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Risk and Opportunity (R&O) Assessment and Related Knowledge Transfer in the Early Phases of Construction Projects – An In-Depth Study of Practice.

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Abstract
This paper presents the results of a series of in-depth case studies into different types of construction projects to examine how risk and opportunity (R&O) are assessed in practice. Data was gathered on how information and associated knowledge of R&O were converted and transferred across the early phases of the projects: from tender, through negotiation and onto construction start-up. The major findings of this research are: (1) While considerable effort goes into formal risk documentation during the tender phase, there seems to be a lack of continuity in how R&O assessment is tracked during construction handover phase and the subsequent design and construction phases; (2) The lack of continuity in R&O assessment across project life cycle can be explained if it is modeled as a knowledge conversion and transfer process rather than an information transfer process; (3) Viewing R&O assessment as a knowledge conversion process points to the need of the adoption of tools that are appropriate for the people involved and the techniques being used in practice.

Keywords
Risk and Opportunity (R&O) Assessment, R&O Knowledge Conversion, Risk Assessment Techniques, Construction Project Life Cycle.

1. Introduction

While the principles and methods used for risk management are straightforward and have been applied in leading companies in the construction industry for decades, risks and uncertainties are reported to be ineffectively managed throughout the project life cycle (Engineers Australia, 2005; Edwards and Bowen, 2005; Jaafari, 2001). One of these reports (Engineers Australia, 2005) identified potential root causes of such construction problems including "poor understanding of formal risk assessment and management processes" as well as "project risks being inadequately assessed and life-cycle implications not being addressed". Discussions have also raised the issues about the knowledge gap between the theory and practice of risk management in the construction industry.

This gap suggests that there is a need for more in-depth studies in order to better understand the nature of this issue. Although much has been written on the theoretical development of risk assessment systems, tools and techniques, very few studies have been conducted to discover empirically what actually happens in practice during the early phases of construction projects. Another issue is the traditional project risk

assessment tools and procedures often over-emphasize risks while paying less attention to opportunities (Chapman and Ward, 2003). Therefore, there is a need to understand how both risks and opportunities are identified and assessed in practice.

This paper presents preliminary results from a research project into Risk and Opportunity (R&O) management practices during the early stages of the construction projects. The focus of the project is on how information and associated knowledge of R&O were converted and transferred during tender, through negotiation and onto construction start-up phase.

2. Research method

In order to gain an in-depth understanding about the issue, a case study research method was employed. Yin (2003) describes case study research as "a process of collecting and analyzing documents, archival records, direct observation, participant observations, interviews, surveys, and physical artifacts". This data sources can then be analyzed together to converge multiple sources of evidence into findings. The case study method was chosen for the following reasons. Firstly, according to Yin (2003), a case study is the best method to answer "how" type research questions by exploring a contemporary phenomenon within a real-life context. Secondly, the case study is proven to have advantages over other research approaches in exploring the risk management practice issues. After reviewing a series of risk management studies from 1991 to 1997, Edwards and Bowen (1998) strongly recommended an increased use of the case study method. They questioned the adequacy and appropriateness of other research approaches, such as opinion-surveys, due to methodological weaknesses that limit the validity and usefulness of the findings. Thirdly, one of the salient features of the case study is that the data collected from different sources can establish logical chains of evidence that provide richer and more reliable information. This helps the researcher to gain a deeper understanding of an issue as well as gain access to a level of tacit knowledge about interpersonal and behavioral issues.

Three in-depth case studies were conducted into different types of construction projects. The first project was a civil engineering project worth approximately AUD100 million, the second was an urban infrastructure development project worth around AUD150 million, and the third was an high-rise building project worth over AUD100 million. The three projects were carried out by the same construction firm and the case studies took place between mid-2005 and end of 2006. The researcher was 'immersed' in a major engineering construction firm to gain privileged access to project documents and personnel as well as to participate in key R&O management activities during the course of each project. The research activities included collecting and analyzing risk management documents, participating in R&O workshops, informal discussions and interviewing project managers and other key project participants.

2.1 Project Description

Study 1: The Civil Engineering Project

This project involved civil infrastructure works being developed for a mining operation. The works included the construction of access roads, administration buildings, industrial areas, water management systems, workshops, and other service facilities. The key project objectives and deliverables were to develop the project on time, within budget, satisfy the required production rate, and respond to environment issues, especially risk and safety issues across the project life cycle. The client required the contractor to provide an effective risk management strategy to address the risks and opportunities throughout the project life cycle. At the time of the case study, the tender and design phases were being completed and the project was progressing into the construction phase. The project was selected because it satisfied two set criteria. Firstly, it was relatively complex in terms of the amount of activities and

information involved during the beginning of project, and secondly, this project implemented risk and opportunity management systems throughout the project life cycle. The aim of this case study was to examine how risk and opportunity assessments were performed across the whole project life cycle.

