A review of methodologies and tools for project risk management

Vanessa Manotas Niño
Laboratoire Génie de Productión / INP-ENIT – Université de Toulouse, Tarbes, France, vmanotas@enit.fr

Philippe Clermont
Laboratoire Génie de Productión / INP-ENIT, Tarbes, France, philippe.clermont@enit.fr

Laurent Geneste
Laboratoire Génie de Productión / INP-ENIT, Tarbes, France, laurent.geneste@enit.fr

ABSTRACT

Risk management process is a methodology that must be applied in all project phases, so there is the opportunity to make important modifications and increase the success likelihood. Each project needs to be analyzed in detail in order to choose the best method at each phase. The objective of this paper is to present two methodologies using the same decision support system (DSS) with analytic hierarchy process (AHP) and different current tools applied in project risk management. This work is the first stage of a doctoral thesis which aims is to create technical and methodological support to improve, from the feedback, risk management in projects and operational forecasting and generate rules of good practice. This work is based on review and analysis of the concepts used in the literature.

Keywords: Risk, criticality, failures, impact, experience feedback

1. INTRODUCTION

In the 21st century, companies have adopted as a rule or strategy work from the project to be able to respond efficiently and quickly to market requirements. However, the implementation of this type of organization is not sufficient to guarantee success. In the current context where the financial, temporal, human, material and normative constraints are more and more significant and where the complexity of projects is increasing, the presence of risks and uncertainties is inevitable, potentially with disastrous consequences.

A project is a complex system that can be decomposed by its structure, their results, its immediate environment and in the result of its future environment (Marle, 2011). To carry it out the project managers must consider a large number of parameters (environmental, social, security) and a growing number of stakeholders, should study the potential positive and negative consequences of decisions, define the project type, the work team, the budget, etc.

The aim of this paper is to present the general model of Project Risk Management (PRM) and compare it with two applications. The first one is an approach to evaluate risk based on the number of risk factors identified and their relative significance (Badri, Nadeau and Gbodossou, 2012) while the second one is a modeling and management of project risks and their interactions (Fang and Marle, 2011).

This work is the starting point for a thesis based on the intersection of two research themes: risk management in projects and Lesson Learning Systems (LL). The originality of the proposed subject is to incorporate LL mechanisms in phases of planning and execution in risk management process and develop a demonstrator to verify the applicability of the proposed. The tool should be able to create alerts serve database to evaluate the successes and failures in system.

The paper is organized as follows: section II presents the research methodology used in the literature review, section III contextualizes the general methodology and its tools in project risk management. The analysis of findings is presented in section IV. Finally, section V concludes the literature review.

2. Research methodology

The research methodology is based on a study and analysis of the concepts used in the literature by different authors, having as research items: Project risk management. The research was completed in two stages: first, it examined some papers found in electronic databases like: EBSCO, ProQuest, ScienceDirect, Scopus, ScholarVox, INPT and Sagaweb, using keyword searches: project management, risk management and lesson learning; in the second stage, it used the snowball method by searching for journal articles.

The literature published between 1950 and up to date from several standards, PhD thesis, books and journals including: International Journal of Project Management, Project Management Journal, International Journal of Information Management, The Journal of Systems and Software, Journal of Management Information Systems.

3. Review of project risk management approaches

The origins of project management dating back to 1950s which was when organizations began to apply different techniques and tools for engineering projects and was formally recognized as a contribution to the management discipline. At the same date, risk management began to gain strength as a management discipline with the use of market insurance to protect companies and individuals (Kwak, 2005; Cleland and Gareis, 2006; Harrington and Neihaus, 2003). Project management integrated risk management as a management support tool that have been applied to all stage of the project life cycle, in this manner, has developed project risk management.

Leter in the 1980's and the beginning of the 1990's, different institutions and research centers began to develop standards in project management, risk management and project risk management involving people and organizations. Figure 1 summarizes most of them and theirs counties of origin .

