DEVELOPMENT OF A RISK ASSESSMENT TOOL FOR POST-PROJECT APPRAISAL

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____

Prof. Dr. Canan Özgen
Director

I certify that this thesis satisfies all the requirements as a thesis for the degree of Master of Science.

____

Prof. Dr. Güney Özcebe
Head of Department

This is to certify that we have read this thesis and that in our opinion it is fully adequate, in scope and quality, as a thesis for the degree of Master of Science.

Assoc.Prof. Dr.İrem DİKMEN TOKER
Co-Supervisor

Prof. Dr. Talat BİRGÖNÜL
Supervisor

Examining Committee Members

Asst. Prof. Dr. Metin ARIKAN	(METU,CE)	
Prof. Dr. Talat BİRGÖNÜL	(METU,CE)	
Assoc. Prof. Dr. İrem DİKMEN TOKER	(METU,CE)	
Asst. Prof. Dr. Rıfat SÖNMEZ	(METU,CE)	
Mehmet AYRANCIOĞLU (M.S.)	(AYKONYAPI)	

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Name, Last Name : CANER ANAÇ

Signature :

ABSTRACT

DEVELOPMENT OF A TOOL TO SUPPORT RISK ASSESSMENT AS A PART OF POST-PROJECT APPRAISAL

Anaç, Caner

M.Sc.,Department of Civil Engineering

Supervisor: Prof. Dr. Talat Birgönül

Co-Supervisor: Assoc. Prof. Dr.İrem Dikmen Toker

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As competition in the business environment increases, knowledge management becomes a critical success factor. Firms should be able to gather, analyze and reuse knowledge to support their strategic decisions. Construction firms should also analyze information in hand (completed and on going project data) and make it a part of their learning mechanism. Post-project appraisal is an organizational learning mechanism aiming to form an organizational memory. Organizational memory is a remedy for organizational amnesia, which is a very common problem in the construction industry due to the project-specific nature of the industry and lack of systematic ways to manage knowledge. Particularly, information about risks and their consequences is an important piece of knowledge that the firms should refer to in the forthcoming projects in order not to do the same mistakes.

Risk management comprises of risk identification, analysis and formulation of risk response strategy to maintain an optimum risk-return structure in a project. It is agreed upon by many researchers that, although risk management is accepted as one of the critical success factors for construction projects, project participants generally do not have sufficient knowledge pertinent to risk management concept and the number of tools which facilitate the risk management process is rather low. Typically, companies carry out a risk assessment exercise at the start of a project and the obtained risk ratings are used to determine contingency. However, after the project is over, a final assessment is not usually carried out. The main idea in this study is that, in order to improve the risk assessment process in forthcoming projects, risk assessment should be a part of post-project appraisal. Risk events that actually happened may be classified according to their sources and impacts (monetary/non-monetary) as well as the effectiveness of utilized response strategies. Consequently, companies may learn from what had happened in previous projects and prepare more realistic risk management plans in the future.

The major objective of this thesis is to develop a project risk management information model for risk assessment using historical data in order to improve risk assessment process in forthcoming projects. The framework is modeled to ensure information continuity throughout the project life cycle by storing and reusing project information that resides in risk event databases. The applicability of the developed database system is tested on a real construction project and potential benefits are discussed.

Keywords: Risk Management, Risk Assessment, Post-Project Appraisal

ÖZ

PROJE SONRASI RİSK DEĞERLENDİRMESİNİ DESTEKLEYEN PROGRAM GELİŞTİRİLMESİ

Anaç, Caner

Yüksek Lisans.,İnşaat Mühendisliği

Tez Yöneticisi: Prof. Dr. Talat Birgönül

Yardımcı Tez Yöneticisi: Assoc. Prof. Dr.İrem Dikmen Toker

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İş dünyasındaki rekabetin artması ile beraber, şirketlerin bilgi yönetimi konusundaki becerileri bir kritik başarı faktörü olmuştur. Rekabet avantajı kazanabilmek için gerekli bilginin toplanıp, analiz edilip, tekrar kullanılarak stratejik karar verme sürecinin desteklenmesi gerekmektedir. Benzer şekilde, inşaat şirketleri de, belirlenmiş hedeflerine ulaşmak için ellerindeki bilgileri (tamamlanmış ve devam eden projeler) uygun bir bilgi yönetimi anlayışı ile kullanmak durumundadırlar. Proje sonrası değerlendirme, kurumsal belleği güçlendirmeyi hedefleyen, kurumsal öğrenme mekanizmalarından biridir. Kurumsal belleğin oluşturulması, inşaat sektorünün proje tabanlı yapısı ve bilginin sistematik yönetim eksikliğinden kaynaklanan kurumsal unutkanlık düşünüldüğünde büyük önem arz etmektedir.

Şirketler gelecek projelerde aynı hataları tekrarlamamak için özellikle risk kaynakları ve etkileri ile ilgili bilgilere gereken önemi vermek zorundadırlar.

Risk yönetimi, risklerin tanımlanması, analizi ve bir projede en uygun getiri-risk dengesini sağlayacak stratejilerin geliştirmesi aşamalarından oluşan bir yönetim sistemidir . Risk yönetimi, bir çok araştırmacı tarafından inşaat projelerindeki kritik başarı faktörlerinden biri olarak gösterilse de, sektör katılımcılarının risk yönetimi konusunda yeteri kadar bilinçli olmadığı ve risk yönetimini kolaylaştıracak karar destek sistemlerinin bulunmadığı, bu sebeplerle de risk yönetiminin çoğunlukla sistematik olarak uygulanamadığı bilinmektedir. Genellikle riskler, proje başlangıcında belirlenir, değerlendirilir ve analiz sonuçları bütçeye eklenecek risk primlerini belirlemek amacıyla kullanılır. Proje tamamlandıktan sonra son bir değerlendirme genellikle yapılmaz. Bu çalışmada, bir firmanın ileride gerçekleştireceği projelerde, risk değerlendirmelerinin gerçekçi olarak yapılabilmesi için, proje sonrası değerlendirme aşamasında, gerçekleşmiş olan problemlerin ve risk etkilerinin değerlendirilmesi ve gerekli bilgilerin bir veritabanında saklanması önerilmektedir. Gerçekleşmiş riskler, etkilerine ve kaynaklarına ya da kullanılan stratejilerin etkinliğine göre değerlendirilebilir ve böylece şirketler gelecekteki projeler için daha gerçekçi risk yönetim planları hazırlayabilirler.

Bu tezin amacı, risk değerlendirme sürecinde kullanılabilecek bir bilgi modeli oluşturmaktır. Model, proje süresince proje risk bilgisinin kaydedilmesi ve risk gerçekleşmelerinin veri tabanında saklanması prensibine dayalı, bilgi akış devamlılığı gösteren bir yapı olarak tasarlanmıştır. Geliştirilen veri tabanı sistemi gerçek bir inşaat projesi üzerinde denenmiş ve potansiyel kazanımları irdelenmiştir

Anahtar Kelimeler: Risk Yönetimi, Risk Değerlendirmesi, Proje Sonrası Değerlendirme

To my beloved family

Birsen, Yavuz, İlker and Çiğdem Anaç

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LIST OF ABBREVIATION

ASP	Active Server Pages
BOT	Build Operate Transfer
CF	Cost plus Fee
DSS	Decision Support System
EPC	Engineering Procurement Construction
HEPP	Hydro Electrical Power Plant
HRBS	Hierarchical Risk Breakdown Structure
IDEF	Integrated Definition Language
IDEF0	Integration Definition for Function Modeling
IEC	International Electrotechnical Commission
IFE	Integrated Facility Engineering
IT	Information Technology
JV	Joint Venture
LAN	Local Area Network
LCOF	Life Cycle Objective Functions
LCPRM	Life Cycle Project Risk Management
LS	Lump Sum
MS	MicroSoft
NPV	Net Present Value
OMG	Object Management Group
OMT	Object Modeling Technique
OOM	Object Oriented Modeling
OOSE	Object Oriented Software Engineering
PC	Personal Computer
PM	Project Management
PMBoK	Project Management Body of Knowledge
PMI	Project Management Institute
PRAM	Project Risk Analysis and Management
RAMP	Risk Analysis and Management for Projects

RBS	Risk Breakdown Structure
RFP	Request for Proposal
RM	Risk Management
RR	Risk Rating
SADT	Structured Analysis and Design Technique
SQL	Structured Query Language
UML	Unified Modeling Language
UP	Unit Price
US	United States
USD	United States Dollar
VAT	Value Added Tax
VBA	Visual Basic for Applications
WAN	Wide Area Network
www	world-wide web

CHAPTER 1

INTRODUCTION

Construction industry is a project based industry. Project is a gathering of people for one uniquely defined objective for a limited timeframe. In construction industry, where the learning of organizations is solely depended on project related information, the need for focusing on project success factors has increased. As the global business force companies to position themselves within the global competitive environment, projects tend to be more complex and require a collaboration of different disciplines in a short period of time. With the increase of uncertainties stemming from the characteristics of international undertakings, the necessity for handling uncertainties arose and risk management concept in international and multi-project environment gained significant importance.

Risk management concept mainly consists of identifying, assessing, handling and monitoring phases. Risk has an important role in decision making in an organization. Many researches confirmed the importance of risk management in project management area. Companies mostly focus on the estimation and quantification of risks and uncertainties in early stages of a project whereas they lack further investigation of cause-impact relation of risk management strategies on further stages. The major risk is the lost knowledge at the end of the project (Kazi, 2005). Continuity in knowledge transfer from project level to enterprise level is required for an efficient organizational learning. In Project Body of Knowledge (PMBoK) by Project Management Institute (2000) it has been reported as, the lessons learned from a project, must be documented to become a part of the organizational memory.

In this thesis, the main aim is to develop a project risk management information model for risk assessment using historical data in order to improve risk assessment process in forthcoming projects. The framework is modeled to ensure information continuity throughout the project life cycle by storing and reusing project information in risk event databases.

Chapter 2 reports the findings of a literature survey on risk and risk management and presents general definitions regarding risk management in construction projects. A summary of previously carried out research studies on risk and risk management in the construction industry is presented in this chapter. Some basic information about information model development is also given in Chapter 2.

Developing an information system model requires the investigation of processes in a system, clearing out the information flow throughout processes and choosing the appropriate software implementations. Chapter 3 reports the research methodology and the steps of the model development process. The proposed process model, use case diagram and risk breakdown structure for the developed tool are presented in this chapter.

In Chapter 4, the fundamentals of the developed database structure and its software implementation are illustrated.

Brief information about the implementation of the developed database on a case study is included in Chapter 5. A real construction project is included in this study to demonstrate the applicability of the system. The name of the project is kept anonymous for the sake of confidentiality. Findings of the case study are discussed in this chapter. Sample reports are given in Appendices.

Potential benefits and possible shortfalls of the developed tool are depicted in Chapter 6 as well as the major conclusions of the research study.

CHAPTER 2

LITERATURE REVIEW

2.1 Risk and Risk Management Definitions

Project actions are executed in an environment where uncertainties are inevitable. Uncertainty exists when there is more than one possible outcome to an action but probability of each of them is not known or quantifiable. In most of the cases in construction industry, the source of uncertainty is the lack of information. According to Jaafari (2001) there exist three principal sources of uncertainties in construction: external factors, shifting of business objectives and poorly defined methods for project realization. Due to the unique nature of each construction process, inherent uncertainties and incomplete scope definition, it is almost impossible to have all the needed information at the time of decision-making and mostly decision problems are solved by expert judgment (Ahmad, 1990). Risks are existent when the outcome of a decision making action has more than one possible outcome. In other words the consequences of decision include uncertainties. Risks are closely related to uncertainties and they are generally related to a negative outcome of an event. Unlike uncertainty the outcome of risks can be quantified as the deviation from forecasted values of consequences to realized values of events. Using statistical and historical data, it is possible to assign probabilities to risk outcomes.

Risk and uncertainties appear in various shapes. In projects the objectives are most often related to time, cost, quality, function and client satisfaction (Hillson, 2004). In organizations, depending on the risk management focus, different relations between objectives and definitions of risk exist. The risk definition is therefore highly dependent on the choice of applied management focus in the organization. Project risk is defined as a "combination of probability of an event occurring and its consequences for project objectives", according to the international standard IEC 62198:2001. According to Project Management Institute, PMI (PMBoK, 1996), a definition of risk should consider both the positive and negative effects of a project objective. This definition covers threats and opportunities with their relation to an event or specific condition. Considering the consequences of a risk, it can be categorized in two groups as: dynamic risk and static risk. A dynamic risk is a risk where there could be both positive and negative outcomes. On the other hand, a static risk is related to losses and negative outcome of an event. Despite this theoretic viewpoint, traditional approaches to risk management focus on the negative effects. Dikmen et al (2004) defines risk management as the definition of objective functions to represent the expected outcomes of a project, measuring the probability of achieving objectives by generating different risk occurrence scenarios and development of risk response strategies to ensure meeting/exceeding the preset objectives.

Considering the number of parties involved in a construction project and the external factors affecting on the performance, risk management plays and important role in the success of a project. The need for risk management system is mentioned in Tah and Carr (2000) as "construction projects are becoming increasingly complex and dynamic in their nature and the introduction of new procurement methods means that many contractors have been forced to rethink their approach to the way that risks are treated within their projects and organizations". An effective risk management system requires the clear understanding of risk sources and macro environmental effects which could only be dealt with systematic approaches. Chapman and Ward (1997) states that the main objective or risk management is to remove or to reduce the possibility of performance loss. Risk management reaches this goal by systematic identification, appraisal and management of project related risks.

In PMBoK(2000) by PMI, risk management is declared as one of the nine functions of project management along with integration, communication, human resources, time , cost, scope, quality and procurement management. PMI classifies risk management processes into four: identification, quantification, response development, and response control.

In risk identification phase, risks that affect the organization or project objectives are identified and documented. Identification process is a continuous process which is repeated throughout the project lifetime.

Risk quantification process, also known as risk assessment phase, involves the evaluation of risks' involvement and interaction with the outcomes of the project outcomes. After this phase significant risk factors are determined. Insignificant risk items are eliminated and a backbone structure for response strategies is determined. Tah and Carr (2000) defines this stage as risk analysis process where various aspects of each risk – likelihood, severity and timing, together with the risk dependency chains are used to determine the effects of the risks on the project and the tasks within the project.

Risk response development stage involves definitions of steps for response of risk events. Responses generally fall into three main categories: avoidance, mitigation and acceptance. At this phase of risk management, company attitude towards risk handling and understanding of risk items play a vital role. Success of a project depends on the accordance of the project outcomes with the company business objectives. This phase finalize the risk management plan to respond the foreseen risks.

Finally risk response control phase checks the effectiveness of risk response action plan throughout the lifetime of a project. This phase involves the monitoring and additional risk response development.

Risk management literature has different ways to define risk management process. There is no common definition on the scope of risk analysis, risk management or risk process. It is therefore explicitly explained in the following chapters how RM process is chosen in this thesis.

2.2 Learning From Risks

In an economy where the only certainty is uncertainty, the one source of lasting competitive advantage is knowledge (Nonaka, 1994). Construction Industry is a project based industry and companies need to systematize learning frameworks through project information. As Ozorhon et al (2005) states, organizational learning is a conscious activity in the organizational context and the most important source of learning is the project related activities that constitute one's own experiences. Also Schindler and Eppler (2003) argues that "the systematic retention of project experiences enables a company to compare its various projects more systematically and document its most effective problem solving mechanisms".

Garvin (1993) states five main activities for a successful learning organization: systematic problem solving, experimentation with new approaches, learning from their own experience, best practices of others, transferring of knowledge quickly and efficiently through the organization. Companies should be able to create standardized procedures for the case of problem solving. As an example, quality management system rules' main focus is this standardization of procedures and documentation. In today's rapidly changing business environment the need for improvement in technology and new methodologies is growing everyday. To be innovative, companies should be able to create internal knowledge on past experience in the business. Experience in the business consists mainly of company's own background, in other words internal sources, or the best practices of other competitors, external resources. A company must be capable to manage this knowledge either by codifying and keeping it available for further access through databases or by personalizing knowledge to share through personal interaction (Hansen et al, 1999).

Project knowledge includes the technical knowledge concerning the product, its parts and technologies, procedural knowledge concerning the producing and using the product and organizational knowledge concerning communication and collaboration between the work teams (Kasvi, 2003).

Learning methods are required for successful representation of historical project data and storage of information for further usage. Schindler and Eppler (2003) classifies the debriefing methods into two classes as:

- Process Based Methods which relate to the processes and their sequence in the course of a project life

- Documentation Based Methods focus on aspects of counter wise representation of the experience and the storage of contents within an organization.

Documentation based learning methods can be listed as:

- Project Evaluation: Action of documenting the project experiences throughout the project life (cited Ozorhon et al, 2005)

- Micro Articles: A method to record the experiences of people involved in the project. This knowledge includes cause and effect relation as well as solutions to problems and stored in databases. The scope of a micro article is generally limited to half a page. The framework of a micro article consists of a topic, introductory short description and a keyword part.

- Learning histories: A method for listing of chronological progress and actions taken including the results of decisions. This information is written down on a 20 to 100 page report by one person referring to other project members' experiences.

- Formation of case bases using computer programs is the collection of each employee's experience in one unique system. Formation of case bases related to project's critical success factors, results or productivity and performance values are the examples of this method.

Schindler and Eppler (2003) also figured out two process-based methods:

- *Post-Project Appraisal* is the name of a method published by Frank A. Gulliver. It represents a special type of project review that includes a strong learning element. Post-Project Appraisal is a documentation method performed by external post-project appraisal unit usually two years after project completion that covers all project information and results of strategic decisions to learn from mistakes and transfer knowledge.

- *After Action review*, originally developed by US Army, is a collection and storage mechanism performed after each decision stage that covers the answers to questions like "what was supposed to happen", "what actually happened", "why there were differences" and "what can be learned from this experience".

In project oriented companies generally looking forward to new projects is more appealing than to orient the causes of problems in past projects. Post benefits of project reviews are generally overlooked and past information is lost. People can be reluctant to engage in activity that might lead to blame, criticism or recrimination. (Argyris, 1977).

2.3 Risks in a Project Environment

The major risk in construction companies is the knowledge loss at the end of the project and resulting organizational amnesia (Dikmen et al, 2005). Tah and Carr (2000) clearly states that the success of a project is dependent on the extent, to which the risks that affect it can be measured, understood, reported, communicated and allocated accordingly. On projects in a stable business environment, uncertainty is high at the time of the project conceptualization and will be lowered with proactive planning and efficient decision making (cited Jaafari, 2001). However complex projects and changing conditions in the business environment forces companies to focus on a continuous investigation of project variables and re-evaluation of the status of objective function (Drummond, 1999). The variation on the project variables will cause changes on uncertainties exposed to risks. New risks can be encountered due to this fuzziness. Strategic decision making procedures foreseen in the early stages of the project can be subjected to change in time. Against this background of complexity and uncertainty the challenge is to pursue project objectives earnestly and to look for opportunities to further improve the project's base value (Jaafari, 2001).