Study 2: The Infrastructure Project

The second case study was based on an infrastructure project delivered through an alliance contract. The project is an inner city bus-way, including provision for two bus stations, nearly one kilometer of tunneling, connection roads and supporting facilities. An alliance team was set up including the client, which was a government agency, the design consultant and the contractor. When completed, this project will provide commuters a public transport link between important public facilities. The project was just entering the tender phase at the time the case study commenced. Therefore, it provided a unique opportunity to look closely at the R&O management activities during the tender, which is one of the most sensitive phases of project life cycle. It was possible to track the development of the risk management activities throughout the tender phase up to the point of transfer to the construction phase.

Study 3: The high-rise Building Project

The third case study was based on a high-rise building project being delivered through an alliance. The project is a 30 storey high-rise building located in the heart of the downtown city. The reason for selecting this project is because of its complexity of a downtown construction work where there is lots of uncertainty regarding the traffic and timing in and out the CBD area. The project just finished the business case review and was progressing to tender development stage when the case study began. The aim of case study is to fill the data gap of the conceptual stage in the first two case studies as well as to collect more data to form multiple sources of evidence for a triangulation process and to validate the findings.

2.2 Data Collection

The researcher was immersed as a participant-observer in the project teams across the projects. By participating in the tender process, we were involved in research activities including collecting and selecting risk documents (R&O registers, R&O workshop documents, estimating spreadsheets, probabilistic simulation models using @Risk software), participating in R&O workshops, informal discussions and interviewing department managers and other key participants in the project risk management activities.

Data was collected and separated into two parts: tender phase and construction phase. During the tender phase, documents relating to risk management included 28 working R&O registers (hard copies and electronic spreadsheets), 6 models and associate results of probabilistic risk assessment using simulation software (@Risk), estimating spreadsheets and tender files, R&O workshop documents, main meeting minutes, emails exchanged on risk issues, all drawings and specifications, and risk consultant reports.

2.3 Data Analysis

The collected data was then examined, classified and arranged according to the chronological order of project events across the early phases. The sequence of phases was pre-tender (project selection, approval to pursue business opportunity), tender development, tender review, contract negotiation, contract review, handover and construction. The data were grouped into topics of key variables following the risk management process across the early phases. A comparative analysis of the data between risk registers and its related risk management activities in each project phases was conducted.

While document analysis was being undertaken, informal interviews and discussions were conducted with key risk management personnel including the estimating manager, the project reviewer and auditor, the business improvement manager and other project service personnel. This was done to ensure that some of the implicit knowledge behind the risk documents being examined could be captured as well as to ensure that the evidence is validated from different sources of data.

3. Findings

From the data analysis, the following issues and results were emerged as important: (1) The R&O assessment profile transfer during early phases and (2) the associated R&O knowledge transfer process.

3.1 The R&O Assessment Process and Profile Transfer during Early Phase

Figure 1 depicts the risk and opportunity assessment steps and the risk profile transfer during the early phases in the case studies, from tender, through negotiation and onto construction start-up. The left hand side of the figure describes what actual R&O assessment activities were observed, the right hand side describes the actual risk profile or risk documentation transfer and the interpreted risk assessment steps. Detailed R&O assessment began when appropriate design and tender documents were available. The R&O assessment can be described through eight steps:

Step 1 – Tender R&O assessment preparation: A number of activities were completed prior to the workshops in preparation for the R&O assessment. An early list of risks and opportunities, mostly based on commercial risks, was produced. The project complexity level and corporate liability limit were reviewed, including the scope of work, abnormal work types, time constraints, any guarantees and insurance required and liquidated damages. A list of potential R&Os were then compiled as a pre-list.

Step 2 – R&O identification: A series of workshops were conducted to identify the potential R&Os. These workshops were a starting point for a qualitative risk assessment process. The first R&O workshop series gathered people from different parties, disciplines and management levels to brainstorm the possible risks and opportunities. The list was then recorded in a spreadsheet as a R&O register. Two or three whole-day workshops were required to arrive at the full list of possible risks and opportunities.

Step 3 – R&O analysis & response: The following workshops continued to update the R&O register by determining the likelihood and consequence of the identified risks. The magnitudes of the risk and opportunities were then identified based on their probability of occurrence (likelihood) and impact level (consequence) with a priority risk matrix.

