

DEVELOPMENT OF WEB-BASED TABLETOP EARTHQUAKE EMERGENCY EXERCISE SYSTEM*

ZHOU Bojia¹, SUN Gang², ZHANG Xiaoyong³, XU Jianhua⁴, LAI Junyan⁴, DU Xiaoxia⁵,
HOSOKAWA Masafumi⁶, HAYASHI Haruo⁷, KIMURA Reo⁸, SAKURADA Yukihisa⁹

¹Senior Engineer, Dept. of Training, National Earthquake Response Support Service, Beijing, China

²Engineer, Dept. of Emergency, National Earthquake Response Support Service, Beijing, China

³Senior Engineer, Dept. of Information, National Earthquake Response Support Service, Beijing, China

⁴Engineer, Dept. of Technology, National Earthquake Response Support Service, Beijing, China

⁵Senior Engineer, Dept. of Technology, National Earthquake Response Support Service, Beijing, China

⁶Group leader and Senior Researcher, Earthquake and Natural Disaster Laboratory, National Research Institute of Fire and Disaster, Tokyo, Japan

⁷Professor, Disaster Prevention Research Institute, Kyoto University, Kyoto, Japan

⁸Associate Professor, School of Human Science and Environment, Hyogo University, Himeji, Japan

⁹Researcher, Disaster Prevention Research Institute, Kyoto University, Kyoto, Japan

Email: zhoubojia@126.com

ABSTRACT:

When the earthquake is there the emergency management personals must be ready for their job. They have to do several jobs during the response to earthquake. If they want to do the right job they must be trained. Training can be done by several techniques and methods. Emergency management personnel develop their capability to make the right decisions to future earthquake, emergency exercises often play a central role. In traditional emergency management exercises participants carry out analysis and discussion on the basis of paper medium information than computer scenario circumstances. This exercise cannot offer the relative truth emergency background. The exercise process cannot be recorded in computer database for after action review. One strategy to enhance the immersive exercise experience is to make use of virtual reality simulation technology to build web-based tabletop earthquake emergency exercise management system. In this paper we present empirical study of how the earthquake emergency exercise system was used in designing and conducting several emergency exercises in JICA earthquake emergency and rescue exchange program between China and Japan. We describe how the exercises was designed and performed, highlighting immersive relevant aspects. In every exercise, analyses were performed on computer recordings of the exercise, statements from the participants and observations made during the exercise. The results indicate that the participants can immerse themselves in exercise character and imagine what it might be like to be that person. The exercise system is an effective instrument to develop participants' abilities in disaster management and suitable for application in the earthquake emergency response exercise at all levels of government in China.

KEYWORDS:

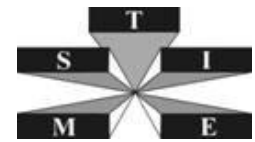
Earthquake emergency exercises, Web-based tabletop system, Virtual reality simulator

INTRODUCTION

Earthquake is a devastating sudden natural disaster. When the destructive earthquake occurs, governments at all levels must promptly respond to such unexpected events. If the emergency management personals want to do the right job they must be trained, especially exercise often play a central role. Emergency exercises can be done by several techniques and methods, ranging from tabletop exercise to full-scale exercises (Perry and Lindell, 2007). The tabletop exercise is an effective form of scientific decision making ability. In China traditional emergency management exercises participants carry out analysis and discussion on the basis of paper medium information than computer scenario circumstances. This exercise cannot offer the relative truth emergency background. The exercise process cannot be recorded in computer database for after action review. One strategy

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to enhance the immersive exercise experience is to make use of virtual reality simulation technology to build web-based tabletop earthquake emergency exercise management system.

