Risk Management of the Submarine Pipeline Project Based on Network Theory

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***Abstract* – In order to solve the transport problem of offshore oil and gas, the submarine pipeline projects will be carried out, thus managing the risks involved become a matter of concern in projects management. To identify the risk sources and risk propagation pathway is important to take effective risk management. This research classifies risk of the submarine pipeline project from participators' perspective. Based on network theory and risk conduction model, a framework of key risks propagation and analysis is proposed in this paper. We give some suggestion to deal with the key risks of the submarine pipeline projects. It is helpful to understand the mechanism of risk conduction to improve the process of risk management in the submarine pipeline projects.**

Keywords – submarine pipeline, risk assessment, risk propagation, network theory

I. INTRODUCTION

Risk management is vital for engineering project which is a process control by complicated contracts and complex relationships among stakeholders. Engineering project are inherently risky due to internal and external conditions. The risk specific to one of the participants in the large engineering project is possible to give rise to "butterfly effect" and affect the performance of the project, due to the interaction among participants. One of key risks from a participant may impact the situation as a whole. Thus this is a worthy issue to research various types of risk propagation among participants.

Academics pay close attention to risk management over the last decade. An engineering project can be regard as a complex system, for cooperation between individuals and organization brought together for the system [1]. However, understanding and managing risks in engineering projects, especially large engineering are challenging tasks [2].

A systematic process of risk management is typically include risk identification and classification, risk analysis, risk monitoring, and risk reporting that parallels four steps for quality management [3]. The overall process of the project risk analysis and management may be described in simple terms of two stages, risk analysis and risk management [4]. The risk analysis may be divided into two phases: identification together with the assessment of risk by qualitative methods and the evaluation of risk by quantitative methods. This paper aimed at identifying sources of risk and risk propagation pathway of submarine pipeline projects, as the starting point of risk management in engineering projects.

There are various approaches have been provided for risk identification. In [5-7], scholars make use of traditional methods include the brainstorming, check-lists, the Delphi method, and expert interview. With the purpose of identify the risk factors more comprehensively, researchers improved traditional methods and proposed new methods such as influence diagrams [8], the fault tree [9] and so on.

From different perspective, risks in large engineering project have been classified. Miller dissected the risk in a large engineering project into three categories, including market-related risks, completion risks, and institutional risks [1]. In [10], Olssama classified project risks into three categories, involving project finance, project time, and project design. Perry and Hayes proposal a set of risk factors extracted from several sources of participant, such as: contractors, consultants and clients [11]. Shen categorized them into six groups listed according with nature of project in [12]. Based on existing literature review and experts' experience, we identify the negative impacts of risks inherent in engineering projects.

Most risks and their control needed to be framed not as technical issues but as managerial problems. Thus, key risks and risk characteristics should be defined in in engineering projects. After that we focus on understanding risk propagation path at the beginning of owners. But, it is difficulty in exposing the mechanism of risk propagation and risk interdependence among participants. Therefore, we make use of the network theory to analyze the complex process. Following the introduction to this study, the section2 proposes key risks in engineering projects and the impacts of project performance. The network theory is recommended, and the propagation frame of key risks in engineering is established in Section3 and the conclusions was drawn in the last section.

II. UNDERSTANDING RISKS IN ENGINEERING PROJECT

A. *Risks in Engineering Projects*

The risks of engineering project have three main characteristics.

1) Risks are multidimensional.

The source and type of risk is multidimensional. Leung et al pointed out that not all project participants would have the same objectives in terms of cost, time, and quality. Conflicts is hard to avoid among participators [13]. While, Different types of risk participators are involved in a project.

2) Risks are interaction.

Risks of engineering projects is dependent. As a result of the correlation of the goals, risks have reference to each other [14]. For example, the variation by owners would cause the change of design plan and construction process.

3) Risks are dynamic.