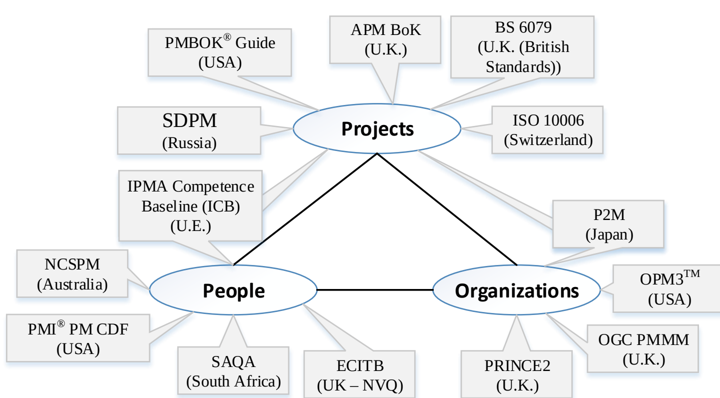

Figure 1. Standards available that focus on projects, people and organizations (Crawford, 2004)

Project risk management processes is a generic approach of five steps: defining, identifying, analyzing, responding and monitoring to project risk. Figure 2 presents a comparison of the structure of project risks management processes, as defined in: PRAM (2004), PMBOK (2012), SHAMPU (Chapman et al., 1997), RAMP (2005).

