Proposing a Developed Risk Assessment Model Based on ELENA: A Case Study in Railway

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Abstract**:** *Effectively managing risk is an essential element of successful project risk management. In this paper, we propose a novel risk assessment technique which uses failure mode and effects analysis (FMEA) method based on ELENA's risk management model. ELENA's project management model incorporates the knowledge of project management provided by the PMBOK and the PRINCE2 methodologies to propose a model that covers both the knowledge of project management and the guidelines about how to use such this knowledge. The process described for managing risk in ELENA is identical to that in AS/NZS ISO 31000:2009. Risk assessment in PMBOK is the result of combining risks probability and impact, whereas present study proposes a new risk assessment model build on FMEA. FMEA analyzes risks through risk priority number (RPN) which contains three parameters including Detection (D), Occurrence (O) and Severity (S). Then, we assigned a threshold value equal to 125 to classify failures or required corrective actions. The purpose of this paper is to improves the accuracy of the assessment and optimize the decision making process in organizations. Finally, a case study of the Gorgan-Bojnord-Mashahd railway is presented.*

Keywords: *Failure mode and effect analysis (FMEA), Risk management, Risk assessment, Risk-Priority-Number (RPN).*

1. Introduction

Today, effectively managing risk is an essential part of successful project risk management. Proper risk management can assist the project manager to mitigate against both known and unanticipated risks on projects. Failure to perform effective risk management can cause many problems for its stakeholders. So, being aware of generic risks and seek for potential risks which may occur in future force organizations prepare plans to identify risks and employ different tools to control them. In this regard, various standards, methodologies and models have been proposed to determine the priority of projects' risks. The PMBOK was created by the PMI (Project Management Institute), to ensure a set of knowledge principles in project management. The purpose is to guide a project manager to fulfil successfully a project [3]. The PRINCE2 is the other risk management methodologies which was created in 1989 by CCTA (the Central Computer and Telecommunications Agency). It is a method of project management structured based on experience gained in thousands of projects and contributions of numerous sponsors, managers, project teams, academics, trainers and consultants. ELENA's process described for risk management is identical to that in AS/NZS ISO 31000:2009. ELENA's model for project management incorporates the knowledge of project management provided by PMBOK and PRINCE2 methodology to create a model which keeps the advantages of previous models in addition to improve their function. Performing risk analysis in PMBOK is the process of prioritizing risks by assessing and combining their probability of occurrence and impact, whereas in this paper we utilize FMEA method for ELENA's risk assessment to be precisely evaluated in comparison to PMBOK. Failure Mode and Effects Analysis (FMEA) is an effective problem prevention methodology which can easily interface with many engineering and reliability methods [1]. It determines the risk priorities of failure modes in an organization through the risk priority number (RPN) value. RPN is calculating through multiplication of the occurrence (O), severity (S) and detection (D) of a potential failure [2]. So, proposed model can have a high potential to identify more risks and improve the safety. The paper is organized as follows. In Section II, a literature review of management methodologies and an introduction of FMEA technique and its advantages is provided. Section III introduces a novel model which

utilizes FMEA method for risk assessment to be analyzed precisely. In Section IV, an example is provided and a study is carried out for Gorgan-Bojnord-Mashahd railway. Finally, the paper is concluded in Section V with a brief summary on topics for future research.

2. Literature Review

There is now an extensive professional literature providing guidelines and frameworks for best practice in project management. In this section a brief review of them will be provided.

2.1. Introduction to PMBOK

"The PMBOK was created by the PMI (Project Management Institute), to ensure a set of knowledge principles in project management. The PMBOK is a detailed framework of nine knowledge areas, broken down into activities across five stages or process groups of the project life cycle, that are claimed to encompass the sum of knowledge generally recognized as good practice in the project management profession" [4]. According to PMBOK [3] project risk management includes the processes of conducting risk management planning, identification, analysis, response planning, and controlling risk on a project. The objectives of project risk management are to increase the likelihood and impact of positive events, and decrease the likelihood and impact of negative events in the project [3].

2.2. Introduction to PRINCE2

"PRINCE2, Projects in Controlled Environments, was created in 1989 by CCTA, since then called by OGC (the Office of Government Commerce). It is a method of project management structured based on experience gained in thousands of projects and contributions of numerous sponsors, managers, project teams, academics, trainers and consultants. The latest version of this methodology tries to approach a generic approach to become flexible to the point of shaping all types of design" [4].

