Electronic Checklist of Risk Items on Construction Projects

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ABSTRACT: Risk management in construction encompasses four main phases; risk identification, quantification, mitigation and control. Risk identification has been recognized as the most crucial phase of a successful risk management program. This paper briefly describes a model, designed to automate the risk identification process. The model facilitates the development of an electronic checklist of items that are likely to give rise to risk on construction projects. A risk classification scheme is proposed, where risks are classified as either generic or domain-specific. Generic risks are those which might be encountered on any project, irrespective of its type (e.g. currency fluctuations). Domain-specific risks, on the other hand, are those which are associated with the nature of the project at hand (e.g. risks encountered on transportation projects might not be encountered in hydro projects). At the core of the model is its relational database, designed to store various risk items. The impact of project domain, size, location and delivery type (Engineering – Procurement – Construction vs. Build – Operate – Transfer) are considered in developing an automated list of project-specific risk items. The proposed model is implemented in a prototype software, which operates in Microsoft Windows® environment. It employs Microsoft Access® as the database management system and incorporates a user-friendly graphical user interface, utilizing dialog boxes, menus and toolbars. The developed system has several practical features, including the definition of one or more references to each stored risk item to enable tracking and reviewing of their sources. It provides three levels of access for security purposes. It is flexible, allowing updates and editing of defined project-specific risks.

KEYWORDS: Risk identification, risk management, construction management.

1. INTRODUCTION

The first and most important phase of a risk management program is risk identification (CII 1988; De Zoysa and Russell 2003), as a risk that is not identified cannot be quantified, controlled, transferred or otherwise managed. The process is particularly difficult as there are no structured methodologies that may be adopted to identify project risks. It remains a process that relies heavily on the experience and insight knowledge of project personnel. Risks have typically been identified through several methods including brainstorming, workshops, checklists, questionnaires and interviews, literature review, and knowledge-based systems (De Zoysa and Russell 2003). Upon identifying risk items to which a project might be exposed, most construction organizations store them in the form of a risk register. Such registers have been identified as "extremely effective tools" by Patterson and Neailey (2002). However, no formal structure has been developed to systematically identify risks to which a particular project might be exposed. Typically, risk management in construction tends to depend mainly on individual key players (Tah and Carr 2000). These individuals adopt different terminology and techniques for describing and managing risks, which could potentially cause inconsistencies and ambiguities. A common language for describing risk is necessary to facilitate a consistent approach to assessment and quantification of its impact.

This paper presents a model, designed to automate the risk identification process and provide a systematic approach to reduce ambiguities. The proposed model accounts for several practical factors when identifying risks to which a project might be exposed, including project location, domain and size. The impact of project delivery system on potential risk items is also considered. The sources from which risk items were obtained are stored to enable subsequent assessment of their reliability. A prototype software, based on the proposed model is developed. It operates in Microsoft Windows® environment, providing a user friendly interface utilizing menus, dialog boxes and a toolbar. It provides various levels of access, ensuring security and integrity of its central database. It provides a vehicle for construction companies to continuously enhance and fine-tune their risk registers to store corporate knowledge, and efficiently draw upon it for potential business opportunities.

2. SCOPE

The proposed model automates the generation of risk items to which a project might be exposed, while embracing flexibility and practicality. It was developed in collaboration with a major Canadian contractor to automate the risk identification process, and as a the first phase towards the development of a risk management program. It is designed to aid practitioners in identifying various risks and opportunities to which a project might be exposed. It automatically generates a list of all risk items and opportunities to which a project is exposed, enabling users to select some or all of them, as per the unique requirements of each project. In addition to risk items, the proposed model stores: 1) the username of individuals who define/edit these risk items on a regular basis; and 2) sources from which these risks were obtained (personal experience/literature review). It is designed to be employed in the pre-bidding stage, building on the knowledge base and user's experience.

An issue that caused some debate between researchers is whether the term "risk" should be confined to define threats, or whether it should be broad to encompass both threats and opportunities. A recent study (Raftery *et al*. 2001) determined that contractors pay more attention to threats than opportunities, even if the attached monetary values were identical. Recently, the trend has been to regard risks as both opportunities and threats, (see the Project Management Body of Knowledge

(PMBoK 2000)). In this paper, it was decided that the term "risk" be used to define uncertain events with both positive and negative impacts on the project. This is because:

1. Opportunities and threats are not qualitatively different in nature, since both involve uncertainty and have the potential to impact project progress;
2. Adopting this nomenclature would aid management in both minimizing the impact of threats and maximizing the impact of opportunities; and
3. This approach would aid management in the adoption of an unbiased approach to risk management (Raftery *et al*. 2001).