The architecture for RAMP follows a more complex multilevel breakdown structure. The top-level processes within this structure are process launch, risk review, risk management and process closedown. The lower-level processes break these down further.

All approaches to risk management emphasize the need to identify risk sources at the outset. This involves determining what risks may be present and classifying them appropriately.

Cooper and Chapman (1987) chose to classify construction risks by their nature and magnitude, categorizing the risks into two major groups: primary and secondary. Tah et al. (1994) used a risk breakdown structure according to their origin and their impact location within the project.

External risks are those which are relatively uncontrollable, including inflation, currency exchange rate fluctuations, legislative changes, and ‘acts of God’. Because of their uncontrollable nature, there is a need for the continual scanning and forecasting of these risks and for the development of a company strategy for managing and controlling the effects of external forces. Internal risks are relatively more controllable and will vary between projects. Examples of internal risks include resource availability, experience in the type of work, the location of the project, and the conditions of contract. Internal risks have been separated into two subgroups: global risks, which affect the project itself and cannot be associated with individual tasks or work packages; and local risks, which affect individual work packages within a project.

2.4 Previous Studies on Risk Management in Construction

Risk Management is a process of systematically identification, analysis and response to risk items. The aim of this process is to minimize the impacts of risks on projects objectives by elimination or sharing of risks. The construction industry is considered to be more risky basically because of nature of the product, construction projects. The number of involved parties in a project, determinants of demand and the vulnerability of environmental conditions to changes are considered as factors defining the risks in construction industry. Risk management in construction has been always considered as an important topic for research. Researches generally focused on developing of process models for risk management.

2.4.1 Project Risk Analysis and Management (PRAM)

One of the well known researches on this concept is Project Risk Analysis and Management (PRAM) developed by the Association of Project Managers. As

Chapman and Ward (1997) describes, PRAM defines nine phases of risk process. Identification is the first phase of PRAM which involves the statement of project objectives, scope, activities and time schedule. In this phase all key information about a project is documented. Second phase is focus phase which mainly defines and plans the processes in a risk management system. Responsibilities in a risk management system (who does what etc) are documented in this stage. Chapman and Ward (1997) argues that risk response should be identified to understand the impact of first iteration through process. In Risk Identification phase, risk sources and impacts are defined and classified. Identification forms a base for response generation required for risk management systems. Structure phase is the fourth phase that verifies the assumptions made and defines interactions between risks, project actions and responses. The key deliverable of structure phase is a clear understanding of the implications of any important simplifying assumptions between risks, responses, and base plan activities (cited Arikan 2005). Ownership phase defines the associations of risk between parties and within parties. Responsibilities for early defined response strategy are distributed throughout management. The aim of ownership phase is basically to provide efficient project management. After the structuring and definition of responsibilities, performance of the projects has to be measured. Estimate phase involves the identification of these measures regarding a reference plan including the uncertainty. This phase forms an understanding of important risks and responses which have impact on project performance measures. Simple numeric probability assignments are done in this phase for the risk chosen in the reference response plan. Evaluation phase starts after estimation, aiming to evaluate the results of estimation phase. In evaluation phase risks are converted into potential problems that must be considered in contingency plans. Plan phase related all delivered risk management process information to project management processes using implementation details such as timing, precedence, ownership and resource usage etc (cited Arikan, 2005). Management phase is the final phase of PRAM that monitors the progress of project and the proposed risk management plans. Revision of response plans is done in case of any deviation from projected plans. Detailed output reports or risk response issues are prepared for the attention ongoing management.

2.4.2 Risk Analysis and Management for Projects – (RAMP)

A more recent approach by the Institution of Civil Engineers and Faculty and Institute of Actuaries (1998) resulted in a more comprehensive process of Risk Analysis and Management for Projects (RAMP), designed to cover the complete project lifecycle (cited Tah and Carr, 2000). RAMP uses a multilevel breakdown structure.

RAMP methodology involves mainly four main activities. These activities are namely, process launch, risk review, risk management and process closedown. Lower level processes break these main activities further down. These activities are executed on different phases of a project. The first and last activities namely, process launch and process close down, each performed once whereas risk reviews are executed several times in essential times of a project and depending on these reviews risk management activities follow a continuous cycles.

Process launch involves the supplementary documentation and preparation for objective definitions and scope development for risk analysis and management. This task is executed at the investment stage aiming to define general objective, scope and timing of investment. Provisional overall strategy for risk review and management activities in the lifecycle of the investment, are stated. Scope of reviews and the stages where the reviews are required in what detail are considered at this stage.

Definition of overall strategies for risk management and overview of project management involving the project stages are considered in this part of RAMP. People involvement has significant importance at this stage because responsibility definitions and life cycle planning of project is done at this stage.

One of the risk management activities or RAMP is risk identification. The aim of this phase is to identify all significant risk factors, sources and uncertainties associated with each project objective. This phase starts with listing of risks without the use of checklists or prompts. Following this, risks are listed in risk register for subsequent review and analysis, with a tentative indication of the significance of each risk and interrelations in between. It is suggested a brainstorming session is carried out for extensive identification and revision of risks. After identification phase comes the risk analysis which aims the assessment of qualitative and quantitative values for likelihood of risks per unit of time, potential consequences of risks, timing of the risk's impact and the acceptance score, by combining the likelihood with the consequence using risk assessment tables. It is important to start with a natural or convenient basis for estimation, and link this to a life-cycle estimate. If there is a range of possible values, it may be acceptable, to represent the range by its mid point or average value. If a risk is related to one or more other risks -in the sense that they share common causes or for other reasons the occurrence of one affects the likelihood of another- the related risks should be evaluated together. The resulting assessment of each risk or group of related risks should be entered in the risk register.

The significance of risks should be reviewed and then they should be reclassified into the categories of significance. For risks, which are 'probably insignificant', the decision must be made as to whether they can be ignored.

Mitigating risks, or lessening their adverse impacts, is at the heart of the effective management of risk. Unfortunately in business activities risk mitigation is sometimes undertaken only at a rather superficial level. If more attention were paid to it, fewer business activities would end in disaster. It is not sufficient just to 'take a margin' for risk, since this results in little risk mitigation being done. If implemented correctly a successful risk mitigation strategy should reduce any adverse variations in the financial returns from a project. However, risk mitigation itself, because it involves direct costs like increased capital expenditure or the payment of insurance premiums, might reduce the average overall financial returns from a project; this is often a perfectly acceptable outcome, given the risk aversion of many investors and lenders. Risk mitigation should cover all phases of a project from inception to close-down.

There are four main ways in which risks can be dealt with within the context of a risk management strategy. Risks can be;

- Reduced or eliminated
- Transferred
- Avoided
- Absorbed or pooled.

There is also the question of whether it is worth carrying out research to reduce uncertainty.

The investment submission on which the decision to proceed or not will be based should bring together

- a description of the project and its baseline
- a description of the most significant risks and how it is proposed to mitigate them
- a description of the residual risks and the effect they will have on net present value (NPV)
- if there are significant alternative options, a recommendation on which should be chosen
- a recommendation on whether the project should proceed
- matters outside the scope of RAMP.

The final stage is to obtain formal approval from the client and any other key stakeholders for proceeding with the project. The decision-makers will take account of both the arithmetical results obtained and a range of intangible factors.

The key task at this stage of RAMP is the monitoring of risks included in the residual risk analysis, risk mitigation strategy and the risk response plan. Other risks also need to be monitored regularly including those in the remaining stages of the investment life-cycle – not only the risks occurring in the present stage. Any significant changes in risk or new risks should be reported and assessed immediately.

Regular monitoring of risks can be undertaken by studying events, situations or changes (sometimes called 'trends'), which could potentially affect risks during the normal management and progress of an investment. These trends must be systematically identified, analyzed and monitored on a regular basis by scrutinizing reports, letters, and notes on visits, meetings and telephone conversations. The results are entered in trend schedules. Ideally, these should be considered at regular progress meetings involving key members of the management team. Finally, the fundamental merits of the investment -whether or not it is worthwhile -should be continually assessed and a risk review set in hand when events occur which appear to have significantly altered the risk profile of the project.

At the end of the investment life-cycle, or on prior termination of the project, a retrospective review will be made of the investment and of the contribution and effectiveness of the RAMP process itself as applied to the investment.

The risk process manager, in conjunction with the client's representative, will first evaluate the performance of the investment, comparing its results with the original objectives. Using risk review reports and the risk diary, an assessment will be made of the risks and impacts which occurred in comparison with those anticipated, highlighting risks which were not foreseen or grossly miscalculated.

The risk process manager will then critically assess the effectiveness of the process and the manner in which it was conducted for this investment, drawing lessons from the problems experienced and suggesting improvements for future investments. The results of the review will be recorded in a RAMP close-down report, which can be easily referred to for future investments. Copies of the report should be circulated to all parties involved and then signed off by every party as an agreed record of events.

Some projects will be terminated as soon as the initial risk review has been completed, because the risk-reward ratio is not deemed to be sufficiently attractive, and other projects will be terminated before the end of their planned life-cycle because of adverse developments. The production of a RAMP close-down report as a guide for other projects is likely to be particularly valuable in these circumstances because the most critical events in the history of the project will have occurred recently.

The PRAM and RAMP approaches attempt to overcome the informality of most risk management efforts.

2.4.3 Project Management Book of Knowledge (PMBoK)

Project Management Institute (PMI) published Project Management Book of Knowledge in 1996. PMI is an organization focused on the needs of project management worldwide. PMBoK that combines the knowledge included in a project under nine functions of project management is published with revisions in 2000. Risk management is one of the nine functions defined by PMBoK. According to PMBoK risk management includes four processes namely: risk identification, risk quantification, risk response development and risk response control. Although the processes are defined separately, they are overlapping, interacting with each other and other fields of project management knowledge.

In PMBoK, risk identification process aims to determine and document the risks most likely to affect the project objectives. This is a continuous process which should be carried out throughout the project.

Risk identification is defined as identifying causes and effects, as other researchers defined. Identification phase gets input factors, like project description, planning outputs and historical data, and aims to convert these factors to identified facts like risk sources, potential risk events, risk symptoms which will be used as input for further processes. This conversion is executed using tools and techniques like, checklists, flowcharting and interviewing.

Project description identifies the nature of the project which has major effects on the risk involvement of the project. A project requiring an innovational approach for execution will definitely contain greater risk. Risk association of projects are usually described in terms of schedule or cost impacts. Some other planning outputs in knowledge field can be reviewed to identify potential risks. Some of the well known project management aspects can be listed as work breakdown structures, cost and time estimates, labor planning and procurement plan. Last important but not the least important input for risk identification is historical information. Historical background of actual events happened in previous projects can have a significant help in identifying potential risks and opportunities. Historical information is available through project files, commercial databases or project team knowledge. Such information collections as team knowledge, is more reliable if documented using learning mechanism such as post-project appraisals or after action reviews. Documentation can relate project files with personal knowledge which will result in clearer identification of cause and effect relations.

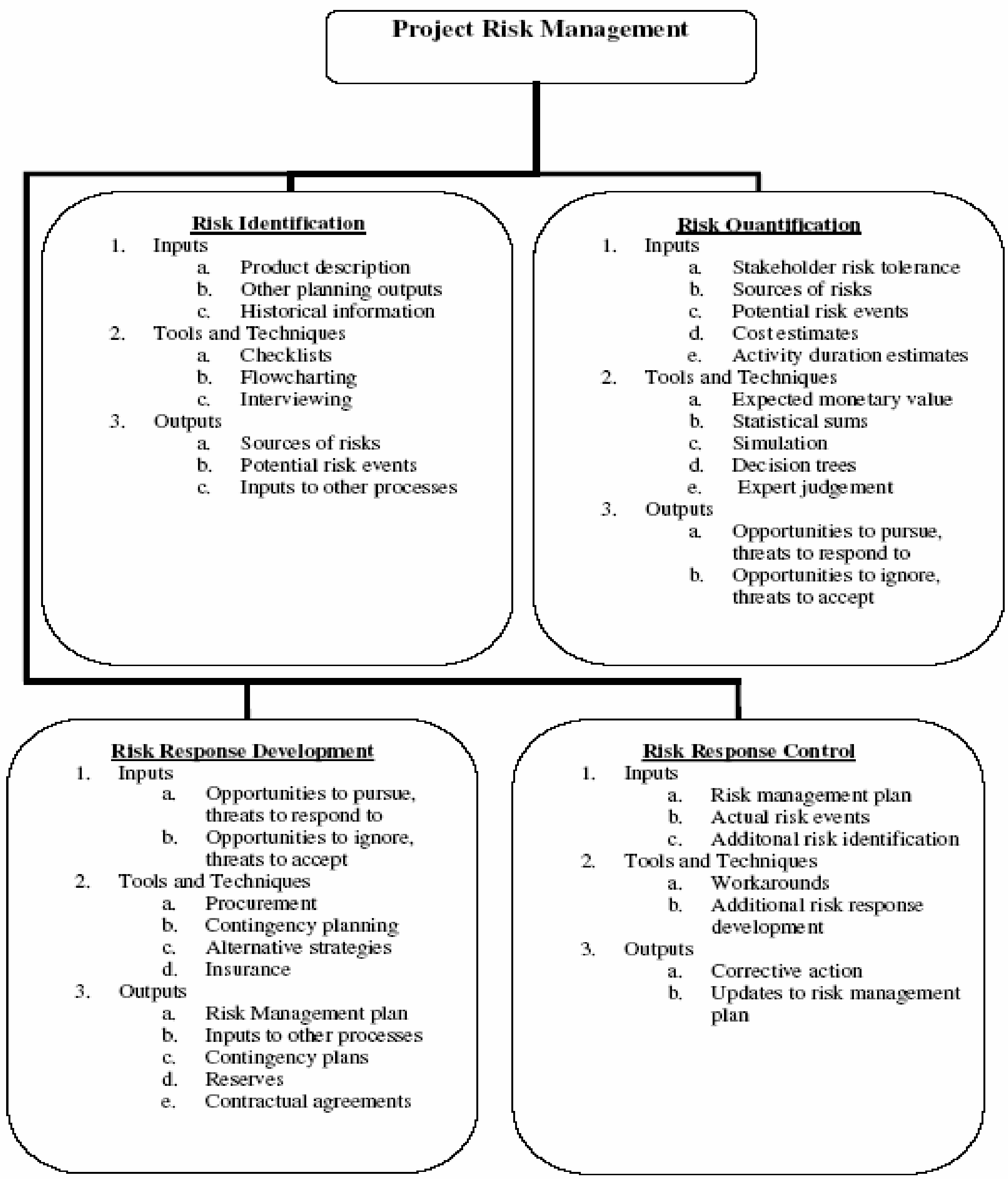

Figure 2.1. Project Risk Management (overview of PMBoK)

Checklists are typically organized by source of risk. Sources include the project context, other process outputs, the product of the project or technology issues, and internal sources such as team member skills. Another tools for risk identification is flowcharting which can help the project team better understand cause and effect of risks. Also risk-oriented interviews with various parties involved in the project may help to identify risks not identified during normal planning activities.

Risk identification aims to identify the risk sources which are categories of possible risk events that have effect on the outcome of the project objectives.

Common risk sources include changes in requirements, design errors, poorly defined roles and responsibilities, poor estimates, unskilled staff etc. Description of risk should generally include estimates of probability that a risk event from that source will occur, the range of possible outcomes, expected timing and anticipated frequency of risk events from that source. Another output from identification phase is potential risk events. They are discrete occurrences such as a natural disaster or departure of a specific team member that may affect the project. Probabilities and outcomes made during the early project phases are likely to have broader range that those made later in the project or after the project appraisal. Identification phase points out the risk symptoms which are indirect manifestation or actual risk events.

Risk quantification is the second process defined in PMBoK. Quantification stage includes evaluation of risk and risk interactions to asses the risk outcomes. Various factors such as interaction of opportunities and threats in an unanticipated way, multiple effects of a single risk event, or false impression of precision and reliability of the mathematical techniques etc make risk quantification process complicated (cited Arikan 2005). Several techniques defined in PMBoK as risk quantification tools. Expected monetary value which is the product of risk event probability and risk event value, statistical sums, simulations, decision tress or expert judgments can be listed as examples of theses techniques. The major output from quantification stage is the list of opportunities that should be pursued and threats that require attention. Risk quantification should also document the sources of risk events and decisions that management has decided to accept or ignore.

Third process is response development which covers the steps for opportunities and responses to threats. Responses are categorized in three main groups: *Avoidance*, which is eliminating the specific threat, *Mitigation*, which is reducing the monetary and/or risk event value of a risk by reducing the probability of occurrence, and *Acceptance*, is accepting the consequences in a contingency plan. Tools and techniques for risk response can be given as procurement planning, contingency planning, and insurance. Response development phase mainly defines the steps and responsibilities occurrence of a risk event. Outputs of risk response development are risk management plans that document the procedures to deployed to manage risk throughout the project, contingency plans which are pre-defined actions steps to be taken and are generally a part of risk management plans, and reserves that are provisions in the project to mitigate cost and/or time related risks.

Final process in PMBoK is the risk response control process. Risk response control involves the execution of risk management plan in order to respond to risk events during the lifecycle of the project. Any change in the risk management process is required the repetitions of identification, quantification and respond process are executed. Tools and techniques defined for response control process are workaround which are unplanned responses to risk events, and additional risk response development, that involves repetition of risk development process due to an inadequate response plan. Corrective actions and updates to risk management plan are the outputs of risk response control process.

In PMBoK approach the risk management process are consecutive and dependent. Outputs and inputs of different processes show a significant reliance. These relations between processes enables the information flow in between and preserve the continuity of overall system throughout the life time of a project.

2.4.4 Recent Research on Construction Risk Management

Recent researches focus on the implementation of these models in practice rather than development. Main discussion of these researches is definition of critical success factors in efficient implementation of these process models. One of the recent researches is carried out by Tah and Carr (2000), which focuses on vital role of common language and an information model for the risk management process. According to Tah and Carr (2000), due to lack of a common language and common process model in which risks and responses are identified, analyzed and dealt with in a pre-defined way, individuals use different methodologies as well as terminologies leading to informality of the RM process. A common language to define risk and related measures in a construction delivery cycle is required. They developed a Hierarchical Risk Breakdown Structure (HRBS) which provides the basis for classifying risk within a project and a risk catalogue that is collection of risks that have been defined using common language and the HRBS. The hierarchical risk breakdown structure proposed by Tah and Carr (2000) is given in Figure 2.2.

