A User- Oriented Implementation of Risk Breakdown Structure in Construction Risk Management

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ABSTRACT

Construction industry is a complex, dynamic and risky industry that often suffers from poor performance leading in increased cost and time, and in decreased quality. In these conditions the dynamic identification and assessment of project risks among a vary range of potential factors is considered of vital importance. The introduction of Risk Breakdown Structure as a hierarchically organized depiction of identified risks was considered a suitable tool in risk management, especially in construction, due to its many advantages in synthetic representation and dynamic nature.

This paper presents a user- oriented implementation of RBS to assist the project managers in identifying and assessing potential risk factors affecting construction process. The evident analogies between WBS and RBS are captured and used in the proposed framework which interconnects them into a 2-D matrix used to associate risks to the specific project activities.

The proposed framework is applied to a government funded design- bid- build project. The obtained results clearly demonstrate the advantages in identifying the most risky activities, the most important risk factors affecting the whole project, and the most significant relationships.

Keywords: *Construction risk, RBS, user-oriented, 2-D Matrix, WBS.*

INTRODUCTION

Construction projects are complex activities involving many participants with different objectives. They are generally considered as long term projects subjected to a vary range of risks and uncertainties during their life cycle.

According to Chan D.WM., (Chan D.WM., Kumaraswamy M.M., 1997) a project is considered "successful" if it is completed on time, within budget and on the specific quality standards. In practice it is well known that projects tend to exhibit cost overruns and schedule delays, causing failures and leading to collapses. In these conditions the application and improvement of Project Risk management becomes of vital importance, representing a key challenge for scientific research. The modification of key risks during the project progress requires an iterative risk management process carried out during the life cycle and considering the specific project objectives and circumstances.

There are a large number of scientific researches on risk management techniques, involving different steps such as: risk identification, risk assessment, risk response, and monitoring and controlling. A variety of tools and techniques can be used to identify possible risks affecting construction projects. However, these tend to produce an unstructured list of risks that often does not direct the manager in knowing where to focus the managerial attention (Hillson, 2002). In order to help prioritizing the identified risks are used qualitative assessments; but this suffers several drawbacks in not considering the patterns of risk exposure.

In big, complex projects where a lot of data is produced, a hierarchical structure is an essential strategy. The most evident illustration of the value of structuring within project management is the Work Breakdown Structure (WBS), which is recognized as a major engine for the project manager because it provides a mean to structure the work to be done in order to accomplish the project objectives. Similar to this, using Risk Breakdown Structure (RBS) is a very practical tool, simplifying and supporting the management process in the later stages. According to D. Hillson (Hillson, 2002), following the pattern of WBS definition stated in Project Management Institute (Project Management Institute PMI, 2000) RBS is defined as "A source-oriented grouping of project risks that organizes and defines the total risk exposure of the project. Each descending level represents increasing detailed information of risk sources to the project". However, it has been recognized (Rasool, 2012) that risk breakdown structure suffers from several deficiencies such as lack of clarity on how to develop it for new projects according to its specific needs and objectives, inconsistencies in definition of risk categories and difficulties in transferring the qualitative/quantitative assessment of risk across the structure. According to M. Rasool (Rasool, 2011) in general there is no clear definition of the meaning of risk categories and the same words can cover different items in different project activities.

This research aimed to develop a user- oriented approach for risk breakdown structure implementation linking WBS to RBS to produce a combined framework helping in identification and assessment stage, and providing support in further stages. This methodology can provide useful information in identifying:

- Which activities have more associated risks
- The most important risk factors affecting the whole project
- The most significant relationships.

Thus, the specific objectives and methods used in this research are as follows:

- The development of a user oriented RBS-WBS,
- The development of a consistent assessment approach adapted to several criteria: fitting different project development stages, offering different views, highlighting the most important relationships.

RISK AND RISK MANAGEMENT PROCESS

Construction projects are complex, involving a wide set of tasks to be conducted within resources constraints and future uncertainties to meet defined objectives. In has been known for a long time that due to a wide range of possible risks projects tends to exhibit cost overruns, schedule delays and quality decrease.

