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## Study on Unconventional Emergency Scenario Design: Taking Life-Rescuing of Dongfang Turbine Co., Ltd. in Wenchuan Earthquake for Example

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### Abstract

Unconventional emergencies have attracted widespread concern in academic field due to its high uncertainty, huge destructiveness and complex management, and studies on unconventional emergencies shall change from “prediction-response” to “scenario-response”. By taking the life-rescuing of Dongfang Turbine Co., Ltd. in Wenchuan Earthquake for example, this paper divides scenarios in accordance with the specific investigations, and proposes several considerations about the unconventional emergency scenario study.

**Key words:** Unconventional emergency; Scenario; DTC; Survey design

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### INTRODUCTION

The frequent outbreaks of unconventional emergencies have brought great harm to the society, which becomes a serious challenge to governments at all levels. Taking

the natural disaster of earthquake in China for example, from Wenchuan Earthquake in 2008 to Yushu Earthquake in 2010, Yiliang Earthquake in 2012 and Sichuan Lushan Earthquake that just happened, each has brought tremendous casualties, and huge economic and social losses.

Unconventional emergency refers to an unpredictable and highly complex emergency with insufficient precursor and the potential of frequent secondary derivative disasters, which will cause serious damage once it happens. The associated emergency management is relatively difficult because of the essential characteristics of unconventional emergency. The multidisciplinary intersection of management science, information science, life science and social science, etc. arouses a large number of research problems, and attracts widespread concern in industrial and academic fields (Fan, 2007). In recent years, the Natural Science Foundation of China (NSFC) has made great efforts in supporting the projects in emergency management field, and many experts and scholars have began to engage in the researches on the management of unconventional emergency.

Emergency management refers to the overall activities and institutional arrangements of early warning, control and handling of sudden events (Ji, Chi, et al, 2006). The traditional emergency management often adopts the mode of “prediction-response”, which focuses on the prevention and prediction from the perspective of risk factors (Wang, 2011). However, because people have not yet fully understood the occurrence and development rules of unconventional emergency, it is difficult for the mode of “prediction-response” to effectively solve the problem that the unconventional emergency per se is unpredictable, so the new paradigm on unconventional emergency study has been constantly explored in academic field in the past two years.

Emergency, especially unconventional emergency, has the complex mechanism of occurrence and evolution

without precursor, which is of “scenario-dependence”. “Scenario-response” is considered as a new paradigm for the management of unconventional emergency. A series of projects supported by NSFC in this field are to finally build theoretical system of emergency management for “scenario-response” type unconventional emergency.

For the contents of scenario, the components of scenario and the specific applications of scenario study in unconventional emergency, academic researches are just at the initial stage. The unconventional emergency has a stronger practical background, so the scenario study shall be based on practice; however, the main obstacle of existing research is the lack of necessary materials to support the scenario study. This paper relies on the key project of NSFC, based on the thinking of emergency management with “indomitable spirit”, by taking Dongfang Turbine Co., Ltd. (hereinafter referred to as DTC) as an object to review the emergency rescue of the Company in Wenchuan Earthquake, studies the scenario elements, scenario construction and other problems about unconventional emergency, to obtain the general problems in scenario study of unconventional emergency, for purpose of providing basic supports for the future study.

## 1. SCENARIO DESIGN

“Scenario” is the description of future situation and a series of facts that make the situation develop from the initial state to the future state (Herman Kahn & Wiener, 1967). Gershuny (1976) thought that the scenario is a general description of future condition and event, and a series of views to justify themselves on the future possible results (Gershuny, 1976). Early scenario study was mainly applied to strategic prediction. Chinese scholars first introduced the concept of scenario into the field of emergency management. For emergencies, Jiang Hui and Huang Jun (2009) thought that the scenario is the occurrence and development situation of sudden event which the decision-making body is facing (Jiang & Huang, 2009). Liu Tiemin (2012) thought that the scenario is the understanding and convergence about the occurrence and development rules of the previous events (Liu, 2012). Combined with the existing views, this paper argues that the scenario is the overall mirror of state and trend shown in the occurrence and development process of the sudden event, which contains the subjective and objective, and static and dynamic meanings.

The occurrence and development of unconventional emergency is composed by a series of scenarios. Xiao Lei (2009) has preliminarily studied the scenario learning methods under the unconventional emergency conditions, believing that the scenario learning should include scenario building, scenario matching, scenario response, and so on (Xiao, Li, & Li, 2009, pp.407-410). Zhang Hui (2012) thought that the scenario-awareness

could be realized by the Internet of Things, the Internet technology and 3S technology (Zhang, Research on Basic Scientific Issues....). Wang Yanxin (2011) reconstructed the scenario with the factor layer, the state layer and the event layer using the fuzzy rules (Wang, 2011). Wang Xuping et al. (2013) constructed a methodological system for the construction and inference of the unconventional emergency scenario (Wang, Yang, Fan, & Ruan, 2013).