The PMBOK is a descriptive methodology that introduces tools and techniques for project management and the sequence used for process execution, while the PRINCE2 provides guidelines about how the techniques of project management should be structured and implemented. So, both the PMBOK and the PRINCE2 methodologies are compatible if used appropriately [4].

2.3. ntroduction to ELENA

ELENA's project guideline is a structured approach for project management that can manage all levels of organization (project, program and portfolio) effectively. This native Iranian model describes the principles, concepts, processes and tools required for project management along with their utilization method in projects with different characteristics. The process described for managing risk in ELENA is identical to that in AS/NZS ISO 31000:2009. ELENA's project management model integrates both PMBOK and PRINCE2 methodologies to keep their advantages in addition to improve each methodology. Compared to the mentioned methodologies, ELENA has many other noticeable merits such as:

- ELENA's guidance is a knowledge base for collecting lessons learned from projects, programs and portfolios.
- ELENA's guideline provides a comprehensive view for organizations by collecting and analyzing various management theories, especially in project management theories, so that they can gain integrated achievements of the top management theories.
- ELENA's guideline reduces deployment time in organizations with predefined structures and patterns along with a specific framework for adjustment.
- ELENA's guideline is the result of practical experience and the use of best practices. Experience of deploying and managing various management systems in organizations like PRINCE2 and PMBOK revealed some weakness which were not possible to modify their structures. All these corrections have

been collected as the best practices in the ELENA's project guideline. So, ELENA's guideline is the result of the best practices of deploying project and operation management systems.

TABLE I makes a comparison between ELENA's project management model and well-known project management models.

TABLE I: Comparison of ELENA's Project Management Model with Worldwide Project Management Models

Attribute	PRINCE2	PMBOK	ELENA
Body of knowledge		√	√
Methodology	√		√
Comprehensive and unified documentation			√
Varied practical criteria		√	√
Customization Capability	√	√	√
Knowledge of design and portfolio management	√	√	√
Compliance and coordination with design and portfolio management			√
Availability of the developer group			√
Compliance with the conditions of Iran's projects			√

There are some studies that use ELENA. Nikkhou, Taghizadeh, and Hajiyakhchali **Error! Reference source not found.** proposed a five-level portfolio management maturity model called ELENA which is based on the structural portfolio management of ELENA guidance approach. This model includes all the necessary concepts, processes and documentations for the portfolio management. Another study by Shojaie et al. **Error! Reference source not found.** proposed ELENA's project management maturity model as the newest project management maturity model which has yet been introduced. It has 5 levels for maturity assessment and provides both continues and discrete assessment results. It was implemented in one of the biggest Iranian construction and industrial companies.

2.4. Introduction to FMEA

"A Historically FMEA was in use by NASA as early as 1963 but became better known when implemented by the Ford car manufacturers in about 1977" **Error! Reference source not found.**. "A FMEA is a systematic method for identifying failure modes of system, process, design, service and machinery. FMEA is widely used by corporations, manufacturing organizations and firms to evaluate the effects of the failure modes. The goal of FMEA is to determine the reasons of the failure modes; after that seeks for ways to reduce or eliminate the chance of failure" **Error! Reference source not found.**.

"In the FMEA approach, failures can be equally treated as risks, and they are prioritized according to how serious (S) the consequences thereof are, how frequently they occur (O), and how easily they can be detected (D). This tool combines the knowledge and experience of people to identify the potential failure modes of a product or process, rank priority for attention according to the respective consequences of the failures, and eliminate the chance of potential failures occurring. The main idea is to generate an RPN for each failure mode" **Error! Reference source not found.**. RPN is the multiplication of Severity (S), Occurrence (O) and Detectability (D).

Risks which may have positive or negative effect, is an indispensable part of both PMBOK's and ELENA's model. According to TABLE I, despite the wide application of PMBOK in identifying projects' risks, it has some weakness. In this methodology the effect of risk is assessed through only two parameters in Probability and Impact Matrix technique which are occurrence (O) and severity (S). While, this paper precisely evaluated risks based on FMEA method. So, the main contribution of this paper is proposing a more detailed risk assessment model based on ELENA's risk management model. This model applies FMEA which determines risk priority based on risk priority number (RPN). RPN is the product of the three input parameters including

occurrence (O), detectability (D) and severity (S). These results help analysts to identity failures and their causes. In this paper we assigned a complex specific RPN threshold value equal to 125 to classify failures. Corrective actions are required for the failures that are have a value greater than 125 RPN. Section 3 will explain this novel method elaborately. This value is determined by organizational strategies.