Not all of the appeals of the project participators are claimed at the same time, but rather changes take place as the changes of project context. Along with project implementation, participators may propose new requirements deviated from the original needs. Meanwhile, the benefits of other participators maybe affected and their expectations could not be achieved. Moreover, risks of similar engineering projects would have different characteristics in different regions. It is difficult for a new comer to identify and assess risks and the relationships among them [15].

B. Two Risk Sources: Endogenous and Exogenous risks

Generally, Risks can be derived from two sources in engineering projects. One is exogenous risks, which consists of social, executive, and environmental impacts.

The other is endogenous risks, consists of the uncertainties existing in engineering projects themselves [16]. However, it is inadequacy to identify and assessment the endogenous and exogenous risk independently and overlooking their interdependence [17]. This paper selected the owner as only one exogenous risk source without depth study of others. We explore the propagation process of the endogenous key risks among participants and project goals in project life cycle.

C. Key Risks versus Participants in submarine pipeline Project

From different objectives, previous researches have been carried out to discuss the risks through their potential impact on cost, time, quality, safety, and environment. On the basis of a comprehensive review of the current literature, Zou generalized 85 risks in general engineering projects, which were categorized into 7 groups, with 8 risks related to owners, 8 to related designers, 39 to related contractors, 4 related to subcontractors/suppliers, 5 related to government bodies, 5 related to superintendents, and 16 related to external issues. According to key risks by Zou, 20 of submarine pipeline risks, from the perspective of owners, designers, contractors, and subcontractors/suppliers were identified in this paper for further assessment, shown in Table I.

TABLE I KEY RISKS IDENTFIED IN SUBMARINE PIPELINE PROJECT

Category	The 20 key risks identified(Acronyms)
Risks related to owners	Tight project schedule(TPS)
	Natural hazard(NH)
	Variations by the owner(VO)
Risks related to designers	Design variations (DV)
	Design mistakes in pipeline (DMP)
	Inadequate site information(ISI)
	Incomplete or inaccurate cost estimate(ICE)
Risks related to contractors	Contractors' poor management ability (CPMA)
	Pipelines corrosion (PC)
	Poor competency of laborer(PCL)
	Unavailability of sufficient professionals and managers(UPM)
	Pipeline defect(PD)
	Welding defect(WD)
	Inadequate safety measures or unsafe operations(ISM)
	Lack of readily available utilities on site (LAU)
	Unavailability of sufficient amount of skilled laborer(USL)
	Prosecution due to unlawful disposal of engineering waste(PUDW)
	Serious environment pollution due to engineering activities(SEP)
Risks related to subcontractors / suppliers	Third party damage (TPD)
	Affection of fishing(AF)

III. THE KEY RISKS PROPAGATION IN ENGINEERING PROJECTS

A. Network Theory

The network theory is a simple model to simulate clearly a chain reaction of events. With the illustration, we could reveal the rule of risk events and take action to weaken negative effects on the system. These measures include interdicting the risk propagation pathway, weakening the generation of negative structures and the amount of faulty information.

The network theory as a theoretical model can be used to simulate the process of risk conduction. When looking at the process of network conduction, we may find that a number of key risk will continue to fall randomly in different directions under external interference and vibration. In the network model, every key risks of project can be regarded as a node, and the adjacent nodes are linked by straight lines to constitute a complex network. For each node, the number of straight lines from the upper nodes is called a node value. The capacity of each node is called the node threshold. When a node value is over the node threshold, the risk conduction of the node happen, causing instability in the lower node. Then network model is shown in Fig. 1.

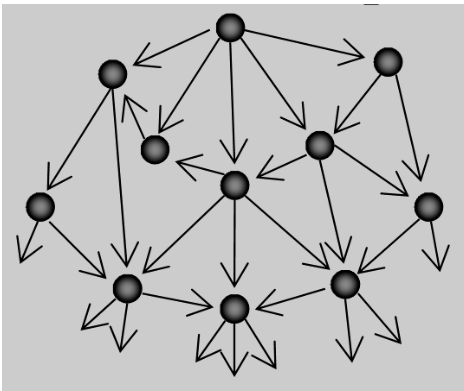

Fig. 1. The network model.

