A CRITICAL REVIEW OF RISK MANAGEMENT SUPPORT TOOLS

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It has been claimed by many researchers that "a risk driven approach" to project management is necessary to increase the success of construction projects. Literature is very rich in conceptual frameworks to overcome the informality of risk management efforts. However, risk management paradigms exist as methodologies rather than systems which can fully support the risk management process. The existing risk management support tools are usually based on quantitative risk analysis whereas the other phases are carried out external to the software. Risk registers and risk assessment tools are proposed as decision support systems which can only be used at specific stages of a construction project for specific purposes such as time/cost estimation at the bidding stage, country risk assessment during international market selection etc. Moreover, the proposed risk management support tools usually do not foster integration of risk management activities between the parties involved in the construction supply chain, do not consider impact of risks on all of the project success criteria, and can not handle subjectivity. In the recent years, the research has shifted to information and process models in which risks and response strategies may be identified, analysed and managed in a formal way by the use of database and model management systems. The major objective of this paper is to make a critical review of existing risk management support tools and propose development of a risk management corporate memory coupled with a decision support tool for successful management of risk.

Keywords: decision support systems, information modelling, risk management.

INTRODUCTION

Risk management (RM) is about 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. Risk management in construction is a tedious task as the objective functions tend to change during the project life cycle, and the risk scenarios are numerous due to sensitivity of construction projects to uncontrollable risks stemming from the macro-environment, existence of high number of parties involved in the project value chain, and one-off nature of the construction process. Risk management support tools are required in order to systematise the process, to overcome some of the analytical difficulties such as calculating performance of the project under different scenarios, and finally to incorporate experience from previous projects into the decision making process. In this paper, what has been covered in the construction management literature till date is

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discussed as well as what shall be done to improve the risk management process in construction. The aim of the paper is not to discuss all the previous work in this area, rather it is to summarise the general research trend by referring to specific examples.

RM IN CONSTRUCTION

Literature review shows that research on RM can be grouped in four categories: (1) development of conceptual frameworks and process models for systematic risk management, (2) investigation of risks, risk management trends and perceptions, (3) application of risk identification and analysis techniques in specific projects and (4) development of integrated risk management support tools. In the following parts, some examples are presented to highlight the general aim and scope of work that may fall in each category.

Development of conceptual frameworks and process models

One of the earliest efforts to define risk management process belonged to Hertz and Thomas (1983), who proposed a step-wise procedure of risk identification, measurement, evaluation and re-evaluation. Further, Hayes et al. (1986), Flanagan and Norman (1993), Raftery (1994), Edwards (1995) proposed reference frameworks comprising of risk identification, risk analysis, response planning, continuous monitoring, feedback for risk learning and action planning. All of these frameworks imply a systematic approach for management of risk by following a risk identification-analysis-response-monitor loop. Moreover, several institutions provided procedural, task-based guides for construction risk management. RISKMAN endorsed by European Community (Carter et al. 1994); Project Risk Analysis and Management Methodology (PRAM) introduced by Association of Project Managers (Chapman 1997); Risk Analysis and Management for Projects Methodology (RAMP) promoted by Institution of Civil Engineers (1998); and PMBoK guide of Project Management Institute (2000), all attempt to eliminate informality of risk management activities and integrate risk management with other project management functions. With slight differences in model architectures, number of separate phases, level of detail and coverage of project life cycle, all of the above mentioned RM process models and reference frameworks share a common goal and have similar characteristics. A more recent research theme is discussion of critical success factors for the implementation of process models. Researchers proposed different decision support systems and information models to implement the conceptual process models in practice. For example, Tah and Carr (2000) pointed out the vital role of a common language and proposed an information model for the risk management process. Jaafari (2001) indicated the importance of management information and decision support systems that can integrate all aspects on a real time basis. Similarly, “soft systems” aspects of RM and human problems of implementation of RM in different organisational contexts have also been discussed by researchers (e.g. Edwards and Bowen 1998). Interpersonal communication of risk and learning from risk experiences have been indicated as important as the “hard systems” approach for the implementation of proposed methodologies.