The operation of above ideas and methods is based on the precise definition of scenario, especially the key elements in scenario. Currently, there is no consensus on the elements of scenario in academic field, which also limits further study on the scenario-response type emergency. The existing knowledge to the elements of scenario are as follows: Wang Yanxin(2012) thought that the scenario elements include disaster-inducing factor, disaster bearing body and hazard-inducing environment (Wang, 2012); Jiang Hui (2012) divided the scenario elements into disaster body, disaster-stricken body and anti-disaster body (Jiang, 2012). Therefore, based on the actual investigations on Wenchuan Earthquake, this paper shall excavate the key elements of scenario to form scenario slices, achieving the “contextualization of event, sectionalization of scenario, datamation of section, structuralization of data” in scientific research. On such basis, the study is exploratory in this paper.

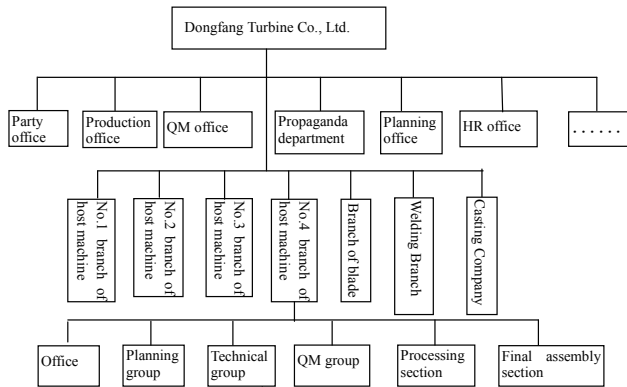
## 2. DTC WENCHUAN EARTHQUAKE LIFE-RESCUING RESEARCH DESIGN

Dongfang Turbine Co., Ltd. (formerly Dongfang Steam Turbine Factory) is affiliated to Dongfang Electric Group under the State-owned Assets Supervision and Administration Commission (SASAC). The Company was founded in 1966, is a third-tier enterprise in Hanwang town in the fracture zone of Longmen Shan, and is an important power generation equipment manufacturing base of China. As the core product of thermal power equipment, the steam turbine often adopts the production mode of single-piece customization, of which the manufacturing process is complex and the processing cycle may last for several months, and the production is generally completed by different production departments (branches) of the Company. Therefore, DTC is a manufacturing enterprise with obvious hierarchy and clear structure (Figure 1).

Wenchuan Earthquake in 2008 has brought unprecedented strike to DTC located in the fracture zone of Longmen Shan. In DTC, more than 500 workers and their families were killed and 134 people were wounded, and the direct economic loss of the Company was up to 5 billion Yuan or so.

The life-rescuing and reconstruction work of DTC attracted remarkable attention. In this paper, the scenario study takes the life-rescuing of DTC in Wenchuan

Earthquake as the object, with a lot of interviews and questionnaires, to depict the critical scenarios in life-rescuing and conclude the general laws of unconventional emergency scenario study from the organizational angle.



**Figure 1**  
**Diagram of Organizational Structure of Dtc**

This paper shall restore the scenario of life-rescuing in DTC, which is achieved by the afterward investigations and interviews. The scenario includes both objective and subjective elements, in addition to what are revealed by the relevant physic information, the description of people is also an important source of objective elements; the subjective elements are mainly behavior, thoughts and judgments of human beings. To restore the emergency rescue course of DTC, attention shall be attached to the key scenario slices, each slice being composed by many representative observation points (specific characters), the descriptions of these points supplemented by objective elements just form the depiction of scenario slices, and the continuous scenario slices just construct the occurrence process of sudden event (Figure 2). Based on the hierarchical organizational structure of DTC, we plan to select 800 sample points at the high, middle and primary levels, with each observation point throughout the whole emergency rescue procedure. The relationship combination between observation points constitutes the scenario of life-rescuing in DTC, and the connection between scenarios shows the development process of whole emergency from disorder to order (Figure 2).

