforts on managing the most important risks to the project, irrespective of their percentage values given.

As this information is written into the spreadsheet, the 'Classification of the Project' is automatically determined. To 'Implement the Management Methodology' is dependent on the risk value (RV) of the project, as shown in figure 21.

Risk Management Methodology Value (%)	Implement the Risk Management Methodology
0 - 5 6 - 20	*SHOULD NOT BE*
21 - 50	*MAY BE*
51 - 90 91 - 100	*SHOULD BE*

Figure 21 - Implement the Risk Management Methodology?

It should be noted that, although this gives a statement of whether the Risk Management Methodology 'SHOULD NOT BE', 'MAY BE' or 'SHOULD BE' implemented into the project, the final decision on whether or not to implement the cyclic Risk Management Methodology into the project must be made by the project management team. The reason for this is that the project team should use the Risk Management Methodology on projects with a heightened risk, as a means of benefiting from the use of the tools, but also to minimise the cost and time drawback which comes from using such a technique within the tight resource requirements of the Automotive Manufacturing Industry as a whole. Therefore, the tool should only provide information on the riskiness of the project, with the final decision being made through the utilisation all of the available information.

6.2 Application of the Front-End Assessment Tool.

The Front-End Assessment Tool should therefore be used to determine if the Risk Management Methodology and it associated tools and techniques should potentially be implemented into a project. However, as this tool was developed towards the end of the research, there was no time to implement it into projects.

It is however felt that the tool can provide an indication as to whether the project is of a high enough risk and importance to benefit from the use of Risk Management. It therefore provides a means to aid the decision making process as to the likelihood of the project being a success, as well as determining those areas of the project where there is lack of confidence. A discussion of the quantitative aspects of the Front-End Assessment Tool will be given in chapter 10.

Therefore, if it is determined appropriate to implement the Risk Management Methodology into the project, it can be continued with, as shown in figure 18, section 5.0.

7.0 THE RISK MANAGEMENT METHODOLOGY.

The Risk Management Methodology was developed in various iterations. The first iteration, figure 22, was used within the CB40 Fender Project.

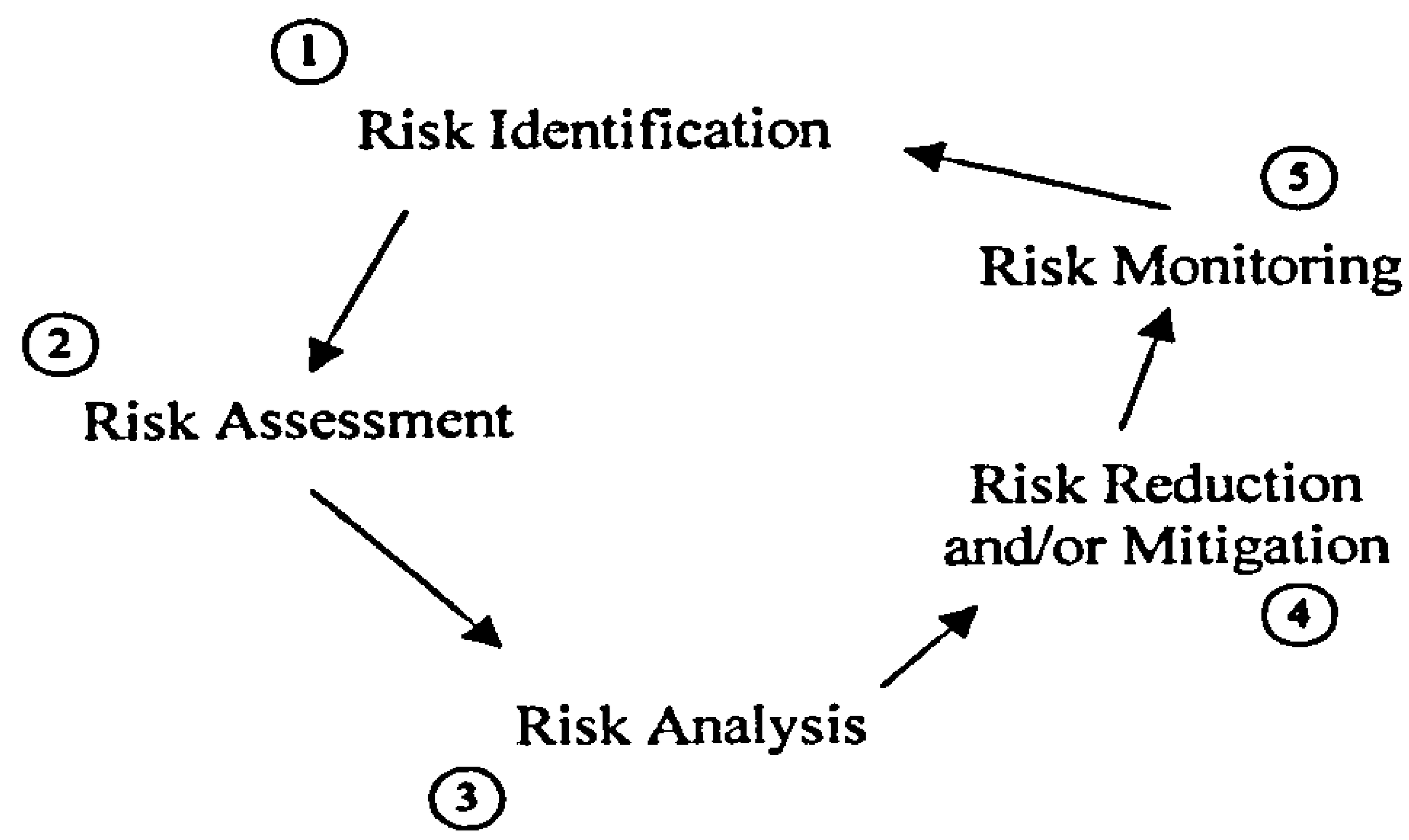

Figure 22 - Initial Design of the Risk Management Methodology.

However, from this first implementation, which will be discussed in section 8.1, it was determined that the initial version of the Risk Management Methodology did not represent the way in which it should be used in practice. The first change to the Risk Management Methodology was the inclusion of a stage for developing the Risk Register.[95] However, developing the risk register cannot be described as a 'stage' within the methodology. The reason for this is that within each stage there is a description of the actions which should be performed, as well as an introduction to the tools and techniques which can enable that particular stage to be completed. The risk register is, on the other hand, a tool which can be used within a stage to enable that stage to be completed. Therefore, because of this, the Risk Management Methodology was re-developed.

The final version of the Risk Management Methodology can be seen in figure 23. It maintains the 5 stages developed in the original methodology. However, the Risk Analysis stage is optional within the process, dependent on whether its use will be of benefit to the project, and will be explained further in section 7.3.

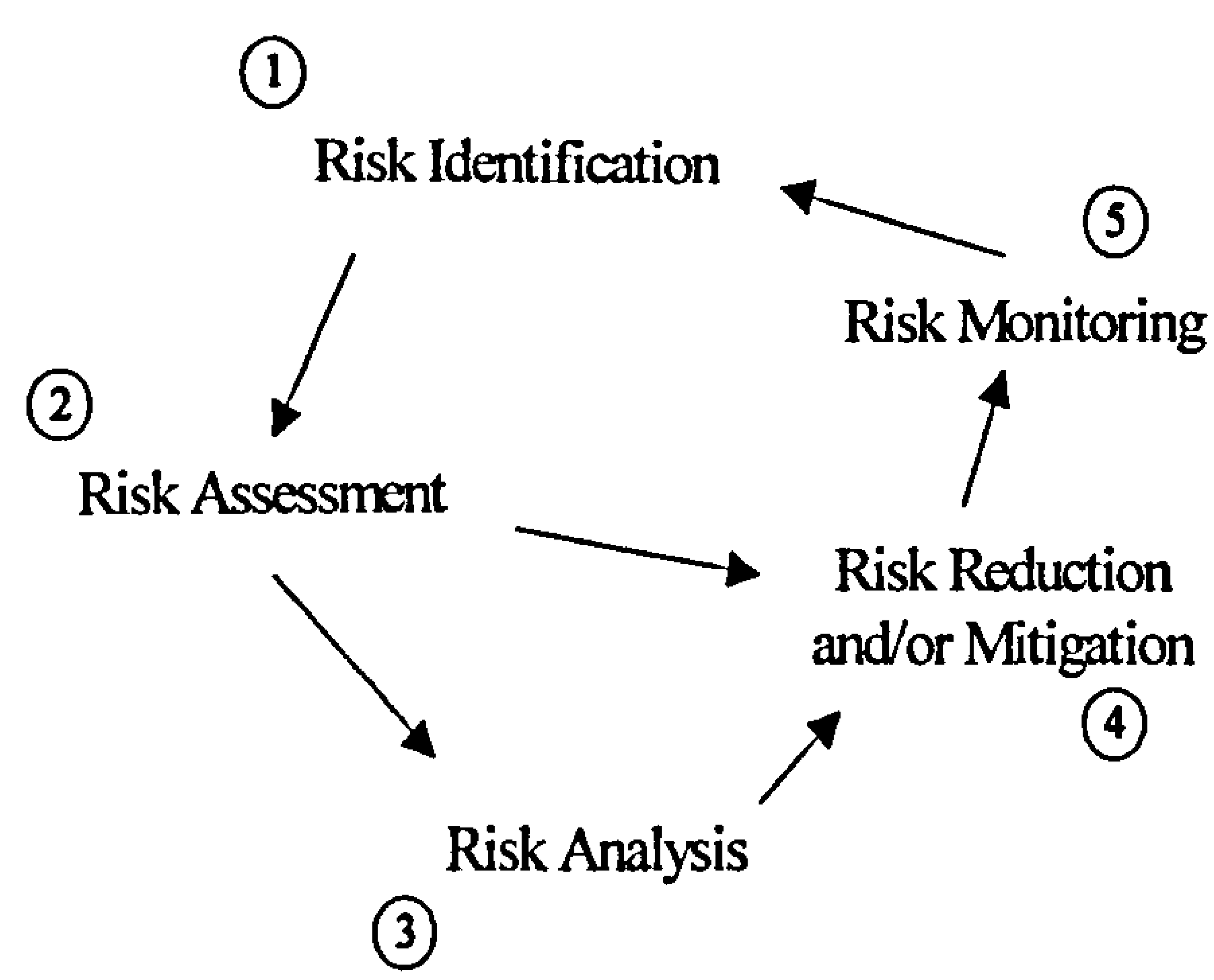

Figure 23 - The Risk Management Methodology.

The Risk Management Methodology can be described as a continuous, cyclic process, which is initiated at the risk identification stage. The overall objective of the methodology should be the successful completion of the project. The process itself consists of 5 stages,

- Risk Identification
- Risk Assessment
- Risk Analysis
- Risk Reduction and/or Mitigation
- Risk Monitoring.

The Risk Management Methodology describes the techniques, tools and methods through which risk management can be implemented into projects. It was developed through a rigorous investigation of the needs and requirements of the Automotive Manufacturing Industry. As such, it provides an overall method through which the risks within a project can be effectively identified, assessed, analysed, reduced and mitigated against and monitored on a regular basis, through the lifespan of a project. It is therefore the tools and techniques underlying each of the stages which constitute the methodology itself. A diagram of the tools and techniques which can be used within each stage can be seen in figure 24.

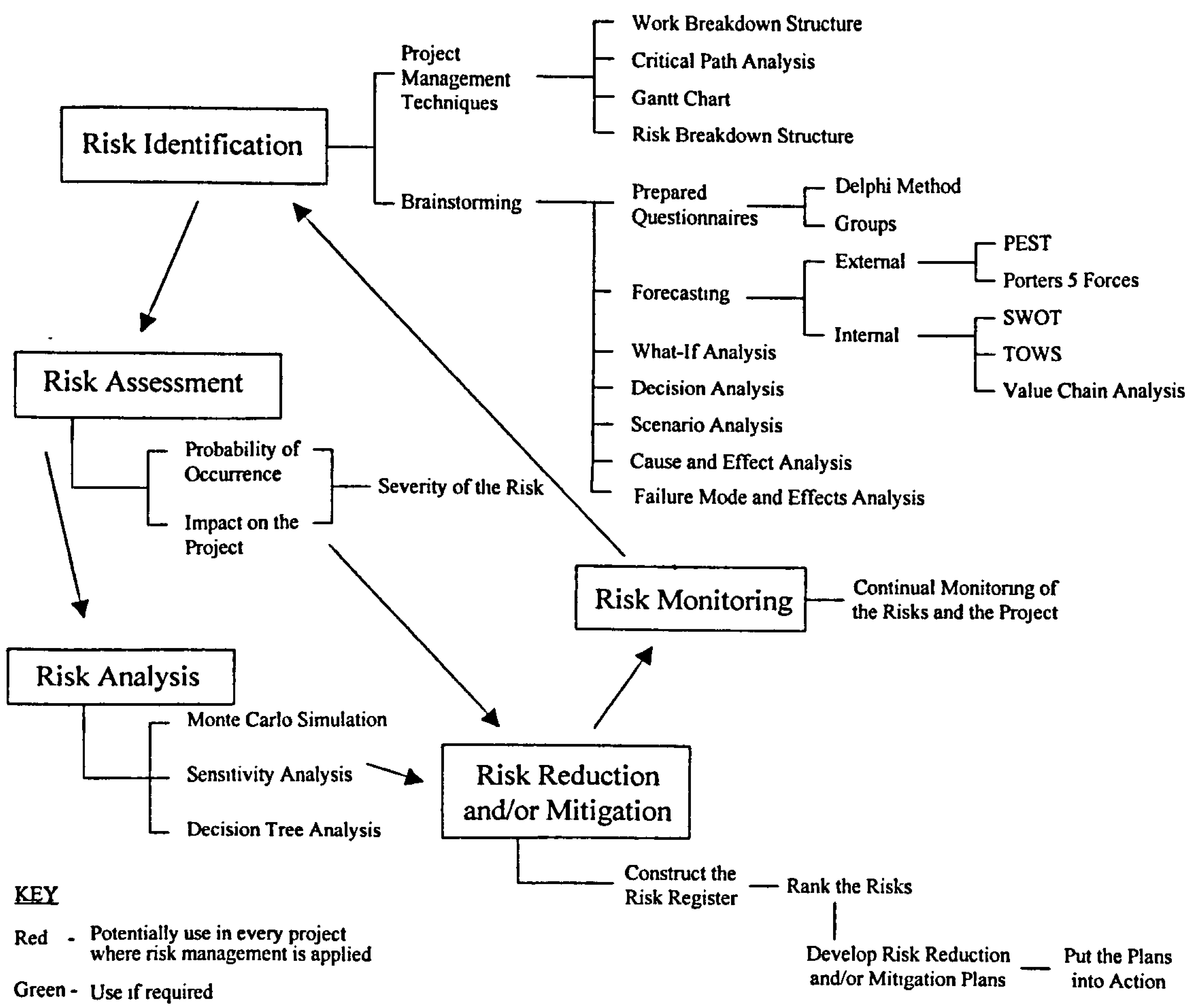

Figure 24 - Tools and Techniques Used within the Risk Management Methodology.

The choice of tools and techniques to use within the project are dependent on the user of the Risk Management Methodology. However, it is suggested that the red tools and techniques be used within every project, as they have been identified through both an investigation of the literature and the application of the Risk Management Methodology into projects as the most appropriate to use within the identification of the risk, whereas the green are those which can be used, if the user deems it to be appropriate.[34] A discussion of the quantitative aspects of the methods and tools used within the Risk Management Methodology will be given in chapter 10.

It should be asserted that the Risk Management Methodology is not a prescriptive method of managing the risks, potential problems and uncertainty within a project. It only provides tools, techniques and methods which offer a choice to the user. The remainder of this chapter will examine each stage of the Risk Management Methodology, identify the tools and techniques which can be used, and give a broad picture of how they can be applied in practice.

7.1 Risk Identification.

At the initial concept stages of a project, managers and project team members frequently make decisions on the basis of great uncertainty. This is often due to the lack of information as to the direction that the project should take and also because the factors which will affect it cannot always be decided at this point. However, it is usually within the initial stages that high-risk decisions are made and the resources for the project authorised and allocated. It is here that the manager and project team must spend a large amount of time and effort to ensure that the decisions are made wisely and that they encapsulate all of the knowledge and expertise available at this point in time. This should thereby ensure that the product or process does not have to be re-designed at a much later date, or that it does not fail completely. It is therefore here that the Risk Management Methodology should be implemented if possible. Furthermore, the risk identification stage is considered to be one of the most important stages within the Risk Management Methodology, as without the appropriate identification of the risks, the remainder of the process can be difficult to accomplish satisfactorily.

Various tools and techniques can be used within the Risk Identification stage, many of which are shown in figure 24. Not all of the techniques need be used within every project. They offer a choice from which the user can select to most appropriately fit the project, the current phase and the results which the user wishes to gain from the process. The risk identification techniques are also not exclusive, and other techniques can be included into this stage if deemed appropriate. As such, they represent examples of the tools and techniques which can be employed to identify the *root causes of the risks and potential problems* within and affecting the project. Further definitions of the tools and when they should be used within the risk identification stage can be seen in the submission *'The Management of Risk - From Theory to Practice'*.[34]

The project must be at a stage where it has actually been initiated before the identification of the risk can take place. The Front-End Assessment Tool should have aided the decision that the project is of a high enough level of risk to potentially benefit from the use of the Risk

Management Methodology, and as such, the management and the team members must be in full agreement as to the level of risk management that will take place, as well as being fully committed to the process throughout the lifespan of the project. The first priority should be the initial development of the project planning material, and as such, only basic techniques need be employed. These can be the initial development of a project hierarchy, an elementary plan as well as objectives of the project. The identification of the root causes of the risks and potential problems can then take place. The application of the Risk Management Methodology into 7 projects has demonstrated that the most useful techniques to use within a project are prepared questionnaires given to a group or team, both internal and external forecasting techniques, 'what-if' 'analysis and cause and effect analysis. These can ensure that the root cause of the risks and potential problems are identified, and not the actual effect of the risk itself. Risks and potential problems should be brainstormed in the generic risk areas, given in figure 25, although they need not be identified for all areas.