When generating the list of potential risk items for a project, it was recognized that the adopted project delivery system has a significant impact on the risks to which a project might be exposed. Engineering/procurement/construction (EPC) and build-operate-transfer (BOT) delivery systems pose different risks that can impact the project being analyzed. Additionally, various types of contracts (e.g. lump-sum, cost-plus) allocate risks differently between contracting parties. The proposed model accounts for project delivery systems and adopted contract type. The following sections provide an overview of the proposed model.

3. RISK CLASSIFICATION

A coherent risk classification scheme has been identified as a crucial step in risk identification (Al-Bahar and Crandall 1990; De Zoysa and Russell 2003). A comprehensive review of risk classification schemes was conducted to establish the current state-of-the-art in the field and identify and categorize the various risk items to which a class of projects may be subjected. Classification schemes reported in literature, along with that developed by the industry partner were reviewed. Most classification schemes reported in literature divide risks based on either: 1) their source (e.g. Odeyinka 2001; CII 1989); or 2) ability to control them (e.g. Tah and Carr 2001). Another classification scheme was proposed by Tah and Carr (2001) based on their nature throughout project life cycle. From this viewpoint, risks are divided into static and dynamic. Static risks maintain their nature throughout project life or until they seize to pose a threat (or opportunity). That is to say, the probability of occurrence of the risk and its impact on project progress remain unchanged. On the other hand, the likelihood of

the occurrence of dynamic risks and their impact vary during the life cycle of the project. The events causing this class of risks should be constantly monitored, the likelihood of their occurring reassessed and their impact re-evaluated.

Figure 1 depicts the proposed risk classification scheme, where risks are divided into two broad categories: generic and domain-specific (or sector-specific). Generic risks are those which are inherent in all projects, irrespective of their nature or the type of work involved. These are divided into five sub-categories based on their sources. These are: commercial, technical, location, client and own risks. Own risks include: 1) those which an organization poses to itself, such as availability of technical know-how and right staff within the organization to carry out a project successfully; and 2) competence of selected partners. Domain-specific risks, on the other hand, are dependant on the project type, and would only be relevant for a specific domain (e.g. transportation, power plants). In the current study, sixteen domains are defined, reflecting the sixteen domains which the industry partner is involved in.
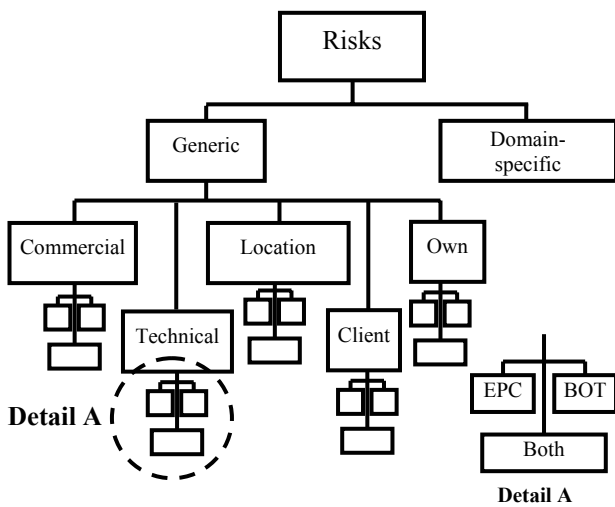

Figure 1. Proposed risk classification scheme

The proposed classification scheme accounts for the adopted project delivery method (EPC vs. BOT). This enables the identification of risks that are inherent under differing project delivery systems (EPC vs. BOT projects). In that regard, risks are classified into three main groups (Figure 1, detail "A"): 1) BOT; 2) EPC; and 3) both risks. The definition of the third category acknowledges the presence of certain risk factors that are applicable irrespective of the project delivery

method and accounts for the fact that a BOT project may include EPC-related risks. This accounts for the nature of BOT projects, which impose additional risks over and above those inherent under traditional project delivery systems. The prolonged planning horizon, increased number of project participants and markedly increased project variables increase a project's vulnerability to external risks (Kumaraswamy and Morris 2002).