Researchers at home and abroad conduct research in the field of emergency management exercise simulation. Application of computer hardware and software technology has been used in the emergency exercises conducted in developed country, such as emergency exercises management software, exercises record database, scenario simulation. Advanced Disaster Management Simulation created by ETC offers challenging, true-to-life virtual environments for training incident command and disaster management teams at all levels. Trainees gain the confidence, practical experience and decision-making skills needed to successfully resolve real-life incidents (ETC, 2008). The multi-level ADMS-Command training suite includes an On-Scene Incident Command Room with a 180-degree immersion theater screen, four field unit positions and an Emergency Operations Center room. VSTEP Company developed RescueSim that is a virtual trainings platform (with a realistic 3D-Replica of over 20 different environments) with which different emergency services and other instances can be trained (VSTEP, 2010). Earthquake on-site rescue simulation used in China National training base for urban search and rescue can meet with the needs of earthquake rescue exercise for teams. There are many different resolution virtual training scenarios such as macro-seismic disaster scenario, on-site rescue scenario, the concrete ruins of individual operation (Cui Zhonghui and Xu Yongzhi, 2006). These studies are primarily on-site emergency commanding, decision-making and rescue strategy exercises mainly for the front emergency management personals instead of rear command post.

Using the experience of other countries for reference especially the method of Japan tabletop exercise and combined with the actual situation of earthquake disaster emergency exercises in China, we developed web-based tabletop earthquake emergency exercise system during the cooperation and exchanges in China-Japan JICA project. In this paper we present empirical study of how the earthquake emergency exercise system was used in designing and conducting several emergency exercises in JICA earthquake emergency and rescue exchange program between China and Japan.

METHOD

We developed the first vision of web-based tabletop earthquake emergency exercise system in December 12th, 2011, made three system vision adjustments from 2011 to 2013. The exercise system provides the relatively realistic earthquake disaster scenes and vivid emergency background. The use of exercise system as a tool for structuring the planning and conducting of emergency management exercises was studied through three exercises during JICA project. The web-based tabletop emergency exercise system consists of four modules include Virtual Scenario Editor of earthquake disaster, Exercise Director Module, Exercise Conduct Module, Evaluation Module (see figure 1).

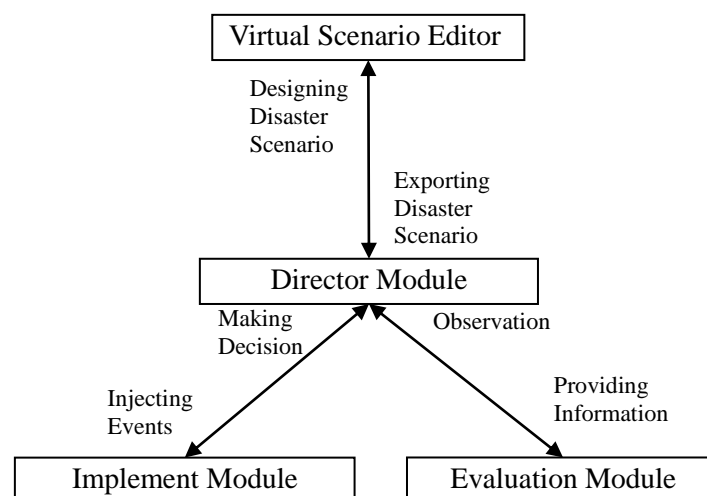
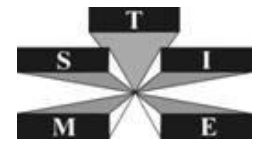


Figure 1 The consists of emergency exercise system



Virtual Scenario Editor of earthquake disaster is used for emergency management personnel or exercise controllers to design urban 3D scenes, earthquake disaster and secondary disasters events. The editor provides a visual way to design virtual 3D cities and emergency events including the scale of earthquake disasters, the location and extent of secondary disasters, the number of victims, rescue missions and emergency management objectives(Jia Qunlin, Zhou bojia,2009). Exercise Controller Prepares the Scenario. The exercise system consists of three-dimensional virtual environments include Chemical plant, Residential Section, Central Business District where dynamic safety and security incidents are created. Exercise Controller Selects and Customizes Scenario from library. Exercise Director Module is used for controlling and running the exercise by the Training Staff or Controller. The controller injects the information of disaster events. The exercise participants analyze the events information through the virtual environment and put forward solution or make decisions by Exercise Implement Module. Evaluators oversee exercise and score participants' performance by evaluation Module.