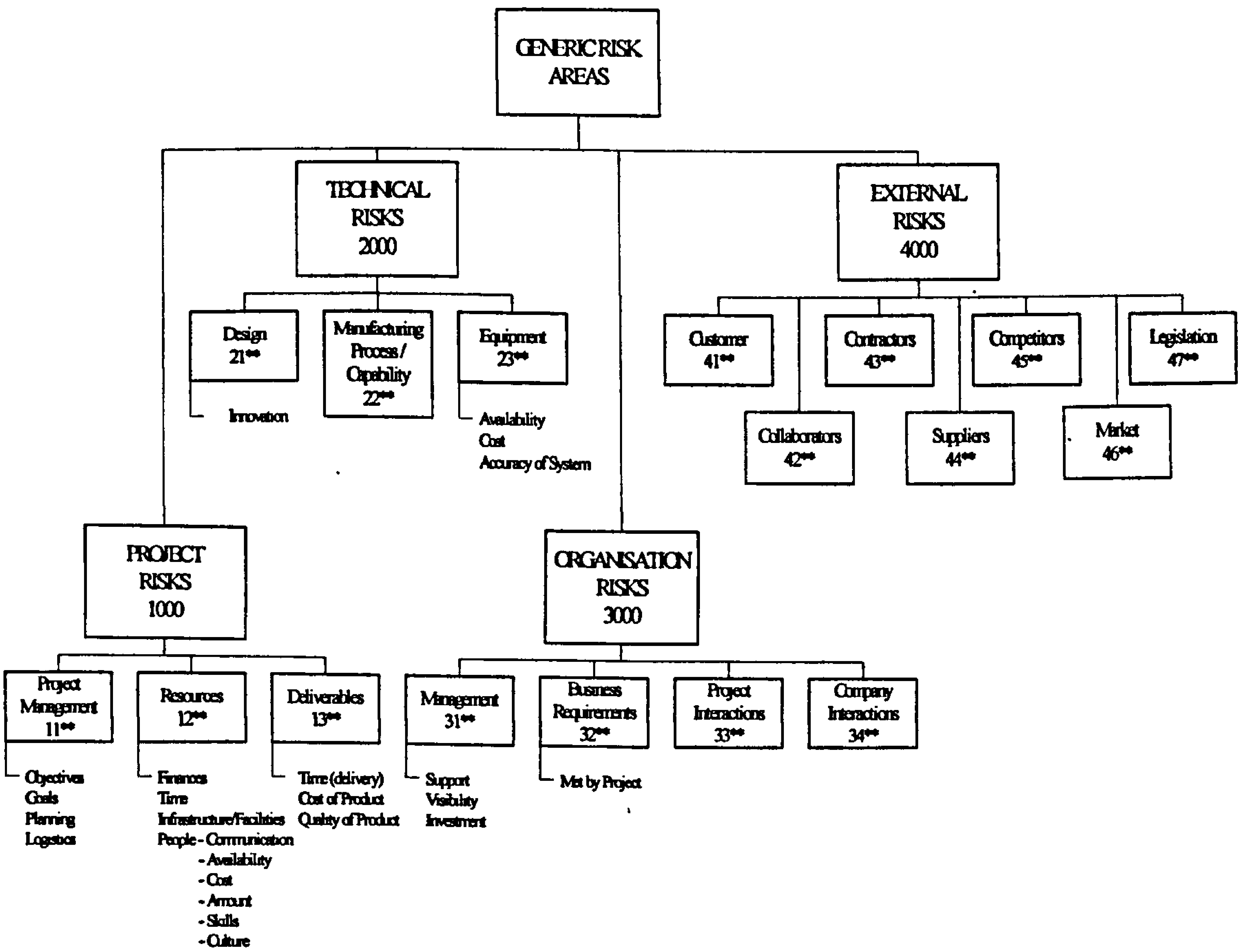

Figure 25 - The Generic Risk Areas.

Once the risks and potential problems have been identified, their meaning and description need to be agreed by the team members and any duplicate risks removed. Each risk needs to be described in a brief and concise way, so that everybody involved in the project fully understands its meaning. The risks should then be allocated a 'Risk Identification Number', so that each individual risk can be identified later on in the process. The risk identification number is based on the generic risk areas, given in figure 25, and is determined from the area in the project where the risk has been identified. As an example, if the risk has been identified as the result of 'Legislation', then the risk number would be 47**, where ** represents the next number in the list within the Legislation area.

Once the risks which may affect the project have been identified, it is of the utmost importance that they are assessed and analysed as appropriate.

7.2 Risk Assessment.

At this stage, each identified risk is assessed for its probability (likelihood) of occurrence and its impact, in terms of time, cost and quality, on either the project phase or the entire project, should it occur. Although within the projects, the assessment of the risks was performed through the use of either non-numeric, VL (Very Low) → VH (Very High), or numeric, 0% → 100% values, it is recommended by the author that the non-numeric assessment is performed within the project, the reasons for which will be discussed in chapter 10. Figure 26 enables the assessors to allocate a non-numeric value to the risks, with the numeric values providing information and understanding as to the corresponding percentage values. The assessment system described here gives the ranges of the probability and impact values with their corresponding category, and is not designed to generate highly accurate values of the probability and impact of the risks within the project. As it is based on the subjective judgement, knowledge and experience of the assessors, it is only intended to give an overall '*perception*' or '*feel*' that the users have for each of the identified risks. Hence, the probability and impact of the risk occurring is determined through using the categories in figure 26. These values will be further discussed in section 10.1.1.

Corresponding Probability Values	Risk Probability & Impact Category	Corresponding Impact (Time/Cost) Values
91% - 100%	VH	91% - 100%
51% - 90%	H	51% - 90%
21% - 50%	M	21% - 50%
6% - 20%	L	6% - 20%
0% - 5%	VL	0% - 5%

Figure 26 - Probability & Impact Table.

Consensus for agreeing on the level of probability and impact for each risk can be achieved using the consensus trees, which can be seen for the probability and impact assessments in figure 27.

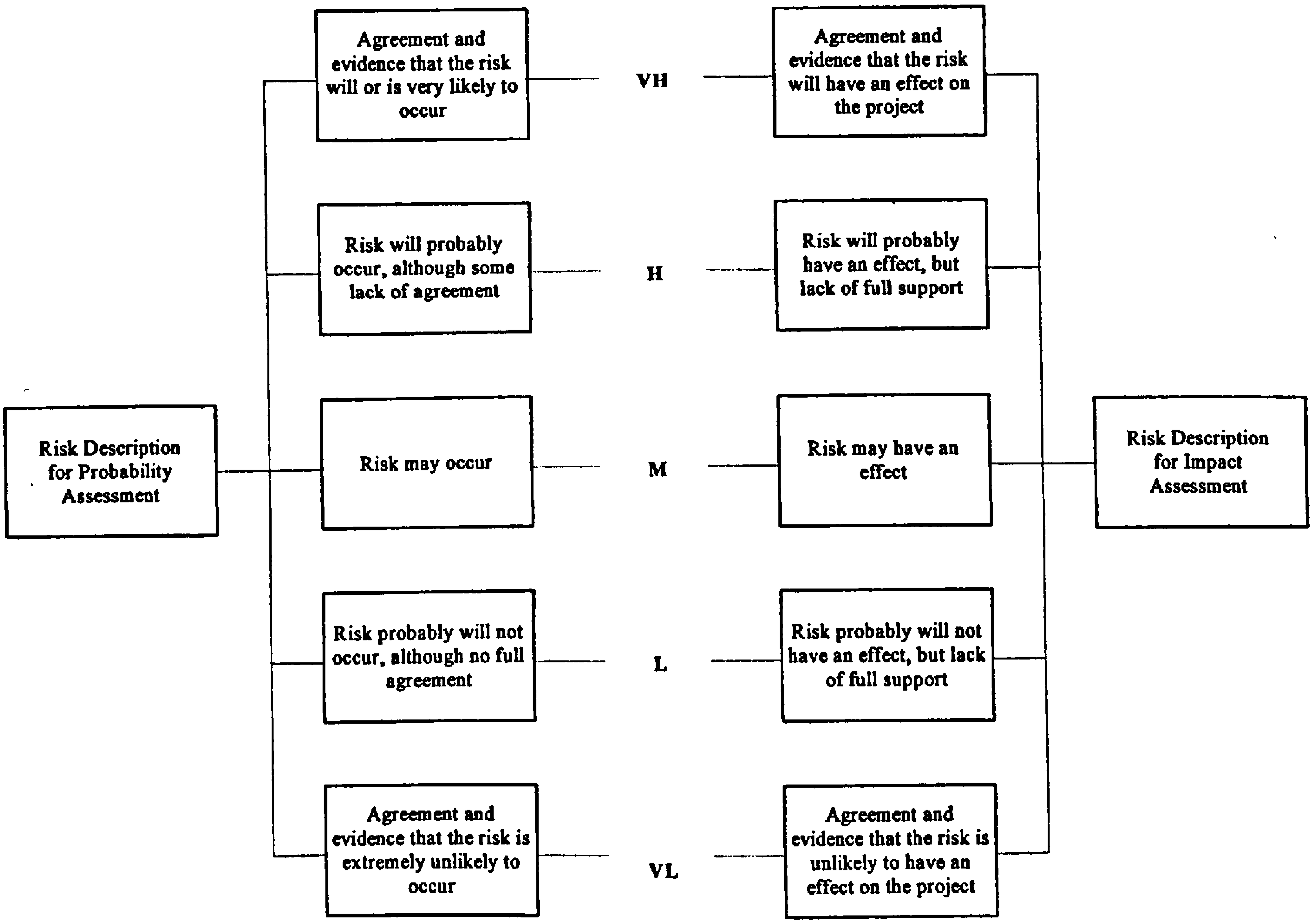

Figure 27 - Consensus Tree for Probability & Impact Values.

Once the risks have been allocated their probability and impact values, the severity can then be determined. When the Risk Register Database System is used to document the risks within the project, this value is automatically generated. Nevertheless, it is extremely important for the project team to understand where the values are generated from, and hence when using non-numeric values of VL → VH, the risk severity matrix should be used, figure 28.

IMPACT ↑ / PROBABILITY →	*VL*	*L*	*M*	*H*	*VH*
VH	L	M	H	VH	VH
H	L	M	H	H	VH
M	VL	L	M	H	H
L	VL	L	L	M	M
VL	VL	VL	VL	L	L

Figure 28 - The Risk Severity Matrix.

The severity value enables each risk to be ranked in order of importance, so that the most severe or highly ranked risks are made explicit and can be acted upon. However, unlike many risk matrices described within the literature, the ranking of the risks within the Risk Management Methodology is not determined directly from the risk severity matrix; the severity value is used alongside the actual probability and impact values to determine the order of importance of the risks to the project at that point in time, and this will be discussed further in section 7.4.

After each of the risks have been assessed, and their severity value determined, the user can then move on to either the Risk Analysis stage, or directly onto the Risk Reduction and/or Mitigation stage.

7.3 Risk Analysis.

Risk Analysis is the only stage within the methodology which is not compulsory. The reason for this is that it has various limitations when being applied to a dynamic and active project. This stage uses computational techniques, such as Monté Carlo simulation, sensitivity analysis and decision tree analysis. [14, 96, 97] These methods allow the effects that varying the decisions within the project and the effects that each decision will have on the overall riskiness of the project to be examined. Therefore, the techniques enable a range of values of the individual risks as well as their effect on the project to be investigated. However, as the analysis techniques are lengthy and costly processes to perform and take a static picture of the project, they do not assist in the active management of the project as a whole. Therefore, the most appropriate time to carry out the risk analysis stage is at the beginning of a project, as a means of determining either the least risky path or project to invest in.

7.4 Risk Reduction and/or Mitigation.

By this point in the methodology, the known risks have been identified, their severity determined and the effects of varying the allocated risk values and decisions within the project may have been analysed through the use of risk analysis techniques. However, one of the most fundamental areas attached to using the Risk Management Methodology is that the information which has been generated is applied and used within the project.

The Risk Reduction and/or Mitigation stage provides the means by which the risks can be ranked in order of priority and for the highest ranked risks to enable reduction and/or mitigation plans to be developed and acted upon within the project. It should be stressed that the ranking of the risks is valid only for that particular point in time. As the project continues, decisions made and risks managed, the ranking of the risks will change. Similar to the severity value, the ranking of the risks is performed automatically within the Risk Register Database System, and the logic behind the ranking can be seen in figure 29.

Probability Value	Impact$_{total}$ Value	Severity Value	Risk Rank
VH	VH	VH	1
VH	H	VH	2
H	VH	VH	3
H	H	H	4
VH	M	H	5
H	M	H	6
M	VH	H	7
M	H	H	8

Figure 29 - The Risk Ranking Table.

This therefore results in the highest severity, probability and impact risks ranked as 1, through to the lowest ranked risks being 8. The non-active risks of M $\rightarrow$ VL severity are given a ranking of 100, to ensure that they are easily identifiable and as such, do not detract from the active risks ranked within the project for that particular point in time.

One of the most appropriate methods which has been determined to ensure that the information which has been generated is actively maintained and utilised within the project has been through the development and use of a risk register. This risk register forces everybody involved in the project to consciously evaluate the risks as an integral part of the decision making process.[98] It also provides the means through which the mitigation actions and decisions can be made in the future, as well as ensuring greater understanding and acceptance of the visible risks.

7.4.1 The Risk Register.

Although there are various references to a 'risk register' within the literature,[6, 8, 99, 100] there is very little information on the design that the system can take, nor on how it can be effectively constructed.[98]

The Risk Register can be described as *'the formal process of documenting the identified risks, their associated probability and impact values as well as their ranking within the project'*.[95] It is a live document, which can aid in the active management of the identified risks and the project as a whole. As such, it should be updated on an ongoing basis. The major forces behind the construction of a computer based risk register database system were that it removed duplication of effort in its construction and maintenance and that it could be held on a central server and updated at various geographical locations.

The Risk Register Database System consists of three separate entities; the Risk Register, the Risk Reduction and/or Mitigation Plans and the Risk Owner. The Risk Reduction and/or Mitigation Plans and the Risk Owner entities are primarily add-ons to the Risk Register, and as such, hold extra information to that within the risk register. The Risk Register entity holds the information on the risks, and is therefore the main focus of the system itself. The information on the risk held within the risk register can be seen in figure 30 below. This gives an example of the Risk Register form, in which the user inserts the information into the Risk Register.

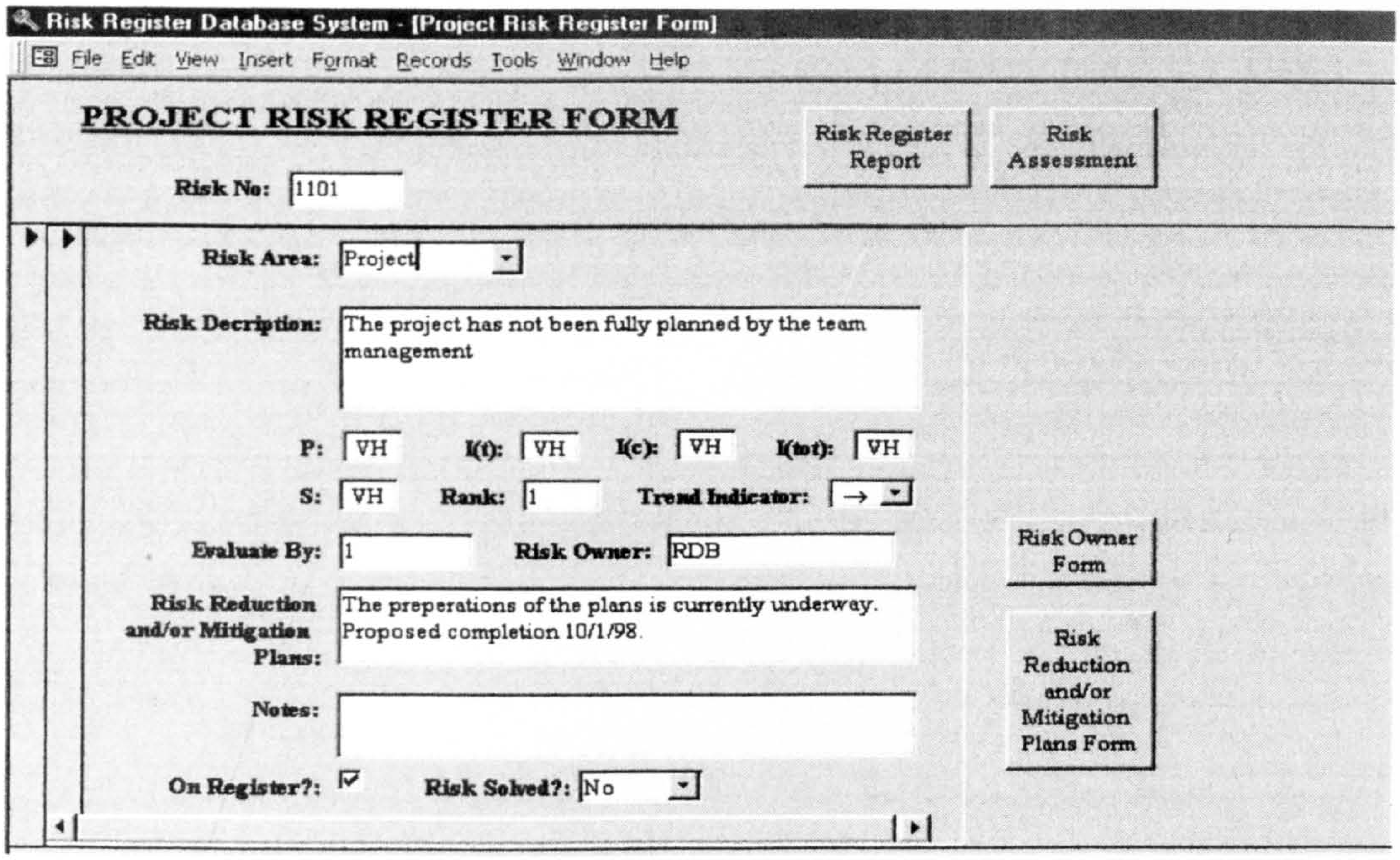

Figure 30 - The Risk Register Form.

Much of the manual effort in determining the severity and ranking of the risks is removed as these values are automatically calculated through the use of Visual Basic® code written into the system. Once the information has been incorporated into the system, it can be easily manipulated and used to both assist in actively managing the risks within the project as well as producing reports for management. An example of the Risk Register report can be seen in figure 31.

Risk Register

Risk Area	*Risk No.*	*Risk Decription*	*S*	*Rank*	*Trend Indicator*	*Project Phase*	*Owner*	*RR and/or M Plans*	*On Reg?*
Project	1101	The project has not been fully planned by the team management	VH	**1**	→	1	RDB	The preperations of the plans is currently underway. Proposed completion 10/1/98.	☑
Project	1301	There is lack of relevant technical experience within the project.	VH	**3**	↑	1.1	KKP	Personnel have been informed of technical requirements of potential recruit.	☑
Technical	2301	The required equipment may not be available by phase 2.3	H	**4**	→	2.3	SJY	Under Review	☑
Organisational	3401	There are potential funding transfer problems	H	**7**	↑	1.1	DP	Alternative methos of transferring funds is under investigation, and will be looked into in further detail	☑
External	4301	The suppliers of the equipment have not been contracted.	L	**100**	→	2.1	HDE	Current talks with relevant suppliers, and an outcome expected by 15/2/98.	☐

SUMMARY INFORMATION

Number of Identified Risks	=	**5**
Number of Ranked Risks	=	**4**
The % Risks Requiring Attention	=	**80.00**

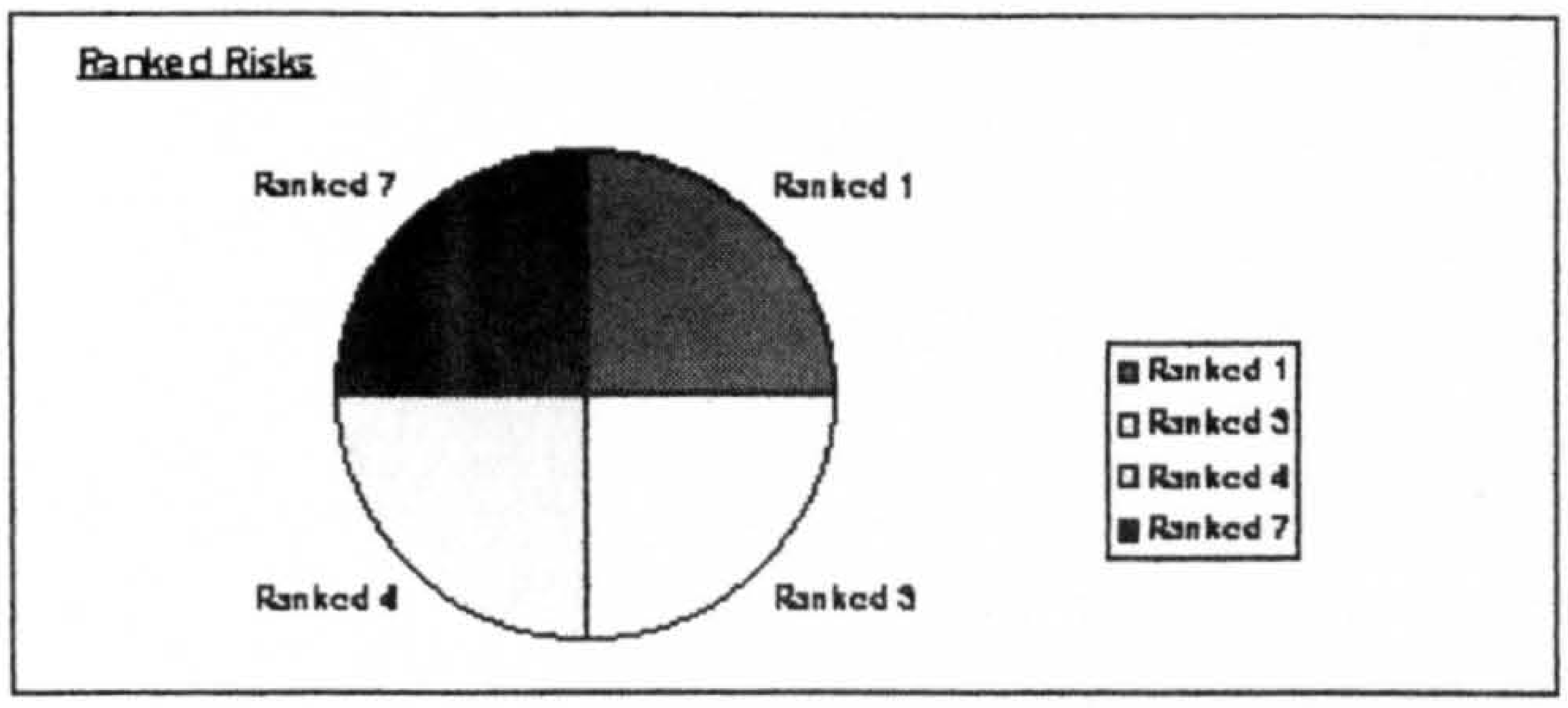

Figure 31 - Example of a Risk Register Report.

