Developing "Risk Source" and "Risk Event" Breakdown Structures: A New Approach to Risk Identification in Complex Environments

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Abstract. Risk identification process, as the early process in risk management, is so essential and must be comprehensive. Routine approaches to the risk identification in construction industry have some drawbacks both in the tools and the concept, due to the inappropriate distinction and classification of the risk source, event and impact and misinterpretation of the "multiple source risk" concept. In this paper, based on a risk management experiment in an EPC urban project, a new approach to risk identification and development of breakdown structures proposed and implemented to improve the "multiple source risk" concept throughout the process in construction industry, and improve the potentials to perform better in risk monitoring and risk response processes.

Keywords: Risk Identification, Multiple Source Risk, Risk Source Breakdown Structure.

1. Introduction

Projects are complex systems and due to their dynamic nature, uncertainty and risks are considered as the inherent characteristics of them. Risk management is a particular form of decision making within project management and is about the project and making a better decision with regard to the management of it [2:pp2-3]. A variety of risk management processes has been studied and introduced in the literature which mainly included risk identification, risk analysis, risk response, and risk monitoring [1, 2, 3, and 4]. Most project risk management process descriptions emphasize a need to identify 'risks' early in the process [5:p105]. The risk identification process is so essential and must be comprehensive, as risks that have not been identified cannot be assessed, and their emergence at a later time may threaten the success of the project [3:p37]. In the risk identification process, it is important to determine risks, source of risks and possible impacts; in other words, determine what might happen that could affect the objectives of the project, and how or why those things might happen [1:p48, 2:p31, 3:p16, 5: p105].

Although some tools and techniques such as checklists and RBSs has been established to facilitate the risk identification process, but there is no clear and appropriate distinction between risks and sources of risks in these tools, and this could be misleading in the identification process and the successors. Furthermore, these tools are unable to help identifying multiple source risks and their related sources. This paper, based on literature review and an experiment in risk management of a construction project, seeks pitfalls of using tools and approaches in risk identification process, and introduces a new approach to risk identification and development of tools called "risk source breakdown structure" and "risk event breakdown structure" and concept of "multiple source risks" and their advantages in improving the process.

2. Literature Review

Conceptually, the relationship between the risk source and the risk event is expressed in terms of probability of its occurrence given the risk source; therefore, probability is a characteristic of the event and not the source. The risk source is the underlying condition or the definite fact that can generate a possible risk event at some time forward from the point of decision making [1:p47, 6:p347, 7:pp73-74, 12:p1166]. "Risk impact" can be defined as the adverse or advantageous effect of the risk event on project objectives [12:p1166]. Many documented researches indicate that the "risk event" itself and the conditions that might arise as result of the "risk response" could act as sources of other risks as "secondary sources" of risks; secondary sources might generate "secondary risk events" [2:p60, 3:p84, 5:p105]. Making such distinction

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between these concepts is so important and advantageous because: (1) Probability and impact of the risk event are determined based on the risk sources as the underlying conditions (facilitates risk analysis process) [1:p57]; (2) The items which should be monitored can be translated into the "source" and the "event" (facilitates risk monitoring process). (3) Management's ability to influence the risk event and risk impact may be limited [1:p47], therefore, risk response strategies could be classified into "response to the risk source" and/or "response to the risk event" for better decision making (facilitates risk response process) [6:p347].

Although, in the construction related literature, it has been indicated that the "primary risk events" may have various sources, but there is usually "or" relationship between the sources and one of the sources would be considered effective in the risk analysis [1:p48, 7:p73,12:p1171]. However, it has been widely accepted that the "secondary risk events" may have multiple effective "secondary sources". According to the non-construction related literature, dominant sources of risk & dangers of failing usually arise either from interaction or confliction between subsystems or from events such as disasters that take the system outside its usual operating envelope [9:pp61-62, 10:p66, 11:p44]. If "subsystems" of a construction project and its context could be defined as "underlying conditions" or "facts", it could be concluded that the "primary risk events" in a construction project usually have multiple "primary risk sources". So that risk identification has to be conducted with approach to this "multiple source risk" concept.