The empirical study is mainly based on three web-based tabletop emergency management exercises with nearly hundred participants from several provinces of China include Jiangsu, Yunnan and Hebei. The participants were all middle-managers in provincial governments working in different administrations. They had responsibilities for different areas in the provincial governments mainly from the emergency offices, the seismological Bureaus and the civil bureaus. The exercise participants are divided into several groups according to their function. The web-based tabletop emergency exercises system injects the information automatically during an hour and a half exercise. The exercise participants collect information, analyze situation, estimate casualty, deal with the emergency events, make decision, and put forward solution. Analyses of the exercise participants' use of emergency management techniques during the exercise were performed on computer recordings of the exercise, written opinions from the participants and observation made during the exercise.

CONDUCTING THE EXERCISE

Integrated in tabletop emergency management exercises experience of China and Japan, We conducted earthquake disaster emergency management exercises relies on JICA earthquake emergency and rescue capacity strengthen project using web-based tabletop emergency management system in order to deepen the understanding of emergency process, promote capacity of disaster response and coordination, advance the application of tabletop exercise in emergency management preparedness and training. We conducted three exercises during the JICA project. Each exercise comprises three steps; preparing the exercise, conducting the exercise, and evaluation of the exercise including disseminating the results.

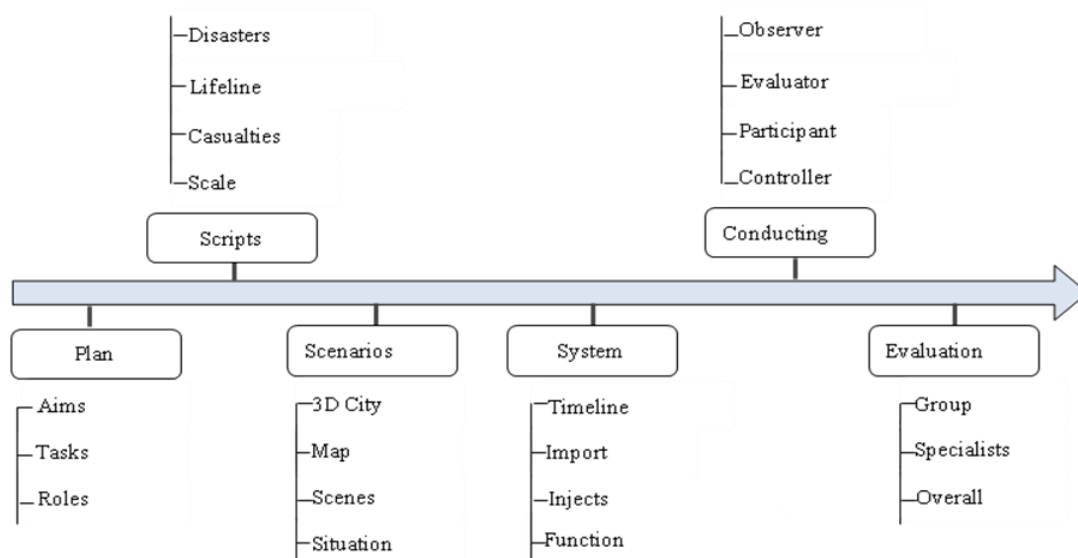


Figure 2 The process of Web-based emergency exercise



Step1: Preparing the exercise

According to the actual needs of earthquake emergency response and work arrangements, the aims and goals of the exercise need to be defined firstly, that is to say, who will participant in exercise, what problem should be solved and what desired effect should be achieve through the exercise. In defining aims and goals the most central criteria are the presumed roles and tasks that the participants in the exercise might have in future emergencies (Borell and Eriksson, 2010) . The main aims and goals must be clear and specific, in other words, the problem of "what, where, who, what, why, and how to do" are definitive, which is the starting point of exercise planning and preparations.