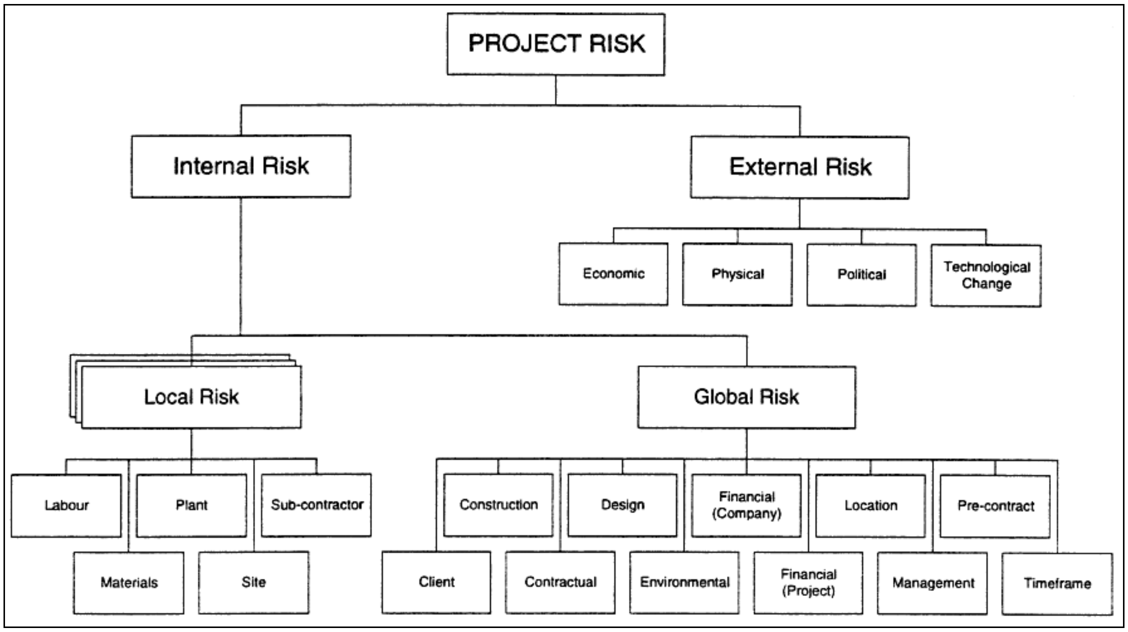

Figure 2.2. The hierarchical risk breakdown structure (Tah and Carr, 2000)

Risks are divided in different groups by HRBS according to their relation to management of internal sources or external environment. External risks are the ones which are uncontrollable and internal risks are relatively more controllable. Furthermore, a common typology for describing risks, is developed which allows risks to be defined using five terms: type, scope, centre, risk and risk factor. a part of the risk catalogue developed by Tah and Carr (2000) is shown in Table 2.1. Furthermore, by using IDEF0 and UML (unified modeling language) modeling techniques, they developed a risk management process model that consists of identification, assessment, analysis, handling, and monitoring processes.

Table 2.1. Part of risk catalogue (Tah and Carr, 2000)

HRBS code	Risk type	Risk scope	Risk centre	Risk	Risk factor
R.1.1.01.003.007	Internal	Local	Labour	Availability	Availability of labour
R.1.1.01.061.004	Internal	Local	Labour	Productivity	Accidents
R.1.1.01.061.065	Internal	Local	Labour	Productivity	Fatigue
R.1.1.01.061.076	Internal	Local	Labour	Productivity	Industrial relations
R.1.1.01.061.108	Internal	Local	Labour	Productivity	Morale
R.1.1.01.061.109	Internal	Local	Labour	Productivity	Motivation
R.1.1.01.061.124	Internal	Local	Labour	Productivity	Productivity of labour
R.1.1.01.061.144	Internal	Local	Labour	Productivity	Safety
R.1.1.01.061.147	Internal	Local	Labour	Productivity	Sickness
R.1.1.01.064.130	Internal	Local	Labour	Quality	Quality of labour
R.1.1.02.003.010	Internal	Local	Plant	Availability	Availability of plant
R.1.1.02.061.125	Internal	Local	Plant	Productivity	Productivity of plant
R.1.1.02.072.018	Internal	Local	Plant	Suitability	Breakdown
R.1.1.02.072.155	Internal	Local	Plant	Suitability	Suitability
R.1.1.03.003.008	Internal	Local	Material	Availability	Availability of material
R.1.1.03.072.156	Internal	Local	Material	Suitability	Suitability of material
R.1.1.03.073.040	Internal	Local	Material	Supply	Damage in storage
R.1.1.03.073.041	Internal	Local	Material	Supply	Damage in transportation
R.1.1.03.073.157	Internal	Local	Material	Supply	Material supply
R.1.1.03.073.171	Internal	Local	Material	Supply	Wastage

According to another approach by Jaafari (2001), project risk assessment must be based on assessing the likelihood of achieving project's strategic objectives rather than a collection of individual assessment of project risks. Risk should be seen as a component of all decisions made continually to respond to project dynamics. In addition, the business objectives, scope, and method of execution should be clearly understood to reduce uncertainties associated with the project.

Jaafari defines key success factors for a successful project management as:

- *Recognition and proactive management of complexities :* Complexity is created by the environment and parties' influence on the project along with the inter relations between project's hardware and software parts.
- *Strategy-based decision making :* Management of projects must deal with real time evaluation and decision making to ensure project does not deviate from strategic objectives.
- *Integration of project phases :* Information should be integrated through out the project life time to maximize the project outcomes relevant to business goals.

- *Inclusion of environmental variables :* Generally the influence of environmental variables on the project is misinterpreted by project management whereas, a clear understanding of these variables is vital for the success of a project management process.

Furthermore, Jaafari (2001) states that life cycle objective functions (LCOF) must be formulated as the vehicle for analysis and management of risks. These principles form the basic structure of life cycle project risk management (LCPRM). All the risks and rewards are defined considering strategic objectives and corporate functions as this approach is a strategic approach. All project decisions are based on all project life cycle information which is generated, integrated, shared and accessed by teams throughout the project life cycle. The system provides a holistic approach to project variables and execution of project management functions using LCOFs as the basis for evaluation. All these issues form The Integrated Facility Engineering (IFE), which provides a consistent framework for interdisciplinary communication throughout the project. This system supports scenario analysis and offers an integrated environment to effectively and interactively apply "What-if" planning; and integrates the management of the processes of planning, engineering, documentation, procurement, and construction management throughout the project lifecycle. Figure 2.3 illustrates the IFE architecture.

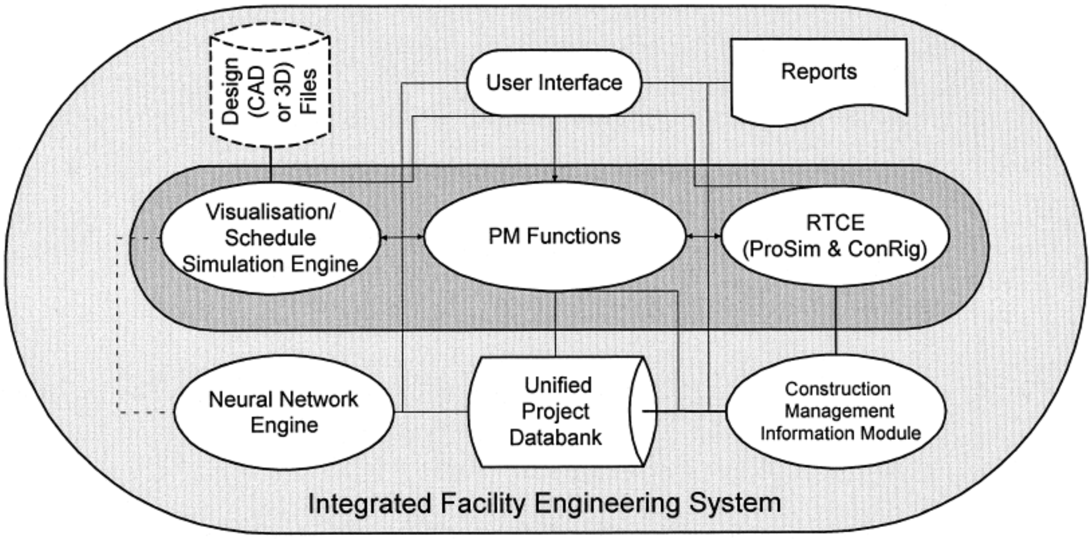

Figure 2.3. IFE Architecture by Jaafari (2001)

2.5 Research Review on Development of Information Model

A model is a representation of a set of components of a system or subject area. The model is developed for understanding, analysis, improvement or replacement of the system. Systems are composed of interfacing or interdependent parts that work together to perform a useful function. System parts can be any combination of things, including people, information, software, processes, equipment, products, or raw materials. The model describes what a system does, what controls it, what things it works on, what means it uses to perform its functions, and what it produces.

IDEF is the Integrated Definition language which was developed as a standard method of documenting and analyzing business processes. The aim is to maximize productivity by means of graphical approaches to system description. IDEF is a well documented robust standard whose documentation is freely available and standardized. IDEF is industry and technology independent and has proven to be applicable in almost every possible context of system development. The technique involves limited notations and graphical approach which decrease complexity and thus increase understandability and communication.

In 1981 the US Air Force Program for Integrated Computer-aided Manufacturing (ICAM) standardized and made public a number of IDEF modeling Techniques (Cited Tah and Carr, 2000). These are IDEF0 which is used to produce function models, IDEF1 which is used to produce information model and IDEF2 which is used for dynamics model. Process model for proposed system in this study is done by using IDEF0.

2.5.1 Integration Definition for Function Modeling – IDEF0

IDEF0, used to produce a "function model". A function model is a structured representation of the functions, activities or processes within the modeled system or subject area. IDEF0 (Integration Definition language 0) is based on Structured Analysis and Design Technique (SADT), developed by Douglas T. Ross and SofTech, Inc. In its original form, IDEF0 includes both a definition of a graphical modeling language (syntax and semantics) and a description of a comprehensive methodology for developing models. IDEF0 may be used to model a wide variety of automated and non-automated systems. For new systems, IDEF0 may be used first to define the requirements and specify the functions, and then to design an implementation that meets the requirements and performs the functions. For existing systems, IDEF0 can be used to analyze the functions the system performs and to record the mechanisms by which these are done.

The result of applying IDEF0 to a system is a model that consists of a hierarchical series of diagrams, text, and glossary cross-referenced to each other. The two primary modeling components are functions that are represented on a diagram by boxes, the data and objects that inter-relate those functions which are represented by arrows.

As a function modeling language, IDEF0 has the following characteristics:

- It is comprehensive and expressive, capable of graphically representing a wide variety of business, manufacturing and other types of enterprise operations to any level of detail.
- It is a coherent and simple language, providing for precise expression and promoting consistency of usage and interpretation.
- It enhances communication between systems analysts, developers and users through ease of learning and its emphasis on hierarchical exposition of detail.
- It can be generated by a variety of computer graphics tools; numerous commercial products specifically support development and analysis of IDEF0 diagrams and models.

2.5.1.1 Syntax

The structural components and features of a language and the rules that define relationships among them are referred to as the language's syntax. The components of the IDEF0 syntax are boxes, arrows, rules, and diagrams. Boxes represent functions, defined as activities, processes or transformations. Arrows represent data or objects related to functions. Rules define how the components are used, and the diagrams provide a format for depicting models both verbally and graphically. The format also provides the basis for model configuration management.

A box provides a description of what happens in a designated function. A typical box is shown in Figure 2.4. Each box shall have a name and number inside the box boundaries. The name shall be an active verb or verb phrase that describes the function. Each box on the diagram shall contain a box number inside the lower right corner. Box numbers are used to identify the subject box in the associated text. A function name is a verb or a verb phrase. A box number is shown.

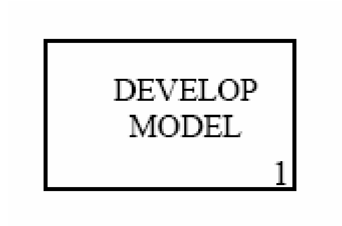

Figure 2.4. Sample Box Syntax for IDEF0

An arrow is composed of one or more line segments, with a terminal arrowhead at one end. As shown in Figure 2.5, arrow segments may be straight or curved (with a 90 degrees arc connecting horizontal and vertical parts), and may have branching (forking or joining) configurations.

Arrows do not represent flow or sequence as in the traditional process flow model. Arrows convey data or objects related to functions to be performed. The functions receiving data or objects are constrained by the data or objects made available.

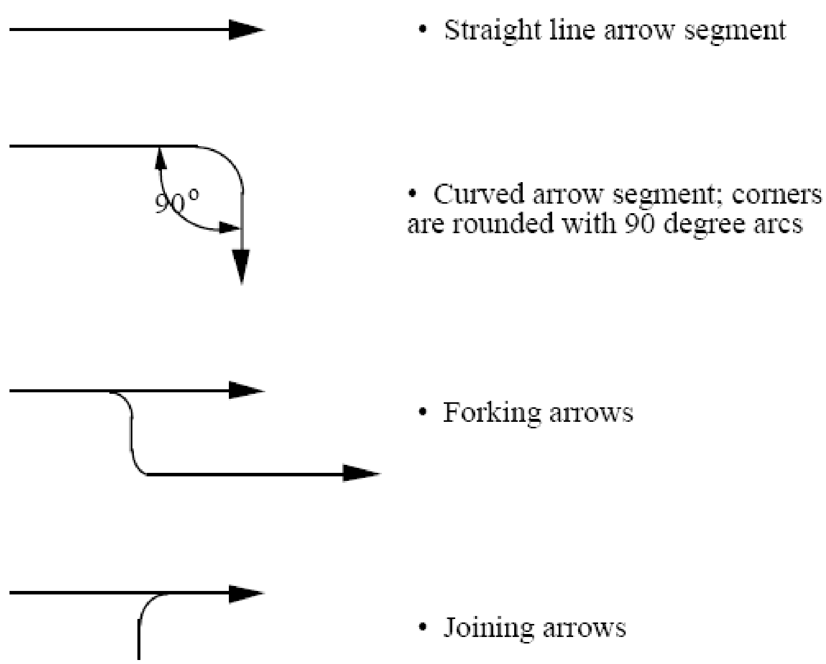

Figure 2.5. Arrow Syntax for IDEF0

2.5.1.2 Semantics

Semantics refers to the meaning of syntactic components of a language and aids correctness of interpretation. Interpretation addresses items such as box and arrow notation and functional relationship interfaces.

Each side of the function box has a standard meaning in terms of box/arrow relationships. The side of the box with which an arrow interfaces reflects the arrow's role. Arrows entering the left side of the box are inputs. Inputs are transformed or consumed by the function to produce outputs. Arrows entering the box on the top are controls. Controls specify the conditions required for the function to produce correct outputs. Arrows leaving a box on the right side are outputs. Outputs are the data or objects produced by the function.

Arrows connected to the bottom side of the box represent mechanisms. Upward pointing arrows identify some of the means that support the execution of the function. Other means may be inherited from the parent box. Mechanism arrows that point downward are call arrows. Call arrows enable the sharing of detail between models (linking them together) or between portions of the same model. The called box provides detail for the caller box. Standard positions are shown on Figure 2.6.

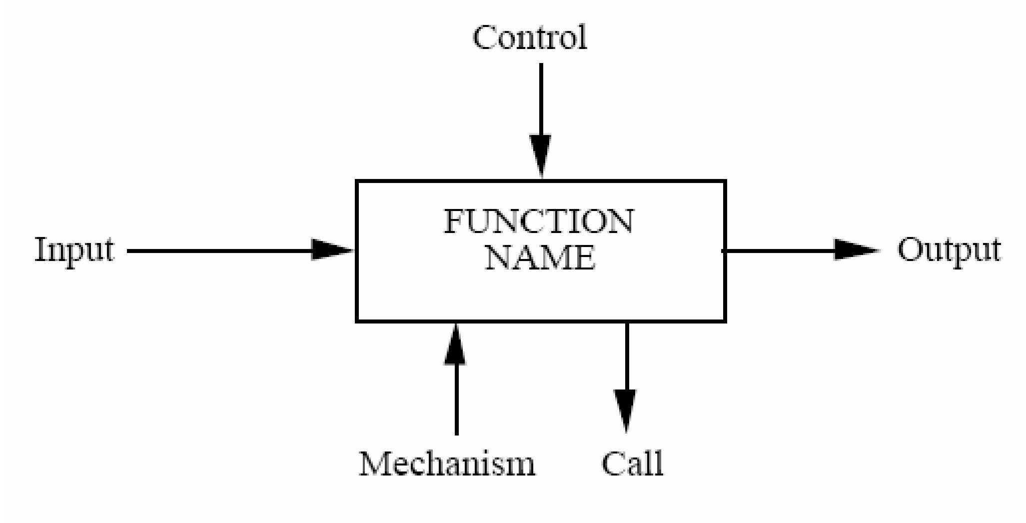

Figure 2.6. Arrow positions and roles in IDEF0 Diagram

2.5.2 Unified Modeling Language (UML)

2.5.2.1 Historical Background

UML is a language for specifying, visualizing, constructing, and documenting the artifacts of a system intensive process. (Alhir, 2003) Identifiable object-oriented modeling (OOM) languages began to appear between mid-1970 and the late 1980s as various methodologists were using different approaches to object-oriented analysis and design (Larman, 1998). The number of identified modeling languages increased from less than 10 to more than 50 during the period 1989-1994. Many users of OOM had trouble finding complete satisfaction in any one modeling language. By the mid-1990s, new iterations of these methods began to appear and these methods began to incorporate each other's techniques, and a few clearly prominent methods emerged. (Hunt, 2000)

The development of UML began in late 1994 when Grady Booch and Jim Rumbaugh of Rational Software Corporation began their work on unifying the Booch and OMT (Object Modeling Technique) methods. In the fall of 1995, Ivar Jacobson and his Objectory company joined Rational and this unification effort, merging in the OOSE (Object-Oriented Software Engineering) method. Booch, Rumbaugh, and Jacobson released the UML 0.9 and 0.91 documents in June and October of 1996. During 1996, the UML authors invited and received feedback from the general community. They incorporated this feedback, but it was clear that additional focused attention was still required. (Hunt, 2000)

While Rational was bringing UML together, efforts were being made on achieving the broader goal of an industry standard modeling language. In early 1995, Ivar Jacobson and Richard Soley put more effort to achieve standardization in the methods marketplace. In June 1995, an OMG-hosted meeting of all major methodologists (or their representatives) resulted in the first worldwide agreement to seek methodology standards, under the aegis of the OMG process. (Hunt, 2000)

During 1996, it became clear that several organizations saw UML as strategic to their business. A Request for Proposal (RFP) issued by the Object Management Group (OMG) provided the catalyst for these organizations to join forces around producing a joint RFP response. Rational established the UML partners consortium with several organizations willing to dedicate resources to work toward a strong UML 1.0 definition. Those contributing most to the UML 1.0 definition included: Digital Equipment Corp., HP, i-Logix, IntelliCorp, IBM, ICON Computing, MCI Systemhouse, Microsoft, Oracle, Rational Software, TI, and Unisys. This collaboration produced UML 1.0, a modeling language that was well defined, expressive, powerful, and generally applicable. This was submitted to the OMG in January 1997 as an initial RFP response.

