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A study for an appropriate risk management of new technology deployment in Nuclear Power Plants

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ABSTRACT

There has been a need for upgrading and replacing the current systems of Nuclear Power Plants (NPP) with new technology due to obsolescence and spare parts issues, and demands for higher performance. However, the processes for new technology deployment in NPPs may encounter risks causing unpredictable outcomes leading to performance or operation degradation. Hence, proper Risk Management (RM) is required for ensuring safety and performance of NPPs since it provides a means to identify risks and minimize their impacts. For these reasons, the purpose of this research is to investigate how risks are managed in practice and to propose the proper RM for the deployment of new technology in NPPs.

1. Introduction

It has been shown that project risk is an uncertain event or condition that, if it occurs, has a positive or negative effect on one or more project objectives such as scope, time, cost, and quality (Project Management Institute (PMI), 2013). Hence, effective management of risk is essential for successful project execution.

Previous studies have been performed to provide an integrated framework for RM as a tool to enhance the performance of NPPs aiming at exploring a broad context of risk (safety, operations, financial/commercial, strategic). This research shows different approach to RM. This research mainly focuses on risk identification and their response strategies of project for new technology deployment in NPPs, the introduction of new technology might have high risks causing significant impacts on safety or performance.

Risks might be substantial in for projects containing unique technical elements or unproven technology (Jeffrey, 2007). Therefore, risks for projects with new technology deployment should be identified, assessed, and managed through proper RM. The process should be proactive rather than reactive in order to increase the probability of project success. As a result, this research was conducted to investigate how risk is managed in practice and suggest a proper RM for the project.

It begins with literature study for the general concept of risk and its management in order to establish a theoretical background of this research. Next, a survey is conducted to investigate how risk is managed in practice. Then a 2nd survey is carried out to prioritize risks identified through the 1st survey. At the same time, the investigation of emerging technologies for NPPs, which is followed by a case study of Field Programmable Gate Array (FPGA) technology.

In the analysis part, results from surveys and case studies are analyzed. This analysis is based on the theoretical framework and interviews with experts. Finally, the results of analysis are shown in discussion and conclusion sections as well as in the proposal for the proper RM (Fig. 1).

2. Research methodology

A research process begins with defining the scope of research and formulating questions for research. In sequence, the methods for investigation are chosen according to the types of research including data collection techniques. Finally, the conclusion will be made by analyzing the collected data.

In this research, the qualitative method, which is based on facts socially constructed and people's experiences rather than objectivity, has been used to collect data since the purpose of collecting data is to evaluate how the risk is managed in the nuclear industry (Ewelina and Mikaela, 2011). The research methodology selected for this research consists of the concept of risk, a questionnaire survey, interviews, a case study, and a statistical analysis of the survey result.

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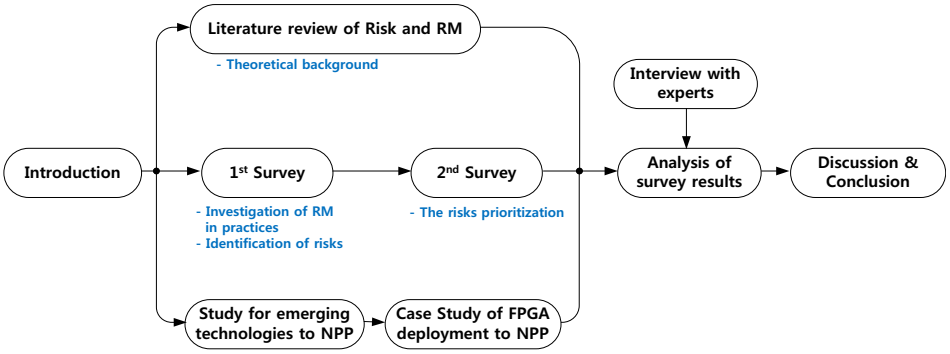

Fig. 1. Outline of research.