With the defined aims and goals as a basic the next step is to develop 3D city and the surrounding areas of exercise, edit disaster scenarios to be used during the exercise. The disaster scenarios are presumed according to the geographical location of the area, topography, population, buildings, lifeline engineering, potential risk, hospitals, school supplies, historical earthquake, emergency plan and resources of the simulated earthquake region. The presumed disaster scenarios include scale of disasters, casualties, house collapses, lifeline engineering damage, secondary disaster, evacuation demand, isolated area, affected people, goods distribution, prediction and subsequent development of disasters etc. Meanwhile the 2D map of exercise that reflect the geographical features and transportation of disaster area with the surrounding areas should be designed. The map of exercise also reflects the location and relationship of command post, hospitals, shelters and other important facilities. The assumption of the disaster also should learn from the historical earthquake response. For example, blank information areas, traffic disruption areas, undefined information, very important situation, emergency events should be set in order to examine the trainees to analyze Information Island and isolated areas, comminute with each other, emergency response.

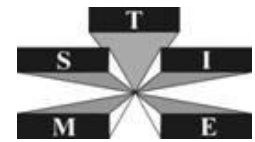
The script-injects for each of the exercise phases and reference evaluation forms are the most important material for tabletop exercise preparedness. The script-injects should be designed according to emergency timetable, response process, trainees' knowledge background and experience learned from practical disaster response. That should include Time, Content, Source of Information, Target, and Types of the Inject. Inject Time refers to when the information be injected. Inject Type refers to how the information be injected, such as paper injects, web-based injects, telephone injects, and fax injects. The exercise controller import Developed script-injects to Virtual Scenario Editor of earthquake disaster, attach to disaster scenario and set trigger condition.

Step 2: Conducting the exercise

Three tabletop exercises were conducted during JICA earthquake emergency exchange program between China and Japan; the information of exercises is in table1.

Table1 Exercise Practice and Improvements

	Date	Participants	Numbers	Sites	Disaster Scenaros	Improvements
Exercise Case1	Feb. 12 th , 2012	Hebei Provincial Governments	24	China National Training Base for Urban Search and Rescue	Ms6.8 Earthquake; Xingtai city; 20km; IX Epicenter Intensity.	Web-based Information Injects
Exercise Case2	Jul. 18 th , 2012	Jiangsu Provincial Governments	32	Jiangsu Provincial Emergency Command hall	Ms6.5 Earthquake; Liyang city; 10km; VIII Epicenter Intensity.	Virtual Emergency Command Hall; Map potting
Exercise Case3	Mar. 22 th , 2013	Hebei, Jiangsu, Yunnan Provincial Governments	32	China National Training Base for Urban Search and Rescue	Ms7.6 Earthquake Zhaotong city; 10km; VIII Epicenter Intensity.	Digital City; Virtual Reality Scenarios; Improved Map Potting



Each exercise was a one-day event, arranged with the instructors of China National Earthquake Response Support Services. That includes three phases. The first phase was background information introduction of simulated earthquake city and the presumed roles of trainees, the second part was the tabletop exercise and the final phase was an evaluation of the exercise. As the simulated earthquake happened, the scenarios of disaster were injected according to the time of inject automatically by web-based tabletop earthquake emergency exercise system.

The exercise participants analyze the injected events of the virtual environment from big screen in the front of tabletop exercise room and web-based software in computer terminals; put forward solution or make decisions to emergency events and take notes into exercise implement Module. The participants also present the dynamic decisions process through map plotting system. Evaluators oversee exercise and take notes into evaluator module. The observers watch the exercise progress scenes displayed in big screen through the presentation of exercise system.