3. Checklist and RBSs Drawbacks in "Multiple Source Risk" Concept

In the literature, checklists and RBSs are introduced as useful templates and tools for risk identification [3:41, 15:p154, 5:p132]; but there are some drawbacks in using them for risk identification, especially in "multiple source risk" concept:

- (Problem 1) The major pitfall in the risk checklists and risk breakdown structures proposed by many researchers is the definition of the word "risk", which may be used to imply "risk source", "risk event" or "risk impact" [8]. Furthermore, in many checklists and RBSs, rather than primary risk sources or primary risk events, secondary risk events or secondary risk sources are discussed [14:p265]. In this case, root causes might be remained undercover. So that, it is not obvious which one of the source, event or impact should be identified.
- (Problem 2) Many approaches have been introduced in the literature for classifying risks such as: location of the source, location of the event, location of the impacts, etc. [14:p265]. Inappropriate classification of risk events and risk sources in these tools causes inability to identify "multiple source risks" correctly. Both risk sources and risk events can be classified into many categories, but categories of the risk event and the related risk source might be totally different. Risk event might have sources from various locations and also risk sources might cause to risk events in various locations. For example a human-related risk source might cause an event in design, construction or occupancy, and a risk event in construction might have risk sources in human resource, procurement and environmental categories.
- (Problem 3) Although Shah (2007) explains that the risk identification can either start with the source of the risk event or with the risk event itself [13:p89], but limited knowledge and vision of the participants due to state of uncertainty [1:p47] could put risk events and risk sources undercover, especially in the "multiple source risks" concept. Even if all risk events are mentioned in the checklist, it is not assured that participants can identify all or most of the primary risk sources.
- (Problem 4) Drawbacks in risk identification are not limited to the checklists and RBSs. When a project involves new features, checklists can provide constraints on creative thought and block the identification of risks that go beyond those in the list [3:p41, 5:p134]. In this case, risk identification tools and techniques are usually used together [3:p39] and if the drawbacks mentioned above resist in the checklists, they might also have negative impact on other techniques such as brainstorming.

4. Development of New Approaches: An Experiment

Authors participated in the risk identification process of a project which consisted of engineering, procurement and construction of an urban tunnel, parts of subway metro tunnel and a shopping centre [16]. In the experiment, the checklists were used alongside the brainstorming process. Based on the drawbacks

mentioned above, participant deduced that there are some defects in the routine checklists and RBSs and their related techniques. In order to continue the risk identification process and due to the extensive scope of the project, the team decided to modify the tool and techniques in order to resolve the problems, with approach to following activities and the methodology shown in Fig1:

- Develop separate checklists and breakdown structures for risk sources and risk events and concentrate on "primary risk sources" and "primary risk events" early in the process, make sure that the primary risk sources are underlying certain conditions (Problem 1).
- Classify the risk sources and risk events categories (locations) separately, noting that the risk sources may generate various risk events and risk events may have various risk sources (problem 2).
- Conduct identification process with concentration on both "risk sources" and "risk events". Switch back and forth between risk source and risk event in brainstorming technique (problem 3)
- Use the modified "risk source breakdown structure" and "risk event breakdown structure" to stimulate the brainstorming process. Concentrate on "multiple source risk" concept in the whole process (problem 4).