In January 1997 IBM, ObjecTime, Platinum Technology, Ptech, Taskon, Reich Technologies and Softeam also submitted separate RFP responses to the OMG. These companies joined the UML partners to contribute their ideas, and together the partners produced the revised UML 1.1 response. The focus of the UML 1.1 release was to improve the clarity of the UML 1.0 semantics and to incorporate contributions from the new partners. It was submitted to the OMG for their consideration and adopted in the fall of 1997. (Hunt, 2000)

Since UML is not a methodology, it does not require any formal work products. Yet it does provide several types of diagrams that, when used within a given methodology, increase the ease of understanding an application under development. There is more to UML than these diagrams, but for the purpose of this study, the diagrams offer a good introduction to the language and the principles behind its use.

By placing standard UML diagrams in your methodology's work products, you make it easier for UML-proficient people to join your project and quickly become productive. The most useful, standard UML diagrams are: use case diagram, class diagram, sequence diagram, state chart diagram, activity diagram, component diagram, and deployment diagram.

2.5.2.2 Components of UML

One has to understand the important aspects of the UML-unified modeling language, before going into details of the tools and use of it. (Alhir, 2003)

2.5.2.2.1 Language

Language is the tool to communicate on a specific subject. Unlike the daily life language, it does not always composed of words, but other symbols of representation. Counting language, where a number of objects are given to represent the quantity or the arithmetic language which uses numbers for this representation are examples. (Alhir, 2003)

Similarly, for the UML to visualize the system by using diagrams where model is the idea and the diagrams are the expression of the idea. Each type of UML diagrams are also known as a modeling technique (Alhir, 2003).

2.5.2.2.2 Model

Alhir defines the model as follows;
''A model is defined as a representation of a subject….A model captures a set of ideas known as abstractions about its subjects.'' (Alhir, 2003)

A model makes it possible to have common understanding of the requirements of the system, and consider the impact of changes that occur when the system is developed. During the creation of the model one of the most crucial things is to decide the amount of information to include. It is important to focus on capturing the relevant information required for understanding the problem, solving it and implementing the solution. It is a problem of managing the abstraction to make up a model to cope with the overall complexity involved in system development (Alhir, 2003).

2.5.2.2.3 Unified

UML was meant to be a unifying language enabling IT professionals to model computer applications. One reason UML has become a standard modeling language is that it is programming-language independent. Also, the UML notation set is a language and not a methodology. This is important, because a language, as opposed to a methodology, can easily fit into any company's way of conducting business without requiring change.

As the primary authors of the Booch, OMT, and OOSE methods, Grady Booch, Jim Rumbaugh, and Ivar Jacobson were motivated to create a unified modeling language for three reasons. First, these methods were already evolving toward each other independently. It made sense to continue that evolution together rather than apart, eliminating the potential for any unnecessary and gratuitous differences that would further confuse users. Second, by unifying the semantics and notation, they could bring some stability to the object-oriented market place, allowing projects to settle on one mature modeling language and letting tool builder focus on delivering more useful features. Third, they expected that their collaboration would yield improvements in all three earlier methods, helping them to capture lessons learned and to address problems that none of their methods previously handled well.

2.5.2.3 Use Case Diagrams

A use case is a set of scenarios that describing an interaction between a user and a system. Use case diagrams describe what a system does from the standpoint of an external observer. The emphasis is on what a system does rather than how.

Deconstructing a use case diagram we find there are four basic components; (Roff, 2003)

System; A system is something that performs a function. It is possible for a system to have subsystems whish are organized components within the overall system.

Actors; the most common notational component of a use case diagram is the actor. An actor is the representation of the one who uses the system. An actor is who or what initiates the events involved in that task. Actors are simply roles that people or objects play. Basically it is better to give generic names such as teacher, student, and customer etc rather than real person names. Actors do not necessarily be people; they could be other systems that are external to the system being modeled.

Use cases; Use cases can be explained as the actions that a user takes on a system. Naming use cases are just as important as naming actors. İt should describe the functionality being performed in the system.

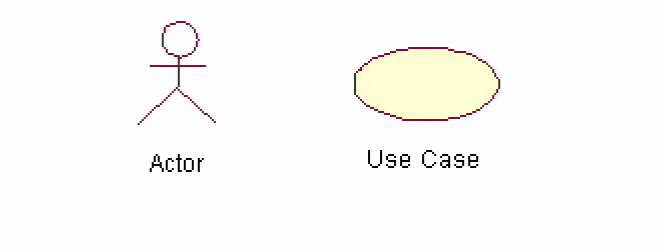

Figure 2.7. Use Case diagrams components; Actor, use case

Relationships; Relationships are illustrated with a line connecting actors and use cases. Use case diagrams are closely connected to scenarios. A scenario is an example of what happens when someone interacts with the system.

A use case is a summary of scenarios for a single task or goal. The picture below is a make appointment use case for the medical clinic. The actor is a patient. The connection between actor and use case is a communication association (or communication for short) (Fowler and Scott, 2000).

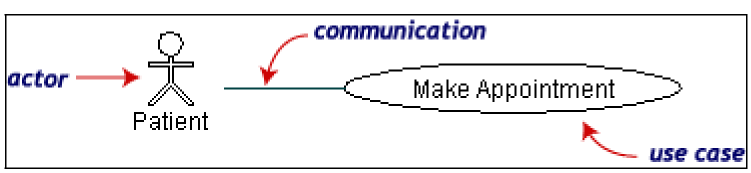

Figure 2.8. Use Case diagrams example

Use cases are used in almost every project. They are helpful in exposing requirements and planning the project. During the initial stage of a project most use cases should be defined, but as the project continues more might become visible. (Fowler and Scott, 2000).

In this part of the thesis, basic definitions regarding risk management and information modeling are presented. Based on these definitions, the developed information model for risk assessment will be discussed in the forthcoming chapters.

CHAPTER 3

RESEARCH METHODOLOGY

The aim of this study is to develop a tool to support the risk assessment procedure at the post-project appraisal phase of the project. Before giving information about the tool general introduction about information modeling will be given.

3.1 Development of a model

A model is a representation of a set of components of a system or subject area. The model is developed for understanding, analysis, improvement or replacement of the system. Systems are composed of interfacing or interdependent parts that work together to perform a useful function. System parts can be any combination of things, including people, information, software, processes, equipment, products, or raw materials. The model describes what a system does, what controls it, what things it works on, what means it uses to perform its functions, and what it produces.

All approaches in risk management agreed on a need for common understanding of risk sources of a project in advance. This need has forced researches to quest for new ways of structuring and categorizing the risk sources appropriately. A common language for describing risks is a significant process as efficient risk management systems have direct influence on success factors of a project. Tah and Carr (2000) states that identifying the problem areas within a plan or a project will help in formation of a strategy to avoid them.

Recent approaches to information modeling methodologies agreed on development of framework that covers information system completely. Since 1980s the importance of object oriented integrated environment increased its popularity and the developers applied these methodologies to design and analyze systems. By the rise of powerful computing tools and advance database management systems, efficiency of management support tools increased. Data warehouses became powerful mediums for integrating operational information via advanced accessibility and data mining. The availability and easy access of historical data increased the need for further analysis and categorization of experience to form knowledge repositories. The first step for mentioned data mining procedure is to convert information which is mostly in tacit form into hard data. Many researches on knowledge management states the importance of codifying information to create explicit knowledge which is easy for sharing and storing in company structure.

Recent evolution of personal computers, computer networks and technological infrastructure, increased the efficiency of data entry procedure by means of time and cost. local area networks (LAN) wide area networks (WAN) and world wide web (www) enabled instant data flow and information sharing between workgroups regardless of geographical separations. However, availability of technological capabilities does not necessarily mean a successful collection of meaningful information. Companies need to develop vision and strategic awareness on information and decision support systems (DSS) that control the data flow in and out of the company with verification and categorization processes.

In this study the focus is on knowledge generation on project information. Project is a temporary endeavor undertaken to create a unique product or service. Every project has a definite beginning and end with distinguishing way to differ from other projects. Project management (PM) is the application of knowledge, skills, techniques and resources to fulfill the objectives of a project. However the application environment of PM is broader and not limited to project itself. Managing project activities is required for successful project delivery but not sufficient. Project management should be aware of the context of a project and the knowledge areas of a project. Figure 3.1 illustrates the project management processes and knowledge areas defined in PMBoK (2000).

Projects involve a degree of uncertainty as they are unique products. Organizations usually define phases of projects to provide better management control and integration between operations. Collectively the project phases are known as project life cycle. Every knowledge area can be investigated in the light of these phase definitions. The aim of this study is to deliver an information model to support assessment of risks by storing historical data regarding the phases of a project on risk management knowledge area.

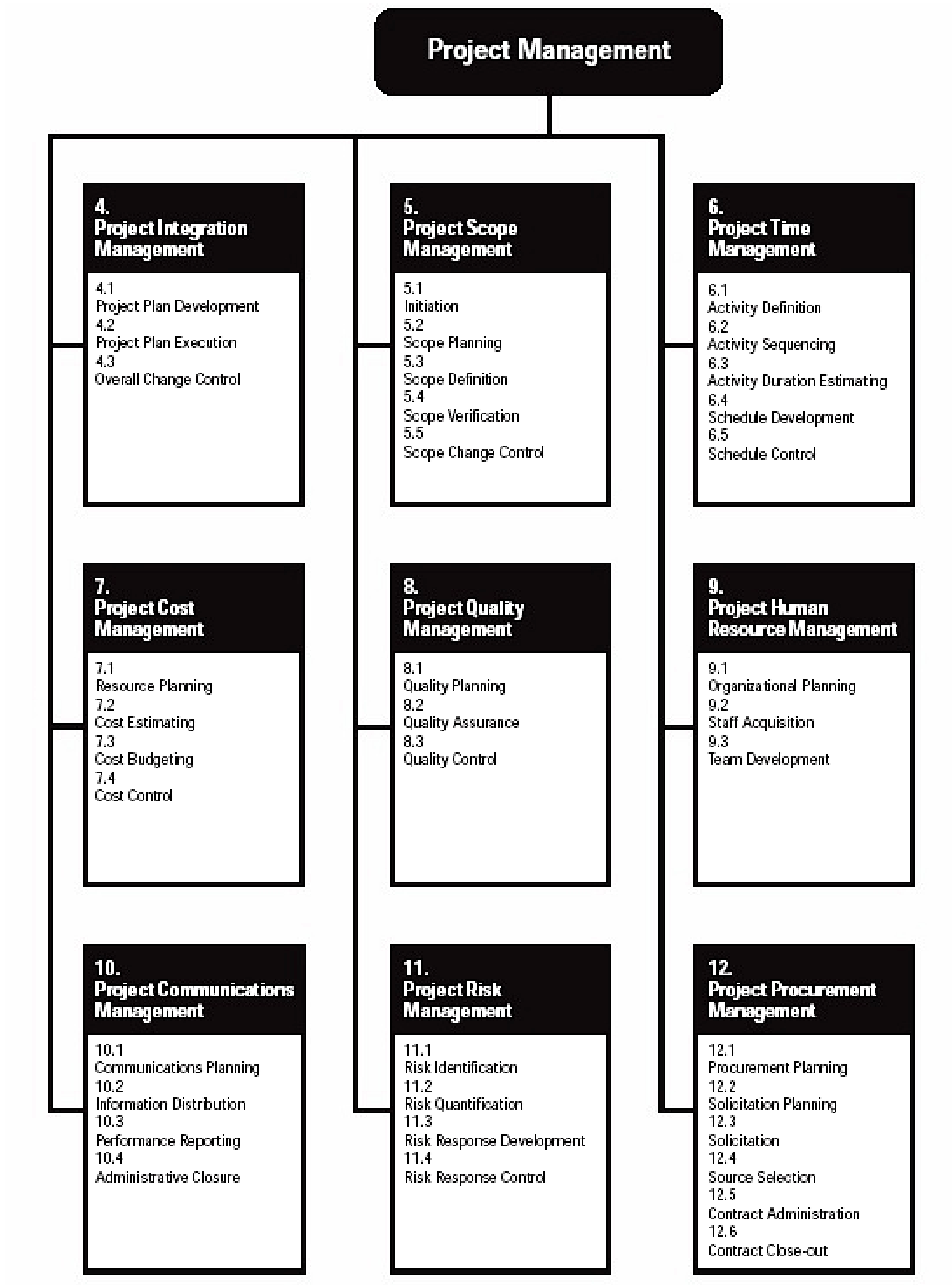

Figure 3.1. Overview of Project Management Knowledge Areas and Project Management Processes (PMBoK 2000)

3.2 Process Model

Understanding the risk management processes is vital to form an effective risk information model. There exist a number of methodologies and researches on defining the risk management. As mentioned on Chapter 2, there exist several approaches to risk management. PRAM (Project Risk Analysis and Management) defined nine phases for risk management processes: define, focus, identify, structure, ownership, estimate, evaluate, plan and manage. Kahkonen (1997) defined a risk and project management process with fewer processes as: organization and scope, risk identification, risk analysis, risk strategy, response planning and continuous control. RAMP (Risk Analysis and Management for Projects) has multi-level process breakdown architecture. Top level processes are defined as process launch, risk review, risk management and process closedown. Similarly PMBoK sums up these functions as identification, quantification, response development and control phases.

Project success is depended on early identification of actions for complexities. As projects have dynamic environments real time management of project variables require, the need for integration between project objectives realization and strategic decision making. Thus an information system development for projects need full functionality which covers the whole system and environmental variables. So far the researches include a process for revision on the evaluation on risk assessment process depending on the information gained from response control mechanisms. The act of revising impact evaluation process was limited to project lifetime.

In a stable environment uncertainty is higher in the early stages of a project. It is lowered through the final stages of project execution which enables a better evaluation of risk impacts on the project actions. A final assessment of risks after the project will improve the success of risk assessment for forthcoming projects by means of historical repositories.

The aim of this study is to define a new risk management process framework throughout the lifetime of a project by introducing a final evaluation of risk impacts at the end. Project lifetime is investigated in three main phases as: pre-project, during project, post-project phases. Firstly the processes included in proposed process model presented in Figure 3.2, will be discussed.

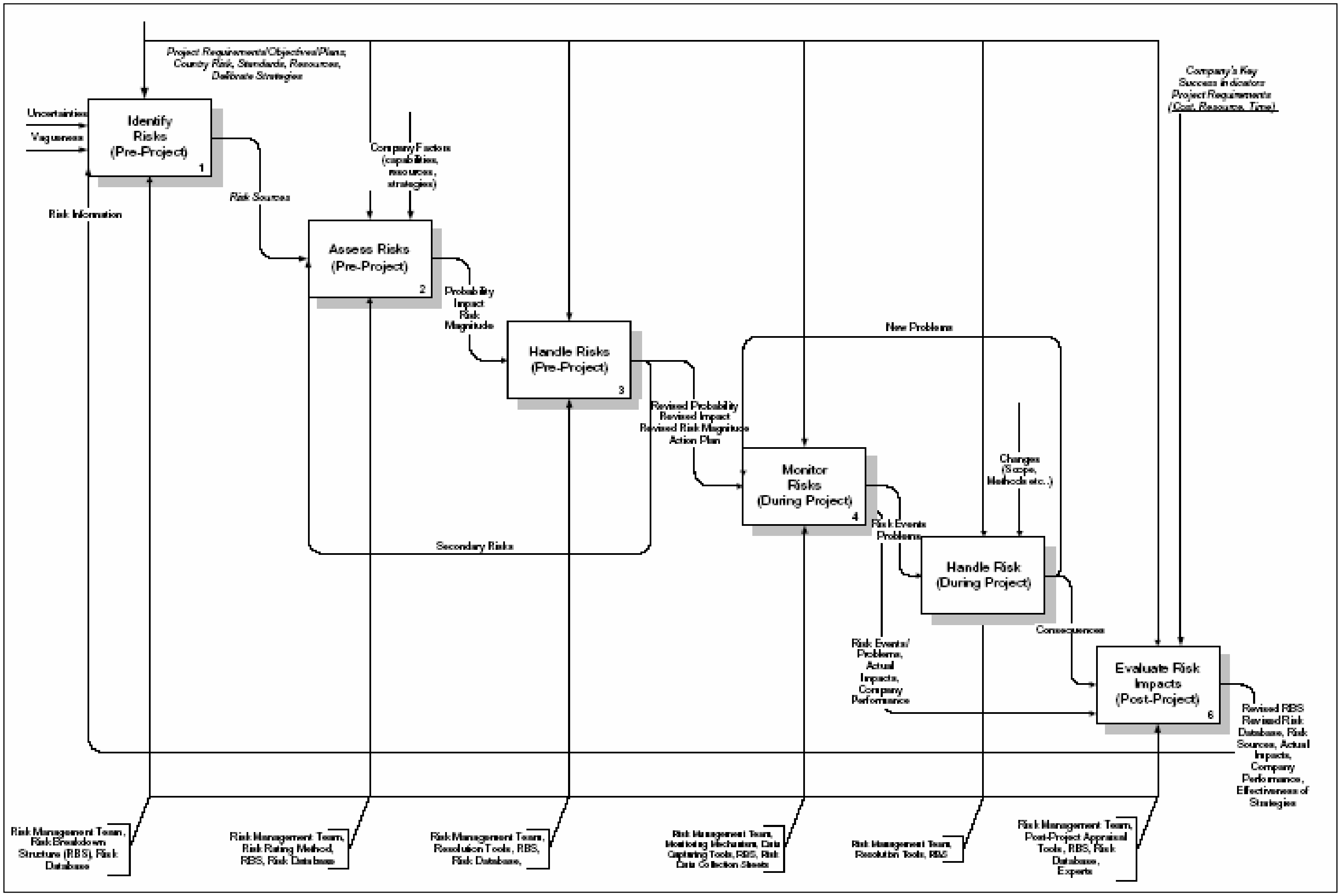

Figure 3.2. Proposed project risk management process model

Initial stage in the risk management process model is the identification of risks. Risk identification is a process where risks relating to a project are determined prior to project start. Determination of risks will vary between projects and companies. Decision maker, risk identifier in this case, deals with a complex procedure to identify the internal and external sources that will affect the nature of the project. Risk identification is accomplished by deciding on the uncertainties and vagueness of the project variables such as project requirements/objectives, country conditions, standards related to execution processes and company strategic objectives for the project.

This process involves investigation of all possible risk sources related to the project using risk management team cooperation and risk breakdown structure (RBS) that aims to categorize common risk sources handled on previous project experiences. Risk breakdown structure includes a predefined coding system enabling hierarchical listing of risk catalogue entries. RBS will be assisting the risk identifier to establish quicker and more efficient assembly of risk sources related to the type of the project and the work packages included. Details of risk breakdown structure will be discussed in the following section. The outcome of this process is the risk sources definition which included information about the type, scope, ownership etc of the risk items. Identification forms a basis for quantification of risk items.