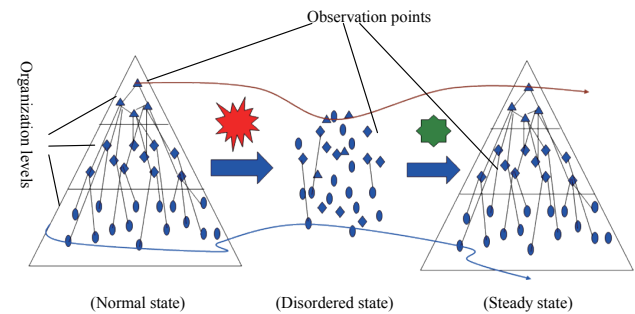
At the beginning of this study, we learned the

**Table 1**  
**Examples of Encoding of Geographic Information of DTC**

Category code	Category name	Subcategory code	Subcategory name	Class code	Class name	Subclass code	Subclass name
1	Plant	27	No.1 branch of host machine	02	First line production area	01	Large piece section

<sup>1</sup>According to the organization in Wenchuan Earthquake, the original Dongfang Turbine factory was divided into Dongfang Turbine Co., Ltd. and Dongqi Investment & Development Co., Ltd.

earthquake relief related information of DTC, such as internal records, external reports, physical evidence etc., including the large-scale documentaries directed by DTC: “Rebirth from Fire” and “Rise to Glory”, and thereby, we had a preliminary understanding about the earthquake relief of DTC.



**Figure 2**  
**Scenario Slices and Evolution Diagram**

### 3.1 Formation of Basic Database

In order to more effectively depict the scenario, under the close cooperation with the Company, this paper establishes several basic databases. The first database is a geographic information system database, in which, according to the layout of DTC at that time, the plant, family area, main roads and other geographic information are encoded, such data is accurate to each floor of every building (Table 1). For example, code 1270201 refers to the large piece section of first line production area of No.1 branch of host machine in the production plants of DTC. The second one is the organization and personnel database, in which, according to the duties in the earthquake, the encoding of relevant personnel is detailed to functions and shifts (Table 2). For example, code 1030602 refers to \*\*\*, a person in Personnel Group of Human Resources Office of Dongfang Turbine Co., Ltd<sup>1</sup>. The third database is the stricken situations of main subordinate units of DTC, including personnel, materials, equipment and so on (Table 3). The three databases mutually corroborate, to provide basic information for the research and basic guarantee for subsequent data analysis, as well as essential approach to depict the scenario.

**Table 2**  
**Examples of Encoding of Organization and Personnel of DTC**

Company code	Company name	Department code	Department name	Subdivision code	Subdivision name	Number	Personnel
1	Dongfang Turbine Co., Ltd	03	Human Resources Office	06	Personnel Group	02	***

**Table 3**  
**Information of Victims of DTC**

Personnel name	Personnel code	Place of death	Time of death	Cause of death
***	1 07 04 03	1 27 02 01	05.12.(21:00)	Bleeding to death

### 3.2 Interview Design

The management and response to unconventional emergency is a complex, and systematic task, and it is hard on one's own to know the basic law of occurrence and development, resulting in difficulties in clarifying related issues in academic research. In order to better settle the problem, the project team conducted interview design at first, namely, 12 employees are selected from two seriously stricken subordinate units of DTC (Branch of blade and Casting Company) and the relevant functional departments (Party Office), let them describe their escape and participation in the rescue when the earthquake happened, and everyone takes an interview for about one hour and a half. After the interviews were recorded and systemized, interview records of about 150,000 words are achieved.

### 3.3 Questionnaire Investigation

The questionnaire design is divided into six stages and lasts for six months.

First stage: Open questionnaire.

At this stage, the questionnaire was mainly open, because the existing limited understanding to the emergency was hard to support the structurally closed questionnaire. We combed the key issues in the

interviews, and outlined the questionnaire. We intended to reproduce the scenario of that time through the description of respondents. The questions at this stage include “What did you see after the escape?”, “What did you do in the first time after you ensured that you were safe? ”, “What did you do under the organized arrangement ?” and so on.

Second stage: Questionnaire filling and improvement. At this stage, based on the open questionnaire and the feedback from investigators, we conducted the structural design on the questionnaire, tried to transform the open questions to closed questions. For example, as for what did you see during escape? The options include “dusty, collapsing houses, people are being buried, crowded moving people, landslides” and so on.

Third stage: Matching between questionnaires and interviews. The early interviews were to make the respondents describe their behavior during emergency rescue without interference. At this stage, we matched the contents of questionnaire with interview records, to check the accuracy of questionnaire to reflect the actual situations. In addition, with such a matching process, we extended the time range and dimension covered by the questions of the questionnaire.

Through the work of the above stages, according to the process description of the respondents, we divided the life-rescuing scenario of DTC into the following five parts (Table 4):

**Table 4**  
**Division of Life-Rescuing Scenario of DTC**

Scenario	Status	Description
Scenario 1	Normal state before earthquake	General situation of DTC at ordinary times
Scenario 2	Individual escape stage	From individual escape to the confirmation of safety of one's own
Scenario 3	Unit self-help stage	Organized self-help of the branch (functional department)
Scenario 4	Company rescue stage	Self-help at the level of DTC Company
Scenario 5	External large-scale rescue	Large-scale self-help after the arrival of Premier Wen Jiabao

It's important to note that there are no strict time boundaries between scenarios under the investigation; meanwhile there are intersections between scenarios. Although the life-rescuing of DTC include such scenarios, the above scenarios are not throughout the behavior of each person.