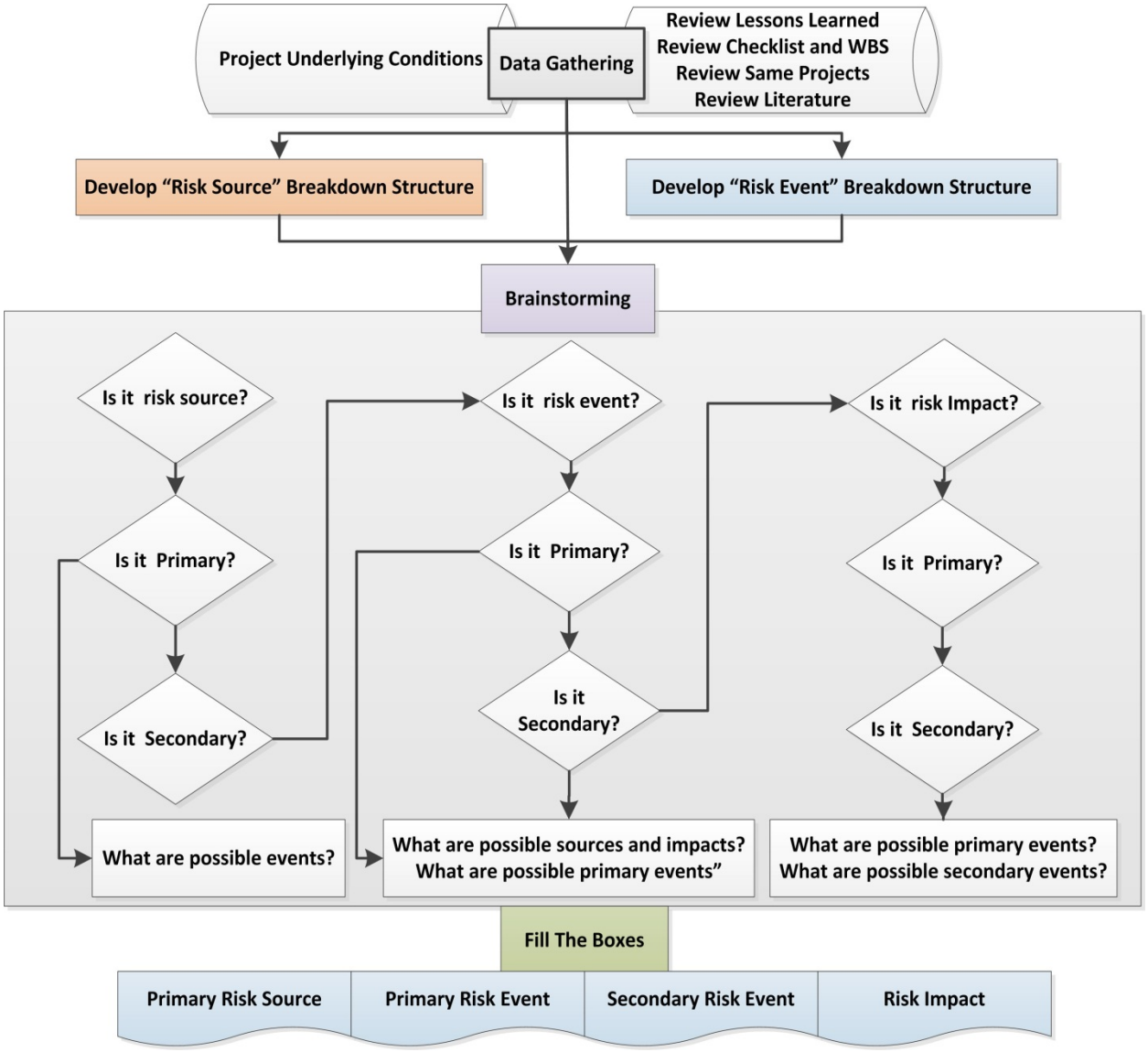

Fig. 1. Risk identification process in the experiment.

5. "Risk Source Breakdown Structure" & "Multiple source Risk Concept"

Level 1	Level 2	Level 3	Level 4
Internal Source	Managerial	Project Organization	Organizational structure & culture
			Experience in similar projects
			Reputation, Capability
			Size & capacity, other projects
		Human resource	Employment policy, wage scales
			Experience and skill of resources
			Behaviour, ethics and culture
			Working time and shifts
			Safety Conditions
		Planning	Scope planning and control
			Scheduling and control
			Cost planning and control
			Resource planning and control
		Procurement	Policy on equipment and machinery
			Cost estimation
			Procurement contracts
			Outsourcing or in-house policy
			Buy from new seller
			Type of Materials and Equipment
			Maintenance-reparation conditions
		Communication	Communication tools and techno.
			Information and report types
		Risk	Risk Planning
			Commitment to risk management
	Commercial & Contractual	Financial	Sources of finance (funding)
			Profit objectives
			Cash flow
			Contingency assets
			Debt levels
		Joint Venture	Joint reputation and experiences
			Joint conditions and background
		Contractual	Clauses on: Termination, delay damages, extension of time, responsibility of design, defect liability period, price escalation, ambiguities in definition, force majeure, guarantees, warranties, etc.
			Price -Cost reimbursement Clauses
			Project System Delivery
			Other agreements and arrangements
	Technical	Technology type	Technology maturity
			Technology constraints
		Complexity	Multidisciplinary approach, Scale, ...
			Familiarity with type work
	Design	Complexity	Multidisciplinary approach, Scale, ...
		Assumptions	Information – Tests-Surveys …
		Processes	Tasks, Calculations, Drawings ,…