Step 4 – R&O Sorting and Ranking: A group of key project personnel were assigned to sort and consolidate the number of risks and opportunities. They reduced the number of risks to create a short list based on their magnitude (high, low, medium). For example, in case study 2 there were approximately 250 risk items and 15 opportunity items divided into 26 categories. The number of high risks had been reduced to 160 before workshop 3 started and reduced further to 35 risks and 20 opportunities after workshop 3 had been finished. The main categories were political and legislative, stakeholder and community, commercial, cost estimates, resources, technique, safety and environment, general construction, and timing. Similarly, in the first case study, the numbers of risk and opportunity items were reduced from more than 100 items to the final 20 risk items and 10 opportunity items. The R&O register retains all items, however only the short-listed items were quantified.

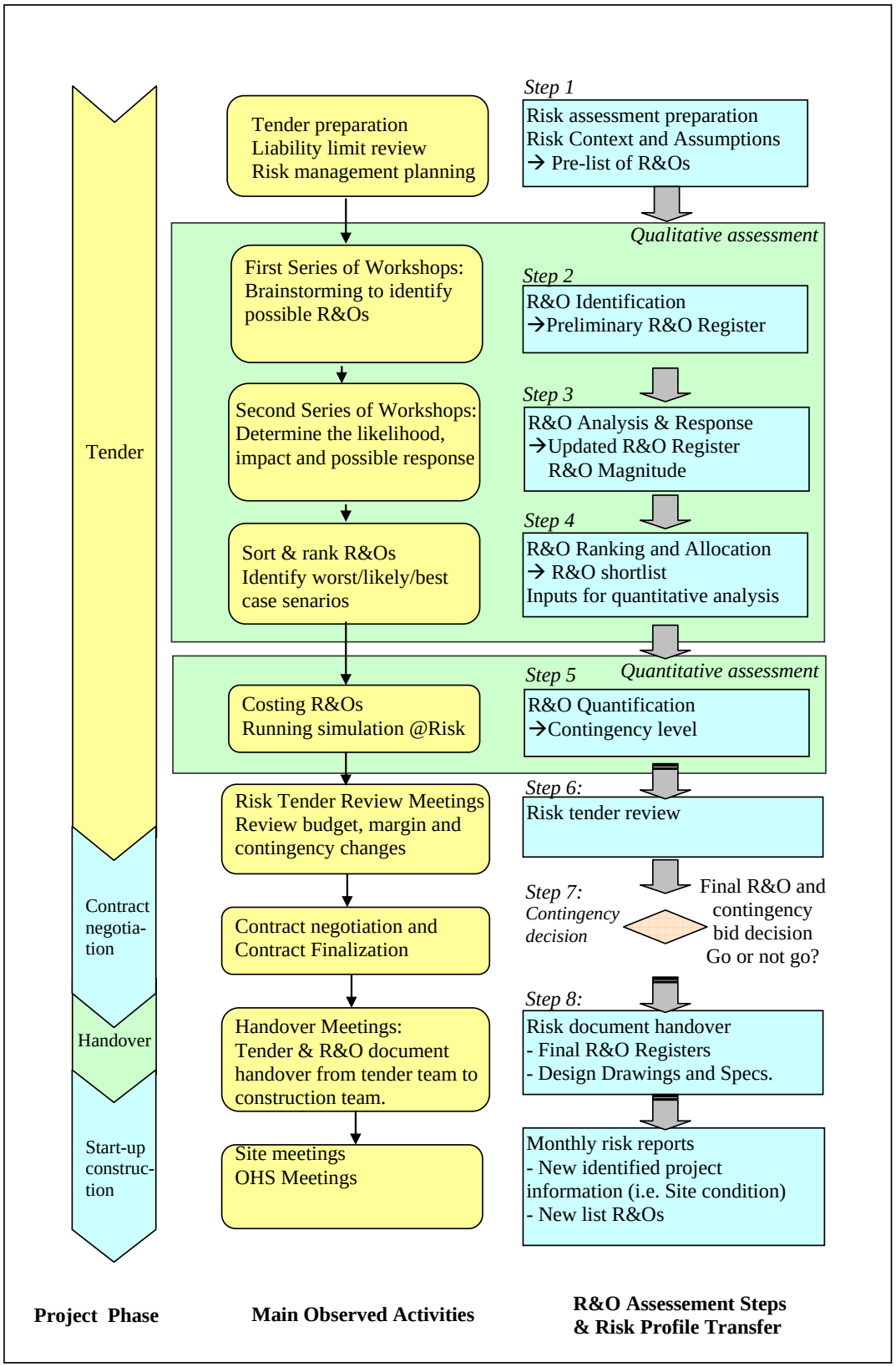

Figure 1: The R&O Assessment Profile Transfer during Tender, Negotiation and Start-up construction