Second stage in the process model is the assessment stage. This phase covers the quantification of risk items by means of probability and impact. Risk assessor assigns risk sources to related work package using subjective judgments. Probability and impact value are represented as linguistic variables, such as very low, low, medium, high and very high. Assessor uses expert opinion and available risk event history databases to conclude on the magnitude of impact the risk item has on the project.

Assessment phase is prior to risk response plan generation. A precise estimation of risk impacts on the project will result in more accurate contingency plan. Risk assessor should include company capabilities, resources and strategies to finalize generic values for specific project-company combination.

It is possible that previously determined potential risk items affect other risks. Affected risk items are categorized using RBS previously mentioned. The main goal of this phase is to conclude on relative risk rating (RR) values. Risk rating is simply the multiplication of probability of a risk item with their severity/impact on the project or work package. Probability and impact values are represented on a Likert (1-5) scale. Correspondences of each number with linguistic expressions are given in Table 3.1.

Table 3.1. Rating Scale and Linguistic Variables

Scale / Value	**Impact**	**Probability**
1	Very Weak	Very Rare
2	Weak	Rare
3	Medium	Medium
4	High	Likely
5	Very High	Very Likely

At the completion of this stage, risk sources are determined, classified and related to work groups or project tasks. Likelihood and impacts of each risk is determined using expert judgment of assessor and company risk repositories on risk rating tables. Probability and impact is assigned a relative value ranging from 1 to 5. Risk rating value is calculated (1-25) regardless of the effect of response strategy which will be determined on the next process. Risk impact on the project varies with strategic objectives for response. Assessment process is not a stand-alone process, thus requires an iterative approach on the determination of risk handling action plan. Risk assessment and risk handling phases are executed simultaneously to minimize the effect of risk items.

Final phase of pre-project risk management system is the response generation/handle risk phase. At the completion of assessment process the risk factors and their effects are quantified. Risk handling phase allows the definition of response strategy and related remedial action for the risk factor. Secondary risks that have been affected by other risks are determined at this phase. Iteratively these new risk factors are processed by risk assessor. Appropriate response action can be chosen from an action catalogue. Main actions for risk response can be listed as: mitigation, control or acceptance. Mitigation of risk involves risk sharing between other parties included in the project or within project organization. Risk control strategy aims to minimize risk rating. Control can be applied on impact, probability or on both of the risk factor variables. Examples of risk control response can be given as: financial coverage of impact, contingency coverage, insurance etc.

After response generation risk management continues with processes which are to be executed during execution phase of the project. After handling risks phase, project management team has risk factor listing including risk rating information related to work packages of the project. Addition to risk identification and quantification, risk handling action plan is generated to relate responsibilities to risk factors and project tasks. All processes in risk management system are executed according to a sequence and in full coordination with each other. Iterative nature of risk management cycles requires continuous control of effectiveness of predecessor phases.

Monitoring phase is mainly data capturing procedure of risk management system. Effectiveness of risk response plans are logged along with realized project data on a periodic basis. Monitoring of risks can be described as a sub-phase to actual execution of response actions. Risk factors realization histories are collected in the form of risk events. This process is crucial for post project evaluation process, so implementation of efficient data collection methods at this stage determines the success of learning capability of a company in the life time of a project.

Handle Risk (during project) is the final process in the execution period of the project. This phase basically covers the execution of response actions and transferring the consequences of risk events to post-project phase. This phase is closely interrelated to monitoring actions in an iterative manner. Changes in response strategy are transferred to monitoring phase for efficiency quantification.

This proposed process model suggests a final process to evaluate the actual impacts of risks. The main idea is to build risk event histories in forms of micro-articles. Relatively defined impact values are collected in a categorized manner based on the risk breakdown structure. Risk registers include ownership information as well as timing and response action information. Codifying of risk histories will allow risk assessors to group risk items according to work packages and project information. Final appraisal of project risk inventory concludes in revision of risk impact values stored in risk catalogues, addition of new risk factors or elimination of risk factors. Realized risk events are recorded with justification information about the risk factor explaining cause-effect relation. Recent database management systems are capable of distribution of this information to support forthcoming project risk identification and assessment phases with use of revised risk catalogues.

With detailed risk data mining mechanisms, risk identification phase can be easily and effectively done with checklists generated from risk catalogues categorized according to work packages in a generic construction project. As risk catalogues are based on historical information of the company, the precision of risk factor coverage and impact estimates will be higher.

Risk management model integrates all processes and these processes interact with each other as well as with other processes from other knowledge areas. Each process involves efforts from one or more individuals or groups of individuals based on the needs of the project. Processes are defined as discrete elements, whereas they overlap and interact in many ways in practice. There exists no common language in the definition of risk management functions thus definition of processes may vary in different researches while the main philosophy behind them is preserved.

3.3 Use Case Diagrams

A use case diagram is a sub class of behavioral diagrams in Unified Modeling Language. A use case diagram is a set of scenarios describing the typical interactions between a user and a system. Use case diagrams define what a system does from the standpoint of an external observer. A use case diagram contains several elements such as, actors, routines and use cases. Actors are the representation of one who uses the system but actors are not necessarily human actors only. Software or hardware components of the system are also defined as actor. Actors are not supposed to be strictly different individuals. Roles are defined in use case diagram according to functions that are to be covered regardless of the size of the project. More than one role can be assigned to one person in the risk management system depending on the size of the project execution plan.

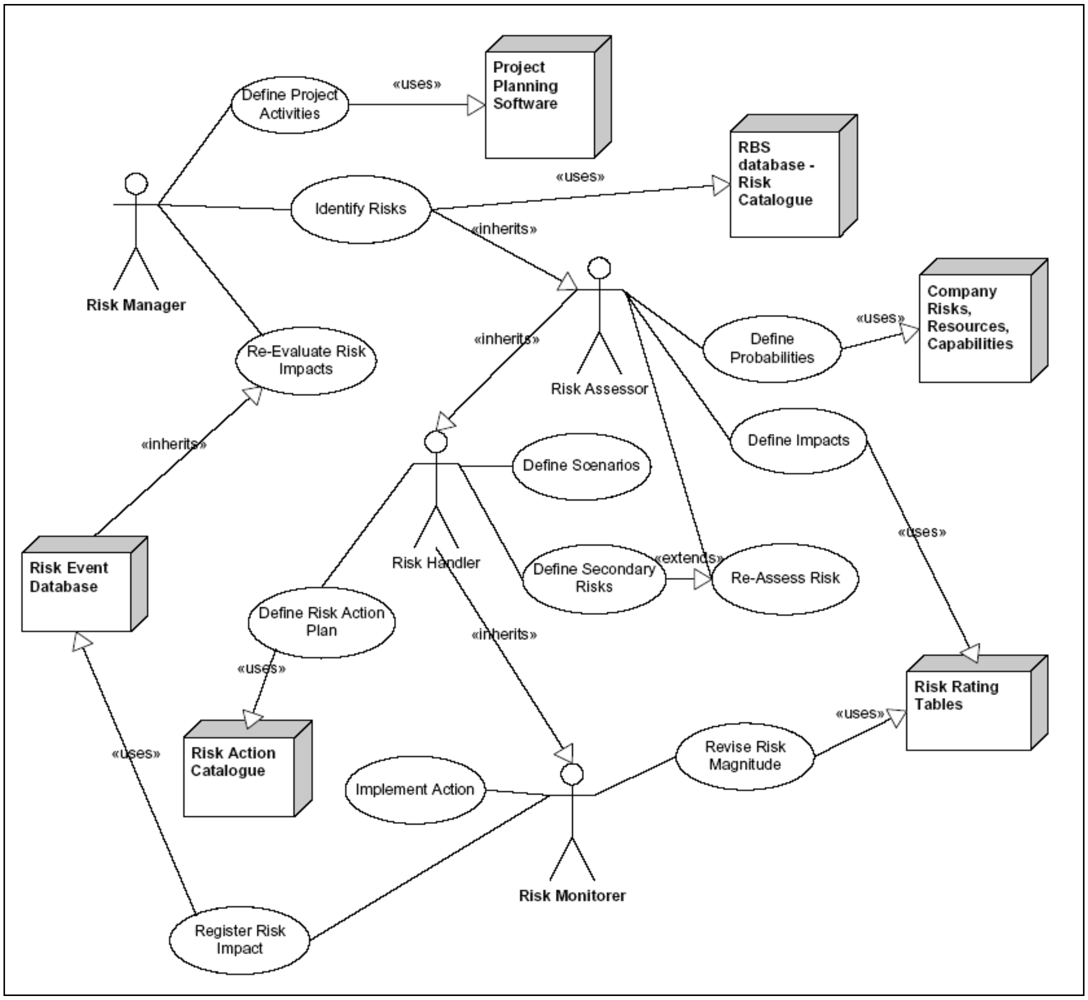

Figure 3.2. Use case diagram for risk management system in a project.

Use case diagram includes four human actors: risk manager, risk assessor, risk handler and risk monitorer. Functions are distributed according to main processes defined in the process diagram. Actor names are given in accordance with dominant processes. Risk manager starts the process by defining project activities and work groups. One of project planning tools, available in the market, can be utilized for this function. Risk breakdown structure has a coding system to organize risks according to work packages. Risk manager inherits this information to risk assessment expert for quantification of risk factors. Risk assessor uses company database for probability estimations considering information such as, organizational complexity, technical capability of the firm, machinery park etc. Company strategic objectives and risk response attitude also play an important role on quantification of risk rating values. Risk impact values are based on risk rating tables which include previously executed projects' historical data. Risk assessor provides quantified values of work packages to risk handler whose responsibility is to determine an action plan based on action catalogues. In case, secondary risks which are affected by different risk factors are added, risk handler and risk assessor work in coordination to minimize these risks effects on the project. Reassessment of such risks is required as previously mentioned on process definitions. Risk monitorer actively works on the execution phase of the project as a part of project information system. Risk monitor records and reports the actualization of risk items as risk registers. Any justification on risk impact change is in risk handler responsibility during the life time of the project.

Use case diagram involves the post project appraisal functions as a part of the system. After the formation/revision of risk event database, risk manager collects these revised impact values, and risk management team collaborate to implement this new values to risk rating tables for further use.

Six software tools defined in the diagram namely; project planning software, risk breakdown structure, company related information base, risk rating tables, risk action catalogue and risk event database. Software tools are defined separately on the diagram, whereas advance database management systems allow system developers to run queries through authorized access.

3.4 Risk Breakdown Structure

All researches in risk management emphasize the need for a common understanding to identification procedure of risk sources prior to the start of a project. A predefined list of common risk sources aims to assist risk identification process. Risk breakdown structure is an extensive list of risks classifying them according to their sources. In this study a template risk breakdown structure is prepared considering mainly two main risk type described as: country related risks and project related risks. Market risks are not considered in this study as the focus of whole system was on projects.

RBS (or risk source catalogue) included four level RBS coding that allows the user to categorize the risk items according to type (country or project related), risk category (economical, environmental, legal, political, socio-cultural, contractual, design, finance, management, owner, parties, resources and site) and risk source. RBS representation of risks within a project formed a hierarchy which is used as a basis for risk assessment model. Highest level of breakdown, type of a risk defines whether the risk item is related to a project issue or a country condition. Category level defines the risk center of an item. Risk source level is proposed to aggregate the project area separation of risks. Lowest level of breakdown is required to implement different risk items which have equal level of relation to project but differences on the actualization of risk events. Totally 73 items are proposed in the risk breakdown structure for a full coverage of potential risk factors that could be faced in a construction project life cycle. These risk factors are listed in Table 3.2

Table 3.2. RBS for proposed project risk management system

RBS Code	Risk Type	Category	Risk Source
01.01.01.00	Country	Economic	Unforeseen changes in currency rates
01.01.02.00	Country	Economic	Unfavorable economic environment
01.01.03.00	Country	Economic	Change in demand
01.02.01.01	Country	Environmental	Natural disasters: other
01.02.01.02	Country	Environmental	Natural disaster - flood
01.02.01.03	Country	Environmental	Natural disaster - earthquake
01.02.01.04	Country	Environmental	Natural disaster - landslide
01.02.02.00	Country	Environmental	Weather conditions
01.02.03.00	Country	Environmental	Poor geological and geographical conditions
01.03.01.00	Country	Legal	Poor legal system
01.03.02.00	Country	Legal	Changes in regulatory frameworks
01.03.03.00	Country	Legal	Delay in dispute resolution
01.04.01.01	Country	Political	War

Table 3.1. Continued			
RBS_Code	RiskType	Category	RiskSource
01.04.01.02	Country	Political	Impact of military on politics
01.04.02.00	Country	Political	Bribery and societal conflict / public unrest
01.04.03.01	Country	Political	Poor international relations
01.04.03.02	Country	Political	Negative attitude towards foreign companies
01.04.04.00	Country	Political	Political incontinuity
01.05.01.00	Country	Sociocultural	Language, religion, traditions barrier
02.01.01.00	Project	Construction	Technical vagueness
02.01.02.00	Project	Construction	Unproven technologies / construction methods
02.02.01.00	Project	Contract	Vagueness of contract clauses
02.02.02.00	Project	Contract	Unfair risk allocation in the contract
02.02.03.00	Project	Contract	Constraints
02.02.04.00	Project	Contract	Time control
02.02.05.00	Project	Contract	Strict quality requirements
02.02.06.00	Project	Contract	Poor standards / Specifications
02.03.01.00	Project	Design	Design errors
02.03.02.00	Project	Design	Delay in design
02.03.03.00	Project	Design	Vagueness in design
02.04.01.00	Project	Finance	Contractor finance
02.04.02.00	Project	Finance	Unavailability / Inadequate budget
02.04.03.00	Project	Finance	Delay in progress payment
02.04.04.00	Project	Finance	Constraints in the contract
02.05.01.00	Project	Management	Poor organization
02.05.02.00	Project	Management	Poor PM (Planning, cost est., control)
02.05.03.00	Project	Management	PM team responsibilities ill defined
02.05.04.00	Project	Management	Change in core management
02.05.05.00	Project	Management	Poor motivation
02.05.06.00	Project	Management	Inadequate number of staff
02.05.07.00	Project	Management	Poor claim management
02.05.08.00	Project	Management	Contradictory objectives
02.05.09.00	Project	Management	Poor management of relation between parties
02.05.10.00	Project	Management	Poor team communication
02.05.11.00	Project	Management	Poor management of risks
02.06.01.00	Project	Owner	Lack of experience

Table 3.1. Continued

RBS_Code	Risk Type	Category	Risk Source
02.06.02.00	Project	Owner	Bureaucratic delay
02.06.03.00	Project	Owner	Change orders
02.07.01.00	Project	Parties	Consultant poor performance
02.07.02.00	Project	Parties	Client poor performance
02.07.03.00	Project	Parties	Designer poor performance
02.07.04.00	Project	Parties	Poor relations with parties
02.07.05.00	Project	Parties	JV partners poor performance
02.07.06.00	Project	Parties	Poor performance
02.07.07.00	Project	Parties	Poor subcontractor performance
02.08.01.00	Project	Resources	Unavailability of subcontractors
02.08.02.01	Project	Resources	Change in labor cost
02.08.02.02	Project	Resources	Unavailability of skilled technical staff
02.08.02.03	Project	Resources	Poor labor relations
02.08.02.04	Project	Resources	Labor poor productivity
02.08.02.05	Project	Resources	Labor unavailability
02.08.03.01	Project	Resources	Change in equipment Cost
02.08.03.02	Project	Resources	Equipment unavailability
02.08.03.03	Project	Resources	Equipment poor productivity
02.08.04.01	Project	Resources	Change in material cost
02.08.04.02	Project	Resources	Cost of raw materials
02.08.04.03	Project	Resources	Material delay
02.08.04.04	Project	Resources	Material unavailability
02.08.05.01	Project	Resources	Custom delays
02.09.01.00	Project	Site	Site constraints (Space constraints, accessibility)
02.09.02.00	Project	Site	Vagueness of geological conditions
02.09.03.00	Project	Site	Site security
02.09.04.00	Project	Site	Site handover delay

This breakdown is provided to assist the identification and assessment phase. Checklists can be generated from this breakdown structure at the identification stage for quick listing of risk identification from the list. However, risk breakdown is not limited to defined items and can be extended by risk experts for proper applications.

CHAPTER 4

THE DEVELOPED RISK ASSESSMENT TOOL

In Chapter 3, details of developing a model for project risk management are given. The aim of the system is to support risk assessment process on the early stages of the project by forming a risk event history. In this chapter, software implementation of this system will be discussed. The background for software development will be introduced before the application.

4.1 The Relational Database Model

A database is a set of information with regular structure. Its user interface allows data access, searching and sorting routines.

A database can be understood as a collection of related files. How those files are related depends on the model used. Early models included the hierarchical model (where files are related in a parent/child manner, with each child file having at most one parent file), and the network model (where files are related as owners and members, similar to the network model except that each member file can have more than one owner).

The first databases implemented during the 1960s and 1970s were based upon either flat data files or the hierarchical or networked data models. These methods of storing data were relatively inflexible due to their rigid structure and heavy reliance on applications programs to perform even the most routine processing.

The relational model for database management is a database model based on predicate logic and set theory. It was first formulated and proposed in 1969 by Edgar Codd with aims that included avoiding, without loss of completeness, the need to write computer programs to express database queries and enforce database integrity constraints.

In 1969, when Codd developed the model, it was thought to be hopelessly impractical, as the machines of the time could not cope with the overhead necessary to maintain the model. Evidently, hardware since then has come on in huge strides, so that today even the most basic of PCs can run sophisticated relational database management systems.

In relational databases such as Sybase, Oracle, IBM DB2, MS SQL Server and MS Access, data is stored in tables made up of one or more columns (Access calls a column a field). The data stored in each column must be of a single data type such as Character, Number or Date. A collection of values from each column of a table is called a record or a row in the table. Different tables can have the same column in common. This feature is used to explicitly specify a relationship between two tables.

4.2 Programming Environment (Microsoft Access)

Access is used by small businesses, within departments of large corporations, and hobby programmers to create ad hoc customized desktop systems for handling the creation and manipulation of data. Access can also be used as the database for basic web based applications hosted on Microsoft's Internet Information Services and utilizing Microsoft Active Server Pages ASP.

One of the benefits of Access from a programmer's perspective is its relative compatibility with SQL—queries may be viewed and edited as SQL statements, and SQL statements can be used directly in Macros and VBA Modules to manipulate

Access tables. Users may mix and use both VBA and "Macros" for programming forms and logic and offers object-oriented possibilities.

Access allows relatively quick development because all database tables, queries, forms, and reports are stored in the database. For query development, Access utilizes the Query Design Grid, a graphical user interface that allows users to create queries without knowledge of the SQL programming language.

Microsoft Access can be applied to small projects but scales poorly to larger projects involving multiple concurrent users because it is a desktop application, not a true client-server database.

MS Access is chosen for development environment mainly because of availability and user-friendly issues of the program. The aim of developing this program had not been delivering a fully functioning system but to illustrate a real life example on a relatively small scale of information.

