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Expressway Emergency Management System Based on the Model of Hall Three Dimension Structure

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Abstract: Expressway emergency management is one of the most important tasks in the expressway operation management. With the development of national economics and the construction of highway networks in China, expressway emergencies have become more frequent than ever before. For the expressway operator, it is very urgent to establish an effective, centralized and cooperative expressway emergency management system so as to guarantee the safety and smoothness of the expressway. We introduced establishing objective and method of an expressway emergency management system. Based on the model of Hall Three Dimension Structure, we proposed the three dimension structure model of expressway emergency management system and established the expressway emergency management system which contains emergency warning system, emergency preparedness system, emergency rescue system and emergency recovery system.

Key words: Expressway, emergency, emergency management system, hall three dimension structure

INTRODUCTION

As one of the critical infrastructure, expressway plays a very important role in the national economic and social development. The clearness of the expressway is one of the most important tasks for the expressway operator (Xiong, 2009). With the rapid growth of the expressway operating mileage and expressway emergencies, the traffic safety is being seriously threatened. Thus, it formed a severe test on the level of emergency management of our expressway operators but also made more urgent requirements. For serious emergencies that may occur, the establishment of a scientific, systematic, comprehensive Expressway Emergency Management System (EEMS) for expressway operator has great significance. However, EEMS is still in the early stage and has not yet formed a system of methods and standards in our country. As a multi-level, multi-section, multi-functional and dynamically changing system, emergency management system has the characteristics of comprehensiveness, timeliness and effectiveness. How to deal with the damage of expressway emergency and to establish a scientific, comprehensive and effective emergency management system have become a new subject in current expressway operation and management work. Therefore, building an EEMS is imminent.

There are few research achievements about EEMS at present. Li (2012) thought that it is very necessary to establish and perfect legal security system of expressway emergency management, improve emergency management organization system and strengthen emergency management security system from the view of the administration. Liu *et al.* (2007) analyzed the demand of the EEMS and designed the general framework of the expressway warning emergency command system based on GIS platform, which includes two modules: warning management subsystem and emergency handling subsystem, respectively discussed their organization and event processing. Zhong *et al.* (2006) referenced to framework of China's ITS system and established the framework of emergency management system. This framework can be divided into four subsystems: information collection system, information transmission system, information processing system and information providing system. Xu *et al.* (2012) established the expressway emergency rescue system which base on four dimensions: emergency monitoring capacity, emergency response capacity, emergency decision and rescue capability and daily management. With the limitations of the current research in mind, the purpose of this paper is to construct a comprehensive and systematic EEMS model based on

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the model of hall three dimension structure, which has an important theoretical and practical significance.

MODEL OF EEMS

Definition of EEMS: As a multi-level, multi-functional and dynamical changing system, EEMS should have the characteristics of comprehensiveness, timeliness and effectiveness (Peng, 2012).

Combined with the relevant theoretical research at home and abroad as well as the content of expressway emergency management, we define EEMS as follows: 1) EEMS covers the whole process of emergency management. 2) It is a dynamical system that made up of the organizational setup, emergency needs of the personnel, materials reserve and transport, communications facilities which utilize various techniques and methods to prevent and treat expressway incident effectively, at the same time reduce the loss, restore the normal operation of expressway.

The purpose of constructing EEMS model: The construction of EEMS is a huge project. The reasonable construction of manpower, material and financial resources will affect the operation of emergency management. Therefore we should grasp the function of the EEMS from general structure and planning level, to work out a completed, standardized basic architecture from a different perspective. Construction on the basis of such a unified framework can guarantee the system meets the requirements of the emergency management. The purpose of constructing EEMS is mainly reflected in the following aspects:

- The construction of the general framework model of the EEMS can provide a consistent representation for the understanding and implementation of the EEMS
- The construction of the general framework model of the EEMS is beneficial to understanding the complex operating mode of the EEMS
- The construction of the general framework model of the EEMS is beneficial to the integration of resources within the EEMS.

Method of the EEMS model: EEMS is a multi-level, multi-section, multi-disciplinary, multi-function and dynamically changing complex system. Its internal structure is complex too. At the same time the various elements have strong relevance and logical relationships between each other. The entire model affected by the time. It is difficult to analysis the development trend of this model by establishing a simple mathematical model or experience judgment. Therefore we need a system engineering methodology to analyze in order to avoid one-sided understanding of the system.