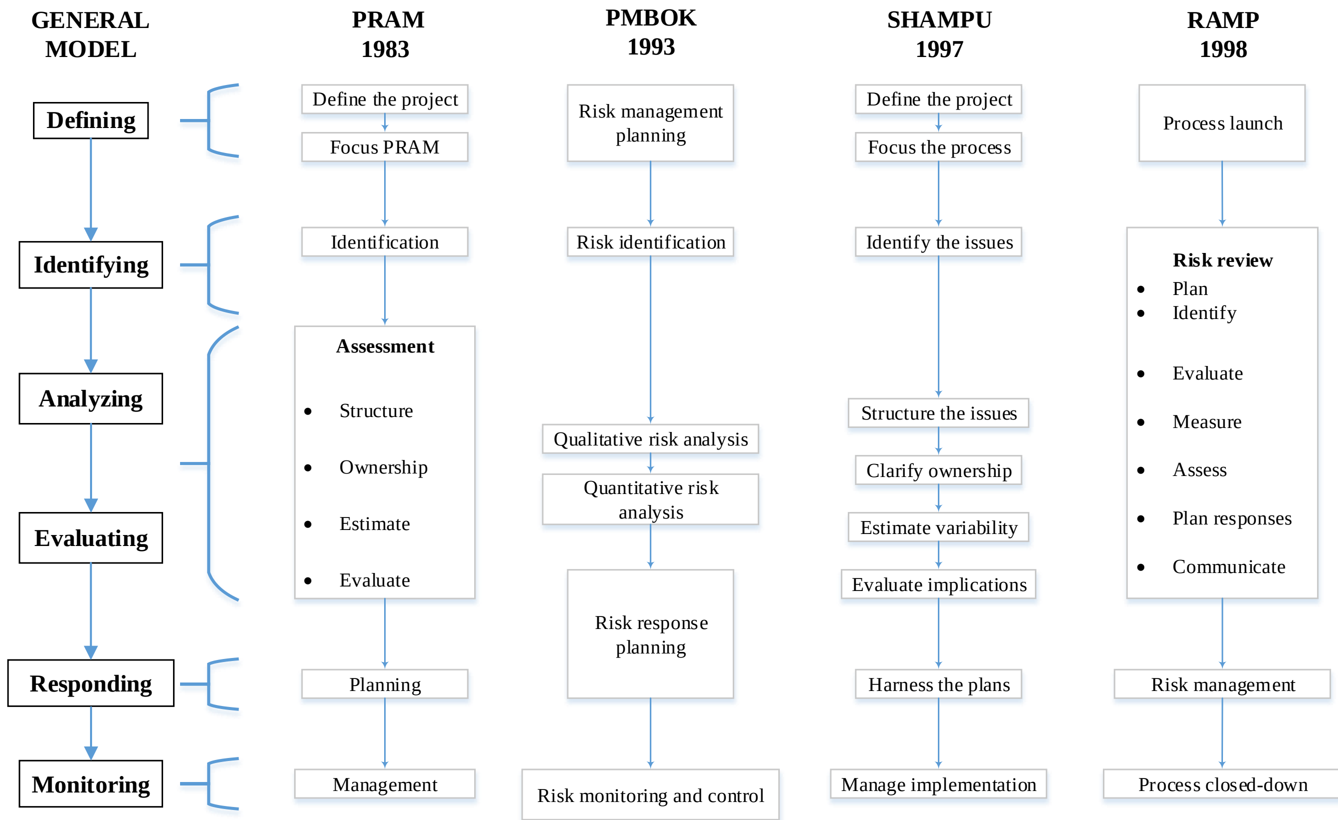

Figure 2. Comparison of project risk management processes

These methodologies are presented as generic models, none is related to a specific industry or particular project and do not go into detailed description and analysis of the risk management processes.

According to Project Management Institute (PMI) (2012), the focus of risk management processes is add value to the organisations and its stakeholders through improving decision making, contributing to a more efficient use of capital and resources, optimizing operational efficiency and providing a framework for the organization. It includes maximizing the probability and consequences of positive events and minimizing the probability and consequences of adverse events to project objectives.

The first step is to establish the internal and external project parameters such as size, duration, target, budget, objectives, stakeholder, team roles and responsabilities, processes, documents, tools and methods that will be used. The purpose is to consolidate relevant existing information and resolve any inconsistencies about the project and its management in a suitable form (Chapman et al, 1997).

There are two methods for the identification: “Retrospective” in which the incidents that occurred in the past are analyzed. There must be a information system to collect and record past problems in projects. “Prospective” that is a study based on process analysis. In addition to common risk identification tools, some authors propose to define the risk typology depending on the project and then to define the associated risks. See Table 2**Erreur ! Source du renvoi introuvable.**.

Table 1. Risk typology

Author	Classification
Villeneuve, 2000	Project, contractual, operational, technical, corporate
Gourc, 2006	Internal: human, organizational, technological, contractual External: technical, political, customer, market, juridical
Pinto, 2007	Financial, technical, commercial, execution, contractual, legal
Beler, 2008	Disaster (natural disasters, technological disaster, health risks), financial, failure of a project, individual risk of accidents
Desroches et al., 2010	Generic risk: external risks to project activity (customers, contractual interfaces, user and operationg site), project governance risks (project organization, development strategy, project management, financial management, calendar management), technology and technical risks (engineering) Specific risk: client, development strategy, project organization, contractual interfaces, project management, financial management of the project, project management calendar, performance management and security, users and operating sites
Nguyen, 2011	Nature, origin, controllability, detectability

For improvement of risk management, studies are underway to integrate a new concept called capitalization, there are a variety of names given to this expression like: lesson learned, experience feedback, experience management, Knowledge Management. The capitalization of knowledge should be applied in all areas and fields, in order to use it to improve performance and avoid future risks.

The other method steps are defined in the next section.

3.1 DECISION SUPPORT SYSTEM (DSS) FOR PROJECT RISK MANAGEMENT

The followings authors (Badri et al., 2012) and (Fang et al., 2011) proposed a DSS to model, assess and analyze project risks. Former authors present a systematic approach of eight steps divided into three phases to evaluate risk and propouse a procedure called "risk factor concentration", while the latter author proposed a simulation-based model to re-evaluated risks and their priorities with five phases, each one divided into steps.

AHP is suitable for multi-objective, multi-criterion and multi-actor decisions from pairwise comparisons for decomposition of the structure, comparison of judgments, hierarchization and the importance of each criterion (Mabrouki, Bentaleb and Mousrij, 2014) and (Saaty, 1980).

Table 2 presents a parallel between two approaches and the general model of PRM. Can be observed that the methods have small changes in the name of the step.

Table 2. DSS with AHP methodologies

<table>
<tr><th>PRM Description</th><th>Badri et al., 2012</th><th>Fang et al., 2011</th></tr>
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1. **Risk identification**

This step should determine the causes, origin and impact of risks on project objectives. The results obtained must allow a better understanding of the nature of the risks and how they can be treated. The techniques should be able to be traceable, repeatable and verifiable. In complex situations, can be combined several techniques (AFNOR, 2010).

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1. **Risk identification**

a) This step involves identification the three elements: risk factors, undesirable events and their impact.