3. Proposed Model

Risk is measured through only two parameters named occurrence (O) and severity (S) in PMBOK methodology. So, in this paper risk is evaluated via three factors to make the assessment more detailed and cover previous researches weakness. This paper employs an elaborated risk analysis technique called FMEA based on ELENA's project risk management model. The proposed risk model is summarized in Fig. 1. A detailed description is as follows:

3.1. Risk Management in ELENA

Project Risk management process in ELENA is defined as the systematic processes of establishing the project risk policy, defining risk criteria, identifying risk, analyzing risk, planning risk, controlling risk and reviewing. Section B will present a novel elaborated risk analysis method based on FMEA for ELENA's project risk management model.

3.2. Failure Mode and Effects Analysis (FMEA)

FMEA is a proactive method that prevents system faults before they occur. Each failure mode will be assessed in three parameters, namely, severity (S), likelihood of occurrence (O), and difficulty of detection of the failure mode (D) [1]. The evaluation system numbers are between 1 and 10 for each of the three parameters as described in TABLE IV-TABLE V-TABLE VI. The main idea is to generate a risk priority number (RPN) for each failure mode (see "(1)").

$$RPN = Severity\ (S) \times Occurrence\ (O) \times Detectability\ (D) \quad (1)$$

The failure modes with higher RPNs are assumed to be more important and will be given higher priorities for correction.

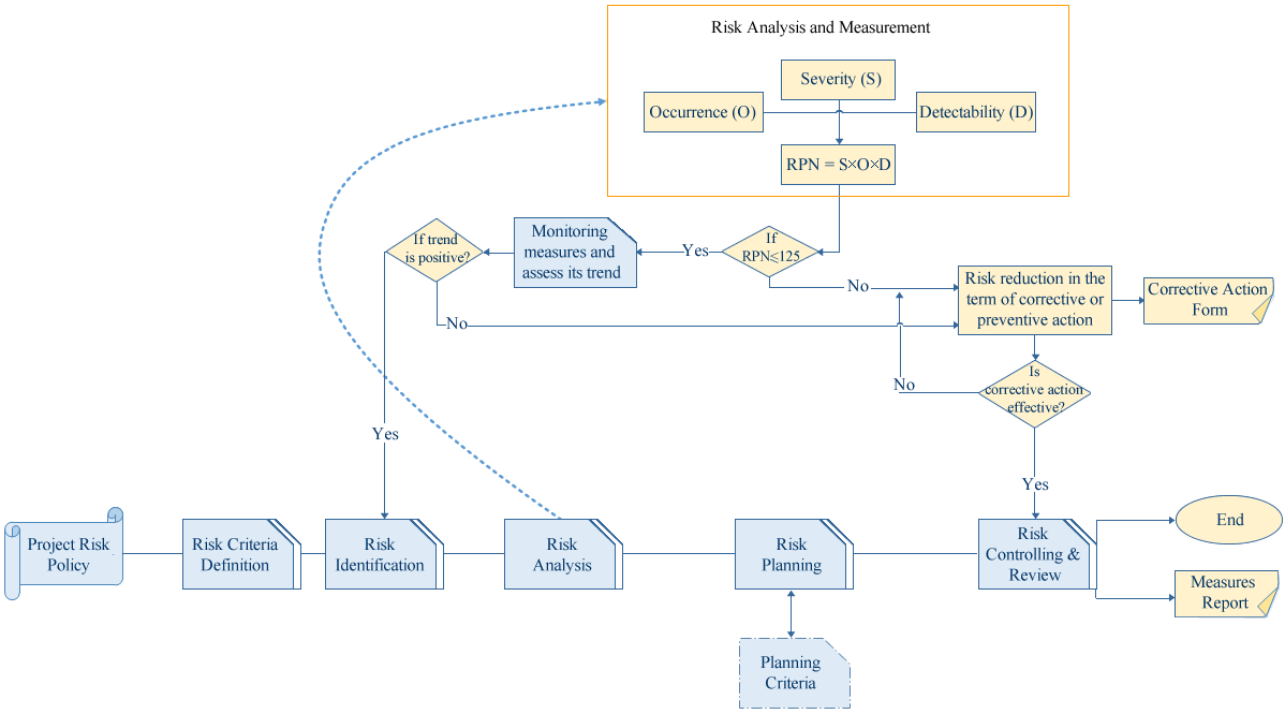

Fig. 1 Proposed risk assessment model based on ELENA's risk management model

The RPNs helps the decision making team to identify the parts or processes that need the priority actions for improvement or appropriate reaction **Error! Reference source not found.**. In this research RPN threshold value is equal to 125 to classify failures which is determined by organizational strategies.