Level 1	Level 2	Level 3	Level 4
External Source	Political	Political factor	Foreign Policy - Sanctions
		Elections	Stability in political institutions
	Legal	Regulatory bodies	Rules & regulations
		Permits	Right-of-Way, Licenses, …
			Import/export restrictions.
	Environmental	Climate conditions	weather patterns
		Underground conditions	Soil, Rocks, Water, Archaeological finds…
	Site Conditions	Underground conditions	Infrastructures, Utilities, Hazardous wastes
		On-site conditions	Sewage and drainage
			Topography
			Dimensions, physical area
			Congestion
			Noise, fume, dust
			Safety and health
		Traffic	Access - Egress Conditions
		Area	Neighbours physical conditions
			Security and safety conditions
			Police, fire and medical support
	Force majeure	Acts of God	Storm, Earthquake, Flood
		Hostilities	Vandalism, War, …
	Procurement	Sellers	Experience and culture
			Qualifications, Timeliness,…
		Human Resource	Availability of Experts
	Commercial	Financial	Inflation
			Exchange Rate
			Taxes and duties
		Market	Number of bidders
			Unemployment rate
			Workload of contractors
	Stakeholders	Client	Experience and culture
			Project management methods
			Priorities
			Financial stability
			Ability to meet obligations
		Others	Rivals
			Consultants, Contractors, …
			Pressure groups
			Interested groups
			Local communities, Unions
			Other Organizations

Fig. 2: Parts of "Risk Source Breakdown Structure" developed in the experiment.

Based on the approach introduced in the experiment, participants developed separate breakdown structures for risk sources and risk events. Parts of the "risk source breakdown structure" are shown in Fig. 2. This approach facilitates the identification of "multiple source risks", as the examples shown in Fig. 3, and make great potential to perform better in successor processes in risk management. These examples verify the concept mentioned earlier and indicate that many items such as "design errors" or "human errors" are usually incorrectly interpreted as "risk sources"; due to their probable nature, they are actually "risk events".

Risk Sources	Primary Risk Event	Secondary Risk Events	Risk Impacts
Working time and shifts **Experience and skill of resources** **Technology constraints** **Behaviour, ethics and culture** **Multidisciplinary approach, Scale, ...**	**Human Error in Construction**	**Rework** **Damage, Injury to employee & workers.** **Damage, Injury to third party.**	**Delay** **Poor Quality** **Liquidated damages.** **Cost Increase**
Underground conditions, Infrastructures, Utilities **Information – Tests- Surveys …** **Stakeholders – Others – Related Organizations**	**Clash with underground utilities**	**Damage to Underground Utilities** **Damage, Injury to employee & workers.** **Damage to Equipment and machinery**	**Scope Change** **Delay** **Cost Increase**
Organizational structure & culture **Experience in similar projects** **Experience and skill of resources** **Behaviour, ethics and culture** **Multidisciplinary approach, Scale, ...** **Information – Tests- Surveys …** **Tasks, Calculations, Drawings ,…**	**Design Errors**	**Rework** **Damage, Injury to employee & workers.** **Damage, Injury to third party.**	**Delay** **Poor Quality** **Liquidated damages.** **Cost Increase**

Fig. 3: Parts of "Risk Identification Sheet" with approach to "multiple source risk" concept developed in the experiment.

6. Conclusion

The risk identification process as the early process in risk management plan is so essential and must be comprehensive. Routine approaches to the risk identification in construction industry have some drawbacks both in the tools and the concept due to the inappropriate distinction and classification of the risk source, event and impact and misinterpretation of the "multiple source risk" concept. So, new approaches to using the risk identification tools and conducting the process should be developed to resolve the drawbacks.

Based on the experiment of risk identification process, authors proposed and implemented a new approach to making breakdown structures and improving the "multiple source risk" concept throughout the process (Fig. 1). In this case, separated "risk source breakdown structure" and "risk event breakdown structure" were introduced as formal tools and the locations and categories of the sources and the events classified separately in each of them (Fig. 2). These tools used to stimulate the brainstorming, switching back and forth between risk source and risk event in the technique. In this approach, outputs of the process should be classified into "primary risk sources", "primary risk event", "secondary risk events" and "risk impacts" to get the most out of it.

Advantages of this approach are: (1) Make distinction among the source, event and impact early in the process; (2) introduce "multiple source risk" concept in a systematic approach; (3) increase the chances of proper source and event identification throughout the back and forth brainstorming in complex environments; and (4) improved ability to perform better in "risk analysis", "risk monitoring and control" and "risk response" processes.

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