The design of the Risk Register Database System gives an example of what has been used in projects within the Rover/BMW group. One of the major advantages of the Risk Register Database System is that it can be easily changed to incorporate the needs and requirements of a particular project. However, not all projects require the use of a computer based risk register. Therefore, an example of a paper based risk register which can be used within projects can be seen in appendix 2.

Within the Risk Register Database System, interdependent risks are documented through placing the risk identification number and a brief statement of their dependencies within the notes section. However, within the paper-based risk register, there are no such spaces for interdependencies to be explicitly stated. One method which could be adopted is to provide a key within the paper-based risk register to link the identified risks. Therefore as the reduction and/or mitigation responses to reduce one risk are developed, its affect on the other linked risks could be identified and action taken as appropriate.

7.4.2 *The Risk Assessment Tool.*

There was also a need for a tool which would enable the user to track the riskiness of a project over a period of time, to determine if the level of risk was increasing or decreasing, as well as to enable a static picture of the riskiness of the project to be determined for project meetings. However, the majority of the literature relating to the assessment or analysis of risk tended to focus on the assessment of the decisions within the project through utilising the project management material. Within the terminology of the Risk Management Methodology, methods of 'assessing' the overall riskiness of the project through utilising the project management material can be described as 'risk analysis'. The Risk Assessment tool however uses the information and decisions which are made through the use of the Risk Management Methodology, and as such gives a picture of the riskiness of the project, based on the identified risks themselves.

The Risk Assessment Tool was therefore developed as part of the Risk Register Database System to enable the level of risk within the project to be determined through using the information which had been generated by utilising the Risk Management Methodology.[101] The tool uses the information held within the Risk Register Database System to produce an assessment as well as a graphical output. A copy of the Risk Assessment Tool can be seen in appendix 3. Even though it does not aid in the active management of the risks, it is of benefit to the use of the Risk Management Methodology, as it provides the user with a method of tracking the riskiness of the project as well as reporting on the level of risk within the project at a particular point in time. This gives the benefit that it requires no extra effort in its generation, in addition to completing the risk register within the Risk Register Database System

7.4.3 Developing the Risk Reduction and/or Mitigation Plans.

The main objective of the Risk Reduction and/or Mitigation stage is that the risk reduction and/or mitigation plans are developed and put into action within the project. These are the plans which have been developed;

1. To ensure that the effect of the risk is reduced through developing plans and actions to either reduce its impact or probability of occurrence within the project.
2. To mitigate the effect of the risk if it actually materialises within the project through the development of a strategy or action plan which can be actioned if the risk occurs, so that the risk itself does not unduly affect the project.

These risk reduction and/or mitigation plans should be managed by a Risk Owner. The Risk Owner is not necessarily an individual who can solve or produce the plans for the risk, but someone who can manage the information and the plans as a whole. Hence, the most important part of this stage is that the plans are put into action within the project.

7.5 Risk Monitoring.

As yet, only the visible, or known risks and potential problems within the project have been identified, assessed, and possibly reduced and/or mitigated against. However, as with all retrospective investigations of projects, risks which were unknown at the outset may materialise at a future point within the project. Therefore, as the project proceeds, new information and knowledge becomes apparent and as such, new risks and potential problems will materialise. Also, risks which were ranked as active within the previous cycle of the Risk Management Methodology could have been reduced and/or mitigated and therefore may no longer require such detailed attention. In addition, previously or newly identified risks may become more important, due to the stage of the project and when they actually arise. Therefore, a systematic review of the project should take place to ensure that the next stages of the project are adequately developed. These should include the identification of the risks and uncertainties as part of the ongoing cyclic process of the Risk Management Methodology.

After this stage, the risk identification should be completed on a regular basis, determined by the needs and requirements of the project, first to identify new risks and potential problems, as well as to re-assess existing risks within the project and remove the 'old' risks from the register, and the process continued through the assessment, analysis, reduction and/or mitigation and monitoring as appropriate.

8.0 IMPLEMENTATION OF THE RISK MANAGEMENT METHODOLOGY.

The Risk Management Methodology has been implemented into 7 projects within the Rover/BMW group. Its application was seen as a strategic decision by management as a means to potentially increase the success rate of the projects. Hence, the projects in which it was implemented were deemed strategically important as well as highly risky. However, due to confidentiality issues and the sensitive nature of discussing the problems which have been experienced by the companies involved, exact details of the projects cannot be given within this piece of work. Evidence can be seen in the submissions, *'The Management of Risk - From Theory to Practice'*[9] and *'Implementation of the Risk Management Methodology: Problems and Solutions'*[34] as well as throughout the remainder of the submissions (see figure 2).

8.1 Initial Testing of the Risk Management Methodology.

The tools, techniques and concepts which were initially developed after the literature review research into the area of project risk management, were applied and tested within the CB40 project. The stages of the methodology implemented into the project were that of identification, assessment, reduction and/or mitigation and monitoring of the risks. The analysis stage was not performed as the implementation took place late in the CB40 project's development process, and the time required to complete this stage would have been too great for the minimal amount of benefit which would have been gained from its use.

The reason for implementing the Risk Management Methodology at a late stage within the project was that it was experiencing problems, and there was general consensus from management that the identification and management of the risks could be used to potentially assist in determining the most appropriate path for the project. Therefore, training in the use of the Risk Management Methodology and its associated tools and techniques, as well as workshops for team members, contractors and individuals involved within the project to identify and assess the risks were organised and run by the author.

8.1.1 Application of the Risk Management Methodology.

The initial identification stage was performed for two purposes; to identify each of the potential options available to the project and the risks within each of the options as a means of determining the least risky as well as the most appropriate path for the project to take. The process is shown in figure 32.

Once the options had been identified and the least risky path established (the 'best option'), a risk breakdown structure was developed to identify the areas within the project where the risks and uncertainties could occur. From this, the risks to the option were identified, assessed and a paper-based risk register was constructed. Training and information as to the allocation of risk owners and the construction of the reduction and/or mitigation plans were given by the author to the team and the process was handed over to the project manager.

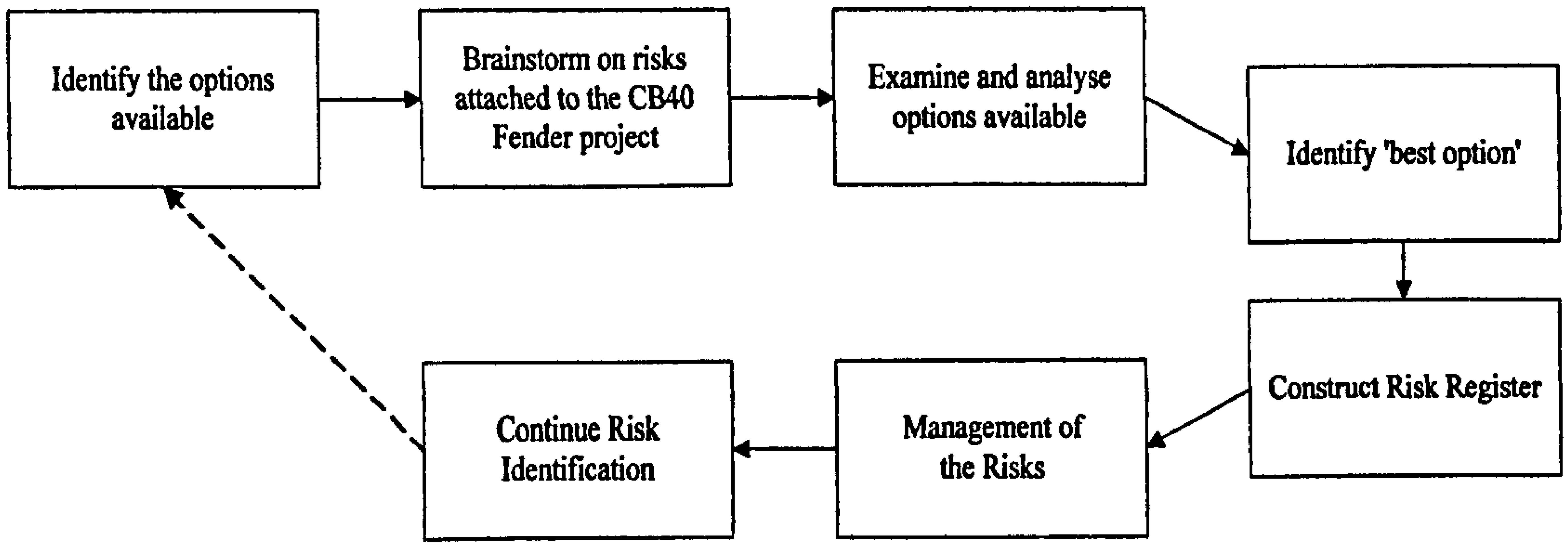

Figure 32 - Process Undertaken to Identify the Options and the Risks within the CB40 Project.

8.1.2 Issues Arising from the Application of the RMM into the CB40 Fender Project.

Various issues were identified from the use of the initial form of the Risk Management Methodology into the CB40 Fender Project. Although these have been discussed in the submission *'The Management of Risk - From Theory to Practice'*,[34] the most salient points will be reiterated here.

The project team members initially used the tools and techniques, both when the author was present, as well as for a period afterward. At first, the project was seen to benefit substantially from the use of the Risk Management Methodology. However, as the project became more intense and the pressures to use the Risk Management Methodology subsided, the continued use of the methodology also declined. When interviewed to determine the cause of this decline, the project team members claimed that there was insufficient time to complete the process, as the problems which existed at the time were deemed more important than potential problems and risks in the future.

The initial test also provided the evidence that the Risk Management Methodology and its associated tools and techniques worked in practice, as well as enabling the identification of which aspects required further development and construction. Firstly, more direction and pressure from senior management were required to enable the Risk Management Methodology to be continually used throughout the project lifespan. More training in the tools, techniques and methods used within the process was also required. Furthermore, there was a need to develop a risk register on a computer package, such as MS® Excel® spreadsheet or MS® Access® database, to reduce the duplication of effort in constructing and maintaining the paper-based register. In this, the information generated from the use of the Risk Management Methodology throughout the lifespan of the project could be easily updated and maintained. Finally, the Risk Management Methodology needed to be changed to its final form (figure 23) to take into account that the risk analysis stage did not need to be completed on every pass.

These amendments were therefore incorporated into the Risk Management Methodology, before it was applied to the final 6 projects.

8.2 Application of the Modified Risk Management Methodology into the CBoM Projects.

The final version of the Risk Management Methodology, given in figure 23, was implemented into the Convergence Bill of Materials (CBoM) projects to determine if the amendments and the overall tools and techniques within the process would work fully in practice. A fuller description of this project can be seen in the submission '*Implementation of the Risk Management Methodology: Problems and Solutions*'.[9]

The CBoM programme, which consisted of 6 individual but interrelated projects, was centred on the translation and convergence of the Bill of Materials between Rover and BMW. The entire programme was considered important for the company to perform as a means of enabling the exchange of design specification and the manufacture of joint Rover/BMW products with the minimum of manual intervention taking place. The organisations would therefore be able to design, construct and manufacture joint vehicle programmes irrespective of geographical location. As this was the first major collaborative programme between the two companies as well as being innovative in nature, it was considered extremely risky as well as strategically important. Therefore, risk management was identified within the programme brief as well as by an external audit body as a requirement to be performed within the project.

Based on the requirement that each of the project managers required the information generated within each project to remain confidential to that project, the Risk Management Methodology was implemented separately into each of the 6 projects. The risk identification, assessment, reduction and/or mitigation as well as the monitoring stages were implemented into each of the projects by the author.

8.2.1 Risk Identification.

The initial project briefs and objectives were used to gain a picture of the project. However as the projects were only at the project definition stage, only draft versions and unstable objectives were available. From this, questionnaires for each project, designed to bring out the potential problems and risks, were prepared. As a pre-requisite to the risk identification workshops, each team member was asked to think about potential problems and risks which might affect the project, the phase and the area in which the risk may arise, how likely it was to occur as well as the potential impact on the project.

The Risk Identification workshops took place within each of the 6 projects in which techniques such as brainstorming using prepared questionnaires, 'what-if' analysis and cause and effect analysis were found to produce the best results. This was in comparison to using scenario analysis, decision analysis and TOWS, which did not provide as beneficial results in the time available. The most appropriate place to implement the Risk Management Methodology was seen to be before the objectives and plans for the project had been fixed, as it enabled 'fear issues' to be removed from the project, open communication to take place from the outset, and the project to be planned with the resultant risks in mind. Therefore, after the initial risk identification had taken place and the project plans fully developed, many of the initial risks could then be discarded as they had been 'written out' of the plan itself.

From these brainstorming sessions, duplicated risks were removed, and each risk allocated a risk identification number, based on its description. After this had been completed, the assessment of the risks could take place.

8.2.2 *Risk Assessment.*

The team members were brought together to confirm the meaning and description of each risk before the probability and impact values were allocated. The probability and impact (in terms of time and cost increase within the project) were assessed primarily in terms of non-numeric VL → VH values, although one team did use the numeric 0% → 100% values. The methods through which the probability and impact values were allocated can be seen in section 7.2. The severity value was not determined at this time, as the projects used the Risk Register Database system in which the value is automatically calculated.

8.2.3 *Risk Reduction and/or Mitigation.*

Once the risks had been identified and subjectively assessed for their probability and impact, in terms of time and cost increase, they were inserted into the Risk Register. The CBoM projects used the Risk Register Database System, which had been developed specifically for these projects, based on the requirements determined from the CB40 Fender project as well as an investigation of the literature. The system itself was used as an interactive method to enable the information on each of the risks to be manipulated as well as automatically calculating the severity and ranking of the risks. Also, given that the projects were being carried out in both the UK and Germany, the IT system enabled the information to be amended and updated at various geographical locations.

As there was a requirement to report the level of risk to an external audit team, a tool which would enable the level of risk at a specific point in time to be determined was constructed. This tool would not enable the risks to be actively managed, it merely provided a static picture of the level of risk within the project. As the risks within the project had been identified and assessed, it was deemed appropriate by the author to base the tool on this information, rather than require a new assessment to be undertaken. This Risk Assessment Tool is described in section 7.4.2. However, as it was initially developed on MS® Excel®, it required extra effort in its maintenance. Therefore, to keep in with the requirements of the Risk Management Methodology, it was incorporated into the Risk Register Database System, as described in the submission '*The Risk Assessment Tool*'.[101]

The project managers were trained by the author in the application of the information which was generated from the use of the Risk Management Methodology. The need for risk owners, as well as the generation of risk reduction and/or mitigation plans for the highest ranked risks was also stressed.

8.2.4 Risk Monitoring.

After the project team members were trained on the use of the risk register as well as instructed to mitigate and/or reduce only the highest ranked risks, the process was handed over to the managers of each project. Each project manager was then instructed by the author on the continuation of the management of the risks, through the use of the Risk Management Methodology. At each team meeting (approximately every 3 weeks), new risks and potential problems were identified, assessed for their probability and impact values and inserted into the risk register. From this, their severity and ranking values were automatically calculated and if they were of a high enough rank, allocated a risk owner and risk reduction and/or mitigation plans developed. The re-assessment of existing risks took place every third meeting, in which the probability and impact values were examined to determine if they had changed and also if the active risks had been reduced to an acceptable level, through the use of the ranking system discussed in section 7.4, or removed from the project.

Throughout this initial period, the author still played an active role to ensure that the process was continued.

8.3 Issues attached to the use of the RMM in the CBoM Projects.

Various issues as to the application of the Risk Management Methodology into the CBoM projects were identified, and it was concluded that the problems were not with the design of the Risk Management Methodology and its associated tools and techniques, but with the implementation of the methodology itself.[9] Initially the Risk Management Methodology should have been applied at the overall programme level, and not at the project level, as problems initially arose with the duplication of risks and lack of communication between each of the projects. This was however improved at a later date, when the management of risk occurred at the highest level within the overall programme.

A process was implemented to ensure that the Risk Management Methodology was used on a continual basis and not just before the external audit was due to be performed. This again was amended through the introduction of risk in the programme management meetings, as well as the Risk Management Methodology being carried out at the programme level. The risk register and the risk assessment tool were eventually maintained at the programme level, with each project having approximately 1 – 2 risks/person to manage at any one time.

8.4 Learning Points as to the Future Use of the Risk Management Methodology.

Various learning points were identified from the application of the Risk Management Methodology into the CBoM projects, which should be applied in future projects. These can be seen in the submission *'Implementation of the Risk Management Methodology – Problems and Solutions'*,[9] and were that;

- It is of utmost importance that the Risk Management Methodology is part of the formal project management procedures within the organisation, on the agenda of project meetings and as a part of external audits.
- Support and commitment should be gained from senior management, the project management teams and the individuals which use the process.
- The Risk Management Methodology should be implemented at the highest level within a project, and cascaded downwards (i.e. implemented in a top-down approach).
- If possible, the Risk Management Methodology should also be implemented at the project definition stage, to ensure that the project plan can be defined with the resultant risks in mind.
- Adequate training as to the use of the Risk Management Methodology and its associated tools and techniques should be provided, as well as ongoing support.

9.0 TRACKING TOOL FOR R&T PROJECTS.[102]

One of the initial objectives of this work was to increase the success of Research and Technology (R&T) projects, through developing a method by which the uncertainty inherent in innovation could potentially be managed.[103] However, within the investigation of the area of Risk Management, it was determined that more benefit could be obtained through the development of a generic project risk management process for the Rover/BMW group and the Automotive Manufacturing Industry as a whole, rather than through concentrating purely on R&T projects. Nevertheless, there was a need to develop a tool to track the probability of success, and hence determine if there was confidence in achieving the required objectives and targets of an innovative project throughout its lifespan. This system would be used in conjunction with a tool which had already been developed to track the strategic importance of the project.[104] As such, the strategic importance and probability of success could be tracked over the lifespan of the project to determine if resources should be allocated to it. Hence, the tool was designed to ensure that the project lies within the strategy of the organisation and that the riskiness of the project does not increase to a detrimental level over its lifespan. The interaction of strategic importance and the probability of success can be seen in the matrix, figure 33.