According to the above characteristics, the Hall Three Dimension Structure mode can become a powerful tool for analyzing EEMS framework model. The model of Hall Three Dimension Structure based on solving large complex system problem such as planning, organization, management, and it emphasizes the hierarchical system structure research. The theory starts from three aspects of the time, logic, knowledge, then research and analysis the linkages between the various elements within the system, as well as the connection between the various elements which can deeply explore the structural characteristics and operational mechanism of the general framework of EEMS model.

HALL THREE DIMENSION STRUCTURE

Hall three dimension structure was put forward by Hall A.D, a communication engineer and system engineering specialist of American, in 1969. Its appearance provides a systematic way of thinking to solve large complex system problems, such as planning, organization, management and so on which has been widely used all over the world (Yu, 2009). The Hall Dimension for project risk management-temporal dimension, environmental dimension, knowledge dimension is put forward in order to improve the ability to control project risk (Yang *et al*., 2010). Based on the thought of three dimension structure system of hall, Li (2008) put forward the three dimension structure model for project management-temporal dimension, logical dimension, knowledge dimension, then the project management integration logical model and integrated management system is established. In view of system engineering, Wang (2008) established an expressway investment project evaluation system which based on the hall three dimension structure theory. Thus, embarks from the whole system, using hall three structure into the construction project integration management, risk management etc, plays an important role in improving the level of our construction project management.

Hall three dimensions structure divided the whole activity process into seven stages and seven steps which are connection closely and considered a variety of professional knowledge and skills of completing these stages and steps at the same time. As this, it forms the three dimension structure by temporal dimension, logical dimension, knowledge dimension. The temporal

dimension refers to the whole process of system engineering activities which ordered in chronological from start to finish. The temporal dimension divided into seven stages: Planning, draw up program, development, production, installation, operation and update. The logical dimension refers to the work that have to be done and the thinking procedure should follow in every stage of the temporal dimension, including defining the problem, determine the target, system integration, analysis, optimization, decision-making, implementation. The knowledge dimension refers to the comprehensive knowledge to solve complex system problems, including engineering, medicine, architecture, business, law, management, social science, art and other kinds of knowledge and skills. The three dimension structure described the frame of system engineering research vividly and formed a hierarchical and tridimensional tree structure system of (Peng, 2012).

THREE DIMENSION STRUCTUREMODEL OF EEMS

Based on the idea of "three dimension structure system", combining with the actual situation of expressway emergency management, this study puts forward three dimension structure model of the EEMS, as shown in Fig. 1.

Temporal dimension: In the three dimension structure, temporal dimension covers the whole cycle life of the expressway emergency management: Emergency warning, emergency preparation, emergency rescue and emergency recovery. In practice, these stages are not completely carried out in accordance with the order. Each stage has its own individual target and is a part of the objectives of the next stage.

Functional dimension: In the EEMS model, the functional dimension composed by organization and command, emergency plan, resource protection and decision aid. Among them, the organization command at the core, coordinating with other aspects of the function and operation; other ways provide solid protection to procedures, decision-making and resources for organization and command.

Knowledge dimension: There is no doubt that knowledge dimension is very important. It specific refers to the theory of knowledge and expertise for the completion of the above-mentioned temporal dimension and functional dimension. Emergency management is a typical problem of cross-level, cross-section and comprehensive which need to explore, mix, penetrate and integrate different interdisciplinary, then provide new ideas, theories and methods to solve such problems.

In three dimension structure, knowledge dimension is divided into several parts in accordance with professional knowledge. However, this division does not mean the split between the professionals. Emergency management must rely on interdisciplinary scientific and cross-section technological knowledge, expert team and take full