Investigation of risks, RM trends and perceptions

Research under this category is directed towards identification of risk factors specific to different projects, project delivery systems, international markets and investigation of risk perception of people within the construction industry. Thus, questionnaires, interviews and case-studies constitute the major research methodology in this category. As there is no single categorisation of risk agreed upon by all researchers and different typologies are proposed serving different purposes, numerous questionnaire studies have been conducted using different typologies. As an example for investigation of risks in specific projects, Tiong (1995) reviewed risks and guarantees in build operate transfer projects by referring to questionnaire findings. As an example for research on risk perceptions, Kangari (1995) investigated risk management perceptions and trends in U.S. construction industry by a questionnaire study. About risk management trends, Simister (1994) reported results of a survey aimed to identify perceptions of people on the benefits of risk management and utilisation rate of different risk assessment techniques in UK. Moreover, there are a number of studies about certain risk categories which are hard to define and measure in construction such as political risk (Ashley and Bonner 1987) and cultural risk (Levitt et al. 2004).

Application of risk identification and analysis techniques

The research under this category is comprised of application of different techniques of risk identification and analysis in construction projects. Researchers demonstrated how the risk management process may be carried out more systematically and efficiently by the use of different techniques. Applicability of various risk assessment techniques has been demonstrated by many researchers. Influence diagramming method for political risk assessment (Ashley and Bonner 1987), cross impact analysis for international risk assessment (Han and Diekmann 2001) and fuzzy event tree analysis for identification of events that may cause failures in underground construction projects (Choi et al. 2004) fall into this category. Also, quantitative risk analysis techniques may be categorised into three groups; probabilistic techniques, fuzzy sets and multi-attribute rating technique. Applications of probabilistic risk analysis techniques, particularly Monte Carlo Simulation (e.g. Bennett and Ormerod 1984; Tummala and Burchett 1999; Ozdogan and Birgonul 2000; Nasir et al. 2003) are widely seen in literature as well as research on shortcomings of and difficulties in implementing Monte Carlo Simulation (e.g. Beeston 1986). Also, several research studies exist in RM literature which applied fuzzy set theory to different decision making problems. For example, Kangari (1988) developed an integrated knowledge-based system (Expert-Risk) for risk management using fuzzy sets, Paek et al. (1993) used fuzzy sets for assessment of bidding prices, Carr and Tah (2001) proposed a software prototype for project risk assessment based on fuzzy logic. There are also applications of multi-attribute rating technique such as Analytical Hierarchy Process (AHP) application of Hastak and Shaked (2000) for international construction risk assessment. Risk rating by multiplying the probability with severity/impact of each identified risk factor and adding them up to find an overall risk score has been utilised by many researchers (e.g. Jannadi and Almishari 2003; AbouRizk and Er 2004) as an effective and simple risk analysis tool in different projects. As well as specific applications, necessary software are also developed by researchers to facilitate application of the proposed techniques. ERIC-S for schedule risk analysis by Nasir et al. (2003) and RAM by Jannadi and Almishari (2003) for quantification of hazard risk are examples for these software.

Integrated risk management support tools

Although, there are numerous models/software that support individual phases of RM, the number of support tools that are integrated with other project management functions, which can be used during the whole project life cycle, and which can support all phases of RM is rather low. Risk Management Support System developed by Aleshin (2001) for international projects in Russia; a generic model, IFE (Integrated Facility Engineering) designed by Jaafari (2001); and the software prototype developed by Carr and Tah (2001) may be listed among potential integrated support systems. Moreover, in Table 1, some of the commercial software used to support risk management process are listed. It is evident from Table 1 that, there are also limited number of software which may provide a full support for an integrated risk management system.

As a result, it can be claimed that, literature is very rich in conceptual frameworks to overcome the informality of risk management efforts. However, risk management paradigms exist as methodologies rather than systems which can fully support the RM process. The existing risk management support tools are usually based on quantitative risk assessment and analysis whereas the other phases are carried out external to the software.

