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Features of a Risk Management Tool Applied to a Major Building Project

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By

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Abstract: The objective of this paper is to illustrate several of the features of a comprehensive risk management tool through its application on a case study project proposed for construction in the Greater Vancouver Regional District (GVRD). The case study, a mixed use building(s) with both office and laboratory requirements, is a unique one-off facility that involves multiple public and private sector stakeholders and a complex program to accommodate over 1800 employees. The stakeholders have expressed specific technical, security, post disaster and environmental design performance requirements, which are constrained by a fixed budget in a booming construction market. Our approach facilitates an integration of risk information with models of the project context to aid in the decision making process and fosters consistency and re-use of information.

1. Introduction

The scale and complexity of infrastructure projects can present significant difficulties for a project manager performing risk management. The lengthy time spans involved in the various stages of the front end of the project, the multitude of stakeholders involved, coupled with requirements to carry out environmental studies and adopt environmental protective measures, complicate an already complex task of designing, constructing, and operating a facility that typically contains a vast number of components and an equally large number of technical and administrative processes (Flanagan and Norman, 1993). Therefore, the task of identifying the risks associated with all facets of the project lifecycle, assessing their magnitude, and the development of response strategies is non-trivial. In some instances the number of categories of risks such as design risk, project scope risk, construction risk, commissioning risk, industrial relations risk etc. can exceed 100 (Fitzgerald 2004) with each category consisting of several individual risk events. Project stakeholders identify and manage risks from their own experience and knowledge. Few, if any, have a complete understanding of the full spectrum of project risks that may occur over the lifecycle of the project. Another difficulty is that it is common for stakeholders to misunderstand to whom each risk is allocated and the degree of control that can be exerted over all facets of the risk. All of the foregoing highlights the need for a structured approach to risk identification and management that considers a comprehensive list of risk events and their attendant properties over the lifecycle of a project.

Effective management of project risks has the potential to bring about cost savings and other benefits. Andersen (2001) draws attention to a study carried out in Denmark, which suggests that savings in the range of 800 Million Euros could be achieved annually in the Danish construction industry through the introduction of formal project risk management. A survey carried out by Voetsch (2003) of more than 150 respondents from various industries such as information and communications, energy, and construction has indicated that a positive relationship exists between the frequency of use of formal risk management
practices and the frequency of project management success, as measured by customer satisfaction, on time project delivery, and avoidance of the project being de-scoped.

Current risk identification approaches applied in large civil infrastructure projects tend to be ad hoc and most often risks are considered in isolation as opposed to events that may be interrelated. The typical time frame for risk identification in these large-scale multi-million dollar projects is tight, in the order of a few weeks to 2-3 months at best. With such a tight time frame it is difficult to perform a systematic, in depth assessment, with most risk values derived from “on the spot” estimates that are not easily reproducible, and for which there is little follow-up. The purpose of our research has been to bring more structure by means of a systematic approach using information technology. The benefits of such an approach enable one to track the history of the risk event and associated properties, query the source(s) of the risk and what happened in the as-built context. In this paper we illustrate selected features of a comprehensive risk management tool, KRIS, on a unique project proposed for construction in the Greater Vancouver Regional District (GVRD).

2. Current State of the Art in Managing Risks within the Construction Industry

At the broad level in both public and private sector organizations, the use of paper-based or spreadsheet-based risk registers for managing risk information on infrastructure projects is widespread, and provides a mechanism to record the risks that are identified for a particular project and to track them through the project’s lifecycle. Contents of registers (Ward 1999) include information about the timing of risks and responses, resources required by alternative responses, information about interdependencies, as well as information on the nature of impacts and risk ownership. Additionally, risk registers have also been implemented as computer databases. Among them are Risk Radar (Integrated Computer Engineering Inc. 2002) and SiteRisk (Andersen 2001). (Hall et al. 2001) describe a spreadsheet-based software tool termed RiskCom that allows the user to record information during the different stages of risk management. Pre-programmed help functions that provide instructions and information on different stages of the risk management process guide the user through the different stages. While all of these approaches assist in the risk management process, they do not reflect directly attributes of the project context, are not dynamic and do not facilitate the incorporation of project updates or changes as new information becomes available. Thus, the associated changes in the project risk profile are not reflected.