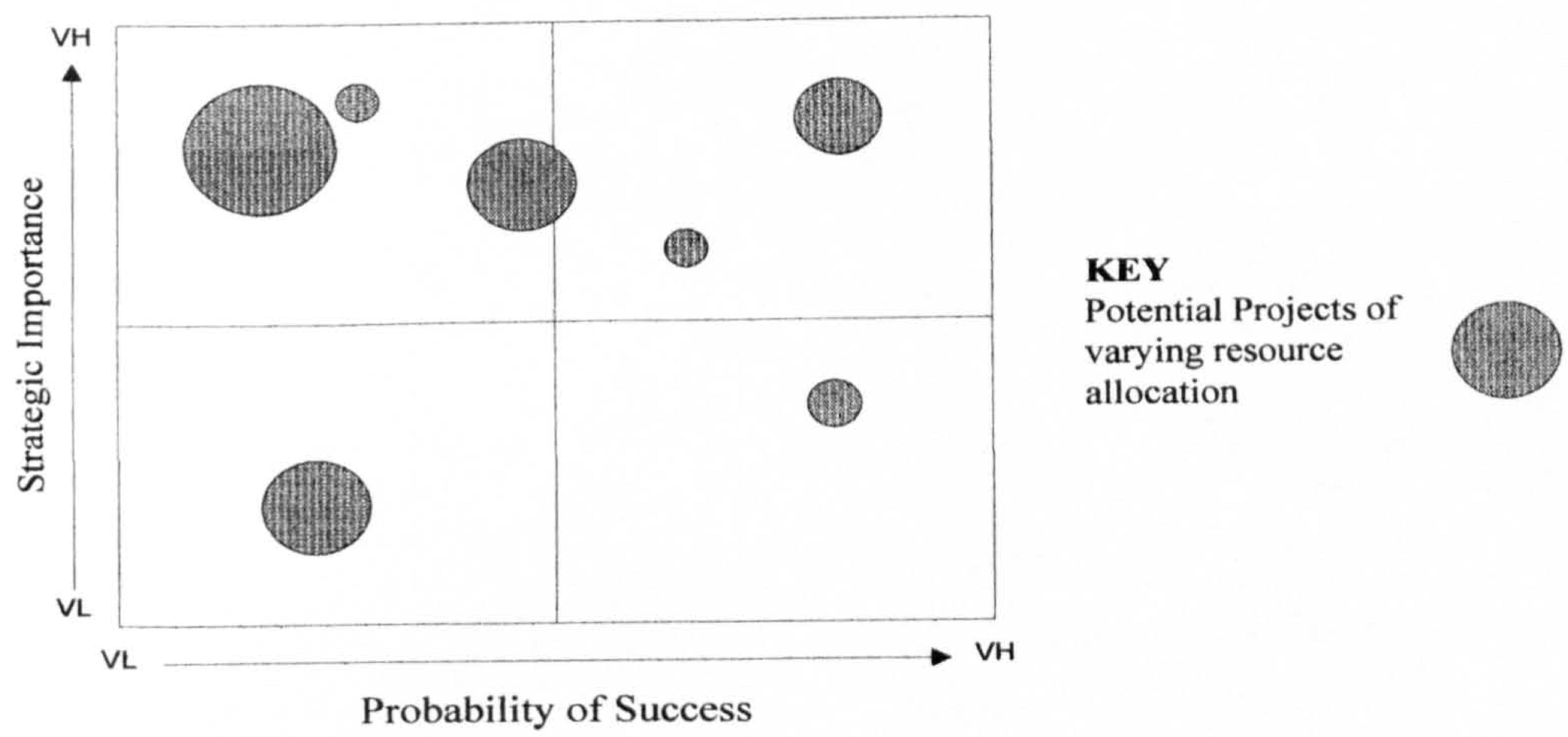

Figure 33 - Combining Strategic Importance and Probability of Success.

Projects which had high strategic importance with a high probability of success (top right hand corner of the matrix) could be proceeded with confidence. Projects with high strategic importance, but with a low probability of success could be initially identified and risk management measures put into place to increase their probability of success. Projects with a low strategic importance but with a high probability of success could be undertaken, but only if deemed appropriate and the resources were available to do so. However, projects placed at the bottom left hand corner which identifies both low probability of success and strategic importance, could be immediately discarded. As such, this provides a method of combining the overall long-term and short-term strategic direction of the company with the risks of developing the new technology. Hence, scarce resources can be efficiently allocated, depending on the factors underlying the grid. The process could be used at pre-determined strategic points within the project to determine deviations from the organisation's strategy and its potential overall success.

A copy of the developed Tracking Tool for R&T Projects can be seen in appendix 4. There are three confidence areas within the tool; the technology is robust for the customer and the marketplace, the project will be delivered to meet its objectives and the internal and external (supply) organisation is capable of delivering the objectives. There are statements, or measures of performance attached to these confidence areas and clarifying statements for which evidence is required within the assessment. The users of the tool score each of the statements based on their benefit and the evidence that they have in their confidence in achieving the statement. The delivery confidence for each of the statements and for the overall assessment is calculated, and can be inserted into the grid. From this, the decision as to whether to continue with the project can be made, based on the delivery confidence as well as the strategic importance of the project.

If there is lack of confidence in achieving the delivery of the project, but the project is strategically important, then the Risk Management Methodology can be applied to the project as a means of potentially increasing the success of the project itself. As the statements also indicate where within the project there is a lack of confidence, extra resources can be applied specifically to these areas to either increase the confidence or fully realise that the project should not be continued.

9.1 Application of the Tracking Tool.

As the tracking tool was designed to enable the probability of success of a project to be determined and tracked throughout its lifespan, it was determined that it should be tested on an existing project. The GIPT project, in which the post-audit review had been carried out (section 3.3) was chosen as it represented a project which was known to the author and to the engineers and project managers who were involved in the test of the tool. The approach used was to fill in the score for each of the statements (measures of performance), with the clarifying statements giving extra information on the meaning of each statement. The results of the project can be seen in figure 34.

Project Phase	Delivery Confidence (%)
Start	37
RMC (at 2 Years)	73
At 6 Years	53

Figure 34 - Results from the Application of the Tracking Tool for R&T Projects.

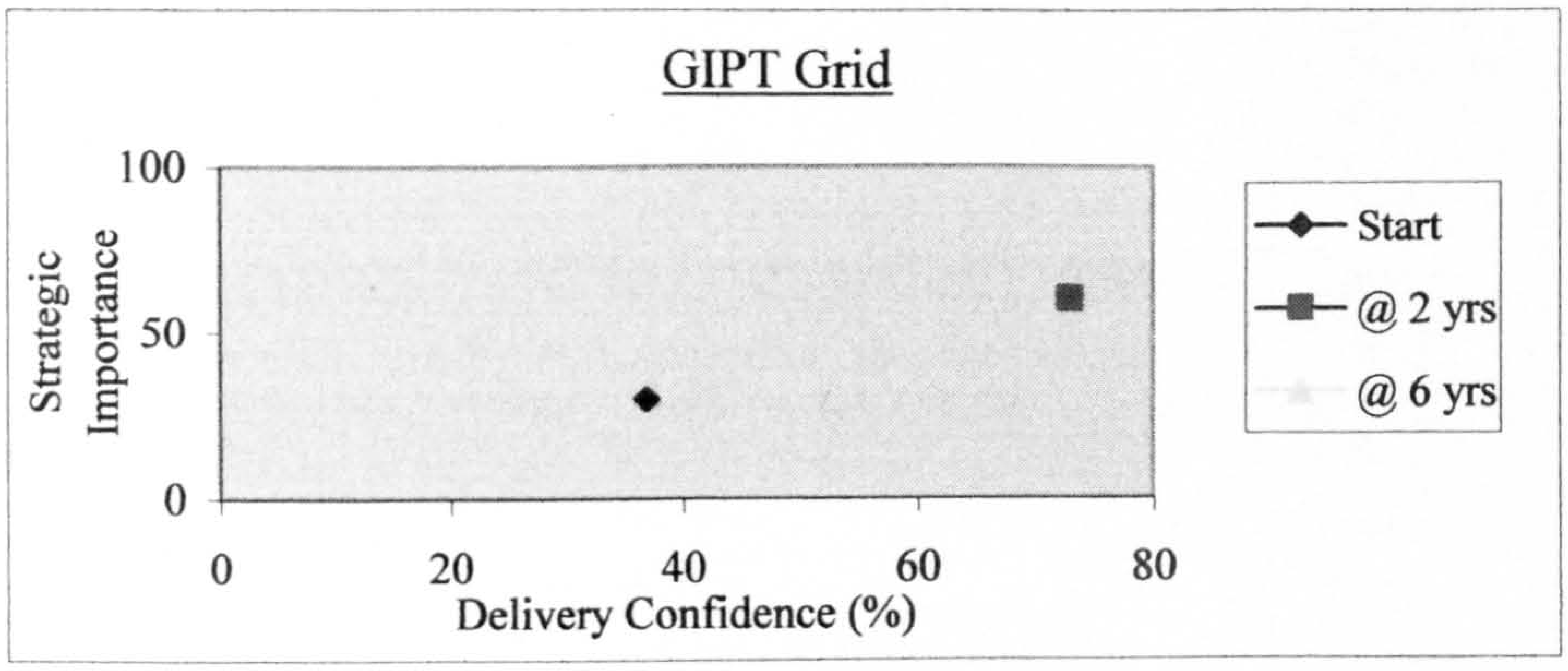

Figure 35 - Grid for the Project.

These results were then placed on the grid, figure 35, where the strategic importance had been previously determined through the use of the strategic importance tool. It can be seen that at the start, the project had both low strategic importance and delivery confidence. However, both of these rose at the 2 year level. Nevertheless, as time passed, the strategic importance and the delivery confidence dropped. Hence, if this tool had been used throughout the project, questions should therefore have been raised both at the start of the project, as to whether the project was right for the organisation, and also at the 6 year mark, as to whether there was still potential benefit in continuing to invest in the technology.

The individuals who tested the tool concluded that;

- the tool covered all of the relevant areas of R&T projects
- the statements were easily understood
- the overall results of its use fitted in with their belief of what took place within the GIPT project.

The main concern of the individuals who tested the tool was that the project could gain a high score, while not achieving the objectives. A high score is achieved through the users inserting a higher score for each statement than there is actual evidence to support. Hence, external examination is necessary to ensure that the score is in line with the evidence which is available within the project for each of the statements. Therefore, after the tool has been used, audit teams external to the department are required to ensure that the users have the evidence to prove that they have judged the level of confidence in achieving the delivery of the statements to an appropriate level.

10.0 THE PROBABILITY & IMPACT DEBATE.

The assessment of risk can be considered to be extremely uncertain, [105] and the most objective and accurate method of assessing risks is to use past, quantified data and information, so that the importance of the risks within the decision making process can be weighted.[106] Chapman and Ward back up the use of quantifying subjective benefits as they enable the most important risks and uncertainty to be identified and more clearly communicated.[8] However, uncertainty and risk are often difficult to predict; their qualitative assessment in terms of probability and impact is subjective and based on the best estimates of experts and people involved in the project. Nevertheless, as Jovanović states, *'one is compelled to predict because he/she needs to take appropriate management action'*.[107] However, quantitative information is not always readily available and qualitative judgements, based on the expert judgement and knowledge of individuals and groups, often need to be used. Therefore, when exact data or information is not available, one has therefore to make assumptions using the knowledge available, past experience and modelling techniques, such as Monté Carlo simulation or sensitivity analysis. These assumptions, as long as they are not fixed, can be considered the best methods currently available to the user of project risk management techniques.

Within the Risk Management Methodology, techniques to assess and order the identified risks within the project have been used, alongside tools to enable the level of risk within the project to be determined. Within this chapter, these tools and techniques will be discussed alongside the assessment of the risks in terms of probability and impact. Also, the methods used for combining the probability and impact of the risks within the Risk Management Methodology will be critiqued, together with the reasons for ranking the risks through the methods chosen. The similarities and complementary nature of the tools developed for use within the Risk Management Methodology will be given, as well as the problems attached to the choice and justification for using the numbers in the ways in which they have been presented. Finally, suggestions for future work on the area of determining more justifiable numbers, as well as the methods of combining probability and impact, will be given.

10.1 The Assessment of the Risks within the Risk Management Methodology.

Both qualifying and quantifying risks within the domain of project risk management is an area of great debate.[108, 109] Therefore, the use of numbers within the Front-End Assessment Tool and the Tracking Tool for R&T projects can also be considered as the cause of much deliberation in relation to their origins and justification. To enable the reader to understand how and why the numeric systems used within these tools were chosen, the author first has to take the reader back to the original objective of the Risk Management Methodology itself. This was to construct and test a project risk management process for use within the Automotive Manufacturing Industry, based on the needs and requirements of the users of the process within that industry. As such, it was to develop and test a system which was required and could be utilised within the tight resource requirements of the automotive sector as a whole. The use of the tools and the requirements that they should follow were based on a study of what both the Rover/BMW group and the industry as a whole required, and within this, quality function deployment was used to ensure that the Risk Management Methodology and the tools within it met the needs of the initial customer.*

The use of risk assessment within the Risk Management Methodology is to assist the decision maker in determining which risks and potential problems may have the most detrimental effect on the project. As Isaacs states, '*assessing risk will not automatically produce correct decisions, but it will enable experts to make better decisions*'.[110] Another important distinction to make between the assessment of the risks within the Risk Management Methodology and that say of the offshore oil and gas or construction industry is that there is little prior data nor need for information such as average wave height at a particular time of year or weather history within projects in the automotive industry. Also, as risk management has not tended to have been performed within this sector, there has not been the need to collect such data on past projects. There is thus more uncertainty and reliance on the subjective judgement and prior experience of the individuals within the project team and organisation as a whole.

Within the Risk Management Methodology, the risks are assessed as part of the cyclic process and inserted into the Risk Register Database System, from which the Risk Assessment Tool can be obtained. However, in addition to this, the Front-End Assessment Tool and the Tracking Tool for R&T Projects use methods to enable the level of risk within the project to be determined. These are all separate, but interrelated tools which form part of the overall Risk Management Methodology and are therefore, by design, complementary in nature. However, to critically discuss the methods through which the assessment of the risks takes place within the cyclic process and the tools themselves, it is important to first examine how the risks are assessed and ranked.

10.1.1 Assessing the Risks for their Probability and Impact Values.

When past data or statistical information is available, statistical modelling should be used to assess or analyse risks. Since past data is not always available or applicable to new projects or product developments, one has to ascertain the most appropriate methods and information to enable the decision making process to be improved.[111]

As shown in figure 23, the assessment of the risks takes place during the second stage of the cyclic Risk Management Methodology. The risks are assessed for their probability of occurrence and their impact on the project (in terms of cost and time) should they occur. It should be stated that the subjective nature of assessing the risks for their probability of occurrence and impact on the project is often cited as a reason for not performing assessments, and both Forth[112] and Altenbach[113] assert that the use of qualitative assessment is subjective in nature. Although subjectivity is brought into the equation, the project team need to use their judgement and knowledge in a project based environment to enable the risks to be assessed as accurately as possible for the point in time at which the assessment is being performed. There is

* i.e. the people who would use the system within the Rover/BMW group.

however a theme within the literature that risk management requires very accurate assessments and measurements of the risks. Nevertheless, Tummala et al state, *'risk management requires the analyst to determine the probability distributions of risk factors, many of which are determined using subjective beliefs and judgements rather than objective information'.*[114] Hence, the use of subjective judgements, to provide a best estimate should be considered as acceptable, as long as the user appreciates their origins.

In all but one of the projects in which the Risk Management Methodology was applied, the method through which the risks were assessed was through using the non-numeric VL → VH terms. As an experiment into the use of the percentage values, one project used numeric values to determine the probability and impact, and these values were combined by linear means. However, as will be discussed in section 10.1.1.1, there are various problems with combining purely numeric values of probability and impact. Therefore, the team was instructed to change their assessment method to non-numeric values. In the longer term, this also aided cross-reference between the interrelated projects. Also, the reasons for using non-numeric VL → VH assessment in future implementations will be discussed within the remainder of this chapter. Therefore within figure 26, the choice of values given are the non-numeric values, with percentage values indicating the level of the VL → VH probability and impact values within the process. The percentage values of classification was constructed and used through the application of the Risk Management Methodology, and is based on research information that people tend to be overconfident in their estimation of risk and as such underestimate the effects. [34, 115] Hence, the values in table 26 are skewed to account for the fact that people underestimate both the effects that a risk could have and the probability that it will happen. This point will be further discussed in the next section. Even though the limits of each corresponding percentage value to the VL → VH values are fuzzy, the system has proven useful to the users of the Risk Management Methodology as a means of differentiation between the levels of assessment within the process.

Therefore, within the Risk Management Methodology, the impact and probability of the risks should be assessed through the use of non-numeric VL → VH values, with the numeric percentage values being given as a means of gaining understanding as to the level of impact and probability of each of the levels of assessment. To assist this even further, the consensus trees were constructed, as seen in figure 26, were used within the projects and in turn, proved to be more effective in gaining consensus within the teams. Although Chapman and Ward suggest qualitative assessment, such as high to low (H → L) should only be used *'as a refinement of the minor/major risk distinction...or as part of a 'simple scenario approach''*[8], the non-numeric assessment of the risks has proven to be an extremely successful method of determining the probability and impact of the risks within the Risk Management Methodology at the point in time at which the assessment is performed. This success has been measured through the application of the assessment process within the Risk Management Methodology into the 7 projects and the benefits which were obtained through its use, which will be discussed further in chapter 11. Nevertheless, the author does accept that there are limitations of assessing risks through their non-numeric values, especially when the values are combined using the probability/impact matrix. These issues will be discussed in the following sections.

10.1.1.1 *Problems with Probability and Impact Assessments.*

The problem areas with probability and impact assessment were identified as;

i. The actual assessment of the risks, using subjective judgements of experts, various professionals and team members.
ii. The assessment of the risks and their relation to each other
iii. Combining the probability and impact values

i. The Subjective Assessment of the Risks.

Within the Risk Management Methodology, the assessment of the risks has not always been based on historical data, because in many cases where the assessment takes place, this data is not always readily available. It is feasible that this may change, as the use of project risk management becomes more prolific within the Rover/BMW group and throughout the Automotive Manufacturing Industry as a whole. However, the process and the assessment of the risks have been primarily in new project areas and product developments, which is where risk and uncertainty are most prevalent and where data on past projects are not relevant or available, due to the fact that this information has not previously had to be documented and that no similar projects have been undertaken in the past.

The perception of individuals, groups and teams is extremely important within the assessment of risk, as it is open to the ideas, interpretation, beliefs and dynamical inferences between people. Therefore, the intensity of an individual's perception or belief in a perceived problem or risk is an extremely important aspect to take into consideration within the assessment of risks. Pidgeon et al however extend this to include the differences in the definition of the risk itself, which in turn can be dependent on the level of perception the individual will have of the risk.[116]

The very definition of risk, which depicts harm and negative outcomes, can also make the concept of qualitative risk assessment a negative topic. As such, an individual's bias can become part of the assessment, and is dependent on the perceived impact and whether they are the recipient of the outcome of the risks themselves. These stated and unstated values of individuals can therefore account for the different perceptions that people have when assessing risks or potential problems. In addition, Begg et al identified that, as a whole, people are risk adverse.[117] Therefore, they will attempt to both reduce risks before they occur and mitigate the effects of risks if they do. Kunreuther and Slovic attribute the increase in concern of risks and hazards to the increase in communication and media coverage and the reduction in trust by the general population towards policy makers.[118] Freudenberg expands on this to conclude that adverse perception can be attributed to underestimates and the over confidence of experts in their ability.[119] An expansion of this is developed by Hall and Crawford, who do not lay the blame on either parties, but on the interface and communication between the two.[120]

Thus, the reasons for individual and team perceptions of risk are extremely complex, and include a wide range of aspects, including psychological, social, political, technical and economic factors. Smith identified that both motivational and cognitive factors make individuals as a whole overconfident in their estimation of risks, where motivational is the result of an individual being rewarded for their ability to perform the task, irrespective of whether they can actually achieve the required result, and cognitive is where thought processes result in an incorrect assessment of the risks taking place.[115] What this means is that people tend to underestimate both the probability that the risks will happen, and the effects that a risk could have if it occurred; the probability and impact of the risk. Therefore, as a means of improving the accuracy of risk assessment, individuals must be able to identify their strengths and weaknesses, re-check assumptions and question their beliefs.