Table 1: Some of the commercial RM software

Tool	Developer	Where it can be used	Which analysis techniques are used	Which RM activities are supported
Predict!Risk Controller	Risk Decisions	Construction of risk registers, integration of risk info with WBS, risk monitoring		Risk identification and monitoring
Risk Radar	Software Program Managers Network	Risk identification and prioritisation	Risk rating	Risk identification and monitoring
RiskID Pro	KLCI	Risk identification, monitoring impact of different mitigation plans, risk reporting		Risk identification and monitoring
@Risk	Palisade Europe	Project cost/schedule risk estimation	Monte Carlo Simulation	Risk analysis
ACE/RI$K	ACEIT	Cost/schedule risk analysis and technical risk assessment	Latin Hypercube sampling	Risk analysis
CRIMS	Expert choice	Comparison of alternatives according to preset criteria	Analytical Hierarchy Process	Risk analysis
Decision Pro	Vanguard Software	Setting up a project model for scenario building	Monte Carlo Simulation, Decision Tree	Risk analysis
Crystal Ball	Decisioneering	Probabilistic modelling of project variables, estimation of cost, time etc.	Monte Carlo Simulation, sensitivity testing	Risk analysis
iDecide	Decisive tools	Construction of project models, risk assessment	Monte Carlo Simulation, influence diagramming	Risk analysis
Monte Carlo	Primavera	Modelling project variables with probability distributions, integrated with various planning software	Monte Carlo simulation	Risk analysis

Table 1: Some of the commercial RM software (continued)

Tool	Developer	Where it can be used	Which analysis techniques are used	Which RM activities are supported
Precision Tree	Palisade Europe	Decision analysis	Decision tree analysis, influence diagrams	Risk analysis
Predict!Risk Analyser	Risk Decisions	Modelling project variables with probability distributions, integrated with various planning software	Monte Carlo simulation	Risk analysis
Risk+	Project Gear	Integrated with MS Project Planner, modelling of project variables with probability functions, risk Gantt charts	Monte Carlo simulation	Risk analysis
Risk Tools	Carma	Risk modelling where qualitative data exists, scenario analysis	Fuzzy sets, neuronets	Risk analysis
SCRAM	SCRAM Software	Stochastic risk analysis and generation of PERT and Gantt charts	Monte Carlo simulation	Risk analysis
RiskTrak	Risk Services and Technology	Risk analysis and reporting (Windows-based tool)		Risk assessment and monitoring
OpenPlan Professional	Welcom Software Technology	Project Management Information Systems	Monte Carlo simulation	Risk analysis and monitoring
Futura	Adlington Associates	Conceptual modelling, risk assessment, action planning		Risk analysis and response planning
SRE	Software Engineering Institute	Decision modelling with risk identification, analysis and response planning		Risk identification, analysis and response
Nickleby KIT	Nickleby HFE	Development of corporate memory, incorporation of experience, intuition, subjective judgements into decision models		Risk identification, analysis, response and monitoring
REMIS	HVR Consulting Services	Structured support for all risk management phases, integrated with other support tools (e.g. @Risk), construction of WBS, risk register, mitigation plans	Monte Carlo simulation	Risk identification, analysis, response and monitoring
Ris3 RisGen	Line International	Risk identification, construction of risk registers, modelling project variables and preparing mitigation plans	Monte Carlo simulation	Risk identification, analysis, response and monitor
RiskKube	RiskCovered	Web-based collaboration for		Risk communication

management of risk

CRITICISMS AND PITFALLS

Following are some shortcomings about the way risk is handled and assumptions made in risk management support tools;

1. Simplistic risk analysis techniques: None of the risk analysis techniques alone is fully capable of quantification of risk impacts on project success. For example, the most widely used risk rating technique based on multiplication of probability with impact is an over-simplistic approach as it is based on the assumption that “risk factors are independent”. There are usually correlations between risks as they may be affected from similar underlying sources such as political risk and economic risk affected from the general forces in the macro economic environment. Thus, a hierarchical structure is necessary to ensure evaluation of risks at each level; where how a risk factor in the upper level affects another one in the lower level becomes a critical issue which can not easily be solved with the classical rating technique. Moreover, in the assignment of ratings (usually using Likert scale), there may be significant differences between the values attached by different decision-makers due to a usually forgotten subject, which is “controllability”. Some people may consider that the probability of occurrence of risk factors is low if they are controllable, by assuming that necessary precautions will be taken to eliminate them, while others may consider probability of occurrence regardless of response. It is very hard to ensure that the rating is done by making the same assumptions about possible responses, capabilities, project success criteria, considering probability and impact independently and having the same risk attitude. Similarly, Monte Carlo simulation may give misleading results if correlations between parameters are not or wrongly defined and it does not reflect the real risk level as some qualitative risk factors can not be incorporated into the analysis. There is also no easy way to define probability distribution function of variables affected from various risk sources. Which risks are considered in assigning probability distributions to variables should be made clear not to over or underestimate some risk factors. It is known that poor risk analysis brings more risk to a project. Also, risk analysis cannot be considered as independent from risk response stage and the contract strategy. The assumptions made in the risk analysis stage determine the overall success of the risk management process.