The importance of risk management has been growing steadily in both public and private sector organizations. Technological and social developments have brought forth new and what have once been dormant risks associated with such phenomena as terrorism, hazardous materials, pollution, and electronic data. The public sector has a mandate and obligation to the public to identify and manage risks to its property, interests and employees in order to prevent losses and unnecessary expenditures. As such, one government department with one of the largest and most diverse real property portfolios in Canada has developed a formal risk management framework to help project stakeholders have a clear understanding of the major risk exposures relative to the project objectives. The first step outlined in the framework is to understand project objectives, typically related to project scope, cost, quality and schedule, which are standard objectives in which tradeoffs arise in any capital facility project. Project managers identify as many risk events as possible on their own, then use a departmental checklist to identify risks events that may have been missed. The probability of the event occurring is rated (high, medium or low) and the impact of the risk event on project objectives is rated (high, medium or low) and a qualitative assessment of overall risk is determined (high, medium or low) by multiplying the linguistic value of probability of risk occurrence by risk impact (For example, H-H=H, H-L=M, H-M=H or M, L-M=L or M and L-L=L). Risk response in terms of mitigation or reduction measures, are identified and dollar values are assigned to cover the risk exposure and residual risk remaining after considering the risk response. The decision to perform a higher-level analysis is left to the discretion and judgment of the project manager and ensures that the problem versus the process drives the analysis. While useful for the initial identification of risks, complementary information with respect to the project schedule, stakeholder information and requirements, physical environment and changes over time is not facilitated by this approach. The features of the risk management tool introduced in this paper demonstrate how we have addressed risk management in complex capital facility projects with multiple and inter-related dimensions.
3. Summary of Approach Used in KRIS

The KRIS approach that we have developed provides an architecture that allows users to model a categorized listing of risk issues and events, and to model their properties. As mentioned previously, while the use of risk categorization or a risk breakdown structure in modeling project risks is highly recommended in the literature (e.g., Hillson, 2003), a standard classification scheme does not exist. The KRIS architecture allows an organization to use a risk categorization scheme of their choice, with flexibility being provided in terms of the number of classification levels used in grouping the risk components. The interface of the KRIS implementation allows users to visualize the entire list of risk components organized into various categories, and expand / collapse parts of the tree in navigating among the entries.

Properties of the risk components are modeled within a frame attached to each component. Instances whereby consistency could be maintained among the values used in modeling different risk components within a specific project and among multiple projects have also been identified and supporting functionality has been developed within the methodology. Examples include the ability for a master list of mitigation measures to be developed and the use of extracts from it in defining mitigation measures for individual risk events.

Another important feature of KRIS is that it integrates a model of project risks with representations of the project context. We have characterized the project context through four views or dimensions, which are the physical (what will be built), process (how it will be built and operated), organizational / contractual (the organizations involved and the relationships among them), and environmental (the natural and man-made environments in which it is being built) – (yet to be treated in entirety is integration with the project’s cost view). Hierarchical representations of these four views are linked to the risk model making use of risk driver – risk issues associations. The integration of views allows for changes in the project context such as design, regulatory and scope changes to be reflected in the risk profile. Risk events arise from the values of the attributes of the components in one or more views (organizational entities, physical aspects of the facility, schedule activities, etc.) which are risk drivers, the presence of which, either singly or in combination with other risk drivers, lead to the potential for a risk event occurring. The tool is dynamic and helps to operationalize risk management knowledge with changes and updates of the project context.

4. Case Study Project

In order to illustrate features of the KRIS approach, we apply it to a unique building infrastructure project proposed for construction by 2011 in the GVRD. The project, a mixed use building(s), is both capital and operationally intensive with a proposed budget in the order of 300 million dollars and a construction period in excess of 2 years. The facility is proposed to accommodate 1800 employees. The volatility in the construction market place, high client involvement in the design because of the uniqueness of the functional program, special technical performance requirements and the multiplicity of stakeholders including all three levels of government are just some of the complexities of the project which make it unique.