Fourth stage: Pre-survey of questionnaire. After the questionnaire was almost determined, we organized a pre-survey of 60 persons in the Company, with such pre-survey we found out the problems of the questionnaire per se. This questionnaire is not a measurement-based questionnaire, but a descriptive questionnaire, so our pre-

survey is not to test reliability and validity, but to find if there is any omission or redundancy in the questionnaire.

Fifth stage: Finalizing the questionnaire. After the repeated discussions with the principal leaders of DTC, the witnesses of earthquake and the early respondents and within the project team, we determined the ultimate contents and format of the questionnaire, with two

versions of questionnaire for mid-high level and basic level. The questionnaire was developed with five scenarios as the clue, including 36 questions in all, requiring about 40 minutes to complete.

The scenario was the core in the questionnaire design, after repeated discussion and analysis; we summarized the elements of scenario as in Table 5.

**Table 5**  
**Key Elements of Scenario**

Dimension	Element	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
Objective elements	Location	The specific location of respondents is corresponding to the geographic information database				
	Physical elements	Disaster, weather, equipment, physical environment, etc.				
	Information	The channels of information sources, the information dissemination methods, the effectiveness of information communication				
Subjective elements	Behavior	Behavior process of investigators, each scenario varied depending on different tasks.				
	Motivation	The specific motivation of action, which is divided into spontaneous instinct, herd behavior, organizational arrangement and responsibilities				
	Feeling and judgment	The specific knowledge on the objective circumstances, the specific judgment on the changes of whole emergency				

Sixth stage: Large-scale questionnaire survey (not yet). In order to accurately reproduce the scenario, the project needs nearly 800 questionnaires. This is a heavy work, especially for the investigation and interview to the respondents witnessing the earthquake, the samples should be representative, and at the same time, the psychological stress of respondents should be taken into consideration, too. Therefore, the implementation is more difficult. We preliminarily consider that the questionnaire should be organized at the level of the Company, and we shall complete the questionnaire survey by levels and stages, to minimize the emotional impact on the Company's employees. We shall carry out a detailed screening of the respondents to form a preliminary list of respondents.

### 3. REVELATION AND FURTHER RESEARCH

The design process of above questionnaire is also an exploration process of this paper focusing on scenario and combining with the emergency practice of DTC. The whole foundational work lasts relatively longer, but it may serve as reference for the follow-up implementation of the project and the research on unconventional emergency management.

At present, the large-scale investigations are still in preparation, but the early repeated interviews and questionnaire design can help us better understanding the scenarios and related issues in unconventional emergency.

1. Understanding and division of scenarios. It

can be seen that the occurrence and development of unconventional emergency are composed by a series of scenarios. The understanding and division of scenarios are the basis for the research of "scenario-response" type unconventional emergency. This paper argues that the scenarios can be analyzed from the subjective and objective perspectives, including the physical elements, the human elements and the relationships between people and things, from the subjective perspective, the scenarios include disaster bearing body, anti-disaster body and hazard-inducing environment. More specifically, the scenarios can be described in terms of time, place, information, physical environment, behavior, motivation and judgment. Such composition of elements is applicable to general unconventional emergencies. The division of scenario depends on the specific performance of the elements. The difference between the performances of elements under different scenarios constitutes the basis for the division of scenarios. The division of five scenarios in DTC is achieved in accordance with the performances of its elements.

2. Response of enterprise to unconventional emergency. Enterprise is a system with relative closeness and certain openness. The response of the hierarchical organization of enterprise to unconventional emergency is a gradual process. DTC, the manufacturing enterprise, has rigorous bureaucratic organization and powerful executive force and focuses on efficiency, therefore, all subordinate units had organized the rescue in the first time after the earthquake, and then the unified scheduling is implemented at corporate level. Moreover, the corporate

culture and social networks of DTC had played an important role throughout the emergency rescue. The basic scientific questions therein need data analysis after large-scale questionnaire.

3. Evolution of scenario. In this paper, the emergency rescue of DTC is divided into five scenarios. The evolution of scenario and the development of unconventional emergency are logically internally consistent. The evolution of scenario is the result of a combination of many elements, while the key events and key elements contribute to the evolution of scenario. The evolution of unconventional emergency is the result of a variety of aspects such as the development logic of event, the recovery process of adaptive organization, and the emergency response of human beings. Therefore, the task of scenario study is to evacuate the critical information and key elements. And the subsequent investigation and analysis of life-rescuing of DTC also brings valuable inspiration for the research on the evolution of scenario.

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