Project risk has been defined as a multi face concept. It can be expressed as “the potential for unwanted or negative consequences of an event or activity” (Rowe, 1977), “a threat and a challenge" (Flanagan and Norman, 1993), "a combination of probability of an event occurring and its consequences for project objectives" (International Standarts IEC62198, 2001; WSDOT, 2010)

According to PMI PMBoK (PMI , 2004), risk includes upside effects, the opportunities, but traditionally focuses on the downside, i.e. the negative effects. A review of risks definitions lead to the following faces of project risk: an event that focuses on the future, emphasize the negative effects, deals with the probability and consequences (Keci, 2012). The level and scope of risks vary from project to project and are tied directly to the context (the environment in which the project will be built such as geography, local regulations, etc.) and content (physical elements of the project such as scope, budget, materials, etc.) of the project (Davis and Prichard, 2000). In these conditions a dynamic risk management is a key element and has been continuously examined from 1978.

"Risk management is one of those ideas that sense that a logical, consistent and disciplined approach to the future's uncertainties will allow us to live with them prudently and productively, avoiding unnecessary waste of resources. It goes beyond faith and luck; the twin pillars of managing the future before we began learning how to measure probability" (Risk Management Reports, 1999).

A variety of risk management techniques has been studied and introduced in the literature:

Berkeley et al. (1991) and Flanagan and Norman (1993) categorized the process of risk management into: risk classification, risk identification, risk analysis and risk response. Project Management Body of Knowledge (PMI, 2004) introduced a five steps procedure including planning, identification, qualitative assessment, quantitative assessment, response planning, while Baloi and Price (2003), included an additional step of risk communication. The Australian and New Zealand Standard (AS/NZS, 2004) is illustrated five steps procedure interconnected to each other;

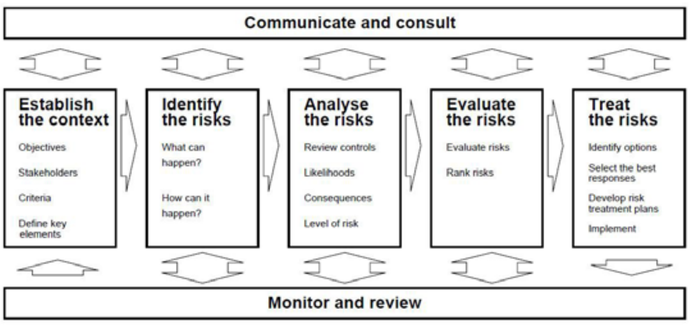

Fig.1: The Risk Management Process according to The Australia and New Zealand Standard on Risk Management(AS/NZS 4360:2004)

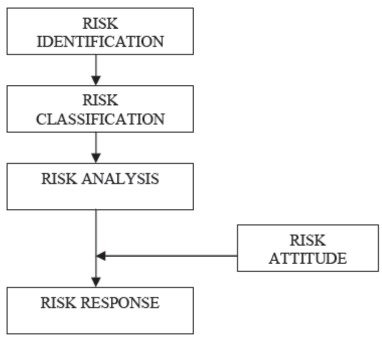

Fig. 2: The Risk Management framework (Flanagan and Norman, 1993)

Similar to this approach, the British Standards (BSI8444, 1996) propose a five steps procedure to manage risks including Identification, Estimation, Evaluation, Response, and Monitoring. Baker (Baker, 1999) has suggested fitting these five steps in a simple circular procedure which will yield a controlled risk environment. Wang (Wang, 2004), in their study about risk management framework for construction projects in developing countries proposed a risk model, called Alien Eyes Risk Model showing the three risk hierarchy levels and the impact connection between risks. Zhou and Zhang (Zhou and Zhang, 2010), proposed a dynamic risk management system for big sized construction projects in China, composed of six main parts, namely event database, risk tracking, risk pre-control, risk assessment, risk identification, and risk database. Despite the wide variety of the techniques they have common objectives: identification of risk sources, their assessment and treatment.

RISK BREAKDOWN STRUCTURE

Introducing RBS

Using traditional RM techniques enables the identification of the project risks, which can be prioritized in the assessment phase to determine the risks which should be addressed first. There is an extensive literature focusing in the risk identification process evaluating the most frequently used tools, their strength and weakness. Based on a study made by Keci and Oztas (Keci, 2012), the most frequent identification tools used in Albanian construction industry were Brainstorming, Delphi technique, check list and Questionnaire.