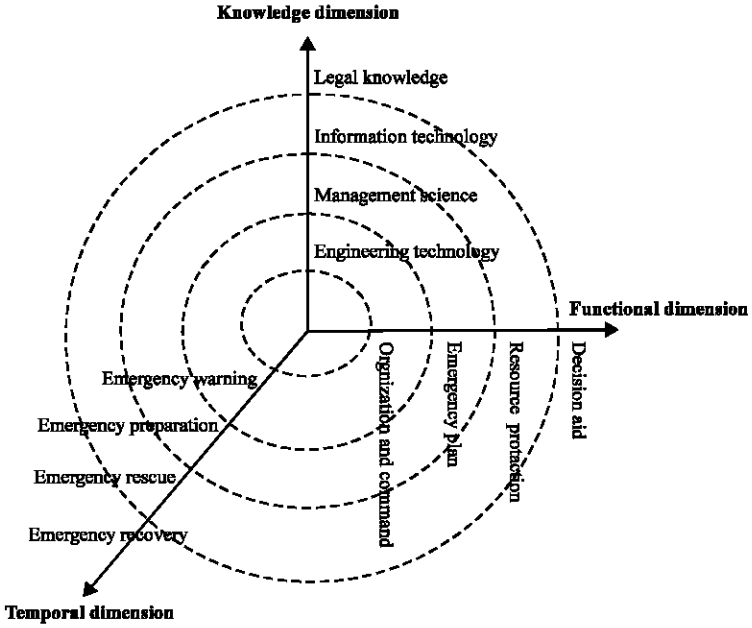

Fig. 1: Three dimension structural model of EEMS

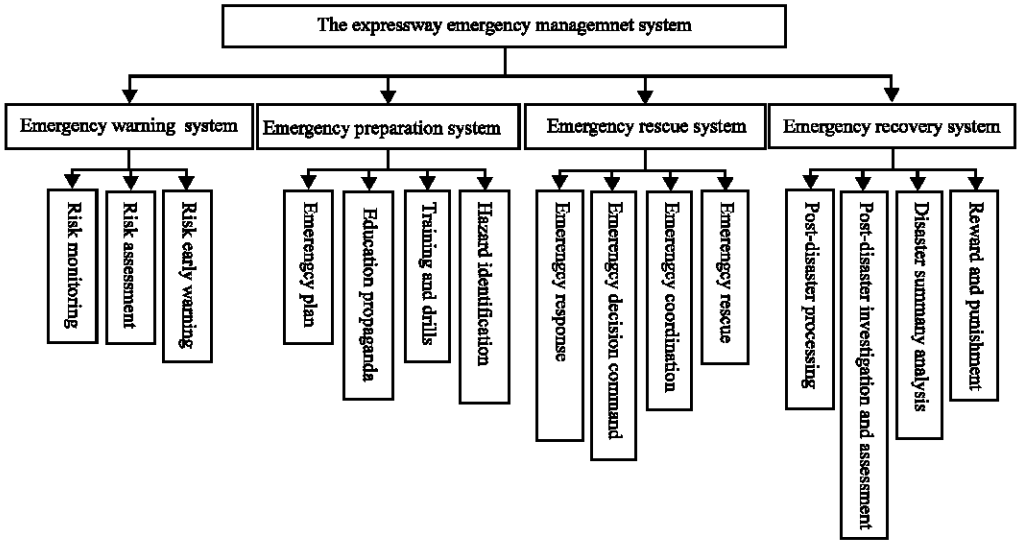

Fig. 2: Framework of EEMS

advantage of a variety of techniques, integrating all kinds of information, knowledge and everyone's talents and wisdom to realize the scientific management.

CONSTRUCTION OF EEMS

Based on the model of three dimension structure, EEMS is to show the relationship between the composition of EEMS and its elements from different aspects and perspectives. Temporal dimension represents different stages of emergency management. The knowledge dimension represents different field of knowledge of emergency management. The functional dimension represents different functional properties of emergency management.

To facilitate the construction of EEMS, we constructed an EEMS which on the basis of the whole process of emergency management theory and combined with the actual situation of expressway emergency management. The temporal dimension is the main line in the system (Fig. 2). The system is divided into emergency warning systems, emergency preparedness systems, emergency rescue system and emergency recovery system and the various elements throughout the whole system analysis and construction.

Emergency warning system: Despite its mutability and uncertainty, before the expressway emergency break out, may also reflect some precursors in some way, for example the weather along the expressway can be monitored before the bad weather occurring. Emergency warning system is an important component in expressway emergency management (Peng, 2012):

- **Risk monitoring:** Risk monitoring is to cassette and monitor the process of the emergency by achieving all kinds of related data. Generally we can create a dedicated expressway meteorological disaster warning and monitoring system, geological monitoring system, heavy fog monitoring system, snow disaster monitoring system, traffic accident monitoring system, service area emergency monitoring system
- **Risk assessment:** According to the identification of danger sources and the actual data received by the early warning and monitoring, analysis internal factors which affect expressway emergency occurred, expressway operator can establish expressway emergencies evaluation index system to assess the risk and improve monitoring and early warning capabilities
- **Risk early warning:** Risk early warning is to publish warning information in advance by media such as radio, newspapers, TV and emergency in the region of the affect area, at the same time, EEMS starting with appropriate warning action