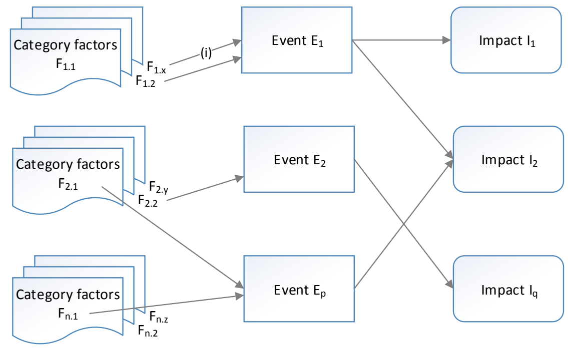

Figure 3. Risk factor approach (Badri et al., 2012)

Method used are observations, interviews, analysis of accidents and incidents, expert judgment, MOSAR (organized systematic method of risk analysis), and INRS guide (industrial risk records)

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1. **Risk network identification**

a) Identify Potencial project risk by classical methods. The result is a project risk list that allow create Design Structure Matrix (DSM)

b) Define risk interactions using the DSM developed by Steward (1981), to handle dependences and relations between items. This is a binary code method that evaluates the existence of dependence, interdependence and independence of precedence relationships between two risks.

<table>
<tr><th></th><th>R1</th><th>R2</th><th>R3</th><th>R4</th></tr>
<tr><td>R1</td><td></td><td>1</td><td>1</td><td></td></tr>
<tr><td>R2</td><td></td><td></td><td>1</td><td></td></tr>
<tr><td>R3</td><td>1</td><td></td><td></td><td>1</td></tr>
<tr><td>R4</td><td></td><td></td><td>1</td><td></td></tr>
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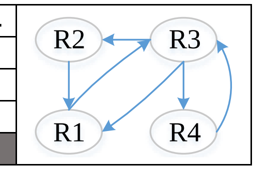

Figure 4. A DSM showing the risk network (Danilovic and Browning, 2006)

Figure 4 illustrates the risk network, which is a binary and square matrix with $DSM_{ij} = 1$ when the probability of R_j triggering R_i. It can be seen that R_3 receiving inputs from R_1 and R_4 and providing outputs to R_1, R_2 and R_4, namely, risk *3* declared as a cause risk *1* and *4*.

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2. **Risk analysis**

Risk analysis is to assess and prioritize the consequences in function of the likelihood of occurrence and their impact of certain risks outlined above, taking into account the information, data and resources available. It must be stablished

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2. **Risk assessment**

b) Identification of causal links between the risk elements. Expert judgment method.

c) Estimation of paired comparison of categories of risk

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2. **Risk network assessment**

c) Evaluation by classical methods of the probability and impact of identified risks.

$$p = \alpha \cdot 10^{\left(\frac{-\beta}{s}\right)}$$

p is used for converting qualitative scale s with parameters $\alpha, \beta > 0$ into quantitative measure

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<td>the strategies and methods to minimize the impact of risks and how to optimize the opportunities. At this stage some tools that allow information processing can be used, the effectiveness of controls and estimating risk levels (AFNOR, 2010; and Marle, 2011)</td>
<td rowspan="2">factor. APH method developed by Saaty in 1970.

d) Estimation of the probabilities of occurrence. Risk factor concentration method.

$$C_{ij} = \frac{x_i y_{ij}}{\sum_{i=1}^{n}\sum_{j=1}^{n} x_i y_{ij}}$$

where x_i is the number of risk factors by category F_i and y_{ij} is the weight of risk factor category causing an undesirable E_j estimated by AHP.

e) Evaluation of the impact of undesirable events.

$$I_i = Max_{\text{impacts set by the organization } (i)}$$</td>
<td>d) Assess the risk interactions network by the causal probability between risks. It needs to transform the binary assessment into a numerical matrix. A Likert scale or AHP is proposed.</td>
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<td>3. RISK EVALUATION

This step intends to make decisions and to prioritize risks that need immediate treatment, based on the outcomes of risk analysis and consider the criteria established (AS/NZS, 2004)</td>
<td>3. RISK NETWORK ANALYSIS

e) Modeling and run of the risk network with simulation in discrete events. The software ARENA® is used.