However, in big complex projects the identification tools will tend to produce an unstructured list of risks very difficult to manage. Based on the WBS concept introduced by PMI (PMI, 2000), the hierarchical structure of risks is a very practical tool. Del Cano and Cruze (Del Cano and Cruze, 2002) decomposed the project into four phases (initiation, balancing, maintenance and learning), developing them into sub-phases, activities and sub-activities. Chapman (Chapman, 2001) proposed to set up a systematically Risk Breakdown Structure (RBS), to facilitate the identification process. The use of RBS, with as many levels as required, gained a great importance as e a better solution for management purposes.

Table1: Risk identification tools: Strength and Weakness (*source: PMI, 2008)*

Technique	Strength	Weakness	Authors
Brainstorming	□ Allows all participants to speak their mind and contribute to the discussion □ Can involve all key stakeholders □ Creative generation of ideas	□Requires attendance of key stakeholders at a workshop, therefore can be difficult to arrange and expensive □ Prone to Groupthink and other group dynamics □ May produce biased results if dominated by a strong person (often management) □ Often not well facilitated □ Generates non-risks and duplicates, requires filtering	Chapman (1997), Baker et al. (1999),Akintoye and MacLeod (1997), Hlaing et al (2008), etc
Delphi Technique	□Captures input from technical experts □ Removes sources of bias	□Limited to technical risks □ Dependent on actual expertise of experts □ May take longer time than available due to iterations of the experts" inputs	Chapman (1998), etc
Check List	□Captures previous experience □ Presents detailed list of risks	□Check list can grow to become unwieldy □ Risks not on the list will be missed □ Often only includes threats, misses opportunities	Akintoye and MacLeod (1997), Simister, (1998), Hlaing et al (2008), etc.
Questionnaire	□ Encourages broad thinking to identify risks	□Success depends on the quality of the questions □ Limited to the topics covered by the questions □ Can be a simple reformatting of a checklist	Simister (1998), Hlaing et al (2008), etc.

A wide range of RBS have been produced under various project objectives and there is no identified “standard practice” for RBS development. Many classifications have been developed over the years; however most of them have considered the source criteria as the most important (Ebrahimnejad, S, 2010). Other classifications made are according to their origin: internal and external risks (ElSayegh, 2008; Tah and Carr, 2001), according to their magnitude: primary and secondary risks (Cooper and Chapman, 1987), according to the project phases (Zou, Zhang and Wang, 2007), according to their importance (Tam, Shen, Tam and Pang, 2007), according to the stakeholders (Rasool, 2012), etc. Other common categorizations are: internal and external, positive and negative, dynamic and static, corporate and individual, etc.

Development of RBS

Different RBS approaches have been adapted to the specific projects requirements highlighting the need for the development of a dynamic tailored based RBS. However, there are interactive components helping in RBS development defined from the literature as follows:

- Risk event (RE): is considered a future event which has a probability of occurrence and some consequences on project objectives
- Risk Category (RC): is a grouping of several RE communed by a specific characteristic.
- Micro Tree (MT): is defined as the decomposition of RC into subcategories.

According to Rasool (Rasool, 2012) any RBS is viewed as a set of micro trees in which each "son" RC can be further decomposed, as long as it is a father node in another MT.

Benefits from RBS

The RBS is a hierarchical structure that represents the overall project and organizational risk factors and events organized by groups and categories (Holzmann, 2010). It offers a variety of benefits not only in identification phase, offering a synthetic view on risk, but also support further stages.

- Risk identification: Beside being used as a simple check list, it gives a general overview to ensure the complete coverage by mapping identified risks in each category
- Risk assessment: identified risks are assessed by allocating them to the specific areas. According to Hillson (Hillson, 2006) assessing risks using RBS provides an additional insight into:
  - Understanding the type of risk exposure
  - Exposing the most significant risk sources
  - Reveling root causes of risks
  - Indicating areas of dependency or correlations between risk, etc
- Risk reporting: rolling up or drilling down to report information according to specific requirements
- Dynamic tailored-based RBS: it can be reduced or broadened, in depth or in breadth (Holzmann, V., & Spiegler, I., 2010), to meet various special requirements according to the level of information available creating in this way an iterative, dynamic system.
- Lessons for future projects: Due to its structured information, it can be used as reference for future projects, or as a comparison tool for parallel projects.