Emergency preparation system: Emergency preparation system is the most critical part of expressway emergency management. If emergency of expressway has carried on the positive and effective preparation, that the harm and

personnel casualties by the expressway emergencies will reduce greatly, at the same time, the loss of national economy and the property may be to a minimum. Expressway emergency preparation can be divided into emergency response plans, hazards identification, education propaganda, training, drills and other activities:

- **Emergency plan:** Emergency plan, which is made ahead of time for possible emergencies, is base on the collecting information and analysis capabilities
- **Hazard identification:** We can manage the hazard identification based on separating different types of hazards, so that a specifically targeted management based on the properties of the respective of hazard can be established
- **Education propaganda:** In the process of emergency preparedness, on the one hand, the emergency organizations should let the internal staff to understand the importance of emergency management by education, training and publicity. On the other hand, the emergency organizations should enable the person who influenced by the expressway emergency to understand and master certain emergency-related knowledge, then help and guide them to participate in emergency preparedness activities
- **Training and drills:** In the emergency management system, both internal emergency organization staff or external organizations and personnel that influenced by expressway should be involved in the training and education to improve their response capacity of all types of expressway emergencies. At the same time, the internal and external organizations and staffs should take part in the multi-section actual drill in accordance with the emergency procedures for emergencies. This can improve the collaborative operation of subsystems within the EEMS; on the other hand, we can get everything ready

Emergency rescue system: The emergency rescue is constituted by a series of rescue operations after the expressway emergency occurs. Its main purpose is to reduce the harm caused by emergencies.

- **Emergency assessment:** Emergency assessment refers to an accurate evaluation of the types of emergencies, affected area and evaluation of potential casualties and property losses after the expressway emergency occur
- **Emergency decision:** In the process of emergency rescue, the leads and experts of emergency management command center should assess the emergency situation assessment and then start decision-making analysis and the appropriate level of emergency response
- **Emergency dispatching:** In the process of constructing the EEMS, emergency response command and decision-making centers should carry out a full range of rescue according to the characteristics and development trend of the emergency. At the sane time they should make reasonable arrangements of emergency personnel, machinery and equipment enter the scene orderly
- **Emergency rescuing:** Emergency rescuing refers to emergency personnel start the rescue orderly in accordance with the deployment and decision of emergency headquarters to reduce the emergency personnel casualties and property losses. Such as implement rescue operation of the personnel and property in time, control the emergency rapidly, indicating the hazardous area, block the scene of the emergency, repair the damaged roads and the ancillary facilities along the road immediately.

Emergency recovery system: Although, the expressway emergency has occurred, the loss is unavoidable but the restoration work must be done as soon as possible. In the restoration of security operations, we also need to sum up the whole process of emergency rescue to find the good and the deficiencies, retain the good places but the deficiencies must be corrected after the rescue operation, so as to gradually improve the whole emergency management:

- **Processing of the post-disaster recovery:** Processing of the post-disaster recovery means the emergency organization take appropriate measures to reduce the negative news and recover the expressway safety operation as soon as possible after the emergencies in the expressway to be properly handled
- **Summary of the post-disaster survey:** After the emergency rescue process, the operator should quickly formed accident emergency investigation team. The investigation team need to investigate how the expressway incident happened, what's each department's reflect after the warning issued, how is the whole process of emergency rescue, whether there exists related emergency personnel delayed the emergency rescue process due to its own reason, whether bring the casualties and economic losses to the whole organization . When the investigation is completed, also have to summary the entire process
- **Reward and punishment:** After investigation and summary, it should reward and punish the relevant

personnel and organizations. Individuals or organizations that bring certain help in the emergency rescue process should give some economic or honor reward, to encourage. In the contrast, we should punish individuals and organizations which take rescue operations do not in strict accordance with the issued emergency decision-making and command organization instructions.

CONCLUSION

EEMS is an important part of the expressway emergency management study. Its perfection or not has significance to improve the expressway safety and efficient operation. This study defined the EEMS and proposed the three dimension structure framework model of EEMS. At the same time, this study took the time as the main clue and constructed an EEMS. We hope it can provide scientific and accurate basis for expressway operators.

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