Calculate number of iterations, using the stability evaluation criteria of the output.

$$\sum_{i=1}^{n} \Delta RF_i^2 < \text{Threshold}$$

ΔRF_i^2 indicates the deviation of the simulated frequency of R_i with the previous simutation.

I. Risk re-evaluation of:
• Risk frequency simulated of R_i
$$RF_i = \lim_{m\to\infty} \sum_{k=1}^{m} k \cdot P_k(R_i)$$
$P_k(R_i)$indicates the probability of R_i occurring k times during the project.

• Risk Consequences of R_i
$$CR_i = \sum_{j=1}^{n} RF_j^i \cdot RI_j$$
RF_j^i indicates the simulated risk frequency of R_j originating from R_i, RI_j is the impact of R_j</td>
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		• Local risk Criticality $LC_i = RF_i \cdot RI_i$ • Global criticality of R_i $GC_i = RF_i \cdot CR_i$ II. Risk prioritization based on re-evaluated indicators of risks and their relative severity in the project. III. Sensitivity analysis. Risk are evaluated in three-level probabilities: pessimistic, most likely and optimistic.
4. RISK RESPONSE Finally, we have the risk assessment, which is to rank and compare risk levels determined by order of criticality. Given the results of this evaluation can be set to follow the treatment of risk (Nguyen, 2006).	**3. RISK ACTION** f) Evaluation and prioritization of identified risk that combines the probability of occurrence Pi and the impact Ii of a undesirable event Ei. $Risk_i = P_i \cdot I_i$ g) Action prioritization. AHP method. h) Action monitoring and control. Prevention plan method.	**4. RISK RESPONSE PLANNING** f) Apply different possible strategies to mitigate the occurrence of local and global actions, changing the parameters values.
5. RISK MONITORING AND CONTROL The monitoring process should provide assurance that there are appropriate controls and responses are in place for the project's activities, identify appropriate modifications to systems and that the procedures are understood and followed. (IRM, 2002)		**5. RISK MONITORING AND CONTROL** g) Monitoring the evolution of the risk network and evaluating the effectiveness of the mitigation actions with the objective to provide feedback for the previous steps allowing improved results.

4. Analysis of findings

Since several years, companies have set up project based organizations to be able to answer quickly and in an efficient way to the markets requirements. However, the implementation of this type of organization is not sufficient to guarantee success. In the current context where the financial, temporal, human, material and normative constraints are more and more significant and where the complexity of projects is increasing, the presence of risks and uncertainties is inevitable, potentially with disastrous consequences.

The risk management have a considerable influence on stakeholders perception of project success, regardless of the chosen approach, always it should included a standard method for identifying, assessing and responding to risks that influence the project outcomes.

AHP is a structured multi-attribute decision method used to facilitate making decisions under risky or uncertain situations. The main advantage of these two methods studied is its capability to check and reduce the inconsistency of expert judgments to evaluate risk interaction and the relative significance of each risk factor.

We can observe that in the analyzed tools on risk management has not systematically included the experience feedback. The idea, then, is to bring together both in a database to improve and streamline processes, and the sooner a risk is identified, the sooner it can be minimized or eliminated. Similarly, the sooner you see the positive dynamics of an action before it can execute, thus streamlining the steps.

5. Conclusion and further work

Different standards referenced in this work present limitations in terms of capitalization of positive and negative experiences and generation of rules or best practices especially with complex projects. To mitigate these difficulties and address continuous improvement issues, we suggest to exploit Experience Feedback and Lesson Learning mechanisms, and identify references, applications, resources, tools, etc.

This study is only based on a comparison of a method for risk assessment in two different contexts. For future works, it is necessary to expand the domain of study by including other DSS that can be used for risk assessment like Multi-Criterion Decision Analysis (MCDA), ELECTRE, MACBETH, Fuzzy method, SMART, SMAA and its integration with experience management where the objetive of these methods are to collect necessary and sufficient information during the project activities and capitalize best practices and failures experiences in projects.

Likewise, study the different methods for selecting the best technique for each stage in risk management process, taking into account the evaluation criteria for different types of projects.

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