Within the Risk Management Methodology, table 26 shows the percentage ranges of impact and probability through which the users used to allocate the non-numeric values. The ranges were chosen as it has been determined that people tend to underestimate the impact and probability of the risks.[34, 115] The numeric ranges and corresponding non-numeric values are skewed to represent this. Hence, the non-numeric value of M (medium) has values of between 21% → 50%, where as if the values were allocated around the 50% value, then the underestimation would not be take into account. However, there are also other aspects to consider when defining the ranges that the non-numeric assessment values could take. As an example, if the range for the VH category was too large, then a larger majority of the risks would fit into this group. This would ultimately result in a large number of risks being of a high ranking. Therefore, if there were not adequate resources to reduce and/or mitigate all of the highest ranked risks, the users would then have to re-perform the assessment of those highest ranked risks, in order to determine which ones were of the most importance to the project at that point in time. Although the re-assessment of the risks does take place within the cyclic process of the Risk Management Methodology, if the ranges of the risk assessment are set to a level to which the user has the ability to differentiate between the risks and hence develop a high-quality assessment within the first pass, then the user can continue with the task of managing the project and the risks.

The boundaries of each of the numeric range categories are extremely fuzzy areas, as there is very little difference between a probability or impact of 20% (classed as L) as there is of 21% (classed as M). This is an issue that was highlighted to the users of the assessment process. The numeric values are there to provide the user with an indication as to the positioning of the non-numeric values, on a scale of 0% → 100%, and the consensus trees, figure 27, can also aid the users in the assessment process. In addition, the assessment itself is subjective in nature, and is used to provide an indication as to the level of probability and impact of the risks, so that they can be ranked in an order of priority for the point in time that the assessment was performed. In addition, when the risks are ranked in order of priority to the project, they are done so taking both the individual values of probability and impact and their combination. Into consideration. The ranking of the risks will be further discussed in section 10.1.2.

Therefore, as long as all of the risks throughout the project are assessed using the same method and values within table 26, the team will be able to rank the risks according to their importance within the project at the point in time at which the assessment was performed. In addition to this, the whole team was involved in the assessment, even though individuals were responsible for different aspects. Therefore, when a risk affected a particular individual, everybody in the team was able to discuss and assess the risk, as well as understand the effects that their actions would have on the risk to another member of the team. Hence, open communication and team work to reduce the effects of the identified risks arose from the assessment method.

There was a consensus among the users that allocating a non-numeric value, based on a range of numeric values was considered the most straightforward to use. In addition, the use of the ranges did not require an exact figure to be placed on the impact or probability of the risk, and enabled the uncertainty in the allocation of values to be brought out, understood and clarified by the assessment team. Finally, assessing the risks through the non-numeric method did not require the rigorous use of numbers which in addition did not detract from the overall process of managing the risk and uncertainty within the project.

ii. The Assessment of the Risks, and Their Relation To Each Other.

The second issue is in the assessment of the risks and their relation to each other. Take for example the values;

- $impact_{time}$ = 2 weeks
- $impact_{cost}$ = £1m

The assessment of the risks may not take into consideration the overall time schedule or cost basis of the project. For example, if the time for the project was 4 weeks, with the overall cost being £10m, in this instance, the time impact would be a greater risk to the project than the cost. Therefore, due to the fact that actual values are used with no context, it is extremely arbitrary to make comparisons of which has the highest impact on the project.

Within the Risk Management Methodology, the overall actual time schedules, cost and quality of the project were not brought into the picture. This is therefore a limitation of the use of the differentiation of the $impact_{time}$, $impact_{cost}$ and $impact_{quality}$ values. The reason for this was that none of the projects in which the Risk Management Methodology was implemented had the relevant information available at that time to be able to accurately determine the increases in actual time and cost figures to be able to make the distinction. Also, the project team members were not in control of their total budgets, due to the ways in which resources were allocated to the project. In addition to this, it was deemed that in the time given to perform the risk management process, there would be little additional benefit in determining the actual increases in time or cost associated with the project, when initial subjective values could be given, and then re-assessed as the cyclic process of the Risk Management Methodology continued throughout the lifespan of the project. However, in the future, it is suggested that, if the relevant information is available, then the differences in $impact_{time}$, $impact_{cost}$ and $impact_{quality}$ in relation to the overall time and cost of the phase or whole project are used within the risk assessment stage of the Risk Management Methodology.

iii. Combining the Probability and Impact Values

Once the risks are assessed for their probability and impact values, these values are then combined in one of two ways. The first is by the linear combination of the probability and impact values, when the assessment has been performed with numerical percentage values, and the second is through the risk severity matrix, when non-numeric, VL → VH, values have been used.

a) Combining Numeric Values of P&I.

Within the Risk Management Methodology, the method through which the numeric probability and impact values (0 → 100%) are combined is through the given equation with the resultant being the severity.

$$\text{Severity}\,\% = \frac{\text{Probability} \times \text{Impact}_{\text{total}}}{100}$$

By comparing the severity of a number of risks, a ranking can be obtained. This is similar to the methods used by Zhi[121] who states that;

$$R = P \times I$$

and Ward,[108] where;

$$\text{Risk Rating} = (\text{Impact Score}) \times (\text{Probability Score})$$

Carter et al[7] combine the probability and impact of the risk to produce a non-linear distribution for the Risk Factor, given as;

$$RF = P + I - (P \times I)$$

Where RF - Risk Factor
P - Probability
I - Impact

Within the equations given above, it is imperative that the probability and impact values are on the same scale (as examples, between 0 → 100%, 0 → 1 or 0 → 10), to enable the multiplication and additions to be carried out correctly. Failure to maintain the same would ultimately produce an erroneous result.

The formulae used within the Risk Management Methodology, by Zhi and Ward provide a linear combination of the probability and impact values. In contrast, Carter et al's method skews the resultant risk value to give a higher resultant than the combination used by the author, Zhi and Ward. This will result in Carter et al's method producing a larger risk factor or value than that of the other methods shown above, and thereby could result in an overestimation of the risk. The reason for this skew could be that, as was stated earlier, there is evidence that people tend to underestimate the affects of a risk, through the overconfidence in their own ability to manage the risk itself. Hence, the formulae by Carter et al would counteract this effect. Nevertheless, this could lead to the assumption that, because it counteracts the effects of peoples judgements in risk estimation, the users should be more confidence to the results of the formulae set out by Carter et al than to the other methods. This is a dangerous assumption to make, as the formulae itself is, like the others, extremely simplistic and is only reliant on the subjective judgements of the users. Therefore, absolute belief by those users in the results of combining the probability and impact values that have been obtained through any of the formulae stated above should be critically examined. In addition, Ward[108] questions the value of combining probability and impact values, and points out, combining the numeric values to create a risk rating or value implies that a trade-off has occurred between time, cost and the quality of the project. Hence, there are various problems with using both linear and non-linear equations, as they can present a far too simplistic method of ranking or rating the risks within a project.

Ward gives a good example of this when he states that the risk rating has no absolute meaning and that a risk rated as 100 is not twice as important as a risk rated as 50. Therefore, a serious problem within the risk management decision making process is that a risk which has a low probability of occurrence, but with a high impact could be of the same or lower level of importance than that of risks with a higher probability of occurrence, but with a low impact. Williams also argues that ranking the risks through the use of P x I has its limitations, especially when relying on lists of risks generated by computer packages and states that *'a computerised "ranking" of the risks by P x I will not necessarily highlight those risks which need to be considered when writing the contract'*.[109] However, in relation to the Risk Management Methodology, the identified risks were wholly owned and managed by the organisation, and therefore, contract management was not considered within the domain of the process. Hence, contingency for the non-delivery of a project within the specifications of the contract is not an issue considered within the use of the Risk Management Methodology. In addition, the underlying mathematics relating to the ranking of the risks within the lists is always given to the users of the system, so that understanding is generated as to their origins. Nevertheless, Williams has an important statement to make, and one should not purely rely on a system that one does not fully understand. Therefore, issues such as training and involvement of users in the design and development of the tools become increasingly important.

Therefore, due to the problems which have been discussed and the reasons given in the previous sections, assessing the risks through the numeric assessment of the risks is not one which is advocated by the author, and it is the non-numeric values, from VL → VH, which should be used within the Risk Management Methodology.

b) Combining Non-Numeric Values of P & I.

Various authors advocate the use of a probability/impact matrix as a means of ranking or ordering the risks in level of importance. For example, Altenbach uses frequency multiplied by consequence to grade the risk within the risk matrix[113], whereas Ward points out that a probability/impact grid *'allows each risk to be characterised by a single risk rating'*.[108] Carter et al also use a probability/impact chart (matrix) to illustrate how the risks are spread within a project, thereby highlighting which risks require the most attention. These can all be considered as using the matrix to rank the risks in order of importance.[7] Chapman and Ward introduce the probability/impact grid as a *'common alternative to both the minor/major risk distinction and later quantitative risks assessment'* and the boxes enable the risks to be ranked in an order of priority.[8] Charette on the other hand, takes the model further to a three-dimensional graph of the severity, frequency and predictability of the risks, where the predictability represents how 'known' the risks are to the user of the process.[84]

Within the Risk Management Methodology, the non-numeric values of probability and impact are combined using the Risk Severity Matrix, given in figure 28. The severity value is subsequently used alongside the individual probability and impact values to determine the ranking of the risk, and will be further discussed in section 10.1.2.

10.1.2 Ranking of the Risks within the Risk Management Methodology.

It has previously been discussed that Automotive Manufacturing Organisations as a whole do not tend to contract out risks and potential problems to their suppliers or contractors; the overall result of this is that the risks are born purely by the company. However, lack of resources in many organisations can result in not every problem being able to be effectively managed and often, there is little benefit of managing those where the cost of doing so outstrips the benefit. Judgement and experience therefore need to be used to evaluate the risks.[108] Managers thus need to be able to determine which potential problems are the most detrimental to the project, and from this, manage those issues which possess the highest-level risk. A beneficial and appropriate method of determining and putting into order which of these risks to work on is needed. This ordering is done within the risk register; the highest ranked risks can then be further evaluated for their causes and effects within the project, whether they can be reduced through appropriate actions or decisions or whether their effects can be mitigated or absorbed into the project itself.

It is however, realised by the author that the system of ranking the risks within the Risk Management Methodology does have its limitations. These have been described by Ward[108] as being;

1. *'individual risk drivers may not be described in sufficient detail to avoid ambiguity and misunderstanding about which risk is being described*
2. *important interdependencies about risks are not readily highlighted*
3. *a table of risk drivers, particularly a long one, provides limited guidance on the relative importance of individual risk drivers'.*

Within the Risk Management Methodology, each of the issues are addressed as following;

1. A full, concise description and risk identification number, as well as generic risk areas ensure limited misunderstanding about the risk being described, as stated in section 7.1

2. Interdependencies of the risks are identified, assessed and managed, through the cyclic process of the Risk Management Methodology. These interdependencies are also noted in the notes section within the Risk Register Database System, as stated in section 7.4.
3. The risks are ranked through their probability, impact and severity values, as a means of determining the most important risks at that specific point in time. These rankings are however re-evaluated through the cyclic and iterative process of the Risk Management Methodology. More details are given in sections 7.4 , 7.5 and 10.1.3.

As was stated in section 11.1.1, literature tends to rank the risks by a combination of their probability and impact values, and as such, does not take into consideration the individual values of the probability and the impact of each identified risk. Within the Risk Management Methodology, this is not the case, as the ranking of the risks is based not only on the combination of the probability and impact values (the severity value) but also on the individual probability and impact values themselves. The risk ranking table, figure 29, gives the method through which the risks are ranked within the Risk Management Methodology. This method of ranking the risks enables the risks to be ranked alongside their individual values of probability and impact. Although Ward[108] criticises the use of numeric or category probability-impact grids as a means of determining a risk rating, he does endorse the use of such grids when non-numeric values are used. Hence, the major difference between the method used within the Risk Management Methodology and that of Ward is that he asserts the use of alphabet initials (A → Z) instead of ranking in numerical terms and as such, '*in principle, each cell could have a unique label thereby indicating which categories of impact and probability a given risk is associated with*'.[108] The reason that Ward gives for using alphabet labelling is that it '*could highlight the subjective nature of assessments and remove the temptation to employ quantified ratings in spurious ranking calculations which may convey a misleading impression of precision and objectivity*'.[108]

Nevertheless, the users of the Risk Management Methodology found that ranking the risks numerically as shown in figure 29 provided a proficient method of ordering the risks in relation to each other at that point in time. The actions within the risk reduction and mitigation stage and the re-assessment of the risks throughout the project's lifespan ensure that the ranking values were not fixed and that they were only as accurate as the judgements themselves.

Through looking at figure 29, which indicates how the risks are ranked into an order of importance, the probability, impact and severity (combination of P & I) values are all taken into consideration. Hence, within the Risk Management Methodology, the highest severity risks are those with a very high probability and impact. However, events with a high severity are those with a very high frequency of occurrence (probability) but only a high consequence (impact). Hence, the probability is considered more significant in relation to the impact of the risk. This method of ranking the risks is however in contrast to Williams, who states that the most significant risks are those which have the greatest impact on the project.[99] Although the author does agree with Williams that high impact risks are important within the project, it is however difficult to reduce the impact of a situation in comparison to its probability. Take for example, the impact of brake failure of a vehicle which could ultimately be from injury to death of its occupants. In this case, the impact, although very high, is stable. However, the probability of occurrence can be reduced though various design improvements and it is therefore the probability which is most important to reduce within the project.

Hence, by taking the values of probability and impact to create the ranking directly from the probability/impact matrix, an absolute value is used. The ranking table of the Risk Management Methodology, figure 29, enables the risks to be ranked through both their probability and impact values and a combination of these values (the severity). Even though this cannot be described as totally accurate, it does give a step up from ranking the risks solely through their probability and impact values. Hence, their independence and sum are used to create a method of ordering the risks to give an indication of which should potentially be acted on first by the project team.

10.1.3 *The Importance of Re-Assessing the Risks.*

Both projects and risks are dynamic entities. Those risks which are the most important to the project at a point in time will and should be different to those at a later date. Hence, through comparing the risks with similar impacts through their probability value, and then acting on those risks which have a high probability and high impact, the project team can be confident that they are acting on the risks which have the greatest impact on the project as well as having the greatest probability of occurrence **at that point in time.**

Inherent in the iterative process of the Risk Management Methodology is that the risks attached to the responses of the mitigation and contingency plans are identified and assessed, and if required, the mitigation/contingency plans changed or not adopted because these possess greater risk than the original risks themselves. Hence, the ranking of the risks is a list of the risks which may cause the most problem to the project **at that particular point in time.** The iterative process of the Risk Management Methodology is to ensure that the risks are re-assessed, and that the rankings change in line with the project phase as well as new information and potential problems within the project. This is important to perform because smaller risks may grow and develop into much larger ones, through natural progression of the project or through interactions with other risks. This tracking of risks in a project is backed up by Ward who states that '*the relative importance of risks inevitably changes as a project progresses for a variety of reasons, and these changes need to be tracked*'.[108]

10.2 The Tools within the Risk Management Methodology.

It is important that any new tool or technique is integrated into the business processes within an organisation. Also, issues such as the impact of the tools on the performance of projects, cultural and people issues need to be taken into consideration and acted upon. As Thamhain states, '*a new concept should first be tried within a small project, and an experienced, high performance team*'.[122] The use of the Risk Management Methodology within the Rover/BMW group has been a test for its further application in the organisation. The reason behind this is to ensure that the process is fine-tuned, and that it has been tested within a 'safe' environment before being implemented into the remainder of the organisation.

As was stated in section 10, there are four tools within the Risk Management Methodology;

- Risk Register Database System
- Risk Assessment Tool
- Front-End Assessment Tool
- Tracking Tool for R&T Projects

These will be discussed in relation to the Risk Management Methodology, the justifications of the numbers used and their similarities.

10.2.1 The Risk Register Database System.

The Risk Register Database System was developed to enable the manual effort to be taken out of documenting the risks and to enable the risks to be managed over various geographical locations. Nevertheless, there have been some problems identified with the use of a risk register within the projects in which the Risk Management Methodology has been implemented.

The risk register, as used within the CB40 Fender project, was initially a paper-based system, which was identified by the project team as time consuming to complete and required duplication of effort to update. Therefore, from this, the Risk Register Database System was developed, to both remove the manual effort attached to updating the register, as well as to enable the information to be maintained over various geographical locations. The risks are now entered into the Risk Register Database System from where the severity and ranking of the risks are automatically determined. The main problems with the tools were identified as being associated with their use, and not with the methods in which the values of probability and impact, severity and ultimately the ranking were determined.

As the probability and impact of the risks are inserted into the risk register database system, the main issue can be considered as the method through which the values are combined and within this, the use of the severity and ranking of the risks. These issues were discussed in the previous section and will not be reiterated here. However, an issue within this is that project team can become detached from how the severity and ranking of the risks are determined, and can believe in the values absolutely. Hence, the team may not undertake to re-assess the risks once they are inserted into the Risk Register Database System. This is an issue that can be tackled through training in the use of the Risk Management Methodology and its tools and techniques as a whole, and will be discussed further in section 10.3.

10.2.2 The Risk Assessment Tool.

The Risk Assessment tool has been introduced in section 7.4.2 as a tool which was developed to enable the level of risk within the project to be determined using the information which had been generated through the use of the Risk Management Methodology. The Risk Assessment

Tool was therefore developed as an integral part of the Risk Register Database System, and as such, utilises the information held within the system itself. It therefore uses the information held within the Risk Register Database System to produce a static report of the risks at a point in time, as a means of reporting on the level of risk within the project at that point and providing a post audit trail, to determine the effectiveness of identifying and managing the risks within the project.

The risk assessment provides four calculations;

- The overall project risk
- Assessment of the overall risk to the project
- % of risks requiring attention
- Number of active risks

as well as a graphical output of the risks identified within the project, in relation to the area of the project in which they arise (i.e. organisational, technical, project or external). As the recommended method within the Risk Management Methodology to assess the risks is by non-numeric, VL → VH terms, the Risk Assessment Tool uses these in its calculations. However, as overall averages need to be determined, these non-numeric values need to be translated into numeric values. It is therefore in this translation that contention can occur, as the VL → VH values are subjective in nature.

The Risk Assessment tool uses the values determined within the assessment stage of the Risk Management Methodology. Hence, the use of non-numerical values comes under the same scrutiny as the assessment of the risks, discussed in section 10.1. However, one other factor within this is that, to provide the basis for the calculations, the non-numeric values are translated into numerical values. This could thereby result in the user taking Wards point when he asserts that this can mislead the user into thinking that the values are precise or accurate.[108] Nevertheless, the backward calculation, using the median value from the range, from non-numeric to numeric is based on the probability and impact values within table 26.

In addition, averaging the risks without taking into consideration the values of the individual risks themselves can be misleading, as there can be a disproportionate number of high or low risks within a project at any one time. As an example of potentially spurious result; towards the end of a project, there may be few risks remaining. However, these risks may be regarded as high. Therefore, in isolation, the average of the risks would result in the level of risk being high. However, within the tool the average is not looked at in isolation, with the visual graphical representation in addition to the % of active risks and their actual numbers being given. This therefore qualifies those risks which are active within the project and hence require managing.