4.3 Application of Proposed Database

4.3.1 Data Groups

A good database design requires detailed planning of inputs and outputs of the system. Database architecture change, especially on relational databases, is a tough task if data mining process has started. Main functions of the risk management process model were, as described in Chapter 3, identification, assessment, handling and monitoring. Some of the proposed digital repositories to assist these processes were risk catalogues, risk rating tables and risk event tables. After implementation and normalization processes of software development phases following data groups are implemented.

Projects Table : This table is defined to record project information including project name, description, start and end dates, duration in months, country name, project value, contract type, payment type, work field. All processes start with the definition of projects as they are the basic elements of construction companies and sources of information in a learning organization. Any of these pre-defined fields in this data group enable users to generate reports and search selective criteria in this work group and relational information in the database.

Parties Table : Every project involves different parties with different responsibilities. In construction industry the number and variety of participation in a project are higher due to the need of coordination in different disciplines. At this second stage of definition, parties are defined or selected from previously defined lists and related to projects. After this definition stage projects and active parties in relation to the projects are defined. This information can be used by risk experts for the determination of risks involved in the project.

Risk Factors Table : Third data group covers risk identification process for each project. User enters project specific risk factors and assigns one of the pre-defined RBS codes, response action and ownership information. At this stage identification and grouping of risks are completed. Proactive actions are related to each one of the risk factors. After a complete data entry for risk factors action plan for each risk factor can be reported. Previously defined risk breakdown structure assists the identification process.

Status Table : Fourth data group involves impact and probability values of each of the risk items. Status values are entered on Likert scale (1-5). Status entry process is a periodic function which requires several entries for one specific risk factor. Every entry should contain impact value, probability value, updating date, phase of the project (basically three phase defined: pre-project, during project, post-project) and justification note if there exists a variation of risk rating value from previous entry. Every risk factor may relate to many status entries whereas, every status entry is related to one and only one risk factor.

Actions Table : This data group covers response functions for the risk items. Basically actions are classified in four groups as: risk control (contract or management strategy), risk finance (contingency or Insurance), risk transfer to other parties and no action (acceptance). None of the pre-defined values are limited to this primary information and can be revised or extended with common decision of risk management team.

Risk Event Table : Final data group is risk event history table. This table is related to post project appraisal functions and involves revised risk rating values for project risk items. Risk event table is organized according to risk catalogue codes, RBS codes, which illustrate the variation of risk rating of a risk source between different projects. Risk event histories contain risk factor relation, change in duration and cost due to this risk factor, revised impact values and event history regarding the effectiveness of applied response strategy. This information is completed after the actualization of that risk item or at the end of the project.

Physical relations of these data groups are shown on Figure 4.1 below.

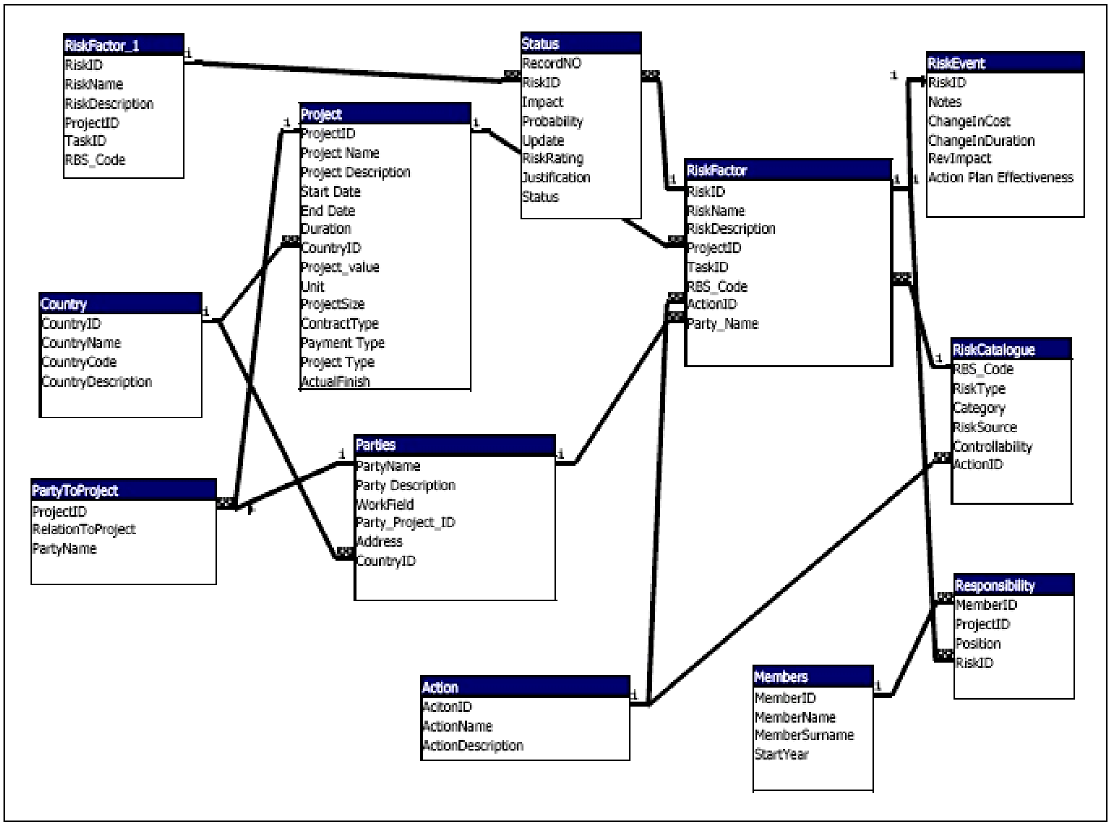

Figure 4.1 Physical relations definitions between MS Access tables

4.3.2 User Interface

To work with a system, the users need to be able to control the system and evaluate the state of the system. In software applications the end-user interaction with the program is limited with the user interface defined by the developer. User interface enables easy control of a complex system and defines an access control system between user and the system. In the proposed risk management database application user interface is developed to direct the users to four main functions as: data entry, reporting, project information entry and new project wizard. The main functions user interface is illustrated in Figure 4.2.

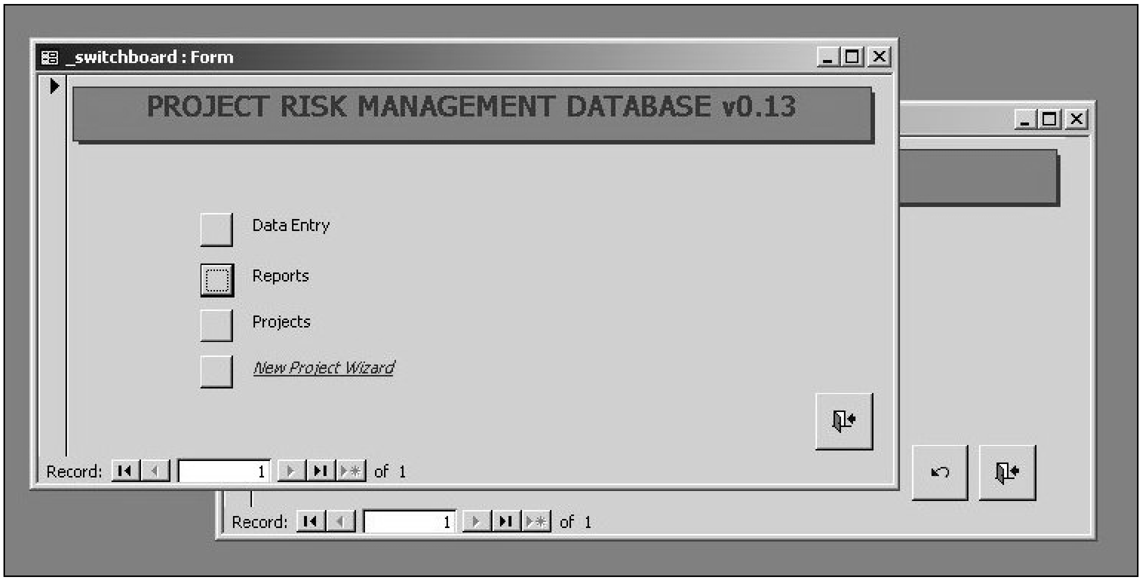

Figure 4.2. Snapshot of main switchboard for database application

Data entry applications are classified as project entry, risk factor entry, party definition, risk factor status entry, risk catalogue entry and post project event entry. These user interfaces are designed to support consistent and fast data entry and query runs. Following figures from 4.3 to 4.6 demonstrates the application interfaces.

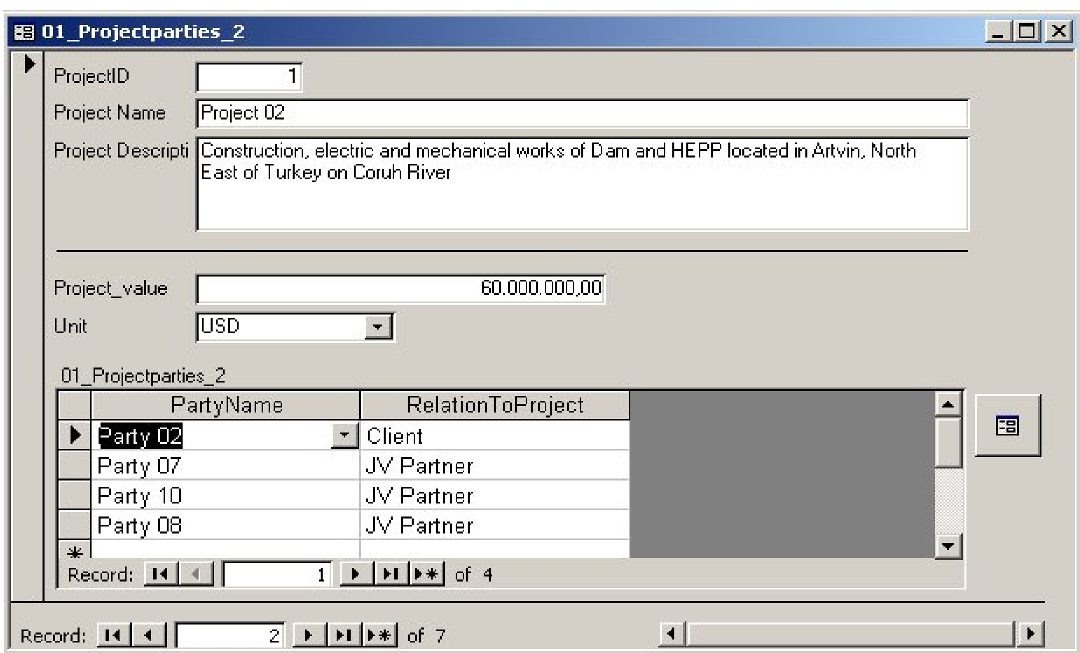

Figure 4.3. Snapshot of project information and parties involved in the projects

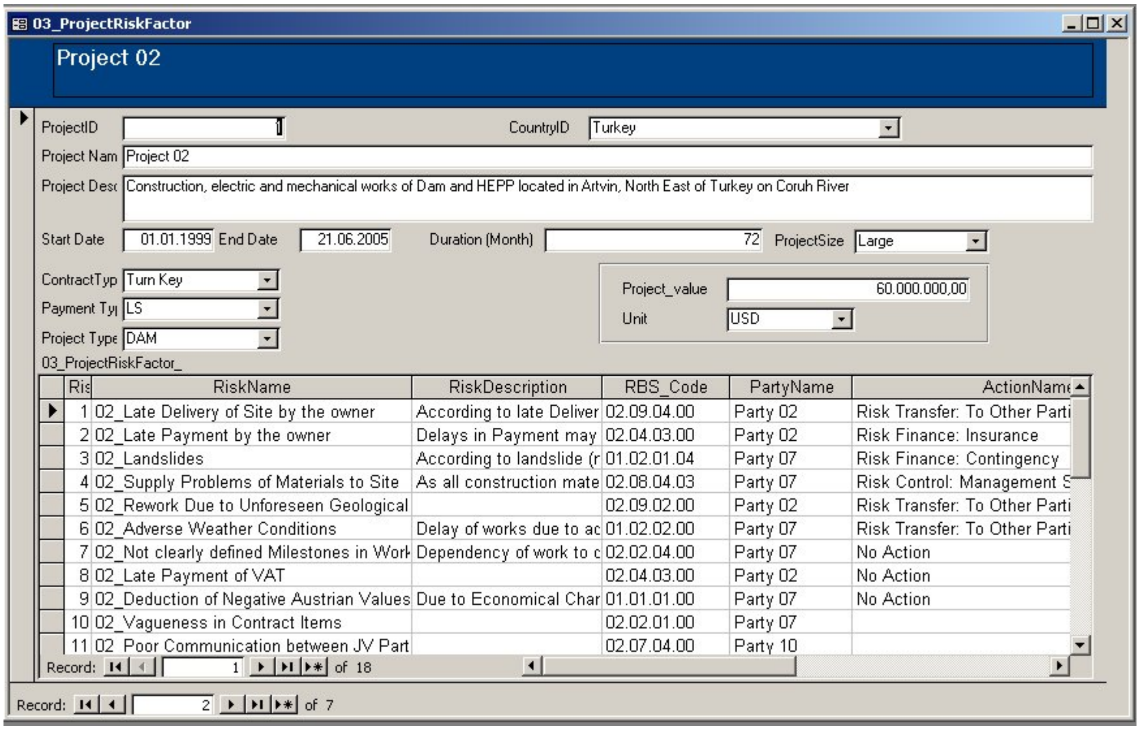

Figure 4.4 Snapshot of project-risk factors entry interface

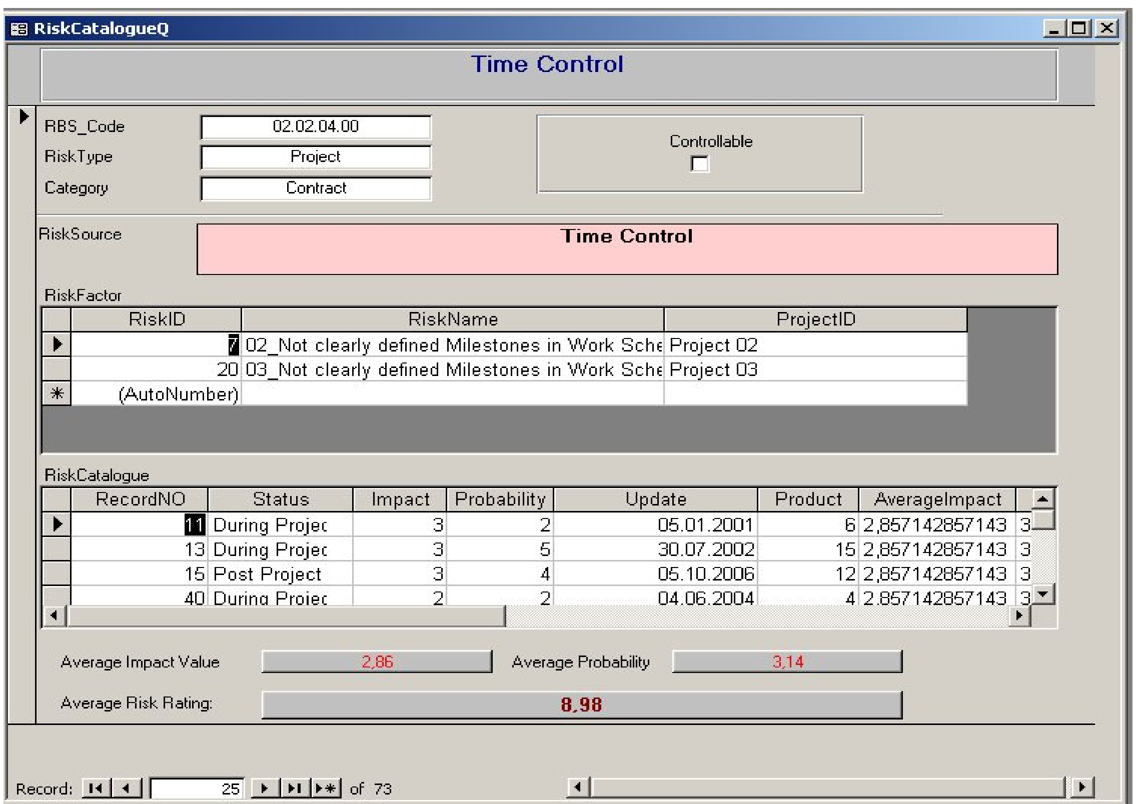

Figure 4.5 Snapshot of risk items probability and impact entry interface

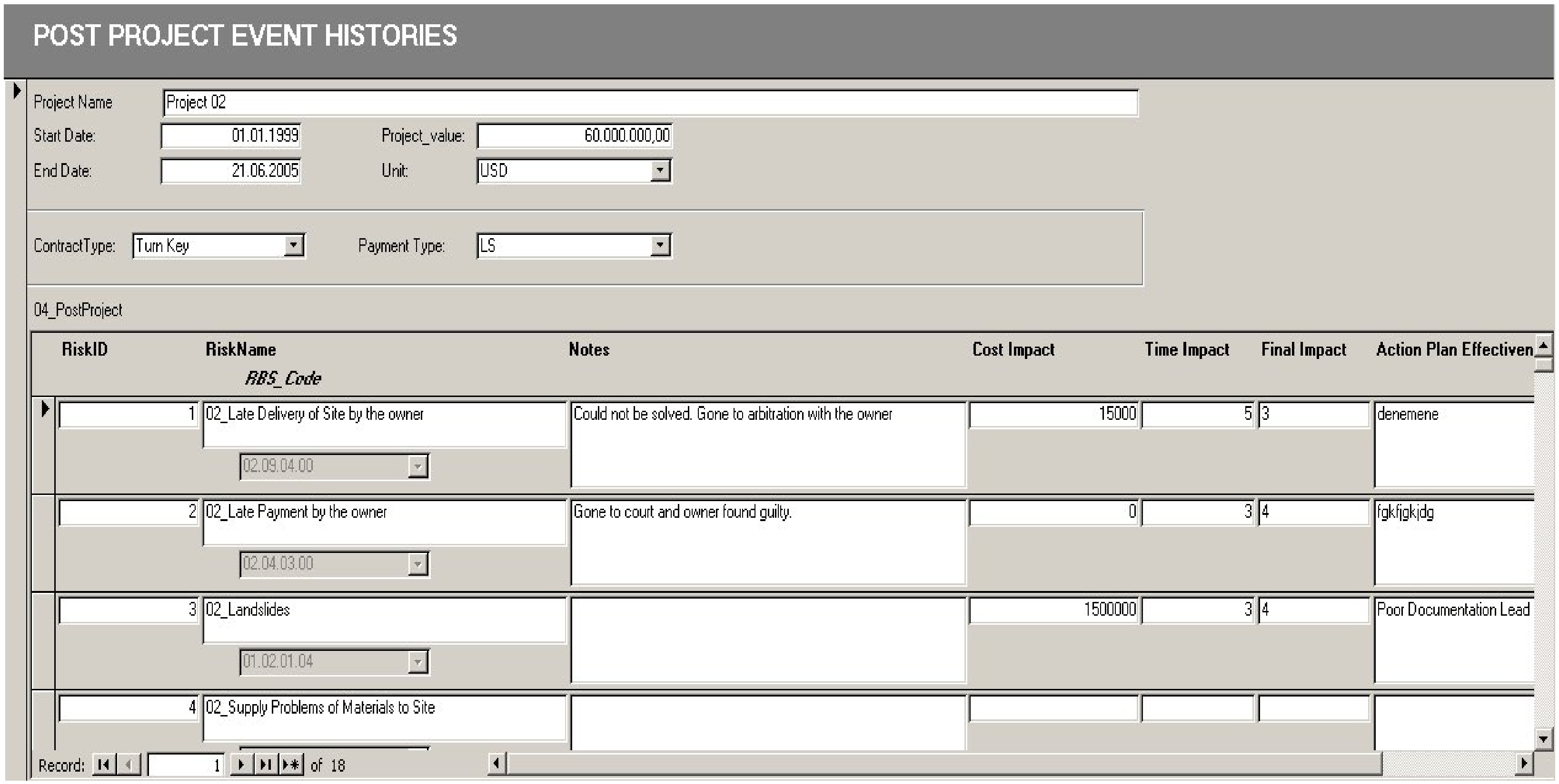

Figure 4.6 Snapshot of post project event history entry interface

Database management system allows formatted report generation from real data including searches and summary options. Samples from these generated reports are given in Appendix section. Developing wizards for software tools is a common approach to help new users understand the logic of the tool. The same approach applied in this application with “New Project Wizard” interface. This interface let the users enter required data in five consecutive steps. Each step involves shortcuts to related data entry forms. These steps are shown in Figure 4.7.