The first exercise was conducted in the tabletop exercise room of China National Training Base for Urban Search and Rescue on February 12th, 2012. There were 24 emergency managers of Hebei province governments from the emergency offices, the seismological Bureaus and the civil bureaus joined in the first exercise. They were divided into three groups, comprehensive coordination group, relief resettlement and professional disposition group. Simulated Ms6.8 magnitude earthquake happened in Xingtai city of Hebei province; the depth of the earthquake is 20km; the epicenter intensity is IX. More than 50 items information each group indicated events within 24 hour after earthquake were injected in. Three groups received not only the same information such as the seismic parameters, main disaster scene and rescue phases, also the different information according to different areas in the provincial governments that participants had responsibilities for. The second exercise was conducted in the Jiangsu provincial emergency command hall on July 18th, 2012. About 32 emergency managers of Jiangsu provincial governments took part in that exercise. The magnitude of simulated earthquake is Ms6.5; the location is Liyang city of Jiangsu Province; the epicenter intensity is VIII. The exercise phases include within 2 hours after simulated earthquake, from 2 hours to 12 hours after earthquake, 12 hours after earthquake to within 24 hours. The exercise lasted 90 minutes but represent after within 24 hours after earthquake. The presumed events are injected in above phases. The third exercise was conducted in the tabletop exercise room of China National Training Base for Urban Search and Rescue on March 22th, 2013. 32 emergency managers from Jiangsu province, Yunnan province and Hebei province participated in the third exercise. They were divided into four exercise role groups; Yunnan Provincial Earthquake Relief Headquarters, Guizhou Provincial Earthquake Relief Headquarters, Jiangsu Provincial Earthquake Relief Headquarters, the central Earthquake Relief Headquarters. Simulated Ms7.6 earthquake happened on the border between Zhaotong city of Yunnan province and BiJie city of Guizhou province. The epicenter intensity of simulated earthquake is VIII. Every group received emergency events, discussed the resource scheduling, events controlling, investigation, formulate measures, comprehensive coordination, social mobilization and media response and recorded the decisions into database of exercise system.

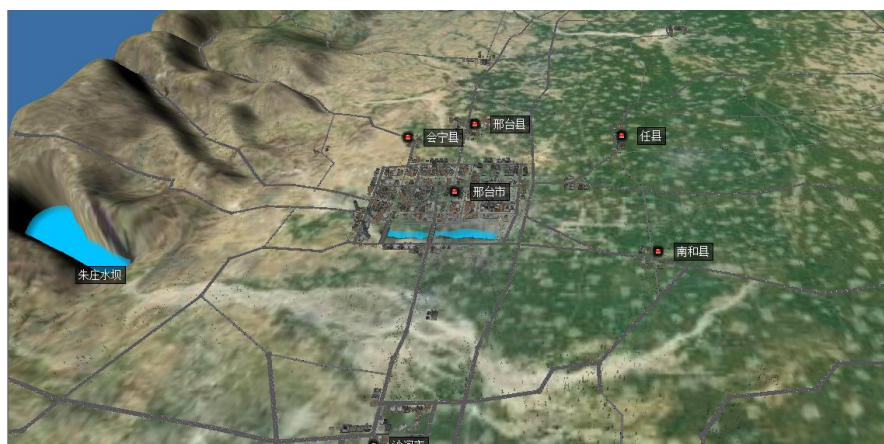


Figure 3 3D City of Hebei Province Exercise

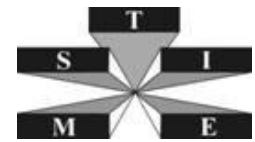


Figure 3 3D City of Jiangsu Province Exercise



Figure 3 3D City of Yunnan Province Exercise

Step 3: Evaluating

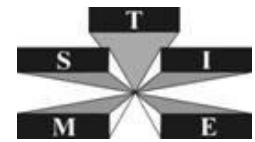
Evaluators oversee exercise; the evaluation process can be recorded in real-time, high efficiency. After exercise the evaluation record and emergency decisions of disaster events from participants can export Table files. We also sent reference evaluation forms with expected action to participants. Immediately after the each exercise a discussion seminar for evaluation followed, which was chaired by the authors. During two hours the participants, evaluators and observers talked about how they had experienced the web-based exercise, and what they thought about effects and results. They were also asked to fill in a form, answering some questions. Based on comprehensive analysis of exercise record and relevant data, comparison of participants' performance and aims of exercise, combined with the emergency schedule, resulted in a report.