It is anticipated that the tenant organization will enter into a lease agreement with the contracting organization who will own the facility. As such, the multiplicity of organizations involved complicates the decision making process to meet both organizations program requirements and brings in risks related to long time lines to reach consensus. The potential for a change in government leadership, or changes in organizational policies (of both organizations) in a government environment that is in flux highlights the need for effective communication between regional and national offices as well as between organizations and the need for a tool that can track the evolution of decision making over time and the potential risks of exceeding the project completion date, not meeting budget constraints, and failing to deliver on one or more key scope objectives.

Other project stakeholders include government authorities from all three levels of government. Adjacent property owner facilities are interested in the opportunity for some shared services. In addition, the tenant department has service delivery responsibilities to the public and to other government agencies. Adjacent
to the project site is a municipal park, which is actively used by local public interest groups with specific environmental mandates (e.g. tree conservation). Risks are associated with the heavy involvement of diverse stakeholders both in project planning, design and execution.

It is uncommon for a facility of this size and with the unique program requirements to be constructed in the region. Thus, the pool of design and project management expertise available that is familiar with delivering such a project is scarce. The tenant organization tends to be influenced by world events and how best they respond to complex domestic or international situations makes it difficult for the scoping of capacities to house personnel and associated technical requirements. In addition, the tenant organization has changing needs which has implications on the flexibility in the building design to accommodate future changes, as well as technical, security, post disaster and environmental design performance requirements. As a result, there is a substantial risk that the project scope will not be responsive to user needs at the time of building occupancy and is therefore a primary risk that the project team wishes to ensure is minimized.

Construction costs have increased by over 45% during the period 2000 to 2005 in the lower mainland, driven by the increase in construction volumes, material costs and limited labour resources (BTY Group, 2005). Recent construction cost escalation rates of 8-10% per year in aggregate and up to 20% with respect to some key trades (electrical and mechanical) as compared to the inflation rate represented by the consumer price index of some 2-3% per year have created enormous budget pressures not withstanding the allocation of dollars in the original budget to address expected construction cost escalation. The performance requirements outlined for this project are constrained by budget limitations in this booming construction market and in a risk averse environment of the contracting organization. Thus the challenge faced by the project manager involves identifying, tracking and managing risks, several of which are interrelated, and which arise from an economic environment at or close to capacity, a complex stakeholder environment, and a technically sophisticated facility for which scope creep is inevitable because of the need to respond to external, uncontrollable events, all within defined budget and time frame constraints. Current tools, while helpful, do not reflect this dimensionality of a project, or ones like it. Such situations have provided the impetus for the kind of approach captured in KRIS.

5. Application Of KRIS Approach on Project

The project manager of the case study project developed a risk register for it using a framework similar to the approach outlined in conjunction with two other owner risk frameworks available and which were considered best practice risk management approaches for infrastructure delivery. These frameworks all take the form of spreadsheets, passive documents, managed and updated on a regular basis by the project team. The register was divided into three risk categories; the first two categories addressed strategic and operational risk events to the programs of both departments and examined the risk/benefits to the owner proceeding with the project. The third risk category addressed project delivery risks and examined those risk events common to project delivery (adverse geotechnical conditions, errors and omissions etc) in addition to those risk events caused by broader government issues and by the two departments involved in the project. This register was used as the base reference document to assess some of the benefits and limitations of applying KRIS to model the project risks. Other documents available included the project charter, schedule, building functional program, environmental phase 1 and phase 2 reports, and preliminary engineering reports. One author of this paper was on the project team for over two years and was therefore familiar with all technical and user requirements of the project.

In what follows, we use the project to highlight features of our risk management tool and to illustrate how it can assist in the decision-making and risk management process of a project. In particular, we demonstrate the modeling of risk properties, the categorization of risks, the integration of project risks with representations of the project context, and the generation of insights into the risk profile of the project through targeted reporting strategies. We believe each of these features improves the risk management process and assists in the decision-making processes in the project planning and execution stages.
5.1. Comprehensiveness of Risk Terminology Definitions

A significant challenge in the construction industry is the lack of consistent risk terminology thereby resulting in difficulties amongst project stakeholders in the communication and interpretation of project risks (De Zoysa 2006). The KRIS approach provides a standardized platform in which risk terminology is made explicit therefore reducing the chance of misinterpretation amongst project participants.