Through the application of the Risk Assessment tool into the 6 CBoM projects, it was found to provide a spotlight on the status of the project at a point in time and can be considered extremely useful as an easy to understand and visual reporting mechanism. The assessment tool was used within monthly programme meetings as a method of reporting on the status of each project and as an indication of where further work and resources should be allocated.

The values within the assessment, as well as the graphical output can be used as a monitoring tool on the status of the project over time as long as these limitations and all of the measurements provided are used. Therefore, to enable the user to fully understand and use the tool as a reporting mechanism, adequate training should be given.

10.2.3 *The Front-End Assessment Tool.*

The Front-End Assessment Tool was designed to aid the decision as to whether the Risk Management Methodology should be implemented into a project. It thereby uses a numerical assessment which automatically generates a statement which suggests whether the cyclic Risk Management Methodology should be implemented into the project. To enable the assessment and statement to be generated, the tool automatically multiplies the importance of each of the statements to the success of the project, and the level achieved to date, to determine the level of risk value from each statement. From this, the classification of the project is determined though combining the level of risk value of the 33 statements within the tool.

The consensus for the values which are determined by the project team is achieved through the use of two tables, given in figures 19 and 20, and hence the values are again subjective in nature. The weighting factor also enables a correcting factor to be included in the assessment, based on both academic studies of critical success and failure factors of projects and an assessment of the judgement of the users of the tool. However, care must be taken when looking at the values.

The level of risk value relies on the equation;

$$\text{If } A \geq NI \text{ Then } R = 0$$
$$\text{Else } R = (NI \times -(A - 6)) \times 4$$

where NI - Normalised Importance to Project Success
A - Level Achieved to Date.
R - Level of Risk Value.

This simplistic formulae gives a basis for comparison, as it is easy to understand, and in the every day working environment and provides a method of filtering out projects that an organisation should have concern in. Therefore, the formulae above only provides additional information on which to base decisions, and if the project needs to go ahead, both the project and the risks can be managed more closely. Nevertheless, it is important to remember that the assessment is subjective, the numbers arbitrary and based on the knowledge and understanding of the users, and only valid for the point in time at which the assessment is performed. Hence, the 'Level of Risk Value' should not be used independently of common sense, and should purely give support to the decision making process. As Issacs states, *'assessing risk will not automatically produce correct decisions, but it will enable experts to make better decisions'*.[110]

Therefore, what this formulae means is that if the weighted level achieved in the project is more than or equal to the required level (i.e. the importance to the project success), the risk value can be considered as zero. However, if the attained level of achievement is less than the required level, then the importance and level achieved are multiplied together, taking into consideration that the level achieved is the opposite way around (i.e. a level achieved of 1 will give a risky value of 5). This value is then multiplied by 4 to increase its differentiation to 100 and thereby bring it in line with the Risk Management Methodology terminology. The main problem with using a formulae such as this is that it relies on the subjective judgements of the users, which are not accurate figures, and also on the users having the required knowledge of the project. In addition, numeric values can also give the impression of accuracy, and that the numbers are to be believed, irrespective of both the input and outcome. Using the weightings does not enable variations in different projects to be taken into consideration, nor new critical success factors to be included in the assessment. Therefore, it is important to review both the factors and their weightings at intervals. Nevertheless, similar risk values can be gained for statements which have a high weighting, but where the project team have determined that it is of low importance to the success of the project, and a low value for the level achieved to date, and for statements which have a low weighting value, but where the project deem that the statement is important to the success of the project, and where the level achieved to date is low. To highlight this point, take for example statement 1 and statement 7, figure 36.

Area	No	Statement	Wt.	**Importance to Project Success 1 - 5**	Normalised Importance to Project Success	**Level Achieved to Date 1 - 5**	Level of Risk Value
Project	1	Clear understanding of the framework, sharp project definition, goals and objectives	9	2	1.8	1	36
Project	7	Control and feedback mechanisms in place (including regular reporting mechanisms)	4	5	2	1	40

Figure 36 - Example from the Front-End Assessment Tool.

The level of risk values are almost the same, for statements which are weighted differently, but the project team have determined that for the project, statement number 7 is more important. In relation to this, the investigation into academic studies of critical success and failure factors has shown that number 1 should be more important to the success of the project. The reason for statement number 7 being the most important is based purely on the judgements of the users of the tool. As an example of this, the project may already have clearly defined goals and objectives, as these may have been clarified as part of the funding process. However, control and feedback mechanisms may not be adequately in place for the project's objectives and goals to be fully defined. Hence, the team may have ranked statement number 7 as being more important to the overall success of the project at that point in time, and hence a greater risk. Although subjective judgements have been attempted to be taken out, through the consensus tables (figures 19 and 20), the values are nevertheless based on the users' view points and their knowledge of the project at that point in time.

When looking at the end assessment, given at the bottom of the tool shown in appendix 1, within the overall classification of the project, the weightings are taken into consideration through ascertaining each level of risk value and then determining the average value for the project. However, the classification of the risk is based on the non-numeric VL → VH and corresponding percentage values used throughout the Risk Management Methodology (see section 7.2). These values were determined at the beginning of the use of the Risk Management Methodology, as a means of enabling consensus to be gained on what VL, L, M, H and VH actually meant, and have proven useful to the users of the Risk Management Methodology as a means of distinguishing between the levels of assessment within the assessment process. However, the use of this is subjective, as it is very fuzzy around the limits of each non-numeric value. Hence, the Front-End Assessment Tool should only be used to assist in the decision making process as to whether the Risk Management Methodology should be implemented into the project and not taken as absolute.

10.2.4 *Tracking Tool for R&T Projects.*

The Tracking Tool for R&T Projects was developed as a separate entity to the Risk Management Methodology, as a means of initially enabling the level of perceived risk within an R&T project to be determined, based on various criteria, and as such, assist the management in determining which project should be funded within the organisation. Therefore, even though the tracking tool was developed separately to the Risk Management Methodology, it is complementary in nature, so that it can easily be used alongside the Risk Management Methodology. The Tracking Tool for R&T Projects is complementary primarily to the Front-End Assessment Tool in that it uses a weighted level of importance for each of the confidence areas. However, unlike the Front-End Assessment Tool, the Tracking Tool for R&T Projects predominantly uses statements determined from the past experience of individuals working within the Rover/BMW group's research and technology department and can be considered as specific to that area. Nevertheless, the tool is however still generic in nature as it tackles many common areas found within research and development projects. This can be seen through its focus on the customer and the market place, the objectives and deliverables of the project, the organisation itself and external influences, such as suppliers and contractors which may affect the delivery of the project. Hence, as the framework for research and development projects are presented, the wording of the statements and the weightings can be altered to fit into an individual project, business unit or organisation.

Within the Tracking Tool, the weighting values enable the score, or level of confidence for each of the statements, to be ascertained by the project team using the assessment tool. From this, the confidence that the team have in being able to achieve the statement or measure of performance, at that point in time is determined. Multiplying the values together can sometimes result in erroneous results, with a low weighted (level of importance) statement having the same delivery confidence as a highly weighted (level of importance) statement, as has been described in section 10.1.2. Nevertheless, the use of numbers is based on the subjective judgements of the project team and the numbers themselves are valid at the point in time at which the assessment is performed.

The tool itself is designed to determine the probability of success of a project, and from this, to track the probability of success over its lifespan. It is also designed to be used alongside a previously developed tool to ascertain strategic importance of the project to the organisation. Together, the tools can provide a picture of the type of project being invested in by an organisation, which ones are important and therefore should be invested in, and those which are deemed too risky. Hence, it can remove some bias from the debate, through using a framework which the assessors must adhere to.

10.3 Discussion of the Similarities of the Tools within the Risk Management Methodology.

There are various similarities between the tools developed and used within the Risk Management Methodology, with a general theme transgressing though them. The main reason for this is so the project teams can use and apply the tools of the Risk Management Methodology within their projects without having to learn new techniques and methods for each. The main similarities are between the Front-End Assessment Tool, which uses critical success and failure factors from the literature in a weighted tool to assist in the decision making process as to whether the cyclic Risk Management Methodology should be implemented into a project, and the Tracking Tool for R&T Projects. However, as the Tracking Tool for R&T Projects was designed as a complementary, although independent tool, to be used in innovative and research projects within the Rover/BMW group, they are not necessarily designed to be used within the same projects at the same time. They are also designed for different specific purposes with the statements held within them being distinct.

The main issue with the tools is that combining the numerical values by multiplication detracts from the individual values, and as such, aspects with different importance could result in having similar levels of risk, or risk values, within the project. These issues have been considered and discussed within the previous two sections (10.1 and 10.2) and it was stated that the method by which the risks are ranked is through using both the individual values of probability and impact and their combination; the severity value. Although the method of combining numerical probability and impact values to create a severity value has been mentioned within this work, this was only used for a limited period of time in one project, and is not the recommended method by which to assess the risks within the Risk Management Methodology. The reason for this is that combining these values can give erroneous results, as was described in section 10.1.1.1, and hence the validity of the numbers resulting from this combination can be brought into question. Therefore, the use of non-numeric methods is the one which is recommended by this author. While the author does recognise that this method also has its problems, this method has been shown through its use to be a legitimate method of subjectively assessing risks and potentially determining the most important risks and likely problems within the project at the time at which the assessment is performed.

Applying weighting values to the statements within both the Front-End Assessment Tool and Tracking Tool for R&T Projects enables differentiation of the importance of the statements to be made. Within both of these tools, the overall risk to the project and the level of risk that each of the individual statements has on the project are determined. Hence, the project team can see where they can reduce the level of risk or increase the confidence of delivering the project within the project as a first estimate. The differences between the tools are in the use of the tools, and this is shown in the statements. The Tracking Tool for R&T Projects is designed to be used throughout the project, to determine if the level of confidence in the technology has increased, whereas the Front-End Assessment Tool has a one-off use, at the beginning of the project, or at a decision point in the project, to assist in the decision as to whether the cyclic Risk Management Methodology should be implemented into the project.

One important issue transgressing though the discussion on the Risk Management Methodology and its tools has been the need for appropriate leadership, training and open and frank communication. Gaining support and commitment from all levels of the organisation is critical in gaining acceptance for the use of the Risk Management Methodology within the projects and the organisation as a whole. Leadership from both within the organisation and the project needs to be gained and once this support is acquired, it should be communicated throughout the project. Therefore, open communication is extremely important in ensuring that the processes are understood and that people within the project focus on the use of the risk management process and ultimately solving the potential problems through actively managing the project itself. The Risk Management Methodology improved open communication to occur between the team members[123] and contractors[124], which in turn enabled the team to gain an understanding of the risks and issues within the project.[125] Training can aid with the acceptance and use of a process within the organisation. This however should not be performed purely at the beginning of the use of the process within the project, but at periodic intervals throughout the project's lifespan to the relevant people within and attached to the project itself. Hence, training on the use of the tools and the cyclic process of the Risk Management Methodology has been designed and used within the 7 projects, and consists of project, team and individual training on the concepts and importance of risk management to the project, and on the tools and techniques which the team can use to identify, assess, analyse, mitigate and ultimately manage the risk and uncertainty within the project. The training has since been re-designed to overcome many of the problems identified in the application and use of the process within projects in the Rover/BMW group.

As Alexander states, '*innovation and commitment should also be developed and maintained throughout the implementation process*'.[126] To enable this to take place however, there needs to be sufficient resources available for the application and use of the process as '*failure to provide adequate funding may contribute to limited success or outright failure*'[126] of the new process. Therefore, it is not only the tools which should be considered, but also the strategy for their use, the people issues and the required resources to enable the process and the tools to be successfully applied to the project.

10.4 Future Work to Justify the Assessment of the Risks.

One of the major philosophies underlying the Risk Management Methodology is not to enable an absolute value to be allocated to each risk. The allocation of probability, impact, severity and ranking of the risks in non-numeric terms enables the project team to gain an understanding of the risks within the project, and whether they are of a potentially higher concern for the project than others. The process is however not stopped there, as the cyclic methodology ensures that new risks are identified, assessed, and managed, and the existing risks are re-assessed on an ongoing basis. As such, the Risk Management Methodology has been used to ensure that the most predominant potential problems are identified and actioned within the project, as well as giving confidence to the project team.[123]

Although the use of numerical modelling techniques has been documented as being of benefit within the domain of project risk management, these were not seen to be of great importance within this initial development and application of project risk management into the Rover/BMW group, and also as a process for use within the Automotive Manufacturing Industry. The reasons for this were firstly that there was an initial need for a project risk management process to be used by project managers and team members. Secondly, as Isaac states, *'some senior project managers expressed concern that the 'number crunching' detracted from the process by dissuading project managers from implementing risk management'*.[110] This was also seen as being a concern of the author as well as project managers within the Rover/BMW group, as the overall objective was to develop a system that would be used and more importantly would benefit the project and the organisation as a whole. When such evaluations are generated via complex analysis techniques, such as Monté Carlo Simulation or sensitivity analysis, the user has less involvement in how their personal contribution generates the end result. In comparison, the formulae used within the Risk Management Methodology are extremely simplistic in nature and it is because of this that that the practitioners can benefit from using the tools. As Ward states, *'any techniques which offer help with this prioritising tasks, especially simple ones, are likely to find willing users'*.[108] This is also backed up by Issacs[110], who in the course of training users in the use of risk management, needed to simplify the methodology being used. These simplified techniques do not offer the most accurate method of assessing risks within projects. What they do offer are methods and techniques through which users can effectively manage their projects in an environment of decreasing resources and timescales and of increased demands placed on them by the ever intensifying competitive market. As Ward[110] points out, not only do simplistic methods produce good results with limited effort on the part of the user, they are also easy to understand. Hence, the Risk Management Methodology and its associated tools and techniques were designed to have little statistical modelling or manual 'number crunching', so that this would not detract from the process of managing the project and the risks.

When looking to the future use of the Risk Management Methodology and its associated tools and techniques to provide more justifiable numbers, statistical techniques such as the Kruskall - Wallis test and Friedmans test were investigated to enable analysis of variance of ranks to be determined.[127, 128, 129, 130, 131, 132] However, as these tests require the ranking of the risks to already be ascertained, they were not deemed as appropriate methods to provide more justifiable numbers in the assessment of the risks. However, these statistical tests could be useful in modelling the effects that different assessors would have in determining the probability and impact values, and hence rankings of the risk.

In looking towards the future of how the estimation of the probability and impact can be improved, various conclusions became evident.

- Further investigation into the ranking of the risks through the use of the individual and combined values of probability and impact, as described in this work could be carried out. Also, ranking in alphabetical terms, as described by Ward,[108] could be assessed to determine the most appropriate to use within the project. This could be achieved through the further implementation of the Risk Management Methodology into various projects which are not related to each other and therefore not dependent or influenced by the methods and processes used in each, where the effects of ranking the risks through the use of individual and combined values of probability and impact and also using both numeric and non-numeric ranking systems. From this, a comparison could be made.
- One method of overcoming the issue with combining the $impact_{time}$ and $impact_{cost}$ values, as discussed in section 10.1.1 could be to produce individual rankings for the time and cost assessments. Hence, $Ranking_{time}$ and $Ranking_{cost}$ could replace the single ranking value, and the team could then decide which of the rankings was the most important to the project (i.e. time or cost). Again, this would require the application of the Risk Management Methodology into further non-related projects.
- Fuzzy logic, which can potentially use the interactions of the risks to determine failure or success, could be applied to the area of project risk management in the assessment of the risks.[133] This is an area which was originally investigated by the author, but due to time and cost restraints was concluded to be out of the scope of this research. However, in the future, this area could be investigated further to determine if more 'accurate' results for assessing the risks and the combination of 'probability' and impact values, based on subjective judgements, can be achieved. This could be achieved by applying fuzzy logic theory to the assessment of the risks and from this, determine the rankings.

11.0 BENEFITS OF USING THE RISK MANAGEMENT METHODOLOGY.

There is little point in using the Risk Management Methodology and its associated tools and techniques if there are no real benefits gained for the project and the organisation as a whole. Although various issues with the methodology, tools and the way in which in which the numbers are used have been discussed in chapter 10, in practice however there have been various benefits identified through the use of the Risk Management Methodology, the Risk Register Database System and the Risk Assessment tool. Also, there are perceived benefits of the Front-End Assessment Tool, which has not yet been implemented into a project, as well as the Tracking Tool for R&T Projects, for which only an initial test was carried out. As the full benefits of using the process can be seen in the submission '*The Benefits of the Risk Management Methodology*'[134], only the most salient points will be discussed here.

11.1 Process for Identifying the Benefits of the Risk Management Methodology.

One of the key aspects in determining a process to ascertain the benefits of the Risk Management Methodology was whether to use qualification and/or quantification of the results. Quantifying the benefits of using a risk management process is inherently difficult to achieve, as Chicken states '*some benefits are intrinsically hard to quantify*'.[135] The main reasons for this is that there is that the project is a single entity, and that there are no comparisons to determine if the results were due to the use of project risk management or other factors. Although statistical data can be collected to determine the number of risks identified, mitigated or transpired, other factors such as resource allocation or time benefits may affect the resources. Therefore, there were various factors which entered into the decision as to not quantify the benefits of the use of the Risk Management Methodology and its associated tools and techniques within the projects. These other reasons against quantification were;

- As the projects were using the tools and techniques, quantification of the results could have been possible if the results of the tools were kept in documented form. However, although the Risk Assessment tool was used to give a static picture of the project at a particular point in time, it was attached to the active risk register database system, which was often updated between and at team meetings. Hence, as the information was continually changing, it was not always possible to obtain the information on the level of risk within the project from the Risk Assessment Tool.

- In addition to this, the Risk Management Methodology was implemented into 'live' projects within the Rover/BMW group, over which the author had no real control. This is in line with Clark et al's view of lightweight project management methods being prevalent within Europe[43], and the authors own experience of the organisation. The role that the author had within these projects was as an implementer and trainer of the Risk Management Methodology and its associated tools and techniques, and hence gaining information on a continual basis was often difficult to achieve. These problems were aggravated by the fact that all of the projects were performed over numerous geographical locations. Hence, once the initially training on the use of the process was performed, it was often difficult to be involved in all of the risk management activities, as well as the team meetings in which the risks and uncertainties were discussed. Also, even though the risk register database system was on a server location and could be accessed at all Rover and BMW locations, the author did not have access to this.

- At the time at which the benefits were obtained from the CBoM programme, the projects themselves were not fully completed. Hence, gaining actual figures with respect to budgets and timing issues was not seen to be totally appropriate, due to the fact that the evidence was not available. The reason that the post-audit of the use of the Risk Management Methodology was carried out at this time was that the author wanted to improve the process and the tools for future use within the organisation.

- In addition, the benefits of many other risk management processes are qualified and not quantified. Therefore, collecting qualified statements from the user on the use of the Risk Management Methodology within the projects would enable a comparison to be made with other risk management processes.

Therefore because of these issues, quantifying the benefits was difficult to perform and from this, it was determined that a qualitative benefit assessment, which could enable the Risk Management Methodology to be compared with existing risk management processes, would be the most appropriate to perform. The benefits of utilising the Risk Management Methodology within the BMW/Rover group were identified, as part of the post-audit review of the CBoM project, primarily through a questionnaire.[136, 137] The questionnaire consisted of two parts, an investigation of the benefits of using the Risk Management Methodology and its associated tools and techniques, and the issues attached to its implementation. The information was gathered through a series of 12 interviews with members of the CBoM project teams. The author participated within these interviews and was able to ask additional questions in relation to specific points. The quotes given are therefore accurate representations of the information generated within the interviews.