Generally the scientific research has been focused on the benefits of RBS in the identification phase, underestimating the other strengthens.

In this study we will present a user- oriented approach for risk breakdown structure implementation linking WBS to RBS to produce a combined framework helping in identification and mostly in assessment stage, and providing support in further phases.

LINKING WBS TO RBS

The evident analogies between WBS and RBS make it possible to interconnect them into a useful technique to associate risks to the specific project activities. Considering the advantages of RBS as a risk identification technique, its combination with WBS would have several additional powerful strengths in:

- Offering a synthetic view on risks affecting each work package;
- Providing perspectives of where are risks coming from and concentrated at (Rasool, 2012);
- Recognizing the most risky work items (WP);
- Each stakeholder can have his own view on the project activities;
- Being compatible with the dynamic nature of construction project risks;
- Successfully over passing the identified deficiencies of RBS (Rasool, 2011) that there is no clear definition on the meaning of risk categories and the same words can cover different items in different project activities.

To generate this type of combined methodology, primarily is performed the identification process using RBS with as many hierarchical levels as required from the project. The lowest levels of RBS are then interconnected with the lower levels of WPs, creating a type of 2-D matrix. The risk values are calculated by multiplying the probability of that risk to happen ($P_{i,1}$) with its impact on the specific WP in case of occurrence ($I_{1,j}$). The assessment of $P_{i,1}$ and $I_{1,j}$ is made based on a cardinal scale approach.

The amount obtained by summing each cell of the rows on the matrix table gives us the value of each risk factor on the overall project. The amount obtained by summing each cell of the columns gives us the value of the risk embraced in each WP. Based on the performed assessment we choose the appropriate response techniques.

Table 2: Linking RBS to WBS

			WBS								
			Work Packages								
			WP_1	WP_2	WP_3	WP_4	…	…	WP_n		
			$I_{1,j}$	$I_{2,j}$	$I_{3,j}$	$I_{4,j}$	…	…	$I_{n,j}$		
RBS										**∑R**	**Order**
Risk Items	R_1	$P_{i,1}$									
	R_2	$P_{i,2}$									
	R_3	$P_{i,3}$									
	R_4	$P_{i,4}$									
	…	…									
	…	…									
	R_n	$P_{i,n}$									
∑R											
Order											

Application case

The example of WBS adopted for this application is the case of a governmental design-bid- build project developed in PMI (Project Management Institute, 2006). The WBS is structured according to the project phases. Both WBS and the developed RBS have three levels.