4. COMPUTER IMPLEMENTATION

The proposed model is implemented in a prototype software that operates in Microsoft Windows® environment. It is coded in Visual C++ Version 6, utilizing Microsoft Foundation Classes (MFC). It provides three levels of access: 1) administrator; 2) management; and 3) project team. Access privileges for each group are listed in Table 1. As the table shows, only administrators have access to all projects, while managers only have access to projects with which they are involved. Microsoft Access® is employed as the database management system (DBMS), using Open DataBase Connectivity (ODBC), which enables real-time updating of the database. The database enables management to query risk items based on the access level of the person who input them, enabling fast queries on various risk items and evaluating their value to the company. If approved by management, the risk item is no longer highlighted, otherwise it is deleted. This process is designed to encourage participation and help capture the company's experience and builds on its reservoir of knowledge and expertise, while ensuring the integrity of the database.

The proposed model provides a simple, friendly graphical user interface, as shown in Figure 2. The left portion of the screen contains a tree view, similar to that of Windows Explorer®, listing a variety of data including defined projects and risks to which they are exposed, stored risk items and sources from which they were defined. Upon double clicking on a risk item defined for a project, the user can edit its probability of occurrence and/or potential impact. The right portion of the screen provides a more detailed description of the project at hand, its domain, cost, project delivery method, location and risk items to which it is exposed, along with their probability of occurrence and potential impact. The user can edit these risk items to suit the unique conditions of each project through: 1) adding risk items; 2)

deleting risk items; or 3) revising a risk item's probability of occurrence and/or potential impact. This increases the model's flexibility, enabling it to continuously adjust to account for dynamic risks (Tah and Carr 2001).
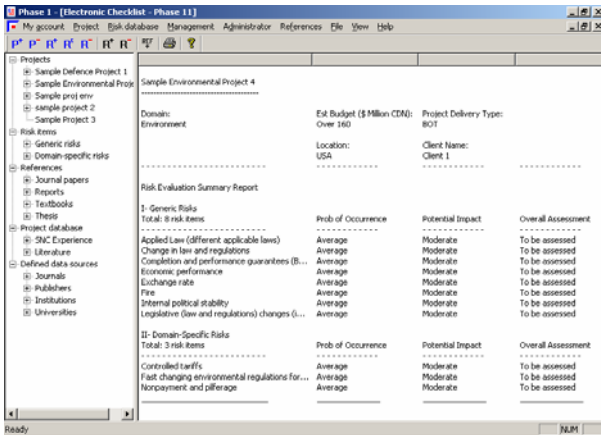

Figure 2. Main software screen

The dialog window shown in Figure 3 is designed to define new risk items. It captures all required data to categorize and store defined risk items in the database. For generic risk items, a sub-category (commercial/technological/client/own /location), while for domain-specific risks, a domain needs to be specified. The list of domains is also user-defined, enabling the software to be tailored to the domains of expertise of the user, and enabling its modification to accommodate emerging domains. The project delivery method that gives rise to the risk item also needs to be defined, along with the minimum project cost with which it is associated. The same dialog window is employed to input opportunities (risks with positive impact on project cost/schedule), as the user can select whether the risk item is a liability or a potential gain. It is worth noting that a description of the risk item is also required as input in order to resolve any ambiguities that might arise regarding its nature and what it covers. Periodic review of defined risk items and their definitions would avoid duplicity and aid in developing a company-wide terminology regarding risk.
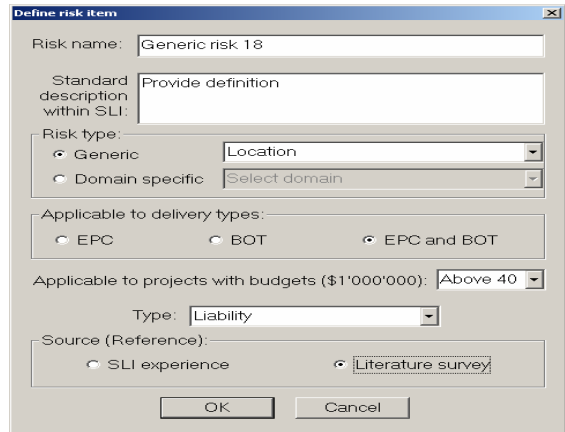