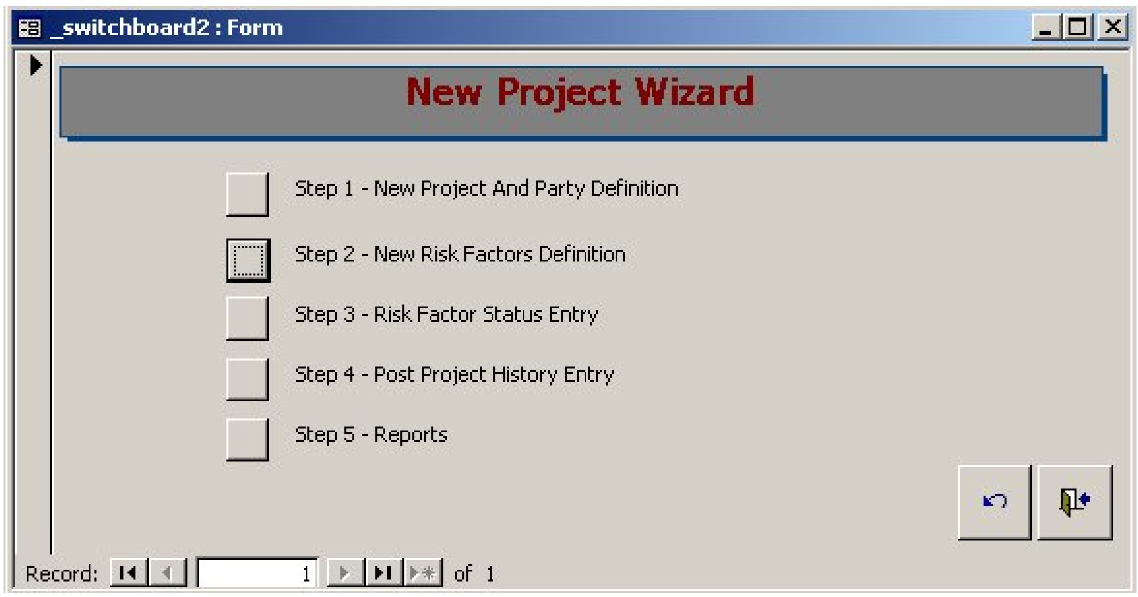

Figure 4.7. Snapshot of “New Project Wizard” application

Detailed discussion of the above mentioned steps is given in the next chapter with a real project application.

CHAPTER 5

APPLICATION OF THE TOOL TO A REAL CONSTRUCTION PROJECT

5.1 Information about the company and the project

As stated in earlier chapters, the aim was to develop an information model to support risk assessment process based on previous experience using post project appraisal tool. The system contains modules to increase the efficiency and precision of early estimates on risk items and response strategies. Furthermore, software application is developed to simulate the processes executed throughout the model including the information libraries within the tool. In this chapter, applicability of the system is tested by a real project executed by an international construction company. Details will be given in the following sections.

5.1.1 Company Information

The case study is about an Austrian company which is an international construction company working in various parts of the world and employed in all the fields of the construction works. As one of the leading providers of construction services in Central and Eastern Europe, the company employs over 45,000 people at more than 500 locations and attains a building performance of more than Euro 10 billion. Complex group structure combines financial bodies with building expertise, thus company also invests in operational phases of projects as well as engineering services.

5.1.2 Project Information

Sample project ("Project 02" as defined in the database) is an energy project that has been executed on Çoruh River in the north-east region of Turkey. Project has been financed and delivered according to a private agreement between Turkish and Austrian governments including another hydro-electrical power plant (HEPP) on the upstream side of sample project. Projects cover civil works, mechanical and electrical instrumentation works of two HEPPs with installed capacities of 300 MW and 115 MW. Works are executed by international consortium between Turkish and Austrian companies. The distribution of construction works between domestic and Austrian company is separately defined for each of the HEPPs. Austrian company is responsible for all civil works excluding earth works for Project 02 and underground executions for Project 03. Third partner for civil works is a Turkish design company whose responsibility includes all design works.

According to contract, the payment system is defined as lump-sum. Progress payment schedule and rough schedule of major milestones are also defined in the contract. Contract defines three different currencies for payment procedures. These currencies are Austrian, Turkish and U.S. currencies. The total contract value for sample project is approximately 58.5 million US Dollars for the Austrian partner's share.

5.2 Steps for data entry to database application

The first step in data entry phase is the project definition. Projects link can be followed on the initial switchboard page of the desktop application (Figure 4.2). A Pre-defined data entry form assists the user to entry required information about the project. This form is shown on Figure 5.1.

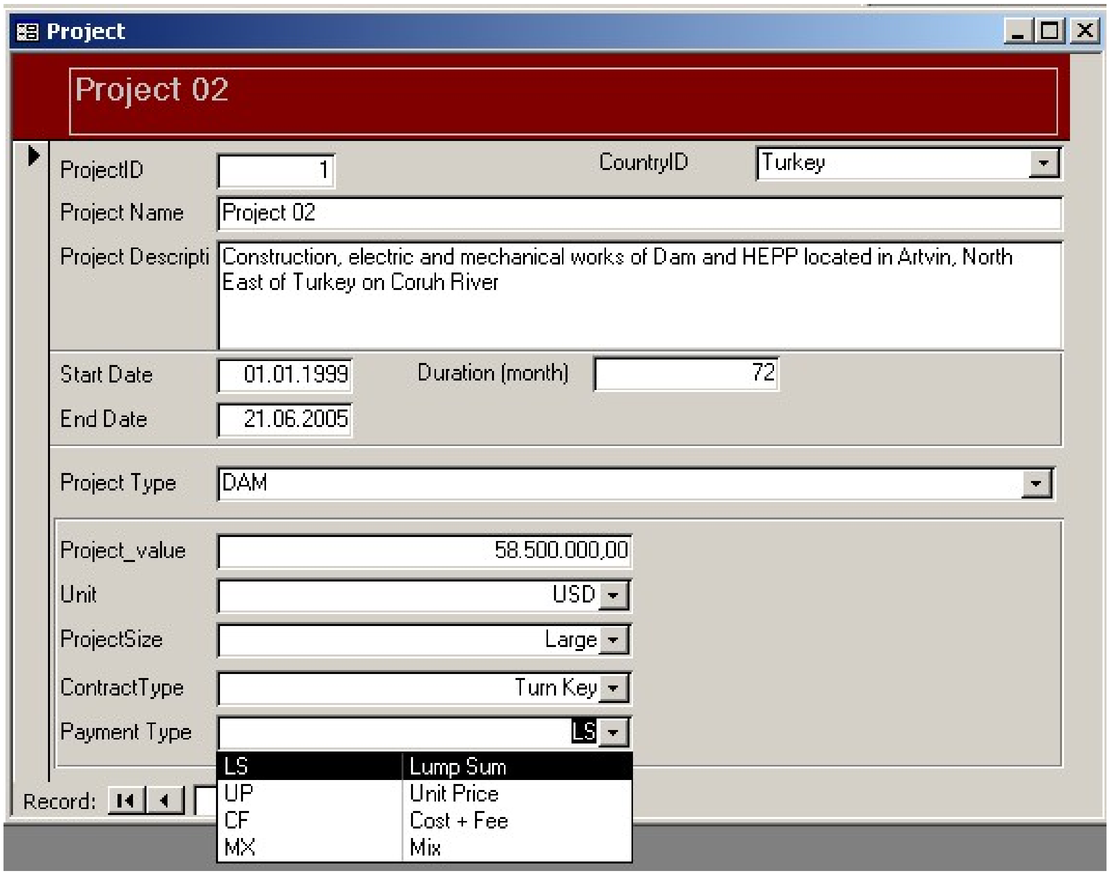

Figure 5.1. Project Data Entry Form

Required fields in this stage of application can be listed as:

- *Country :* A selection to be made from the a complete list of countries in the world
- *Project Name:* Project name as defined in the contract
- *Project Description:* A brief explanation of the project and scope of work
- *Start / End Date:* Start and end dates should be declared. If the project is in execution phase end date can be entered as contractual finish date.
- *Duration (months):* Contractual duration initially defined in contract. Any change in duration should be implemented in post project appraisal phase with related risk history.
- *Project Value:* Contract value initially defined at the start of the project. Any change in contract value will be entered in post project appraisal phase with related risk history.

- *Unit / Currency: C*ontract value currency. Initially five currencies (USD- US dollars, EUR – Euro, YTL – New Turkish Lira, ATS – Austrian Schilling and YEN – Japanese yen) are defined in the system however not limited to these currencies.
- *Project Size:* This field is required to classify projects according to their contractual value (from the viewpoint of the contractor). In this study projects are classified into three: *Small* (0-10 million USD), *Medium* (10-30 million USD) and *Large* (Greater than 30 million USD).
- *Project Type:* Type of work package is defined at this field. Project types assumed for this study are housing, building, transportation, energy and industrial projects.
- *Contract Type:* Project delivery type is defined at this field. Preset values include design-bid-build, design-build, turnkey, BOT/BOOT, EPC, construction management, force account.
- *Payment Type:* Progress payment type defined in the contract. Preset values are lump sum (LS), unit price (UP), cost plus fee (CF) and mix type.

These fields will allow users to analyze and categorize previously entered risk data according to project attributes. As our study focus on only one project, this part is designed to illustrate further capabilities of this application.

Second step is definition of parties involved in the project. Their relations to the project are defined as shown in Figure 4.3. Pre-defined relations to a project are main contractor, JV partner, supervisor, client, construction subcontractor and consortium partner. Parties and relations to the project can be chosen through pull-down menus.

Thirdly, risk identification phase is carried out under the supervision of project manager in accordance with previously executed risk analysis. Interview sessions are organized to hindsight the history of the project. Project manager as being one of the earliest members in the project has insight information about almost every process.

Project manager covers risk manager role in the model, proposed in Chapter 3. Risk factors list is prepared in the light of project managers know-how and previously documented correspondences on claim topics. Data entry for risk factor entry is illustrated in Figure 5.2.

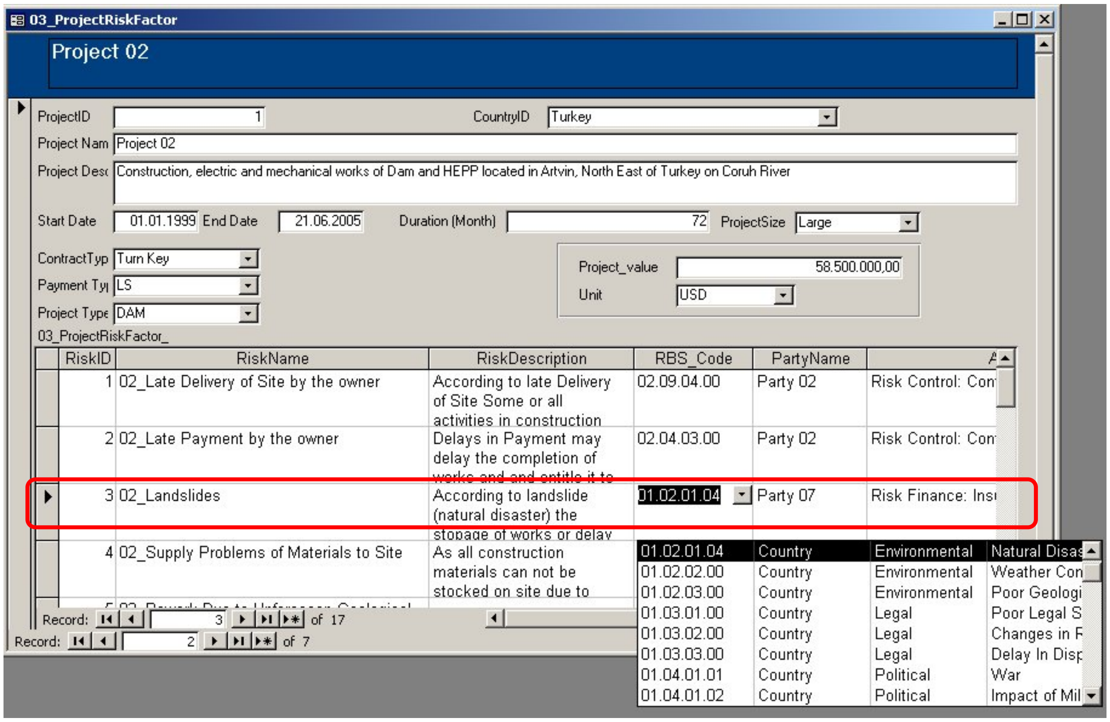

Figure 5.2. Risk factors definition phase for sample project

This interface includes project information defined on previous steps and a subform for risk items definition. Risk manager as proposed in the information model defines the project activities and in accordance with those activities, risk sources are defined for the project. As boxed out in Figure 5.2 risk factor requires following information to be assigned.

- *Risk ID* – Automatically generated integer value system keeps in relational database for uniqueness of record.
- *Risk Name* – Name of the risk factor defined by risk manager. Risk name should involve project number as header information to avoid any misunderstanding for further processes.

- *Risk Description* – Brief description of risk factor can be given to inform other users about the cause-impact relation for this risk.
- *RBS Code* – This field can be considered as the most important field for post project appraisal procedures. Defined risks are assigned to a RBS code defined in the risk catalogue. Using a pull-down menu all risk catalogue information can be accessed. RBS codes for a system are unique for a system which acts as the common language between different project risks.
- *Party Name* – Risks can be related to parties involved in the project. Using the pull down menu involved parties for that project can be selected for that risk factor.
- *Action* – Response action is defined in this field.

Risk factors related to risk identification process for sample project, are listed below.

- *Risk 01* - According to the late delivery of sites by the owner construction works and following instrumentation works can be delayed.
- *Risk 02* - Delays in payment schedule may affect the material supply and cash flow forecast, thus completion of works can be delayed. Any delay will result in additional costs for contractors.
- *Risk 03* - Insufficient or inappropriate geological surveys will result in reworks due to unforeseen geological conditions.
- *Risk 04* - Payment of VAT is not clearly defined in the contract.
- *Risk 05* - Due to earthquakes stoppage of works or delay in some or all activities of civil works may occur.
- *Risk 06* - Due to landslides stoppage of works or delay in some or all activities of civil works may occur.
- *Risk 07* - As all construction materials can not be stored on site, continuous flow of materials should be ensured in accordance with the availability of materials on the market.

- *Risk 08* - Adverse weather conditions may threaten the access to site as well as working conditions on site. Delay of some of all activities may arise due to weather conditions.
- *Risk 09* - Milestones in the schedule is not clearly distributed between JV partners. Dependency of work to different JV partners and arguments regarding delay of work is not clearly defined in the contract. Sharing of risks and milestones may cause disputes between parties.
- *Risk 10* - Due to economical changes in both countries (Turkey and Austria), vague items in contract may lead to disputes between owner and general contractor.
- *Risk 11* - Some contract clauses are not clearly defined or inconsistent with the rest of the contract.
- *Risk 12* - Socio-cultural differences between foreign company members and domestic workers may cause low productivity or communication problems between two parties.
- *Risk 13* - Additional works out of lump-sum price bill of quantity may not be fully paid by the owner if not correctly documented.
- *Risk 14* - Change in technical or management core team may cause loss of knowledge and loss productivity
- *Risk 15* - Austrian company is new in Turkish market, thus some procedural problems in documentation may lead to delay of payments or execution of works.
- *Risk 16*- Poor communication between JV partners will lead to poor technical quality and disputes due to delay or lack of works.
- *Risk 17* - Poor contract clauses between JV partners will cause problems in dispute resolution process.

After the identification process of basic risk factors and assignment of ownership according to contract clauses, risk assessment procedure is executed by interviewing with risk manager. Likert scale is used for representation of linguistic values assigned to risk impact and probability. User interface for risk assessment procedure is illustrated in Figure 5.3.