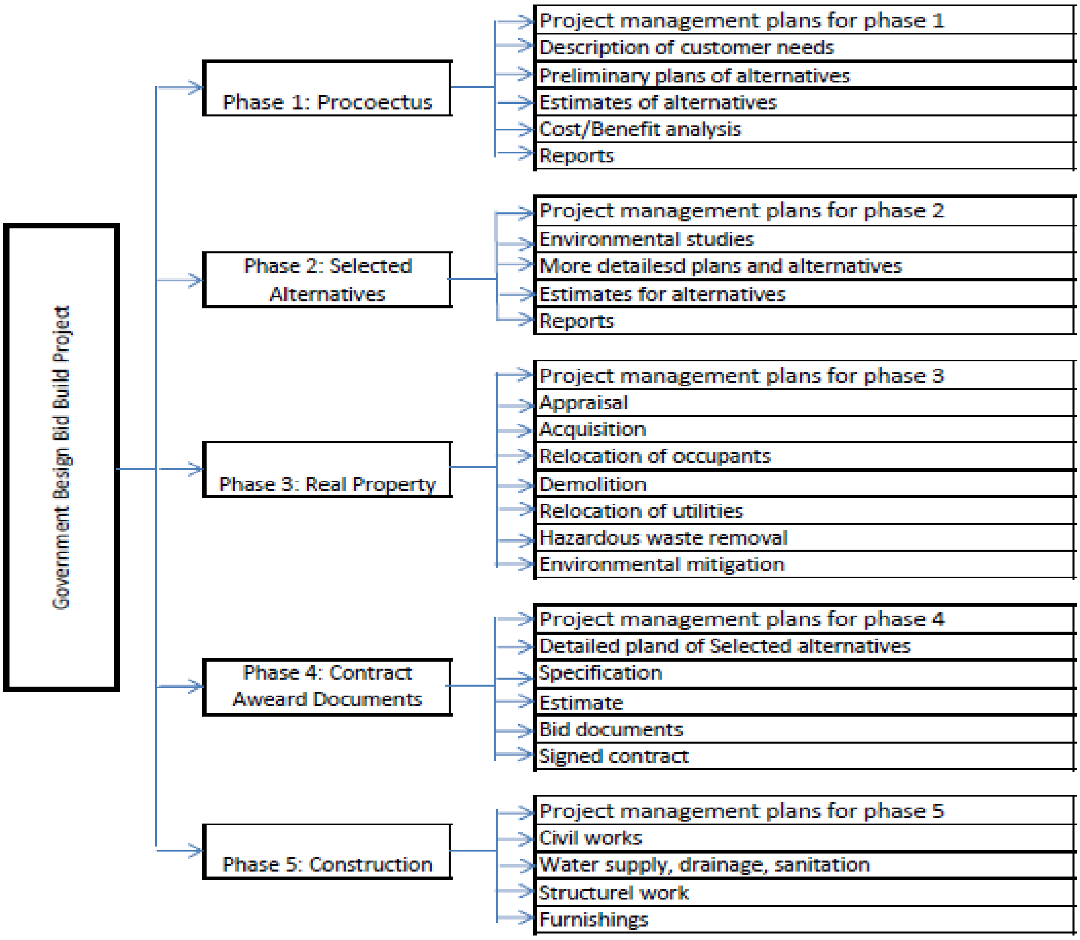

Fig. 3: WBS for a Government funded Design-Bid- Build Project

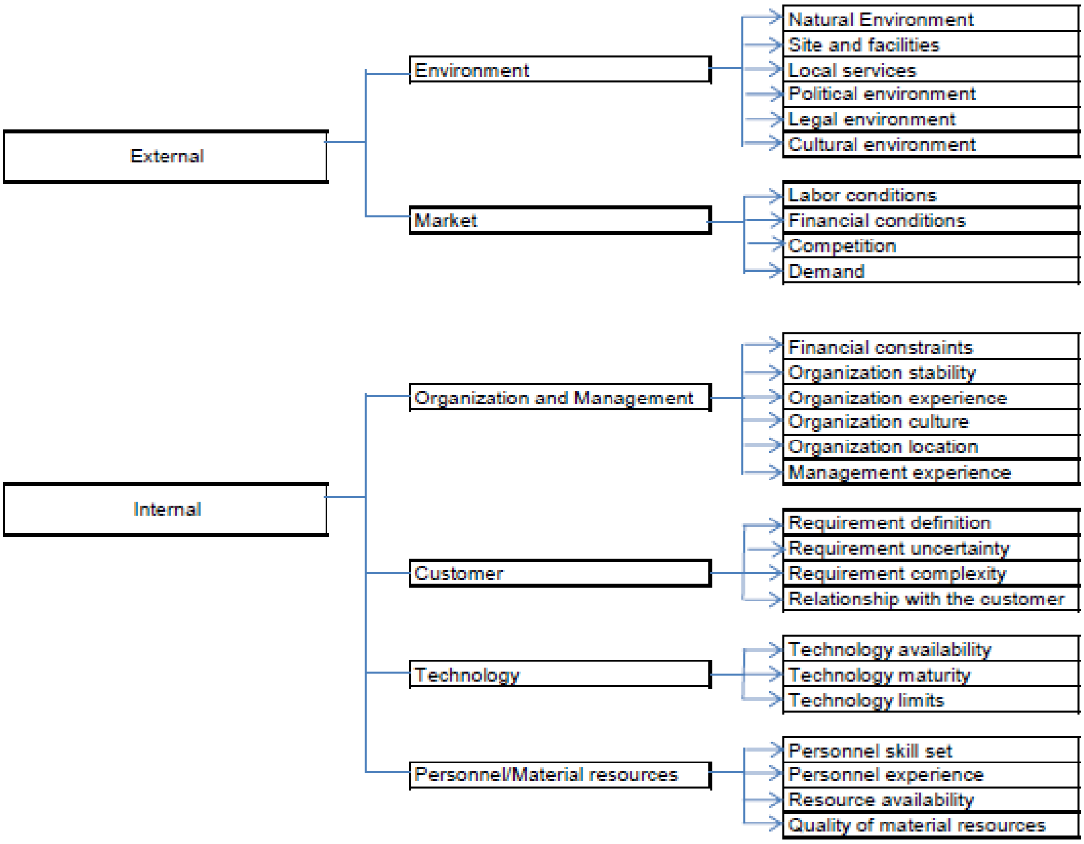

Fig. 4: RBS framework

The lowest levels of WPs and risk sources will be considered while applying the combination, forming a 2-D matrix 30x27. For simplicity reasons only one branch of WBS combination with RBS will be shown.

			WBS						
			Phase 5: Construction						
			Planning	Civil Works	Water supply, derange,	Structura l Works	Furnishin g		
			Impact	*I*	*I*	*I*	*I*		
RBS								**∑R**	**Order**
Organization and Management	Financial constraints	*Prob.*	P=2, I=3 R=6	P=4, I=4 R=16	P=2, I=2 R=4	P=4, I=5 R=20	P=4, I=3 R=12	58	**2**
	Organization Stability	*Prob.*				P=2, I=2 R=4		4	**5**
	Organization experience	*Prob.*	P=3, I=4 R=12	P=2, I=2 R=4		P=3, I=4 R=12		27	**3**
	Organization culture	*Prob.*		P=2, I=2 R=4		P=2, I=2 R=4		8	**4**
	Organization location	*Prob.*		P=1, I=2 R=2				2	**6**
	Management Experience	*Prob.*	P=5, I=5 R=25	P=3, I=5, R=15	P=3, I=4 R=12	P=2, I=3 R=6	P=2, I=3 R=6	64	**1**
∑R			43	41	16	46	18		
Order			**2**	**3**	**5**	**1**	**4**		

To assess the risk affecting each work items, 5 construction managers were asked to express their opinion on a scale 1 to 5, applying two-dimensional scaling, the probability of recognized risk factors in case of happening as well as their expected consequences on project.

Table 3: Likelihood and Consequences of risk factors

No	Likelihoo	Description	No	Likelihood	Description
1	Very Low	The occurrence is not anticipated	**1**	Insignificant	Minor/negligible impact
2	Low	Trivial likelihood however could occur	**2**	Minor	Trivial/small impact
3	Medium	Possibility less than 50 – 50	**3**	Moderate	Moderate/Reasonable
4	High	Possibility more than 50 – 50	**4**	Major	Critical Danger
5	Very High	Almost certain it would occur	**5**	Catastrophic	The effect is completely undesirable

These considerations allow us identify which activities have more associated risks, the most important risk factors affecting the whole project, as well as the most significant relationships. The Structural works is the most critical activity followed by planning and civil works. From the large variety of risks lack of management experience, financial constraints and lack of organization experience resulted to be the most critical ones. Special attention must be paid to the relationship between planning and management experience, which results to have the highest risk value.

Based on this assessment the response technique will be taken adequately. The dynamic tailored-based nature of the combination RBS-WBS will help in the monitoring and controlling phase by reducing or broadened, in depth or in breadth (Holzmann, V., & Spiegler, I., 2010), to meet various special requirements according to the level of information available.

CONCLUSION

The construction projects embrace two main areas of difficulties: the complexity of the projects itself and the risks that could affect them. In these conditions a successful and effective implementation of risk management tools and techniques becomes indispensable for reaching the project objectives. The developed combination RBS – WBS assist managers in both areas offering a synthetic view on risks affecting each activity, recognizing the most risky WP, providing perspectives on risks development and concentration, etc. The compatible methodology with the dynamic nature of construction project risks and the successfully overpass of the identified RBS deficiencies gives to this methodology clear benefits for a user- oriented implementation.

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