Figure 3. Dialog window to define new risk item

The software employs a two-stage approach to identify risks to which construction projects (within the sixteen pre-defined domains) might be exposed. The first stage is project definition, which is carried out employing the dialog window shown in Figure 4. All variables required to determine risk items to which a project might exposed are input using that dialog window. Upon defining the project, and based on its domain, estimated cost and delivery method, a broad group of risk items is retrieved from the database. The data included in the dialog window shown in Figure 4 is all the input that is required of the user to generate its checklist of risk items.
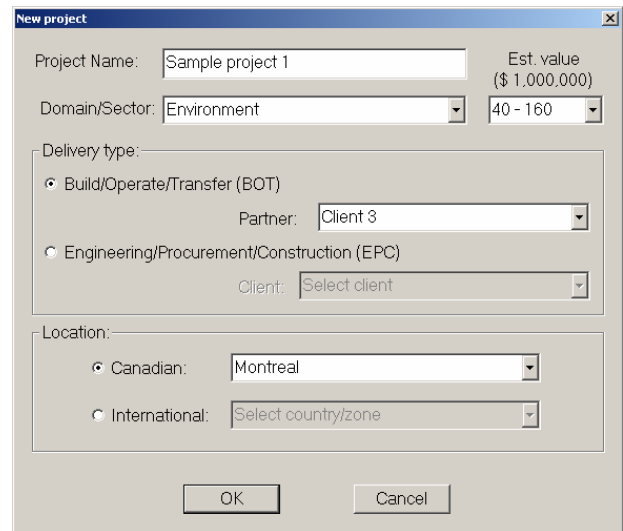

Figure 4. Stage one: project definition

The second stage employs the dialog window shown in Figure 5, and entails selecting risk items relevant to the project at hand from a list of risk items that might potentially impact a project. As the figure demonstrates, the dialog window

contains two lists of the generic and domain/sector specific risk factors. The project shown in Figure 4 is an environmental project constructed using the BOT delivery system. As the figure shows, the software retrieves relevant risk items from the database and lists them alphabetically for the user to select some or all of the listed items. In the case shown in the figure, risks applicable to both: 1) BOT-related risks; and 2) risks applicable to both EPC and BOT delivery systems are considered relevant. This query is carried out for both generic and domain-specific risks (in this case, environmental) to develop the electronic checklist shown in Figure 5. Once this list is developed, it could be subject to further review for further additions and/or deletion, as the project team deems fit. To reduce ambiguities, a description of a risk item can be reviewed by double-clicking on its name.
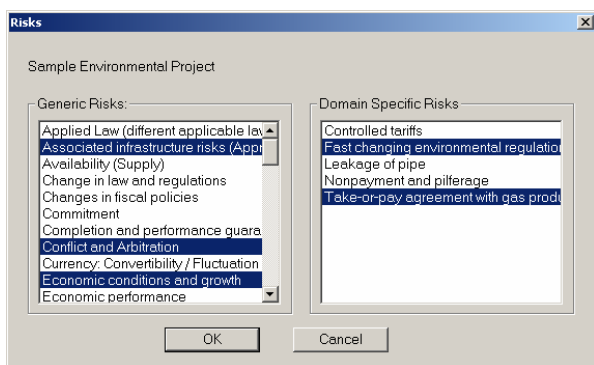

Figure 5. Stage two: selecting risk items

Upon completion of this stage, a project-specific checklist of risk items is developed as shown in Figure 2. These items can later be revised to account for the dynamic nature of the construction industry. The effort required to generate a risk checklist for a construction project has been reduced to two simple point-and-click dialog windows.

5. CONCLUSIONS

This paper presented a model, designed to automate risk identification for construction projects. The project was part of a collaborative research program with a major Canadian contractor. A robust risk classification scheme is proposed to aid in the risk management process. The proposed model employs a two-step approach to generate project-specific checklist of risk items that require management's attention. It is implemented in a computer software that operates in Microsoft Windows[®] environment. It provides a

user-friendly interface, minimizing the time and effort required to identify risks to which a project might be exposed. It aids in achieving conformity in risk terminology within the company, aiding construction companies to develop a well-defined business culture towards risk management.

6. REFERENCES

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Table 1. Levels of access enabled in proposed model

Privileges	Administrator	Management	Project Team
Access to projects	All	Restricted	Restricted
Define new risk items	Yes	Yes	Yes*
Define new project/deleting project	Yes	Yes	No
Associating risk item with project	Yes	Yes	Yes*
Deleting risk item from project	Yes	Yes	No
Defining new user	Yes	No	No
Viewing user privileges	Yes	No	No

* Pending management approval