2. Poor definition of risk: When the literature is investigated, it is clear that there are numerous risk checklists and risk breakdown structures proposed by different researchers. The major drawback in some of these lists is “inconsistency”. The word risk may be used to imply source, consequence or probability of occurrence of a negative event. When sources are mixed with consequences, this leads to a major inconsistency and wrong formulation of the risk model. For example, a consequence like cost overrun should be considered on a different platform than sources such as inflation, technical risk or changes in project scope. Thus, the cause and effect relationships as well as when they are expected to happen should be identified before the construction of risk checklists. It is very difficult to produce a generic risk checklist applicable to all project settings however, development of experience-based databases like PERIL (Project Experience Risk Information Library) may help building generic risk libraries applicable to different construction projects, which is an underrepresented topic in the construction management literature.

3. Lack of integration: It is set forward by many researchers that the major problem of risk management support tools is lack of integration (Jaafari 2001). Integration of;

- Hard systems with soft/human issues,
- Structured information with unstructured information,
- Project objectives (short-term) with strategic (long-term) objectives,
- Tasks of risk management with project management,
- RM activities in one company with those in other project participants,
- All tasks (identification, analysis, response, monitor) of RM with each other,

are required for success. The traditional linear approach (Step-wise procedure carried out at a certain stage of project, rather than a cyclic and continuous procedure followed during the whole project life cycle) and disjointed activities (e.g. separate risk quantification and response strategy determination) may not meet the necessary risk management requirements of the industry. Also, risk models that focus on single performance criteria (cost, time, safety etc. only) may not reflect the overall risk level of the project.

4. Vagueness of expectations from risk management: The literature is full of risk models built to help the decision-maker to determine the contingency value that reflects the risk level of the project. Construction of risk models based on quantitative risk assessment, which is a static approach, is a must for better contingency planning; but building more accurate cost/time plans is only one benefit among numerous potential benefits which can be achieved by applying a dynamic RM process. Better quantification of project risks and better forecasting of future outcomes are among important reasons why professionals use RM tools, however this provides a very limited scope. The aim of RM should be better response planning by what-if scenario building, effective monitoring of risks and project success in order to revise plans, better communication of risk between project participants, construction of corporate memory to introduce experience-based solutions of how risks can be avoided and finally, learning from risks. Thus, more research on these issues, demonstrating potential benefits of RM philosophy is necessary as well as mathematical models built for better estimation and forecasting. The role of RM, which also embraces management of opportunities, as a value-adding activity in construction should be stressed more vigorously.

PROPOSED RISK MANAGEMENT SUPPORT SYSTEM

In the light of the above discussions, authors are trying to develop a RM support tool which is capable of identification of relationship between risk sources, consequences, responses and project success criteria, and integrating all tasks of risk management. A simple representation of proposed way of modelling relationships is given in Figure 1. The proposed RM software is comprised of the following modules:

Module 1. Definition of Risk Breakdown Structure, Work Breakdown Structure, Project Organisation Breakdown Structure and activities (schedule)

Module 2. Definition of interrelations between risks, project objectives, activities, responses/strategies and ownership

Module 3. Construction of project performance model (integration of objectives like time, cost, quality)

Module 4. Scenario building by changing values of preset variables (objectives, responses, ownership, constraints as well as risk scenarios) and simulation of the project performance under different scenarios