Step 5 – R&O Quantification: This step quantified the risks and opportunities by costing them into the amount of dollar impact and likelihood probabilities. Only those risks and opportunities in the short list in step 4 were quantified. The magnitude was calculated by multiplying the probabilities and dollar value. The best, worst and most likely of each of the R&O items were the input values to a Monte Carlo simulation model. The model then produced the range and probabilities of all possible outcomes to the project cost or duration in the form of a probability distribution. From the distribution, the worst and best cases of project cost and the associated contingency values were derived. It was noted that different forms of probability distributions, such as beta or uniform or a triangular distribution, were assumed for the different kinds of risk input variables in the case studies.

Step 6 – R&O tender review: The project team conducted a series of tender review activities to revisit the commercial conditions, insurance required, and the contingency level. The R&O assessment knowledge is included in the project management plan, with the expectation that it would be updated throughout the project life cycle. The reconciliation of the budget, time, margin and contingency changes captured the outcomes of contract negotiation and finalization.

Step 7 – Contingency Decision: During the contract negotiation and finalization, the contingency value was updated to capture all the changes in the risk profile. The contingency values were varied during the tender review, contract negotiation and finalization phase. Data comparison between the output of quantitative process and the final tender price revealed that the basis for setting the contingency in the negotiation stage is quite different to that used in the quantitative step. The data shows a discontinuity between the process of risk assessment before and after the negotiation.

Step 8- Risk Document Handover: Finally, the R&O assessment results were transferred from the tender phase to the project implementation team by a handover process. Data analysis firstly showed the amount effort spent on risk assessment after a project progresses from tendering phase to construction phase decreases considerably. Rather than identifying new risks or updating known ones in the risk register, the focus early in the construction phase shifts to detailed technical and operational aspects of mobilization and getting started. Discussions with the project team are being conducted to examine whether the assessment remains “alive” during the transition into the construction phase.

In summary, while risk documentation was quite formally done at tender phase and the R&O management process closely followed the risk management procedure described in AS/NZS 4360 (2004), there seems to be a lack of continuity in how R&O were assessed during the subsequent negotiation, handover and construction phases.

3.2 R&O Knowledge Transfer during the Early Phases

While considerable effort goes into formal risk documentation during the tender phase, the transfer of risk profile and documentation shows some disconnection in the process during the negotiation, handover and construction phases. This disconnection and lack of continuity can be explained if it is modeled as a knowledge transfer process rather than as an information transfer process.

Figure 2 depicts the R&O assessment process during early phases according to three processes: activity process, information process, and knowledge process. The first two processes were created by simplifying observed risk management activities described in Figure 1 and classifying them following the three main steps of risk management: identification, assessment and evaluation. Then, by synthesizing and combining the observation data from case studies and from Figure 1, an interpreted knowledge transferring process is described.