The benefits were obtained from the post-audit review of the CBoM projects and the application of risk management into the CB40 Fender project, discussed in the submission *'The Management of Risks- From Theory to Practice'*.[34] The benefits of using the Risk Management Methodology and its associated tools and techniques were identified as being qualitative and subjective in nature. They also depended on the project in which the risk management was implemented, and as such, they will be described in relation to their respective project.

One issue which has been identified from the interviews is that the Risk Management Methodology was not owned by an expert in project risk management within the projects, but by the project/team leaders of the projects themselves. The users of the Risk Management Methodology had very little, if any, previous experience of risk management, and hence the concepts, tools and techniques were novel to them. The benefits were therefore based on their own opinion and expectations of the Risk Management Methodology, and not on a direct comparison with any other risk management processes. The questions themselves were direct in nature, and as such required a descriptive answer and not yes/no replies. They also relied on the personal views and experiences of the team members who used the Risk Management

Methodology and its associated tools and techniques and were asked by people detached from both the project, the company and the author. Therefore, the questions themselves were not leading and hence the results can be considered as unbiased.

11.2 Benefits of the Methodology.

As was stated in section 5.0, the most appropriate time for the Risk Management Methodology to be implemented into the project is at the initial stages, as it is here that the concept, objectives and direction of the project are able to be developed with the resultant risks in mind. Through implementing the Risk Management Methodology at the beginning of a project, these risks, potential problems and fear issues identified at this early stage were able to be considered within the project plan and as such, were reduced and removed through developing appropriate objectives and directions for the project. Hence, one of the main benefits of using the Risk Management Methodology within a project is that it enables the risks and uncertainties to be made visible through their identification, assessment, analysis and continued management. Therefore, because the risks are visible, deviations from the proposed plans are identified and efforts made to reduce and mitigate the risks and potential problems. As was stated within the post-audit review of the CBoM projects, '*the Risk Management Methodology was used to influence the concept of the project and ensure that there was the same understanding of the project and the issues*' and '*through identifying the risks at the project definition stage, the risks were able to be minimised through writing the project definition, objectives and plan to reduce the risks*'. [138] These aspects were seen through the team members being able to use the list of identified risks to re-write and amend the project definition as well as plan the activities of the project. In addition, the team members were able to communicate openly, both externally and internally to the project, from a very early stage. This highlighted many of the issues and potential problems that were faced, not only as individual teams, but as a collective alongside other members, contractors and collaborators of the overall programme.

The decision making process was also improved, as the use of the process '*increases the confidence in the project and the decisions made through knowing what the major risks were and then being able to minimise them or keep an eye on them*'.[123] As such, the increase in open communication and the fact that the team members were able to discuss and document the issues and potential problems in a structured manner improved their confidence in the project from an early stage. This can be attributed to the increase in the amount of relevant information within the project, and as such, decision making was improved as the decisions themselves were made with the resultant risks and potential problems in mind.[123] Project management techniques were stated to have been used more effectively, as the team were using the risk and project management tools and techniques as a means of more effectively planning the project with the risks and potential problems in mind. Hence, this resulted in the project being managed more competently. As the risks were effectively managed, the number of problems which were expected to arise did not occur and hence this aided in improving the management of the project and confidence of the team as a whole. However, not only were improvements to the management of the project noted, the performance of the technology itself was also seen to improve. Therefore, through the pro-active management of the projects, it was noted that '*the Risk Management Methodology improved the performance of the project through* *enabling the project management to gain control and undertake pro-active management of the project itself*.[139] This occurred through the team members looking at the risks and problems which might occur within the project and either changing the scope of the project in the early stages, and/or putting together reduction and/or mitigation plans to manage the risks and problems themselves. This was seen as a change from the reactive, fire fighting working practices which were considered and seen to be prevalent within the company. The attitudes in the way which people dealt with the risks also improved. As such, the project members '*lost the 'fear' of the risks and became aware of how they could be controlled*'[138], through understanding and managing the risks and ultimately the project more effectively.

The reasons for this more effective management of the projects and the risks have been attributed to various aspects. Firstly, '*once the risk is written down and defined, it cannot be overlooked*'.[125] This documentation, in the form of the Risk Register Database System and the Risk Assessment Tool, gave visibility of the risks to both the project and programme team members. Also, the Risk Management Methodology '*gives a formalised and focused approach to the management of the risks within the project*', and as such, the '*benefits are due to the formal process of documenting the risks, storing them in one place and acting upon them*'.[140] As such, its use ensures that '*the risks are managed and solved through ensuring that the process is carried out*'[123] and '*success was seen through getting rid of the risks or potential problems from the risk register*'.[138] Hence, the tools became an important part of the Risk Management Methodology, as they provided a focus for discussion and management of the risks. In addition, the confidence and success of the team was seen to improve through the reduction in the level of the risks which were documented within the Risk Assessment Tool.

Improvements in the cost, time and quality issues were identified as benefits from the use of the methodology, and were seen in the reduction of time, cost and improvements in the quality of the products which were developed. These aspects were considered extremely important, due to the limitations to the budget and resources.[123] Although performance improvements, in terms of cost and quality, were determined from the investigated literature on the other risk management processes, quality benefits, such as the ability to identify in the early stages where improvements to the product could be made, were exclusively identified to that of the Risk Management Methodology. This is an extremely important factor to manufacturing organisations, as quality improvements play an important role in achieving customer satisfaction within a highly competitive market. As Cherkasky states '*there is little doubt that a focus on quality has emerged as the universal strategy to ensure that a company's survival in both domestic and international markets*'.[141]

The identified change from predominantly reactive, fire fighting methods to pro-active management of the project is an extremely important benefit of the use of the Risk Management Methodology within the Rover/BMW group and the manufacturing sector as a whole, in comparison to the other risk management processes. Burns states that within western manufacturing organisations '*management that is first class at firefighting is recognised, rewarded and promoted; it recruits and trains its successors to have the same abilities*'.[142] In addition, Burns states, through converting to pro-active working practices '*resources and time made available through problem avoidance can be used to achieve economy in indirect costs, to bring forward a new* *product development ahead of competition or delay commencement in order to have more up-to-date information (market/technical/competitiveness), while still meeting a competitive launch date against competitors who are using traditional methods*'.[142] Therefore, the attitude of the individuals involved in the projects changed, and the feel-good factor, which used to be gained through firefighting methods, was now felt through the use of the Risk Management Methodology and its associated tools and techniques.

People issues, such as improved teamwork, communication and working practices were seen as major benefits from the use of the Risk Management Methodology. Firstly, the use of the Risk Management Methodology enabled '*a common understanding of the risks and issues to be gained*'[125] through the open and frank communication which resulted from the identification and assessment of the risks. Hence, overall the communication and the working practices of the teams were seen to improve from the point at which the Risk Management Methodology was implemented into the projects. It allowed '*potential problems risks and fear issues to be brought out into the open and discussed*'[125] as well as '*improving communication with team members*'.[123] This increase in communication also extended outside of the projects themselves, through enabling '*communication with contractors*'[124] to take place more effectively. Therefore, more open communication resulted in the teams considering the implications of their decisions and deliverables on others. Fear issues, such as a lack of understanding of the technology and cultural issues attached to the project were also able to be identified and discussed and in some cases removed from the project through measures such as bringing in external contractors to decrease the skills gap. From this, the flow of communication between the individuals within, as well as external to the projects improved significantly, and this benefited the projects as a whole through an understanding of the impacts that one team had on another, and the anticipation of when deliverables, such as equipment and information, were required. Therefore, through these aspects, the use of the Risk Management Methodology and its associated tools and techniques was concluded to aid in the successful completion of a project.[134]

11.3 Benefits of the Tools.

The tools which were developed as an integral part of the Risk Management Methodology provided a means by which the project was able to be assessed for its level of riskiness as well as documenting the identified risks. The Front-End Assessment Tool had a major perceived benefit of being able to give a level of risk to the project and whether there would potentially be any real benefit of implementing the cyclic Risk Management Methodology into the project. It can therefore aid the decision as to whether there would be any potential benefit of implementing the Risk Management Methodology. Therefore, as the use of the Risk Management Methodology requires resources to be applied at the beginning as well as throughout the project's lifespan, it is of utmost importance that the benefits achieved through performing the process are worth the resources used. The Risk Management Methodology should only be used in projects which possess a high risk and are strategically important for the organisation to perform. The Front-End Assessment Tool aids the decision as to whether the Risk Management Methodology and its associated tools and techniques should be implemented within the project.

The Risk Register Database System provided the means by which the identified risks could be seen, updated and in effect managed within the projects, irrespective of geographical location. It also enabled reports on the risks within the projects to be automatically generated as well as reducing effort in the construction of the risk register. As the Risk Assessment Tool was an integral part of the Risk Register Database System, it required no extra effort in its generation, in addition to the construction of the risk register. Although the Risk Assessment Tool does not assist in the actual management of the risks within the project, it provided a report of the level of risk within the project at a specific point, based on the information already generated through the use of the Risk Management Methodology. This can be extremely useful in determining how risky the project is as well as a reporting mechanism for project meetings and reviews. In addition to these benefits, as the tools were computer based, this reduced the overall time required to document the actions required to manage the risks. Also, although these tools do not provide the means by which the risks are managed, they did however help in ensuring that the reduction and/or mitigation plans were developed for the highest ranked risks, as well as providing methods of determining which risks may have the largest effect on the project as a whole. Although resources were spent on the maintenance of the tools, and in the overall management of the risks, these aspects were counteracted through the increase in visibility of status of the project and from this, the overall confidence of the team was seen to increase accordingly.

Even though the Tracking Tool for R&T Projects is not an integral part of the Risk Management Methodology, it enables R&T projects to be tracked for their probability of success as well as increasing the confidence that the targets within the project will be met. This can thereby enable projects which have a low probability that the targets and objectives would be met to be highlighted and potentially terminated, as a means of reducing the amount of resources which are invested in projects which fail.

11.4 Comparison of the Benefits of the Risk Management Methodology with other Risk Management Processes.

The benefits of using the Risk Management Methodology and its associated tools and techniques have been described. However, there has yet been no comparison of how the benefits of this methodology compares with other risk management processes.

Figure 37 gives a comparison of the benefits of other risk management processes in relation to those identified from the use of the Risk Management Methodology.[7, 18, 33, 65, 79, 80, 81, 82, 83, 84, 85, 114, 143] The benefits have been classified into 5 areas to enable comparisons to be made; business strategy and objectives, project management and decision making, management of risk, people issues and external issues.

The benefits quoted from the literature are a summary of those identified within all of the processes and no one process possesses all of the stated benefits. A tick in the column 'Benefits RMM' state that this benefit has also been identified in the post-audit review of the Risk

Management Methodology and its associated tools and techniques.[134] A gap in the column indicates that that benefit has not been determined. However, as the questions in the post-audit reviews were not leading, it cannot be explicitly said that these benefits are not achievable from the use of the Risk Management Methodology. The column 'Additional Benefits of the RMM' state the benefits which are additional to those within the documented literature.

Since the documented literature was not designed to purely define the benefits of each of the processes, it cannot therefore be assumed that these are the only benefits of the identified processes. However, what can be stated is that, while there is a general consensus between the benefits of the use of the Risk Management Methodology with those gained from the use of other risk management processes, the Risk Management Methodology does appear to provide additional benefits.

	Benefits		
Area	**Risk Management Processes**	**RMM**	**Additional Benefits of the RMM.**
Business Strategy and Objectives	1. Identify opportunities 2. Take advantage of opportunities 3. Corporate knowledge of project risks is documented and therefore not lost	1. 2. 3.	• Overall benefits of using the Risk Management Methodology able to be escalated up to organisational level - no explicit evidence to support this statement.
Project Management and Decision Making	4. Better plans generated 5. Ensures that requirements are well stated and well understood 6. Decision are compatible with project policies, goals and objectives 7. Insight, knowledge, and confidence for better and more explicit decision making 8. Judgement and intuition presented meaningfully 9. Systematic and logical approach to decision making 10. Provides guidelines to aid problem formulation 11. Allows analysis of alternative options 12. Reduction in exposure to risks 13. Statistical information enables better modelling of future projects 14. Improves the performance in terms of time and cost 15. Determines specific factors to time and cost overruns 16. Less reactive to more pro-active management	4. ✓ 5. ✓ 6. ✓ 7. ✓ 8. ✓ 9. ✓ 10. ✓ 11. ✓ 12. ✓ 13. 14. ✓ 15. 16. ✓	• Influence concept of the project • Increase the amount of relevant information within the project • Decisions made with the resultant risks in mind • Decisions on future directions of project improved • Quality benefits also realised • RMM made the team use project management techniques more effectively • Enabled risks to be escalated to a higher level within the organisation
Management of the Risks	17. Pre-planning ensures risks are promptly managed 18. Gives an increased understanding of the risks within the project 19. More rational risk taking 20. Overall reduction in risk exposure	17. 18. ✓ 19. ✓ 20. ✓	• Improvements in the performance of the technology noted • Ranks risks in order of priority • Troubleshooting before the event • Number of potential problems expected to materialise did not occur
People Issues	21. Documentation ensures that information an knowledge does not remain with one person 22. Communication improved both inside and outside of the organisation 23. Team building and teamwork improved 24. Increases awareness about risks to the project 25. Avoidance of crisis 26. Identifies party best able to deal with the risk	21. 22. ✓ 23. ✓ 24. ✓ 25. 26. ✓	• Change in peoples working practices, from reactive to pro-active management of the risks • Real risks separated form fear issues • Gave a feel good factor to the project teams • Two way communication able to take place more effectively
External Influences	27. Helps formulate the contract strategy 28. Enables right suppliers to be identified	27. 28.	• Enabled external dependencies to be delivered

Figure 37 - Comparison of the Benefits of the Risk Management Methodology to other Risk Management Processes.

The additional benefits of the Risk Management Methodology, such as the realisation of quality benefits, improvements to the technology and changes to working practices from reactive to pro-active management, indicate that the methodology developed within this research is more suited to Automotive Manufacturing Organisations than the other risk management processes. This is backed up in chapter 3, in which the needs and requirements of a risk management methodology for use within the Automotive Manufacturing Industry are discussed. However, as these aspects have already been discussed in section 11.2, they will not be reiterated here.,

Although not explicitly stated within the documented evidence of the benefits of the Risk Management Methodology, it can be said that the process itself can aid the organisation in identifying and taking advantage of opportunities available. This is more pertinent with the Tracking Tool for R&T Projects, in which it can be used to aid the decision as to which projects should potentially be invested in to achieve the strategic direction of the organisation. The documentation of the risks within the Risk Register Database System can provide a repository of all risks and potential problems identified within the projects as well as their reduction and mitigation actions, which can prove useful as a record of risks.

One important difference to the use of the Risk Management Methodology is that it is not designed to help formulate a contract strategy, as this factor is not part of the overall objectives of the process nor an identified need within the Automotive Manufacturing Industry. Hence, extremely accurate results to enable contingency planning and resource allocation, are not a requisite of the Risk Management Methodology, and will be discussed further in chapter 12.

12.0 A RISK MANAGEMENT METHODOLOGY FOR AUTOMTOIVE MANUFACTURING ORGANISTIONS.

Risk and/or uncertainty have been identified as an integral and inadvertent part of projects. Therefore, the research described in this work has developed and tested a method by which risks, potential problems and uncertainty in projects within the Rover/BMW group can be actively managed. Chapman et al state that *'efforts must be tailored to suit the project, to ensure that the most appropriate methods are employed'*.[79] However, the author believes that it is not only the project which efforts must suit, but the requirements of the organisation and industry as a whole.

Within chapter 2 it was identified that risk management is used in many forms within various industrial sectors. However, as a whole, the use of project risk management has not tended to be used throughout the Automotive Manufacturing Industry. Within the Automotive Manufacturing Industry, and especially prevalent within the Rover/BMW group where projects are carried out either in house or on a collaborative basis rather than contractually, there has been no real need to identify which risks should be written into agreements or contracted out. The various methods of managing project risk were critically discussed and it has been identified that a major difference between those processes and the Risk Management Methodology is that of the use of contingency allocation and contractual agreements. These methods require in-depth and accurate analysis or assessment of the risks as a means of understanding which risks to take on within the project, which not to accept, which to transfer to contractors or to allocate large contingencies to. The risks identified within the project are all part of the risks belonging to the project, and as such, need to be managed within the project itself. Also due to the lack of resources and the methods through which resources are allocated to research and development projects, there tends to be a lack of funds available to allocate as contingencies. If additional funding at the beginning of the project is required, then questions will arise as to the need for the extra resources. So instead of requiring to allocate contingencies and contract out the risks, project teams need to understand and effectively manage the risks in-house.

Like many of the risk management processes discussed in chapter 4, the Risk Management Methodology itself was developed as a generic risk management process for use within the Automotive Manufacturing Industry. It was based on the needs of the users within the Automotive Manufacturing Industry, and as such, can be said to fit in with the methods of project management used within this industry as well as the requirements of the methodology itself, described in chapter 3. Therefore, the Risk Management Methodology can be compared to the deliverables of each of the risk management processes as shown in figure 17.

The Risk Management Methodology is designed to be implemented into the project as early as possible, and hence uses the developed information on the project's objectives and tasks to aid in developing the project plan (deliverable 1). Therefore, not only should the project plans, objectives and key tasks be identified and understood, their development is further aided by the identification of potential problems and risks. As such, the use of the Risk Management

Methodology should assist in developing the project plans and therefore becomes part of the management and development of the project as a whole. From this, the subsequent risks and potential problems can be further identified (deliverable 2), and classed (deliverable 3) to ensure their ease of recognition within the entire process. The risks are then assessed and potential analysed (deliverable 4), prioritised within the project (deliverable 5). Also, the interrelationships should be understood and inserted into the risk register where appropriate (deliverable 6). These interrelationships and interdependencies are also able to be identified through the iterative process of the Risk Management Methodology (deliverable 11), as they cannot only be identified in the initial use of the process, but in subsequent cycles. The active or ranked risks are allocated owners (deliverable 7), who are responsible to manage the mitigation and/or contingency responses to reduce, mitigate and manage their risks (deliverable 9). The risks can be transferred between collaborating or contracting organisations, however the risk should be owned by the OEM as ultimately they are the recipient of the effect of the realised risk.

The two outstanding deliverables identified within figure 17 are the go/no go decision on the feasibility of the project and the use of the risk management process (deliverable 8) and the identification of the variations in the actual vs. planned (deliverable 10). The Front-End assessment Tool was designed to fulfil the requirements of the go/no go decision as to whether the Risk Management Methodology should be implemented into the project. This tool aids the decision as to whether the Risk Management Methodology should be implemented, based on the level of risk within the project. It can also however enable both senior management and the project team to critically evaluate the project, and determine whether the level of risk is too great. Also, the Tracking Tool for R&T projects can enable the feasibility of innovative research projects within the Rover/BMW group to be evaluated.

Deliverable 10 is however, not fulfilled within the Risk Management Methodology. The reason for this is that the identification of variations in the actual versus planned activities does not aid in the active management of the risks and therefore does not meet the objectives of the Risk Management Methodology itself. However, when audits are completed, such as the determination of the benefits of using a process, this deliverable can be fulfilled. Hence, the Risk Management Methodology was not only developed for use within the Automotive Manufacturing Industry, it can be described as being generic in nature and condenses many of the deliverables into one methodology.

Much like the SCERT method[80], total accuracy has been relinquished within the Risk Management Methodology, to enable an easy to use and flexible method which will enable the users to start thinking about the risks to their projects. The method through which the risks within the Risk Management Methodology are assessed is subjective in nature. Nevertheless, it does provide a starting point for the users of the Risk Management Methodology to be able to rank the risks in a way which is easy to understand, and in effect, enable them to use risk management within their everyday project management activities. The Risk Management Methodology may not ultimately supply the most accurate method to manage every project. It purely offers another useful and usable tool to the project manager to be used within a project as appropriate.