3.3. Processes of the Proposed Model

In this section procedures of new risk assessment model will be explained through ELENA's risk management processes (Fig. 1).

1) Determine the project risk policy.
2) Define risk criteria.
3) Identify risk.
4) Analyze risk using FMEA method (described as follows):
   - Collect the system function information.
   - Identify potential failures of product/process; this includes problems, concerns, and opportunity of improvement.
   - Identify consequence of failures to other components/next processes, operation, customers and government regulations.
   - Identify the potential root cause of potential failures.
   - Detectability rating: likelihood of the process control to detect a specific root cause of a failure.
   - Occurrence rating: estimation of the frequency for a potential cause of failures.
   - Severity rating: rank the seriousness of the effect of the potential failures.
   - RPN calculation: product of the three inputs rating; severity, occurrence, and detectability.
   - Specifying the high risk. RPN represents the overall risk of each failure.
     If RPN≤125, then measures should be monitored and trends should be assessed. 1) If the trend is positive, then back to (3). 2) If the trend is negative, risk reduction in the term of corrective and preventive action should be done (It required to fill the corrective action form). Then if the corrective action is effective, go to (6). Otherwise, risk reduction in the term of corrective and preventive action should be done.
   - If RPN≥125, risk reduction in the term of corrective and preventive action should be done. Then if the corrective action is effective, go to (6). Otherwise, risk reduction in the term of corrective and preventive action should be done (It required to fill the corrective action form).
5) Plan risk considering planning criteria.
6) Control risk and review. This is the final step and the measures reports are available.

4. Case Study

The Case study for Gorgan-Bojnord-Mashahd railway is investigated. This project connects the northeastern parts of the country (including Golestan and North Khorasan provinces) through the Mazandaran province to the national railway network. In this section, risk is measured based on different stakeholders' opinion including project manager and PMO manager. Members are assigned scores to detectability, occurrence and severity parameters (from 1 to 10 provided in TABLE IV-TABLE V-TABLE VI) according to the real situations. TABLE II provides a list of identified risk in Gorgan-Bojnord-Mashahd railway, then risks are assessed based on proposed FMEA model explained in section III.

TABLE II: Measuring RPN Based On FMEA

Identified Risk	Detection (D)	Occurrence (O)	Severity (S)	RPN (D*O*S)
Lack of supervision on controlling the domestic producers	5	5	2	50
Hurry to open plans	2	2	2	8
Delay in contractors proceedings payment	5	4	3	60
Change in execution of upper hand documentations	3	3	1	9
Failure to properly operate alarms	5	5	3	75
Inappropriate contractor selection	3	5	3	45
Failure and breakdown of traverses during operation	6	3	2	36
Breakdown of Welded Roof Rails	5	5	3	75
Disruption of project logistics	6	3	2	36
Unclear insurance laws and regulations	5	4	2	40
Incomplete transfer from basic design to implementation design	3	4	5	60

In our risk analysis study, calculated RPN numbers are compared to 125 as a baseline, then high priority risks are identified. TABLE III displays high priority risks which require corrective or preventive actions as a risk response.

TABLE III: Risk response according to risk priority

Identified Risk	Risk Response
Lack of supervision on controlling the domestic producers	Implementation of comprehensive supply chain quality control system
Hurry to open plans	Planning to complete all stages of the project simultaneously
Delay in contractors proceedings payment	Use Information Technology in financial payments criteria
Change in execution of upper hand documentations	The exact identification of parliamentary approvals
Failure to properly operate alarms	equipping Network with CTC Smart Security Systems
Inappropriate contractor selection	Planning for the presence of all eligible contractors
Failure and breakdown of traverses during operation	Quality control before installing traverses
Breakdown of Welded Roof Rails	Identification of welding materials manufacturers from abroad
Disruption of project logistics	Identification of various transportation methods
Unclear insurance laws and regulations	Use of external reinsurance
Incomplete transfer from basic design to implementation design	Choosing a top consulting firm

TABLE IV: Scoring Risk Identify by FMEA (Severity)