Within KRIS, a risk event is defined as the potential variability in a project parameter from its anticipated value (e.g., higher than expected inflation rate during the construction phase), or one or more discrete scenarios in which the possible states of nature that can be realized can be identified, but the one which will actually occur as well as its outcome is not known with certainty (e.g., a slope failure occurs or not, and if it occurs, its extent). A common problem is that practitioners do not make a distinction between a risk event and a risk issue. For example, a risk event found in the project risk register “heritage constraints” may be better defined as a risk issue and risk events (a subcategory under risk events) could be defined as “archaeological concerns identified on the site” or “building identified for demolition is greater than 50 years old and meets ‘heritage’ definition”. These risk events are specific and easily understood by any stakeholder reviewing the risk register. Figure 1(a) illustrates a portion of the project risk register developed for the case study project.

Figure 1(b) illustrates the ability of the risk management tool to model various properties of a specific risk event such as mitigation strategies. In this case the mitigation strategy for the risk event ‘Heritage buildings encountered on site’ has been identified. The user can identify the most appropriate mitigation measures for the risk event (in this example, search heritage register), the most appropriate stakeholder to allocate the risk event (in this example the contracting organization), and the stakeholder affected by the risk (in this example the successful bidder). The user can also provide information on other properties of the risk event such as a risk description, driver, measures affected, and values among others. This approach helps an organization develop and use a consistent set of terminology in naming risk events and in populating their properties such that the source of risk information can be tracked over time.

Another benefit of the KRIS approach is the documentation of assumptions and risk drivers. As previously mentioned, KRIS allows associations to be made between risks and representations of project context components signifying the drivers of a particular risk. Figure 1(c) illustrates how potential risk drivers are modeled in the tool and the integration of project dimensions. In this example, the presence of a heritage building in the physical location ‘Parking A’ is a risk driver for the risk event ‘Heritage buildings encountered on site’. If the location ‘Parking A’ no longer was associated with the project (for example, this portion of the land was divested) then the presence of a heritage building at this location would no longer be a risk driver of the risk event under consideration and the model is able to reflect this change in project context.

Furthermore, the tool also allows sources of information such as websites, documents, and media files to be referenced and associated with representations of risk components. Thus, representation of each risk within KRIS allows for the compact documentation of all sources of information that leads to its identification as well as the sources of information that are used in assisting with the quantification and allocation processes. Documentation of assumptions facilitates an understanding of the range of risk events and their valuation, and allows for the incorporation of new information as it becomes available or validation of assumptions.

5.2. Categorization of Risks

Risk categorization offers advantages such as focusing attention on similar types of risks that are likely to have a bearing on a project in unison and allowing comparable mitigation strategies to be developed for a set of risks that share common characteristics (Al-Bahar and Crandall 1990). While most authors agree on its usefulness, the literature on risk management rarely agrees on the categorization strategy that should be adopted. The PMI Risk Management Specific Interest Group (2002) utilizes a taxonomy consisting of
Figure 1. Risk view (a) and properties of a risk including mitigation strategies (b) and risk drivers (c)
three levels. For example, it employs a Management category, sub-divided into Corporate, and Customer / stakeholder management sub-groups. Risk areas such as Organizational stability and Financial are listed under the Corporate sub-group. Other authors (e.g., (Al-Bahar and Crandall 1990) have adopted a two-level approach with risk issues being directly listed under several risk categories.

The advantage of the KRIS approach is that the interface is flexible such that an organization may use one of the schema suggested in the literature or devise its own categorization approach that relates to its thinking and terminology. The risk view, illustrated in Figure 1(a), demonstrates one approach to categorizing risks and the flexibility of the tool enables modeling of risks to be performed at different levels of detail based on the information available and organizational requirement.