Module 5. Construction of corporate risk/response memory

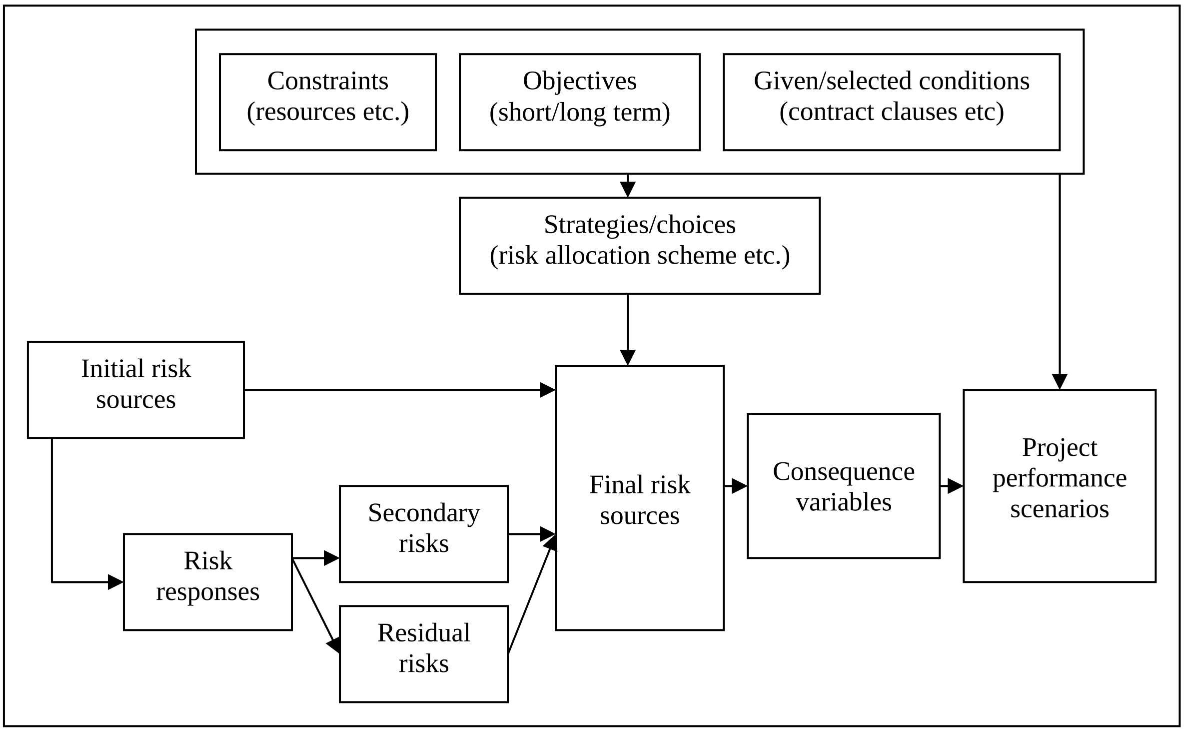

Figure 1: Representation of relationships between risk sources, consequences, strategies and performance

The main aim of these modules is to ensure construction of the project performance model using the built-in risk breakdown structure and setting the relations between risk, response and performance by referring to cases in the corporate memory. The project performance model will be used to assess how the value of the project success criteria may change with respect to different scenarios and after an initial plan is prepared, the project performance model will be used to monitor project success so that the initial plans can be revised. The lessons learnt about risk-response-performance relationships will be stored in the corporate risk memory to improve decision making in the forthcoming projects. Currently, this tool is at the prototype development stage and interviews are ongoing with construction professionals to modify the basic architecture with respect to their expectations and suggestions. The reliability of the prototype model will be tested on a real construction project.

CONCLUSIONS

When the literature on RM in construction is investigated, four categories can be identified according to the scope of work which are; (1) development of conceptual frameworks and process models, (2) investigation of risks, risk management trends and perceptions, (3) application of risk identification and analysis techniques and (4) development of integrated risk management support tools. Although literature is very rich in conceptual frameworks, management paradigms exist as methodologies rather than systems which can fully support the RM process. The research focus shifted to development of integrated decision support tools in recent years, but more work is required in this area. The pitfalls of the current approach are classified as; simplistic risk analysis models; poor definition of risk, interrelations between sources, consequences and responses; lack of integration and finally, vagueness of expectations from risk management. A decision support tool coupled with a corporate risk/response memory is proposed to ensure integration of all tasks of RM and building of project performance models by defining the relations between objectives, activities, risks and response strategies.

REFERENCES

AbouRizk, S and Er, K C (2004) Implementing a structured risk analysis process: experiences and lessons learnt. *In*: Chinowsky, P and Songer, A (Eds.), *Specialty Conference on Leadership and Management in Construction*, 24-26 March 2004, Hilton Head, South Carolina, USA, ASCE 305-313.