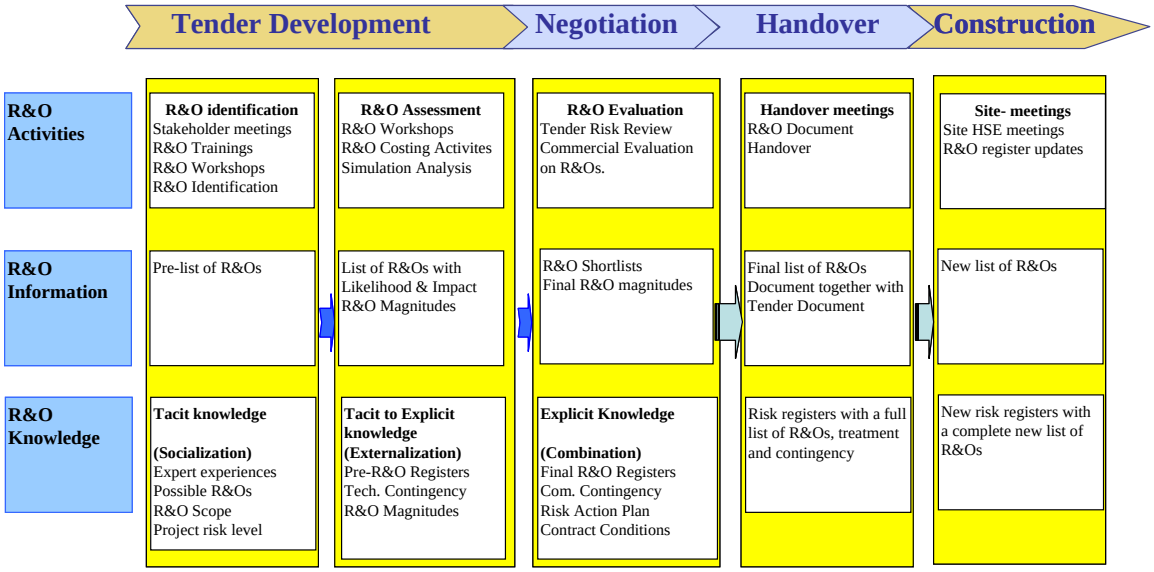

Figure 2: R&O Knowledge Transfer Process during Early Phases

In Figure 2, the R&O assessment process is described as a process of creating and transferring knowledge about uncertainty from tacit to explicit knowledge through the four processes of Socialization, Externalization, Combination and Internalization as per the SECI Knowledge Conversion Model of Nonaka and Takeuchi (2005). According to them, knowledge is created in a process of knowledge conversion. The process begins when people initially share their tacit knowledge by communication with other people (socialization process), then capturing it in analogue or digital form (externalization process). After that, people combine "different bodies of explicit knowledge" by exchanging and combining knowledge of different sources through media as meetings, documents, telephone conversation (combination process). Finally, they embody the shared knowledge into implicit knowledge (internalization process), then transfer this knowledge with other group of people, and the process continue again (see Figure 3).

Tacit to Tacit **SOCIALIZATION**	**Tacit to Explicit** **EXTERNALISATION**
Explicit to Tacit **INTERNALISATION**	**Explicit to Explicit** **COMBINATION**

Figure 3: SECI Knowledge Conversion Model (Nonaka and Takeuchi, 1995)

Based on this viewpoint, preliminary observations from the case studies showed that even though the R&O information (i.e. the identified R&Os, risk documents and risk reports) was formally done and transferred across project phases, the R&O knowledge (i.e. expert experience, results of risk assessment, expert's contingency judgements) was not effectively captured, shared and communicated. Data analysis combining with observed R&O activities showed that although socialization and externalization processes occurred (i.e. the pre-tender meetings, the risk identification workshops), combination and internalization processes were not clearly addressed. Historical information from previous similar project has not been combined with the subjective judgment knowledge of experienced project personnel in the analysis process and there was a lack of a database system to capture the existing knowledge for use in future project. Another observation is that by modeling the risk assessment process as a knowledge conversion

process, risk assessment from tender to negotiation can be described as a process of turning tacit knowledge to become explicit knowledge.

3.3 Some Implications for the Use of R&O Assessment Tools and Techniques

Viewing R&O assessment as a knowledge conversion process highlights the need to adopt R&O assessment tools that can enhance the effectiveness of knowledge elicitation, capture, consolidation and communication. Based on observations from the case studies about the use of tools and techniques, two propositions seem to emerge. Firstly, the simpler the tool is, the easier the transfer of risk information and knowledge. For example, R&O workshops can be seen as a socialization process and R&O register is an effective and straightforward tool to capture and turn implicit knowledge about uncertainty into explicit knowledge about risk and opportunities. The R&O register readily captures information that is "externalized" in such workshops, although not all the associated knowledge is captured. A mechanism is needed to capture this associated knowledge and to combine it and make it available later in the R&O process. Secondly, while sophisticated analysis tools (e.g. simulation) are typically used by experts as part of the R&O process, the final decisions are often made by senior managers who do not necessarily understand the underlying concepts and assumptions behind the analysis. Effective ways to transfer this underlying knowledge around the assumptions needs to be further developed and studied.

4. Conclusion

Three in-depth case studies into different types of construction projects were conducted to examine how risk and opportunity are assessed across early construction project phases in practice. Data was gathered on how information and associated knowledge of R&Os were created and transferred during tender, negotiation and construction start-up phase. The analysis of data reveals that while considerable effort goes into formal R&O documentation during the tender phase, there seems to be a lack of continuity in how the R&O assessments are transferred during construction handover phase and subsequent design and construction phases. This lack of continuity in R&O assessment across project life cycle can be explained if it is modeled as a knowledge creating and transferring process rather than a sole information transfer process. By viewing R&O assessment as a knowledge transfer process, it points to the need of the adoption of risk management tools that are appropriate for the users involved in the process at different phases rather than the complicated tools they usually used. It also highlights the need for developing a knowledge base R&O management framework for effectively communicating knowledge about uncertainties over project life cycle.

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