To some extent, engineering projects exhibit the characteristics of complex network systems. We utilize the network model to analyses the propagation mechanism of key risks in engineering projects. When one of the participants accepted some risks causing external risk events or top-down propagation, he will first absorb and deal with the risks. However, the accumulative risk exceeding the bearing capacity will lead to the risk receiver to transfer risks to the relevant participants.

B. Key Risk Propagation Pathway based on Network Model

The network model is a hierarchical propagation mode motivated by the top sources of risk, but it may give rise to the entire system, or to the domino effect. The relational graph between 20 key risks and the project life-cycle is shown in Fig. 2. Project owners as the topmost sources of risk are accepted some risks causing external risk events. Project owner will first absorb and deal with the risks. Then the owner has to shift risks to the related participants until increasing to exceed the tolerance range of owner. The network model of 20 key risks propagation in engineering project is presented in Fig. 3, which can effectively represent the risk propagation mechanism among participants.

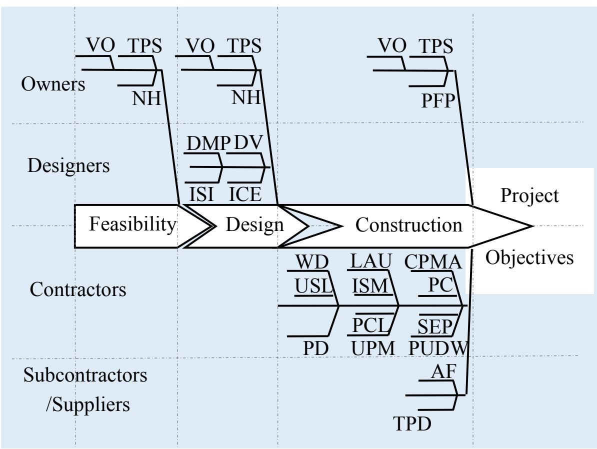

Fig. 2. Connections of risks, participators and project life cycle by Zou

By Fig. 3, we established key risk propagation model based on the network theory. The model is three-dimensional, crossing over the whole project's life cycle, including with feasibility phases, design phases, and construction phases, and indicating a set of project objects as follow as five parts: cost, time, quality, safety, and environment. Fig. 3 simulated the propagation of 20 key risks of submarine pipeline projects in three phases of a project life cycle. In Fig. 3, the direction that may passed indicated by the solid line, the virtual transfer among risks is indicated by the dashed line which may be endogenous in the phase.

During feasibility phase, owners first influenced by external risk events which caused by politics, economics or law. The owner would not transfer risks, such as "variations by the owners" (VO), "Natural hazard" (NH), and "tight project schedule" (TPS), to designers, until the risks exceed the tolerance range of owners.

In the design phase, " Design variations" (DV) may result from issues such as ''variations by the owners'' (VO). "Design mistakes in pipeline" (DMP) often appears in projects with a tight project schedule (TPS) where some processes need to be adjusted to meet the timeline. Meanwhile, other risks (e.g. VO, DMP and TPS) also may be propagated or repeated emergence in the design phase.

As the leading participant in the construction phase, "contractors' poor management ability" (CPMA), "lack of readily available utilities on site" (LAU), and "poor competency of laborer" (PCL) are regarded as the inevitably inherent risks of contractors. However "pipelines corrosion" (PC) may involve Natural hazard" (NH). The conflict between high demand and low supply led to "unavailability of sufficient professionals (UPM) and managers and skilled laborer (USL)". But we infer that "tight project schedule" (TPS) may have some negative effect on them. For example, there is not enough time to pick or train professionals, managers and skilled laborer. Due to "tight project schedule" (TPS), safety regulations (ISM) may be ignored by contractors without training all employees concerning safety awareness. "Pipeline defect (PD)" and "Welding defect" (WD) would happen, on account of the poor supervision scheme and incomplete insurance scheme in China. In addition, the growth of cost will cause profit decline, so contractors will face risk danger. The two issues related to engineering waste (PUDW) and environment pollution (SEP) are mainly brought by engineering activities. Moreover, contractor may overlook the above issues, due to "tight project schedule" (TPS) and "natural hazard" (NH).