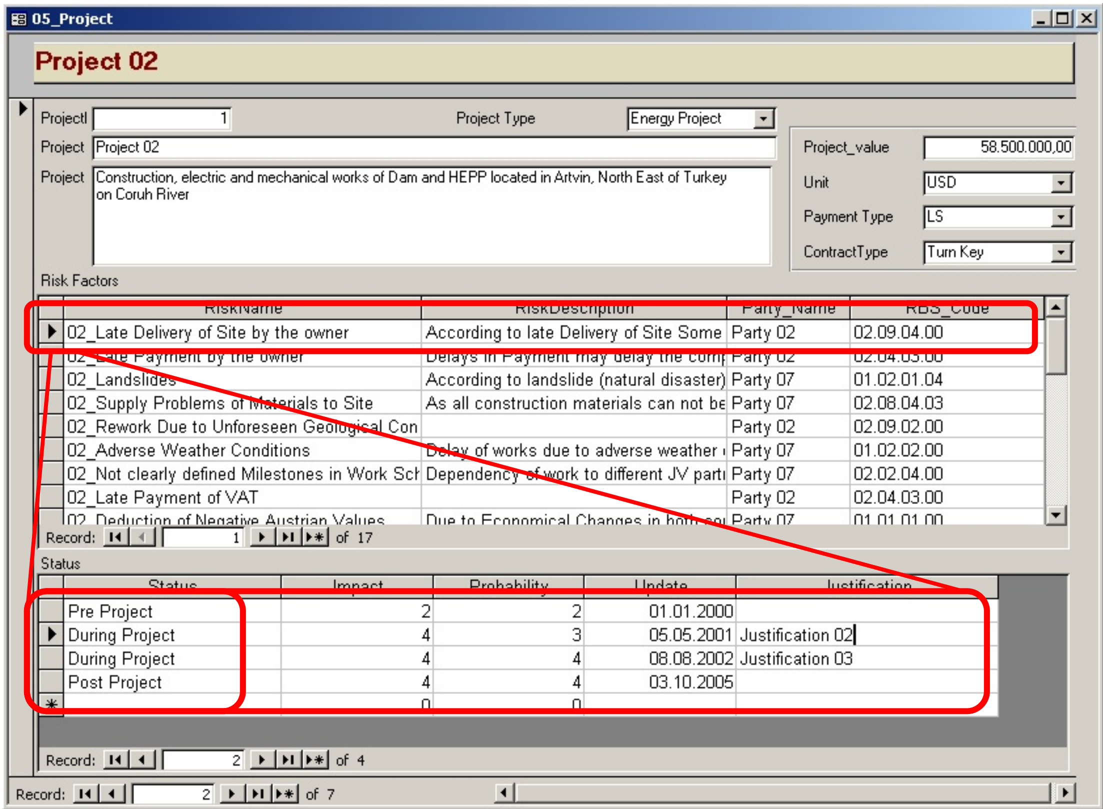

Figure 5.3. Risk assessment Interface

Risk assessment values are recorded in form of status values for risk factors. Initial assessment values are captioned by "Pre-project" assigned in status field in the sub-form. Monitoring, reassessment and post-project assessment procedures are also executed on this page. Sub-form displays assessment entries related to selected risk factor in upper part of the interface page. Every risk factor involves more than one status entry. In a complete set, "Pre-project" assessment values represent the initial assessment results. "During Project" assessment values represent post-response assessment values and revisions according to actualization of risk factors. These values can be updated on a periodic basis throughout the life cycle of a project. "Post-Project" values represent the final assessment of risks after the completion of project. Historical information about these values is recorded in post project event history table entries.

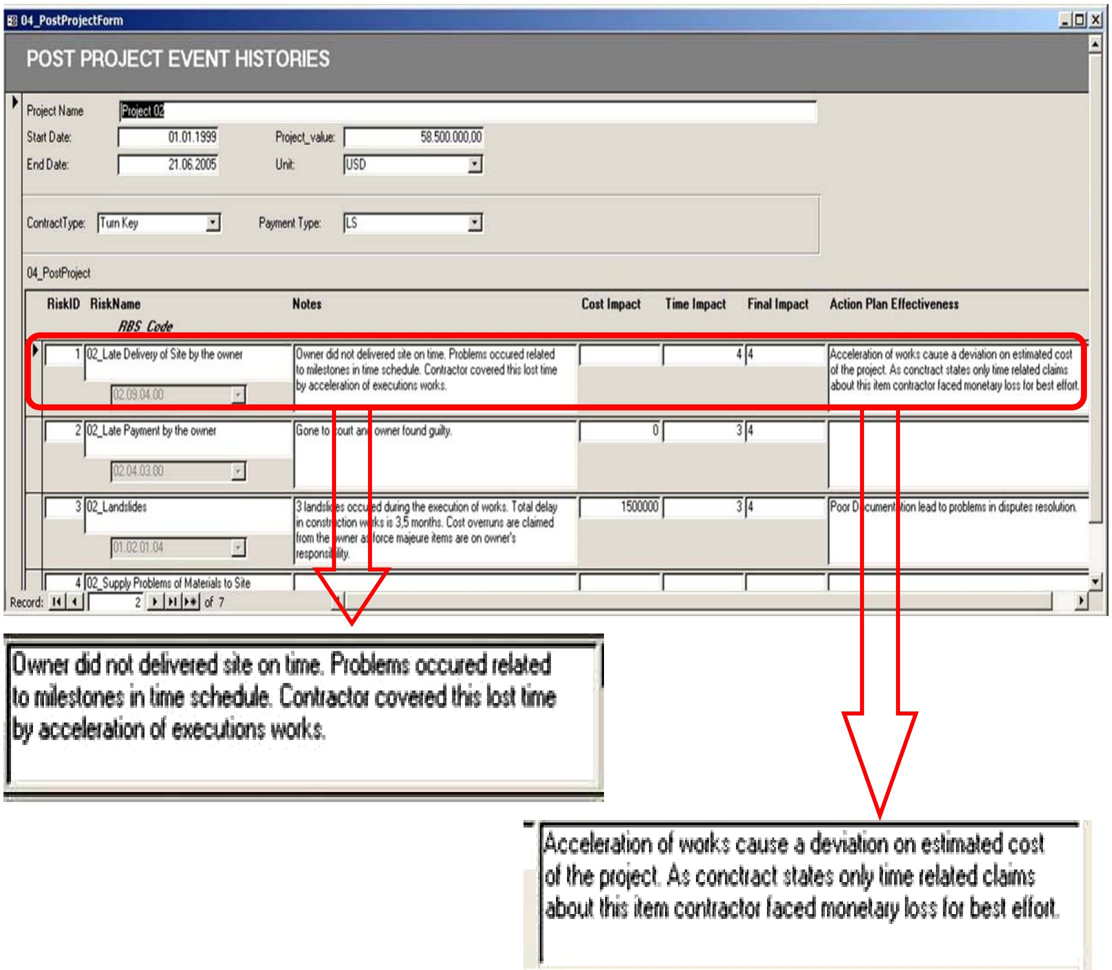

Figure 5.3. Post Project Event Histories Interface

After risk rating and response development processes final meeting is organized with the project manager to finalize the study with risk event history registers. Final assessment of risk events evinced the change of attitude towards risk items when historical data is available. Table 5.1 and Table 5.2 represent the risk impact and probability assignments before and after the project.

Table 5.1. Risk factor rating distribution before the project

Impact / Probability	1	2	3	4	5
1			Risk 06		
2		Risk 01 Risk 02 Risk 03 Risk 11	Risk 14	Risk 09 Risk 04	
3				Risk 15 Risk 13	
4		Risk 07	Risk 10 Risk 05		
5					

Risk assessment values are summarized in Table 5.1. 13 out of 17 risk factors were defined before the start of the project. Risk 08, Risk 12, Risk 16 and Risk 17 were not foreseen before the start of the project. These risks were considered as secondary risks. Subjective risk rating values can be calculated by multiplying impact and probability values.

Table 5.2. Risk factor rating distribution after the project

Impact / Probability	1	2	3	4	5
1					
2	Risk 17	Risk 14	Risk 14 Risk 12		
3		Risk 11	Risk 02 Risk 05 Risk 06 Risk 09 Risk 15	Risk 16	
4		Risk 08	Risk 07 Risk 03 Risk 10	Risk 01	Risk 04
5					

The deviations from Table 5.1 to Table 5.2 represent the dynamic and subjective structure of risk assessment process in a project. It can be concluded from these tables that initial assessment of risks had to be reevaluated at the end of a project to find realistic consequences on a project. Predefined risk tables and rating tables are considered to be useful tools for estimation procedures. MS Access enables users to generate real time reports by automatically collecting and organizing project information. Three example reports are given in Appendix section.

Application was not delivered to test the improvement accuracy in the assessment process, but figured some important lessons from project information. The focus was on risk management process and risk event histories whereas it can be extended to cover more processes and integrated with other knowledge management tools built in the organization. One shortcoming of this sample application was the number of implemented projects. With increasing number of executed project information and dedication from project management, the accuracy of the system can be increased.

CHAPTER 6

CONCLUSION

As companies position themselves for global market opportunities, projects tend to be more complex and require a collaboration of different disciplines in a short period of time. With the increase of uncertainties and variances in project objectives, the necessity for handling uncertainties arose and risk management concept in international and multi-project environment gained significant importance.

RM is a formal process for systematically identifying, analyzing and responding to risk events throughout the life of a project. Companies mostly focus on the estimation and quantification of risks and uncertainties in early stages of a project whereas they usually do not investigate the cause-effect relation of risks, contract conditions and strategies in the later stages of project realization. Major problem in construction projects is the information loss at the end of a project. An efficient RM can only be achieved by using a systematic approach which fully supports the RM system throughout all the stages of a project. All researchers working in the field of development of RM systems agree on the need for common understanding of risk sources of project in advance. A common language for identifying risks in RM has direct relation with project success as appropriate risk identification enables effective response strategy delivery. As previous works on risk management suggest, risk breakdown structures involve predefined detailing and coding system of risks according to their sources. RBS can assist risk identification process as a checklist for generic projects. Success of a project risk management system can be quantified by the deviation from preliminary assessment of tolerable risk impacts on the project to the objective functions of the company.

In this thesis, a process model has been developed for risk assessment as a part of post-project appraisal. Its main idea is that companies may carry out risk assessment in forthcoming projects by referring to lessons learnt in previous projects. Processes are based on the common functions in a risk management system. These processes are classified according to the delivery phase of a project. A project delivery is considered to have three phases: pre-project, during project and post-project. In the first phase of a project, risk identification, assessment and risk handling/response development processes are completed. Second phase, at execution stage the project, consists of repetitive risk actualization recording and risk action execution processes. Revision and extend of risk identification is carried along with real time response generation. All records and risk logs are transferred to next and final stage of project, post-project phase, for a final assessment of risk events and effectiveness of response strategies. A use case diagram and a RBS are developed together with the process model as the basis for application of the developed model.

Sample software application is illustrated with a real project implementation. An international construction company is chosen for the case study. A hydro-electrical power plant project in north-east region of Turkey which was executed with a consortium of two Turkish companies and Austrian company was defined as the case study project. Risk items defined on the early stages of the project are collected by interviews with project manager who has the risk manager role in this application. After collection of related correspondences and claim management reports, a final appraisal of risk items was carried out with risk manager. Risk assessment as a part of post-project appraisal indicates that the judgments of decision makers at the start and end of the project may differ significantly. During post-project appraisal, it became evident that the management weakness and organizational disorder had significant effects on the success of the sample project, whereas they were not assumed to be very important during pre-project risk assessment.

The developed tool has got some advantages;

- As an organizational learning tool: The proposed tool may be used to store risk information regarding risk sources, consequences etc. and users may refer to this information while preparing their risk management plans. If used for many projects, similar projects may be easily found and more informed decisions may be given based on the data stored in the corporate risk memory.

- As a reliable risk assessment tool: The basic bottleneck of risk assessment as stated by the practioners is the subjectivity of decision-makers and thus, low level of trust in the outcomes. If the proposed tool is utilized, the justification of the decisions about risks and responses will be apparent and previous projects may be used to support subjective judgments.

- As a systematic risk management tool: The developed tool lists down all risk management activities that should be carried out during the pre-project, project and post-project phases and guides a potential user about how risks can be managed and points out/provides the information requirements at different stages. Also, the developed RBS makes risk identification easier and more systematic. It may create a common language within the organization about risk events.

- As a post-project appraisal tool: The outputs of the tool may be used to generate a post-project appraisal report that includes the information about risk events occurred in a project, their effects on project outcomes, response strategies used and their effectiveness.

Project management functions require a full coverage of project variables and functions, which are not limited with the project environment. Interaction between different knowledge areas is required for a successful application of project management system supported with organizational learning tools. Learning from risks faced during a project is important as cause-impact relations of problems faced in a project becomes more apparent. Assessment of such items in advance results in improvement in project success thus competitiveness in the market.

Risk management process requires the full commitment of project management from the start till the end of a project. With this tool, the risk management process becomes a part of the project life cycle and the awareness of people on systematic management of risks increase. Moreover, in this study, the aim was to demonstrate how the conceptual models of RM may be applied in practice. User feed back supports the idea that risk assessment process can be improved with the systematic use of historical data and conceptual models may be successfully applied in practice if necessary tools are developed.

As identified by the experts during case study, major drawback of the risk assessment procedure as a part of post-project appraisal is the cultural barrier. Major difficulty in creating risk event histories may be the lack of commitment of project management staff. Companies are not eager to dig deep on the loss of a past project rather than looking forward to new opportunities in the market.

Some other shortcoming of the proposed system and tool may be listed as; the difficulty of storing risk data which is intangible, unwillingness of people to talk about problems faced in a project, difficulty to model the interrelations between risk events (individual effects are considered in the tool rather than the combined effects).

As a final word, the research study is aimed to develop a conceptual model about how companies may learn from actually realized problems and integrate the lessons learnt to their decisions in the forthcoming projects. The tool developed to implement this model showed a satisfactory performance in the case study. However, its effectiveness should be tested on a number of projects, in different companies, at different stages of projects so that it can be denoted as a reliable generic tool. Also, in a further study, the assessment procedure used in the tool may be revised, company-specific tools may be developed and the RBS can be tailored according to company/market specific needs.

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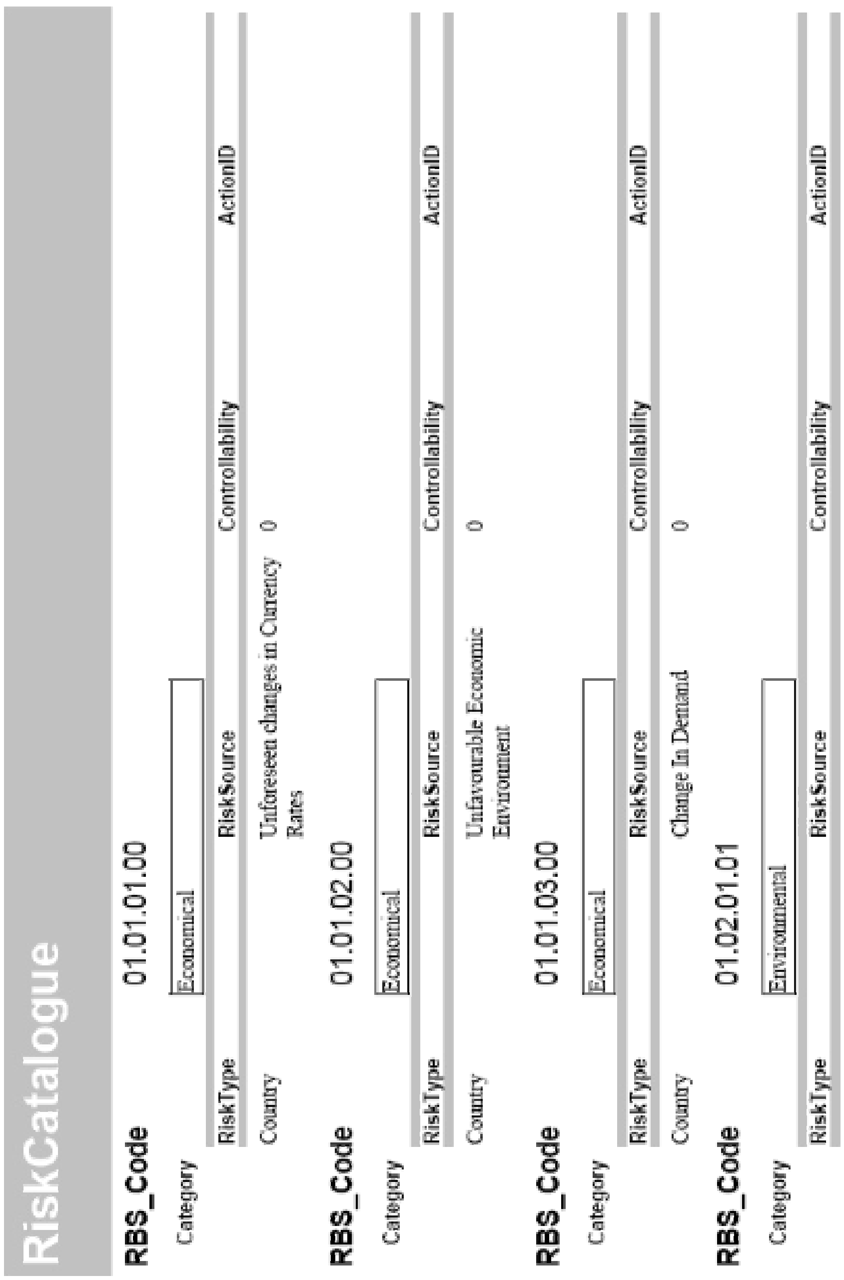
APPENDIX A

SAMPLE REPORTS GENERATED BY MS ACCESS TOOL



RiskCatalogue

RBS_Code 01.01.01.00

Category: Economical

RiskType	RiskSource	Controllability	ActionID
Country	Unforeseen changes in Currency Rates	0	

RBS_Code 01.01.02.00

Category: Economical

RiskType	RiskSource	Controllability	ActionID
Country	Unfavourable Economic Environment	0	

RBS_Code 01.01.03.00

Category: Economical

RiskType	RiskSource	Controllability	ActionID
Country	Change In Demand	0	

RBS_Code 01.02.01.01

Category: Environmental

RiskType	RiskSource	Controllability	ActionID
Country	Natural Disasters: Other	0	

Figure A.1 A Sample Report for Risk Catalogue listing represented in the Database Application

Project Risks

Project Name	Project 02	Payment Type	LS
Project_value	58.500.000,00		
Unit	USD		
ContractType	Turn Key		

Party_Name	RiskID	RiskName	RiskDescription
Party 02	1	02_Late Delivery of Site by the	According to late Delivery of Site Some or all activities in construction works can be delayed.
Party 02	2	02_Late Payment by the owner	Delays in Payment may delay the completion of works and and entitle it to reimbursement of its additional costs
Party 02	5	02_Rework Due to Unforeseen	
Party 02	8	02_Late Payment of VAT	
Party 02	18	02_Natural Disaster - Earthqua	According to Earthquakes (natural disaster) the stopage of works or delay in some or all activities of the constrcution works
Party 07	3	02_Landslides	According to landslide (natural disaster) the stopage of works or delay in some or all activities of the constrcution works
Party 07	4	02_Supply Problems of Materi	As all construction materials can not be stocked on site due to storage problems contious flow of materials should be ensured in accordance with the availability of materials on the market
Party 07	6	02_Adverse Weather Conditio	Delay of works due to adverse weather conditions

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Figure A.2 A Sample Report for Project Risk listing represented in the Database Application

Post Project Risk Event Appraisal Report

Project Name	RBS_Code	RiskName	Notes	Cost Impact	Time Impact	RevImpact	Act.PlanEffect.
Project 02							
	01.02.01.04						
	Party 07	02_Landslides	3 landslides occured during the execution of works. Total delay in construction works is 3,5 months. Cost overruns are claimed from the owner as force majeure items are on owner's responsibility.	1500000		3 4	Poor Documentation lead to problems in disputes resolution.
	02.04.03.00						
	Party 02	02_Late Payment by the owner	Gone to court and owner found guilty.	0		3 4	
	02.05.09.00						
	Party 10	02_Vaguness in contracts between JV partners		250000		3 3	
	02.09.02.00						

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Figure A.3 A Sample Report for Post Project Risk Event Appraisal Report represented in the Database Application