Alesin, A (2001) Risk management of international projects in Russia. *International Journal of Project Management*, **19**, 207-222.

Ashley, D B and Bonner J J (1987) Political risk in international construction. *ASCE Journal of Construction Engineering and Management*, September, 447-467.

Bennett, J and Ormerod, R (1984) Simulation applied to construction projects. *Construction Management and Economics*, **2**(3), 225-263.

Beeston, D (1986) Combining risks in estimating. *Construction Management and Economics*, **4**(1), 75-79.

Carr, V and Tah, J H M (2001) A fuzzy approach to construction project risk assessment and analysis: construction project risk management system. *Advances in Engineering Software*, **32**, 847-857.

Carter B, Hancock, T, Morin J and Robin N. (1994) *Introducing RISKMAN: The European Project Risk Management Methodology*. UK: NCC Blackwell Limited.

Chapman, C (1997) Project risk analysis and management: PRAM the generic process. *International Journal of Project Management*, **15**(5), 273-281.

Choi, H H, Cho H N and Seo J W (2004) Risk assessment methodology for underground construction projects. *ASCE Journal of Construction Engineering and Management*, **130**(2), 258-272.

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

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

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

Hastak, M and Shaked, A (2000) ICRAM-1:Model for international construction risk assessment. *ASCE Journal of Managemet in Engineering*, **16**(1), 59-69.

Han, S E and Diekmann, J E (2001) Making a risk-based bid decision for overseas construction projects. *Construction Management and Economics*, **19**, 765-776.

Hayes, R W, Perry J G, Thompson P A and Willmer, G (1986) *Risk management in engineering construction*. London: Thomas Telford Ltd.

Hertz, D B and Thomas, H (1983) *Risk analysis and its application*. Chicehster: John Wiley & Sons.

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

Jaafari, A (2001) Management of risks, uncertainties and opportunities on projects: time for a fundamental shift. *International Journal of Project Management*, **19**, 89-101.

Jannadi, O and Almishari, S (2003) Risk assessment in construction. *ASCE Journal of Construction Engineering and Management*, **129**(5), 492-500.

Kangari, R (1995) Risk management perceptions and trends of U.S. construction. *ASCE Journal of Construction Engineering and Management*, **121**(4), 422-429.

Kangari, R (1988) Construction risk management. *Civil Engineering Systems*, **5**, 114-120.

Levitt, R E, Horii, T, Mahalingam, A, Orr, R and Taylor, J (2004) Understanding and managing the effects of institutional differences in global projects. *In*: Chinowsky, P and Songer, A (Eds.), *Specialty Conference on Leadership and Management in Construction*, 24-26 March 2004, Hilton Head, South Carolina, USA, ASCE, 7-25.

Nasir, D, McCabe, B and Hartano, L (2003) Evaluating risk in construction-schedule model (ERIC-S): construction schedule risk model. *ASCE Journal of Construction Engineering and Management*, **129**(5), 518- 527.

Ozdogan, I D and Birgonul M T (2000) A decision support framework for project sponsors in the planning stage of build-operate-transfer (BOT) projects. *Construction Management and Economics*, **18**(3), 343-353.

Paek, J H, Lee Y W, and Ock, J H (1993) Pricing construction risk: Fuzzy set application. *ASCE Journal of Construction Engineering and Management*, **119**(4), 743-756.

Project Management Institute (PMI) (2000) *A guide to the project management body of knowledge (PMBoK guide)*. Newton Square: Project Management Institute.

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

Simister S J (1994) Usage and benefits of project risk analysis and management. *International Journal of Project Management*, **12**(1), 5-8.

Tah, J H M and Carr, V (2000) Information modeling for construction project risk management system. *Engineering, Construction and Architectural Management*, **7**(2), 107-119.

Tiong, L K (1995) Risks and guarantees in BOT tender. *ASCE Journal of Construction Engineering and Management*, **121**(2), 183-188.

Tummala, R and Burchett, J F (1999) Applying a risk management process (RMP) to manage cost risk for an EHV transmission line project. *International Journal of Project Management*, **17**(4), 223-235.