Before construction phase, contractors and owners should investigate the credit standing and capability of subcontractors and suppliers in order to make sure that they can fulfill the contract on schedule. Whether you can select competent subcontractors and suppliers mainly depends on management ability of contractors.

C. Strategies to Control the Risk Propagation

In order to reduce the negative effect on project performance, strategies should be carried out from the perspectives of participants and project life cycle. We make

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three suggestions for controlling risks propagation of submarine pipeline.

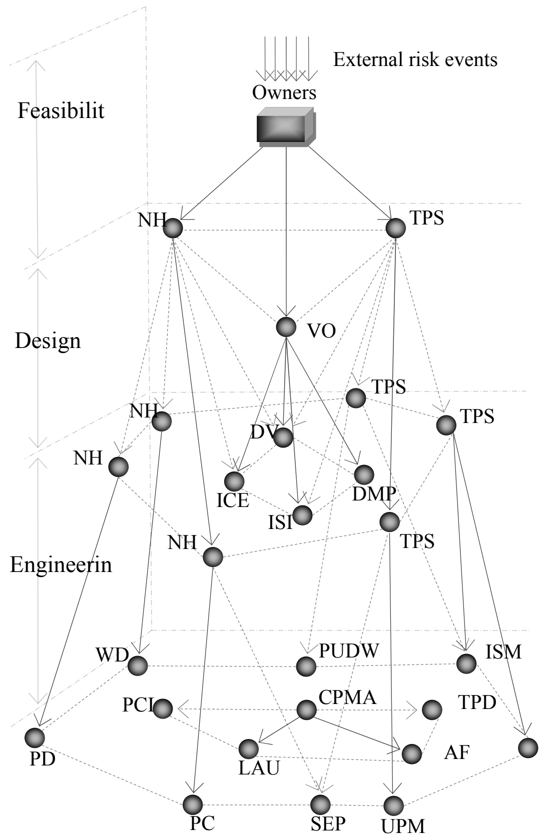

Fig. 3. Network model of key risks propagation on submarine pipeline project

1) Strengthening risk tolerance of participants. It is the most important to strengthening risk tolerance for owners as the first receiver of external risk. Owners should formulate a sufficient schedule without redundant time, so "tight project schedule" (TPS) as one of owners' risks may be avoided from transmitting risks to designers and contractors.

2) Reducing propagation speed of key risks. Still in the case of owners, appropriate fund plan and financial security instruments, for example, a fixed rate loan contract and secure standby cash, should be used to reduce propagation speed of risks associated with the funds.

3) Interdict the propagation pathway of key risks. If owners can take charge of purchasing building material in advance, the risk will be avoidable which caused by "suppliers' incompetency to deliver materials on time" (SIDM).

IV. CONCLUSION

This paper has presented a network model to analyses propagation process of key risks in submarine pipeline projects. The network theory is used to put forward a framework of risk propagation and simulated key risks propagation among different participants in three phases in project life cycle. Most of all, the direction of risk propagation has been summarized up as two types: 1) vertical propagations (e.g. VO to DMP) and 2) horizontal propagations (e.g. CPMA to LAU). In addition, this paper has make three suggestions in order to control risks propagation.

Based on the network model, participants can identify and understanding the risks associated with themselves and propagation pathway. The model also can help assess the risk sources and protect risks before they happen. In the end, the risk propagation caused by owners will have a widespread and profound impact according to the network model. Owners should be responsible to lead other participants to control risk propagation by working cooperatively during the whole project life-cycle in managing potential risks effectively.