Nevertheless, as stated in chapter 10, more accurate, scientific methods can be developed in the future, as the Risk Management Methodology is a starting point for future developments and applications into the industry as a whole. As Chapman states *'research into this area...must be applied, involving experimentation by those who are willing to try new ideas and approaches'.*[89] The Risk Management Methodology is one approach, used within two distinctly different organisations in the same industrial sectors. It has enabled them to make the most of limitations to resources and time often inherent within organisations, as a starting point to manage the risks to their projects in a formalized, although not formal, way.

13.0 CONCLUSIONS.

The primary objective of this work was to develop a methodology which could be used to enable the risks, uncertainty and potential problems within a project in the Automotive Manufacturing Industry to be effectively, efficiently and actively managed as a means of increasing the overall probability of success of the project. To enable this objective to be realised, various steps were taken, to ensure that this industrial sector would require, benefit from and use the project risk management process.

13.1 Investigation of Risk Management.

The literature review can be split into 2 sections. Firstly a review into the application of risk management within various industrial sectors identified that they primarily used risk management tools and techniques as a means of decreasing life-threatening hazards, to increase their financial and operational safety, and to satisfy both government and self-imposed regulation. Although it was identified that manufacturing organisations also need to increase the safety of their financial investments and operations as well as decrease life-threatening hazards, it was determined that these aspects do not affect their business to such an extent as many of the other stated industries. The management of project risk within the Automotive Manufacturing Industry is also not stipulated by the customer, as it is within government and defence contracts.

Secondly, a review of the Automotive Manufacturing Industry determined that the use of modern-day project management techniques was identified as being a relatively new concept to the industry compared to many of the other sectors investigated. From this it was recognised that the use of project risk management was not prevalent within the Automotive Manufacturing sector. The reasons for this were identified as being the focus on Japanese imported management, operational and production activities, and the fact that there is no requirement or client demand for the use of project risk management.

However, with the need to reduce lead times, to increase the quality of the products as well as to reduce the time and costs required to develop and manufacture a product, there is a potential need for organisations within the Automotive Manufacturing Sector to ensure that risks and problems attached to their products and processes are reduced or solved before they are fully developed.

13.2 Review of the Automotive Manufacturing Industry.

Therefore, although a gap in the use of project risk management had been identified through researching the literature, what needed to be determined was if there was a real, practical need for project risk management within the Automotive Manufacturing Industry.

This investigation took the form of an examination of the literature as well as a post-audit review of the GIPT project. Taking into consideration the use of project management techniques in the Automotive Manufacturing Industry, the investigation concluded that there was a need to actively manage the risks within their projects as a means of reducing the delivery time to their customers, to increase the quality of their products as well as reduce the amount of resources allocated to projects, especially new product developments (NPD).

13.3 Requirements of the Risk Management Methodology.

The post-audit review and investigation into the needs and requirements of a Risk Management Methodology, designed specifically for use within the generic project management constraints of the Automotive Manufacturing Sector, identified that it should;

- Be able to be implemented into a project at any time
- Be simple to use, and easy to understand, requiring few new and complicated techniques for an individual to acquire.
- Add to the project management knowledge of an individual, but be suitable for a non-professional user of project management techniques.
- Be flexible and iterative.
- Enable the risks to be actively managed throughout the lifespan of the project.

Various project risk management processes were investigated for the objectives of the methodology, the stages and tasks contained within it, and the deliverables of each of these stages. This therefore provided a review of risk management processes, as well as a comparison of their differences and similarities of the deliverables. From this investigation it was determined that, although they have all been designed to manage project risk, they are all different in their approach to project risk management and their usage in practice. In conclusion, although some were developed as generic processes, none had been reportedly designed nor applied specifically to the Automotive Manufacturing Industry. Therefore, a Risk Management Methodology, based on the needs and requirements of the Automotive Manufacturing Industry was designed and constructed.

13.4 Development and Implementation of the Risk Management Methodology.

The initial form of the Risk Management Methodology was tested on the CB40 Fender project, and from this various amendments were made and tools constructed. The final version of the Risk Management Methodology and its associated tools and techniques were implemented into the 6 CBoM projects. Within the implementation of the Risk Management Methodology, the Risk Register Database System, the Risk Assessment Tool and the Front-End Assessment Tool were developed and constructed. A Tracking Tool for R&T Projects was also developed as a means of determining and tracking the probability of success of a technology project throughout its lifespan.

The implementation of the Risk Management Methodology into the CB40 Fender and 6 CBoM projects concluded that the problems were not with the design of the Risk Management Methodology, but with the actual implementation itself. These problems were identified as being that more training on the use of the tools and techniques were required, that the process should be implemented at the highest level (programme) and not at the individual project level, and that it needed to be an integrated process within the project management procedures within the organisation before it is implemented into projects. Various learning points were thereby determined and integrated into the implementation procedures of the Risk Management Methodology. These were that;

- Within the projects, the Risk Management Methodology was integrated into the formal project management procedures in operation.
- Risk management was on the agenda within the project team meetings.
- Risk management became part of the external audit of the project
- The Risk Management Methodology was implemented in a top-down approach.
- Adequate training and support for the use of the tools and techniques was available for the project teams.

Questions posed from the use of numbers within the methodology and its associated tools and techniques have also been addressed and it was concluded that although the assessment of the risks within the Risk Management Methodology is a subjective process, one must take these first steps to be able to visualise, understand and manage the risks within a project. However, in future applications of the Risk Management Methodology, it is suggested that the assessment be performed using non-numeric, VL → VH values, with the numeric probability values giving an *indication* to the user as to their corresponding percentage values. Nevertheless, even though the use of numbers are subjective in nature, as long as they are understood to be and that they are only relevant for that point in the project, then the team can use the information effectively.

13.5 Benefits of Using the Risk Management Methodology.

Through the post-audit reviews of the projects, various benefits of its use were identified. These were that the Risk Management Methodology and its associated tools and techniques enabled;

- Risks to be made visible through their identification, assessment, analysis and management.
- Deviations from the proposed plan to be identified, and effort made to reduce and/or mitigate against the effects of the risks.
- The decision making process to be improved, through increasing the amount of relevant information within the project.
- A change in the working practices of the individuals and teams, from reactive, firefighting to pro-active management of the project.

It can therefore be concluded that the use of the Risk Management Methodology and its associated tools and techniques provide the means by which the risks and potential problems within the Rover/BMW group and the Automotive Manufacturing Industry as a whole, can be actively managed and as such, assist in the successful completion of the projects.

The Risk Management Methodology and its associated tools and techniques were designed specifically for use within the Automotive Manufacturing Industry. The methodology itself is also designed to be non-prescriptive, as it merely offers tools, techniques and methods by which the user can actively manage the risks and potential problems within the project. The implementation of the methodology into the CB40 Fender and the CBoM projects has enabled the risks, uncertainties, potential problems and the project as a whole to be actively managed efficiently and effectively throughout its lifespan, resulting in an increase in the overall success of the projects for the benefit of the organisation.

14.0 FURTHER WORK.

Opportunities to take the work further were identified as being;

1. The implementation of the Risk Management Methodology and its associated tools and techniques into further projects, in which the learning points from the CBoM projects are incorporated.

Various learning points from the implementation of the Risk Management Methodology into the CBOM projects were identified and have been discussed within section 8.4. To ensure that all of the problems with respect to the implementation have been resolved, it is imperative that the Risk Management Methodology is further applied to projects within the Automotive Manufacturing Sector. To aid its use, the new projects should ideally involve the individuals from the CB40 and CBoM projects as a means of increasing its use and understanding. The procedures for the use of the Risk Management Methodology and its associated tools and techniques which have been inserted into the project management procedures within the Rover/BMW group should also be used as reference and training material. This application could also ensure that the Front-End Assessment Tool worked effectively.

2. Quantifying the benefits further with performance indicators relevant to the organisation.

Although it was stated in chapter 11 that quantifying the benefits is intrinsically hard to perform and that for the implementation of the Risk Management Methodology into the 7 projects it was not appropriate, both indicators and additional measurements could be further developed. In addition, the indicators and measurements should be used within the projects stated in point 1 stated above.

Therefore, quantifying the data through using performance indicators, such as % identified risks mitigated, % identified risks which transpire, increase in resources spent on mitigating the identified risks in relation to benefit (in terms of time/cost) achieved, could be used to quantify the use of the methodology within the organisation. To enable this to take place, the gathering of relevant information should take place at specific points throughout the project. Also, appropriate trends in the quantified benefits should be looked at to ensure that improvements are made within the projects and the use of the tools themselves. However, care must always be taken when creating new performance indicators in any organisation, as they have to be measurable, repeatable, relevant and cost worthy to perform.

3. With reference to section 10.4, the improvements to the estimation of the probability and impact can be further explored in the following areas;

   - Further investigating the ranking of the risks through the use of the individual and combined values of probability and impact, as described in this work, and also ranking in alphabetical terms, as described by Ward,[108] could be assessed to determine the most appropriate to use within the project.

- Investigating the advantage of producing rankings for time and cost assessments, where $ranking_{time}$, $ranking_{cost}$ and $ranking_{quality}$ could replace the single ranking value. The team could then decide which of the rankings was the most important to the project (i.e. time or cost).
- Applying fuzzy logic to the assessment of the risks, to determine if more 'accurate' results for the combination of probability and impact values, based on subjective judgements, can be achieved.

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i) *'a technology or practice being used for the first time by members of an organisation, whether or not other organisations have used it previously'*
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ii) *'introducing practices that are new to adopting organisation'*
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APPENDIX 1.

FRONT-END ASSESSMENT TOOL.

Front End Risk Assessment.

Area	No.	Statement	Weighting 1 - 10	Importance to Project Success 1 - 5	Normalised Importance to Project Success	Level Achieved to Date 1 - 5	Level of Risk Value
Project	1	Clear understanding of the framework, sharp project definition, goals and objectives.	9		0		0
	2	The goals are stable and achievable.	9		0		0
	3	Targets of the project are defined and achievable	6		0		0
	4	Fully developed project management activities (schedule, plans, activities, task allocation).	6		0		0
	5	Rigorous use of Project Management Process	7		0		0
	6	Duration of the project is known, stable and achievable.	5		0		0
	7	Control and feedback mechanisms in place (including regular reporting mechanisms).	4		0		0
	8	Regular quality review in place.	3		0		0
	9	Implementation strategy of project in place.	7		0		0
	10	Full time, experienced and competent project manager.	5		0		0
	11	Cross-functional project team	4		0		0
	12	Project team members experienced, motivated, good quality and possess relevant skills.	6		0		0
	13	Roles and responsibilities clear and communicated to all parties.	4		0		0
	14	Open and clear lines of communication.	6		0		0
	15	Adequate and available resource allocation.	4		0		0
	16	Funding for the project adequate and secure.	4		0		0
	17	Logistical requirements adequate and secure.	1		0		0
	18	Facilities and equipment will be available when required.	3		0		0
	19	Implementation of project deliverables considered.	5		0		0
	20	Project finish date known and close down planned.	7		0		0
Technical	21	Appropriate technology has been identified for the project.	5		0		0
	22	Technology known, understood and innovation is manageable.	4		0		0
	23	Performance of technology has been demonstrated.	3		0		0
	24	Manufacturing capability of producing the technology.	3		0		0
Organisational	25	Senior management support obtained	7		0		0
	26	Project priority is stable.	1		0		0
	27	Project goals aligned with technology and business strategy.	6		0		0
	28	Interdependencies with other projects managed.	1		0		0
External	29	Customer / end user defined, committed and supportive.	3		0		0
	30	Project is responsive to customer requirements.	5		0		0
	31	Adequate contractor / supplier resources available at right time.	1		0		0
	32	Suppliers / contractors / collaborators proven and signed up.	1		0		0
	33	External market factors (knowledge, stability, etc) considered.	1		0		0
							0.00

The Project is Classed as *VL*

The Risk Management Methodology *SHOULD NOT BE* **Implemented into the Project.**

APPENDIX 2.

PAPER-BASED RISK REGISTER.

Risk owner (Date)	Risk Description	Ranking	Risk Reduction Plans	Risk Mitigation Plans

APPENDIX 3.

RISK ASSESSMENT TOOL.

Risk Assessment

Risk No.	***Risk Area***	***Risk Decription***	***P***	***I(t)***	***I(c)***	***I(tot)***	***Sev***
1101	Project	The project has not been fully planned by the team management	VH	VH	VH	VH	VH
1301	Project	There is lack of relevant technical experience within the project.	H	VH	VH	VH	VH
2301	Technical	The required equipment may not be available by phase 2.3	H	H	H	H	H
3401	Organisational	There are potential funding transfer problems	M	VH	VH	VH	H
4301	External	The suppliers of the equipment have not been contracted.	L	M	M	M	L

Key: *P* *: Probaility*

I(t) *: Impact (time)*

I(c) *: Impact (cost)*

I(tot) *: Impact (total)*

Sev *: Severity*

RISK ASSESSMENT

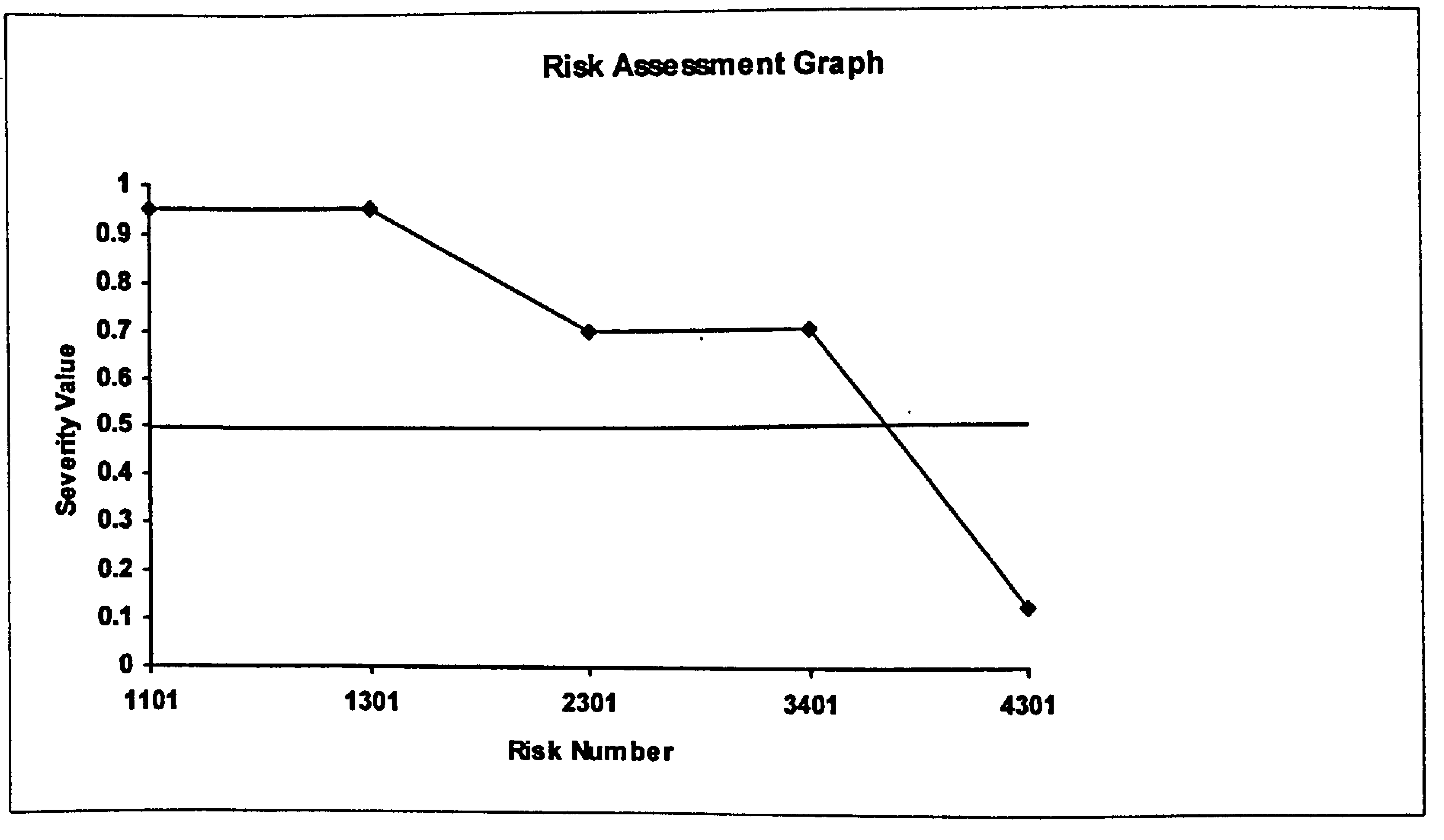
Overall Project Risk = **0.69** **(The sum numeric severity value/No of identified risks)**

The Assesment of the Overall Risk to this Project is = **H**

However

The % Risks Requiring Attention = **80.00**

Number of Active Risks = **4**



APPENDIX 4.

TRACKING TOOL FOR R&T PROJECTS.

Confidence Areas	No.	Statements (measures of performance)	Weighting Level of Importance 0 - 4	Score 0 - 4	Possible Score	Actual Score	% Delivery Confidence	Guideline Statements (Evidence Required
The technology is robust for the customer and the marketplace	1	Market and technology changes that have an impact on this project have been reacted to	3		12	0	0	· Relevant trendlines are available and understood · Impact of possible / likely technology changes are understood
	2	The customers needs are thoroughly understood	3		12	0	0	· Relevant customer learning has been commissioned and captured · The planned deliverables have been validated for the customer
	3	Competitor research is thoroughly understood	4		16	0	0	· Investigation of competitors has been carried out · Patent/IPR search carried out
	4	The technology is completely protected from IPR risks	4		16	0	0	· Patent preventing use have not been taken out (by competitors) · IPR has been taken out
The project will be delivered to meet its objectives	5	The project deliverables have clear performance measures and targets which are achieved	4		16	0	0	· Performance measure and target (1) · Performance measure and target (2)....... · Critical performance parameters have been identified - (1), (2), (3) · The problems, conflicts and constraints in delivering the performance measures have been managed and eliminated
	6	The technology is mature	4		16	0	0	· Technology has been developed to required level of maturity
	7	The obstacles to delivering project objectives in the time have been eliminated	4		16	0	0	· The plans for this project cannot fail to deliver the objectives in the time required · The project is frequently reviewed and controlled
The internal and external (supply) organisation is capable of delivering the objectives	8	The team structure is robust and committed	3		12	0	0	· Project team understands and commits to their project responsibilities · There is sufficient skilled resource to deliver the project to requirements
	9	There is strong leadership for the project	3		12	0	0	· There s high level support for this project · There is an experienced and dedicated (time) project leader
	10	The plans for the project are perfectly robust	3		12	0	0	· The plans have been fully developed · The requirements of the plan are fully achievable
	11	This project can be implemented	2		8	0	0	· The organisation (incl. suppliers) has the skills, tools and processes to use the deliverables of the project · The deliverables can be integrated into the product and manufacturing processes · The project will deliver its quality and cost objectives in the time required for the application
	12	There is full communication with all parties	1		4	0	0	· All relevant parties have been identified · There is efficient communication between project and identified parties
	13	The relationship of the project with Rover and BMW predevelopment is understood and managed	2		8	0	0	· Other impacting pre-developments are identified · Impacts and conflicts are identified and managed
	14	There is long term stability in the allocation of resource to this project	3		12	0	0	
	15	The suppliers / contractors involved are appropriate and trustworthy.	3		12	0	0	· The financial base is secure · We have absolute confidence the contractor/ supplier will deliver to cost, quality and time targets (resource, funding, skills and experience)
					Overall Confidence		#VALUE!	