2.1. Concept of risk

According to the PMBOK® Guide, risk might be described as 'an uncertain event or condition that, if it occurs, has a positive or negative effect on one or more project objectives' (Project Management Institute (PMI), 2013). The Risk Cube Methodology is commonly used in assessing and managing risk. It focuses on selecting critical risk sources according to their probability and impact. The risk probability and impact matrix shows the combination of risk impact and probability and is utilized to decide the relative priority of risks. Risks that fall into the red-shaded cells of the matrix are the highest priority, and should receive the majority of risk management resources during response planning and risk monitoring/control. Risks that fall into the yellow-shaded cells of the matrix are the next highest priority, followed by risks that fall into the green-shaded cells (Cube Method to Derive Cost Risk, 2004).

2.2. Questionnaire survey

The questionnaires included both short-answer and essay questions instead of multiple choices. Questions were used to receive the most accurate responses from respondents. The questionnaires were made in Korean in order to avoid any misinterpretation that could occur. To avoid the misunderstanding of questions resulting from the limitation of the method of survey, a brief example of or explanation of the answer was provided. In addition, respondents, who could provide the necessary information for the research, were selected.

Two surveys are conducted to get the information. Twenty-three (23) feedbacks with valid responses were received for each survey. Questions in the first survey were formulated in a way to ask about how the RM is processed (identification, assessment, and response of risk), how it is familiar with the NPP field, and what is expected from the application of it. Among this twenty-three respondents, it consists of 35% are 3–10 years' and 65% are longer than 10 years' experienced experts in the area of NPP I&C design and maintenance, etc. After the design of questionnaire and selection of experts, questionnaires were sent to experts through email (distant experts) and directly to the respondents (near experts). Telecommunication was made with distant experts and discussions were held with near experts related to questions in the survey for getting the unbiased judgment.

As a follow up to the first survey, the questionnaire of the second survey is made to analyze the result of the first survey.

The purpose of this survey is to assess the priority of the risks identified through the first survey. The probability and impact assessment among the qualitative RM methods was selected to formulate the questions. This method uses the probability of risk occurrence and the corresponding impact if the risk occurs. As a result, the questions begin with evaluation of the probability of risk occurrence. In sequence, the respondents were asked to evaluate the corresponding impact on time, cost, quality, and scope when it occurs.

To get accurate information of how the RM is processed in the nuclear industry for deployment of new technologies, engineers with at least three (3) years (mostly longer than 10 years) experience in designing I&C systems were chosen as respondents. In addition, all respondents have received tertiary education and have adequate knowledge of NPP technology.

The scale for assessing the probability of risk and the impact of its occurrence is shown in Tables 1 and 2.

2.3. Data analysis method

The risks are primarily identified by the first survey and literature review. In addition, the data from the second survey includes the likelihood of occurrence of each risk and their impacts on project objects such as cost, time, scope, and quality. Based on these data, all risks are calculated through Eq. (1).

$$r_{xy}^{z} = p_{xy} i_{xy}^{z} \tag{1}$$

where x = ordinal number of risk; y = ordinal number of valid respondent; z = ordinal number of project objective; r_{xy}^{z} = significance score assessed by respondent y for the impact of risk x on project objective z; p_{xy} = likelihood of occurrence of risk x, assessed by respondent y; i_{xy}^{z} = impact of risk x on project objective z, assessed by respondent y.

The average score (Eq. (2)) for each risk is used to compute a risk significance score. All identified risks are ranked in accordance with this average score.

$$R_{xy}^{z} = \frac{1}{n}\sum_{y=1}^{n} r_{xy}^{z} = \frac{1}{n}\sum_{y=1}^{n} p_{xy} i_{xy}^{z} \tag{2}$$

where n = total number of valid respondents; R_{xy}^{z} = significance score for risk x on project objective z.

Table 1
Scale for probability.

Risk	Probability				
	Very low	Low	Moderate	High	Very high
Risk A	0.1	0.3	0.5	0.7	0.9

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