This research has reached a practical results, but further researches will help to strengthen risk management capabilities. For example, how to measure the risk tolerance and risk propagation speed?

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REFERENCES

[1] "Tavistock Institute, Independence and Uncertainty – A Study of the Building Industry". Tavistock Publications, London, 1996.

[2] R. J. Chapman, "The controlling influences on effective risk identification and assessment for construction design management," International Journal of Project Management, vol. 19, no. 3, pp. 147-160, 2001.

[3] T. W. Kwan, and H. Leung Gentili, "A risk management methodology for project risk dependencies" Software Engineering, vol. 37, no. 5, pp. 635-648, 2011.

[4] S. Chihuri, and L. Pretorius., "Managing risk for success in a South African engineering and engineering project environments," South African Journal of Industrial Engineering, vol. 21, no. 2, pp. 63-77, 2010.

[5] Y. Ke, S. Wang, A. P. C. Chan, and E. Cheung, "Understanding the risks in China's PPP projects: Ranking of their probability and consequence," Engineering, Engineering and Architectural Management, vol. 18, no. 5, pp. 481-496, 2011.

[6] T. Al-Rouson, S. Sulaimin and R. A. Salam, "Supporting architectural design decision through risk identification architecture pattern (RIAP) model," WSEAS Transactions on Information Science and Applications, vol. 6, no. 4, pp. 611-620, 2009.

[7] Y. Sun, D. Fang, S. Wang, M. Dai, and X. Lv, "Safety risk identification and assessment for Beijing Olympic venues engineering ," Journal of Management in Engineering, vol. 24, no. 1, pp. 40-47, 2008.

[8] Ossama, "Managing construction risks," Journal of Architectural Engineering, vol. 2, pp. 3-10, 1996.

[9] L. Y. Shen, and G. Wu, "Risk assessment for construction joint ventures in China," Journal of Construction Engineering Management, vol. 127, no. 1, pp. 76-81, 2001.

[10] Zhu H, Lin P, Pan Q. "A CFD (computational fluid dynamic) simulation for oil leakage from damaged submarine pipeline". Energy, vol. 64, No.1, pp.887–899, 2014.

[11] P. X. W. Zou, G. Zhang, and J. Wang, “Identifying key risks in engineering projects: life cycle and stakeholder perspectives,” in Proc. 12th Conf. Pacificrim Real Estate Society, Auckland, New Zealand, pp. 22–25, 2006.

[12] Sun Y, Wang Z. “Aged Submarine Pipeline Failure Analysis Based on Accident Tree and Fuzzy Algorithm”. 2013 Fourth International Conference on Digital Manufacturing & Automation (ICDMA). IEEE Computer Society, pp.118-121, 2013.

[13] Yi-Jia L I, Jian-Xing Y U. “Quality Risk Analysis of Submarine Pipeline in Construction Period Base on FEMA and Fuzzy Theory”. China Safety Science Journal, vol.22, No.1, pp.112-117, 2012.

[14] P. X. W. Zou, G. Zhang, and J. Wang, “Understanding the key risks in engineering projects in China,” International Journal of Project Management, vol. 25, no. 6, pp. 601-614, 2007.

[15] Fang C, Marle F, Zio E, et al. “Network theory-based analysis of risk interactions in large engineering projects”. Reliability Engineering & System Safety, vol. 106, No.2, pp.1–10, 2012.

[16] Zhou Z, Irizarry J, Li Q. “Using network theory to explore the complexity of subway construction accident network (SCAN) for promoting safety management”. Safety Science, vol.64, No.2, pp.127–136, 2014.

[17] Ding H Y, Cong-Huan L E, Zhang P Y. “Risk assessment of the submarine pipeline subjected to the dropped loads”. Ocean Engineering, vol.28, No.1, pp.25-30, 2010.