5.3. Integration of Project Context and Changes

The KRIS approach models the project context (the physical, environmental, process and organizational views of the project) and integrates risk information with such representations. Risk events are therefore not considered in isolation but as events that may be interrelated. As noted previously, risk registers, either in paper-based form or in the form of spreadsheets or databases are poorly suited to accommodate changes in the risk profile as a result in changes in the project context and objectives. In their current form, risk registers do not incorporate an explicit representation of the project, and given that the circumstances of a project change, for example due to a change in regulations or change in design, the users of a risk register have to manually identify risks that were related to the original state of affairs, eliminate the risks that are no longer applicable, and then identify new risks that relate to the changed circumstances. Additionally, the large number of risks and the significant number of information elements associated with each risk tend to make the use of a paper-based or spreadsheet based form of a risk register extremely difficult to navigate. Ease of navigation is a feature decidedly desirable during the tasks of risk identification and risk allocation that typically require input from a group of individuals from various disciplines and with differing perspectives on project risk.

The case study project has been modeled in the early formative stages of the project when little information is available. Consequently, highly aggregated representations have been used to model the various views of the project. For example, as shown in Figure 2(a), a very simple representation of the project schedule has been used for illustrative purposes only, with the main purpose being to demonstrate that the user can link risk entities to the time domain. The organizational/contractual view is also shown in Figure 2(b) and enables the user to link risk entities to the associated organizational entity. The user is also able to determine which risks are allocated to a selected organizational entity using a querying function of the tool. Since the physical and environmental dimensions of the project are modeled as shown in Figures 2(c) and 2(d), the user can place or review risk entities in spatial context, as the physical and environmental view components are mapped onto the location set shown at the top of figure 2(d). Similarly, activities are mapped onto the same location set, allowing the user to determine the spatial and temporal distribution of risks.

KRISs’ architecture allows the user to adopt a bottom up approach, a top-down approach, or a combination of the two for developing a project’s risk register. For the bottom up approach, one first develops the various views, which assists in identifying risk drivers and hence potential risk events. Alternatively, using a knowledge management feature of the system, one can start with a master risk register, which represents the experience accumulated over many previous projects. Then, using this risk register and the various views of a project, one can determine which risks in the master risk register are applicable, as well as which ones should be added because of the uniqueness of the project. Finally, one can use a combination of both approaches in which the user makes use of information from a master list or by modeling a dimension of the project from scratch. The KRIS approach enables user flexibility in modeling the risk profile of the project and facilitates knowledge management in an organization because future users can refer to information from past projects.
Figure 2. Screen snapshots illustrating model of project context including aggregate schedule (a), organizational view (b), environmental view (c) and physical view (d)
5.4. Generating Insights Through Flexible Reporting Structures

The risk management tool has a querying functionality that enables the user to unlock the data within the project model and generate reports. The efficient and adaptable reporting functionality allows the user to generate multiple views of targeted data specific to the objectives and concerns of interest. The user first selects the views that are of interest in the 'Select Criteria' screen illustrated in Figure 1(a). In this case, the user is interested in eliciting all risk events that occur in the schedule phase 'Planning', at the location 'Parking A', and that affect project parties 'G001' (in this example, G001 represents the contracting organization). The user then selects in the 'Report Content Profile', illustrated in Figure 1(b), the entities of interest with respect to the views highlighted in the 'Select Criteria' that are to be shown in the report. In this example, 'Performance Measures' for methods of estimating likelihood/consequence and methods for incorporating risk into the economic analysis in addition to 'Mitigation Strategies' for time and cost will be shown in the output report. The tool is therefore able to generate customized reports that integrate information from both the spatial and temporal dimensions and to the level of detail on a range of parameters that are of interest to the user or his client.

Figure 3 Screen snapshots illustrating querying capacity of the risk management tool including select criteria (a) and report content criteria (b)

6. Conclusion

Risk management provides valuable input to project decision-making. In this paper we have made use of the case study in illustrating some of the challenges faced by practitioners in carrying out the risk management task, as well as some of the shortcomings of current practice. The computer-based approach that we have introduced allows an integration of risk information with models of the project context as described by four views – environmental, physical, process, and organizational/contractual. The
methodology allows the re-use of information and facilitates consistency. Ongoing work is directed at exploring visualization strategies that can be used in mining the base of risk and project context information, and also towards exploring how information can be meaningfully elicited from project participants in modeling project risks.

References