Effect	Severity of Effect	Ranking
Very High	Failure to achieve defined functions - The alternative solution has a huge impact on cost and revenue (Cost >5000000€)	8-10
High	Failure to achieve defined functions - The alternative solution has a huge impact on cost and revenue (Cost 3000000<x<5000000 €)	6-8
Moderate	Failure to achieve a specified function in an element - It affects costs and incomes but is defined by the likelihood of occurrence (Cost 1000000<x<3000000 €)	4-6
Low	Failure to achieve specific performance in an element but with acceptable peripheral performance - Impact on cost and scheduling is low (Cost 100000<x<1000000 €)	2-4
Very Low	Failure to achieve specific performance in an element but with acceptable peripheral performance - Impact on cost and scheduling is low (Cost <100000€)	0-2

TABLE V: Scoring Risk Identify by FMEA (Occurrence)

Probability of Failure	Failure Probability	Ranking
Very High	Most probably (more than 50%) it occurs	8-10
High	Most probably (between 25% and 50%) it occurs	6-8
Moderate	It is unlikely to occur during the project. It occurred in previous projects (between 25% and 50%)	4-6
Low	Very unlikely to occur during the project. It rarely happened in previous projects (between 5% and 10%)	2-4
Very Low	Very unlikely to occur during the project. It rarely happened in previous projects (below 5%)	0-2

TABLE VI: Scoring Risk Identify by FMEA (Detection)

Effect	Severity of Effect	Ranking
Definitely	In the meantime, there is no approach/mechanism of the processes to identify the risk and to prevent from occurring.	10
Very High	Very negligible chance (about 10%) the system methods can identify risk and prevent from occurring.	9
High	Negligible chance (about 20%) the system methods can identify risk and prevent from occurring.	8
Moderate	Very low chance (about 30%) the system methods can identify risk and prevent from occurring.	7
Moderate	Low chance (about 40%) the system methods can identify risk and prevent from occurring.	6
Low	Moderate chance (about 50% to 60%) the system methods can identify risk and prevent from occurring.	5
Very Low	Moderate chance (about 70%) the system methods can identify risk and prevent from occurring.	4
Rarely	High chance (about 80%) the system methods can identify risk and prevent from occurring.	3
Very Rarely	Very high chance (more than 90%) the system methods can identify risk/ prevent from occurring.	2
Complete Uncertainty	Procedures and procedures can identify risk and prevent from occurring.	1

5. Conclusion

In this paper, a novel approach for measuring project risk is introduced in an attempt to overcome the shortcomings of the risk assessments in available studies. In this paper, a more accurate risk assessment method is presented based on ELENA's risk management model. This paper precisely evaluated risks based on FMEA technique in which risks are measured through three parameters including detectability, occurrence and severity. Comparing with the PMBOK and the PRINCE2 methodologies, the advantages of the ELENA are 1) being a body of knowledge and a methodology simultaneously, 2) having comprehensive and unified documentation, 3) compliance with the conditions of Iran's projects. Finally, performance of this novel risk assessment has been evaluated with a real case study in Gorgan-Bojnord-Mashahd railway.

6. References

[1] S. K. Oraee, A. Yazdani-Chamzini, and M. H. Basiri, "Evaluting underground mining hazards by fuzzy FMEA," SME Annual Meeting, Feb. 27-Mar. 02, 2011, Denver, CO.

[2] H. Safari, Z. Faraji, and S. Majidian, "Identifying and evaluating enterprise architecture risks using FMEA and fuzzy VIKOR," Intell Manuf, 2016, pp. 475–486.

[3] A Guide to the Project Management Body of Knowledge, PMBOK Guide, Fifth Edition, 2013.

[4] S. Matosa, and E. Lopesa, "Prince2 or PMBOK – a question of choice," Procedia Technology 9, 2013, pp. 787-794.

[5] Sh. Nikkhou, K. Taghizadeh, and S. Hajiyakhchali, "Designing a Portfolio management maturity model (Elena)," Procedia - Social and Behavioral Sciences, 2016, pp. 318-325.

[6] S. Shojaei, S. Nouri, S. Haji Yakhchali, and Y. Rahimi, "Project Management Maturity Assessment with a new Elena Project management Maturity Model: a case study of Saba tower," in *11th International Project Management Conference*, 2016.

[7] J. Yu, and S. Lee, "A Conflict-Risk Assessment Model for Urban Regeneration Projects Using Fuzzy-FMEA," KSCE Journal of Civil Engineering, Vo. 16, 2012, pp.1093-1103.