RESULTS

After each exercises, questionnaires were sent to participants, observers and evaluators. The observation during the simulated Xingtai earthquake exercise as well as the questionnaire survey in evaluating phase indicate using the web-based earthquake emergency exercise system had the following effects:

- The participants can immerse themselves in exercise character and imagine what it might be like to be that person through the videos and pictures of disaster situation on large screen in the front of tabletop exercise room.
- The participants can better understood the exercise scenarios and make decision though received the disaster information based on computer injects as same to actual emergency response.
- Through electronic map plotting, the participants present the dynamic decisions process, zoom in and zoom out electronic map in details, recorded the content of plotting into database, and also export the pictures for future discussion.

In the simulated Xingtai earthquake exercise, some observers suggested exercise controller should improve the



utilization rate of large screen and inject more information in types of pictures, video and text. Some participants thought that map potting system should be added more layers and the operation of exercise conduct system should be simplified. The web-based earthquake emergency exercise system was amended to the second vision according to exercise feedback. Improved functions of exercise system included system's user interface, emergency procedures, map level, and virtual emergency command hall.

After the second exercise, the feedback of evaluating indicated that virtual emergency command hall and the virtual 3d disaster scenarios made the participants have a feeling of practical earthquake emergency response in rear command post. The results indicate that the participants can immerse themselves quickly in exercise character. Some observers referred that the marks of map potting system should be added according to military potting and the sound environments of disaster scenes should be improved. The exercise system was amended to the third vision according above suggestion. After the third exercise, the feedback of observers and participants indicated that using the web-based earthquake emergency exercise system had salient effects and the participants develop their abilities to response to emergency situations in limited exercise time. Especially, the participants can learn the disaster situation from 3d virtual city. The mode of web-based exercise is valuable to spread to other provincial exercises.

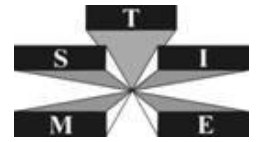
Conclusion

The results show that the web-based exercise was successful. This suggests that the approach with utilizing earthquake emergency exercise system as a basic for planning and conducting the exercise was successful. It also made evaluation and organization of exercise easy and convenient. Using the web-based exercise had salient effects on operation mode, diverse information and scene presentation. In the conducting of emergency exercise, the exercise was successful in helping participants improve disaster response and coordination capacity, also enhance participant understand the process of earthquake emergency according to comprehensive, three-dimensional disaster information provided by exercise system. Using electronic technology, virtual reality technology, three-dimensional modeling technology in web-based system to build a more realistic disaster environment, not only can directly visualize the disaster scene, also can let the participants feel tension, enthusiasm in exercise and develop their abilities to handle the future emergency. Moreover, the processes of exercise were recorded in electronic database for after review and evaluation easily.

However some three-dimensional events occurred in exercise process according to the preset and didn't be changed with the participants' emergency response. In terms of the exercise evaluation, the results of assessment should be rapidly statistics and intuitive charts reflect the exercise effects according to aims and goals. The future exercise system should be non-scripted, which means that there are on pre-determined outcomes, and what happens in the system is based only on the participants' decisions. The three-dimensional emergency disaster scenes have physics-based simulation (Zhao Qiping, 2005), where fire, smoke, gas clouds, leaks, etc., spread as they would in the real world and react to things like wind direction and speed as in real life. All features of disaster are based on real-world timing, such as how a person's injuries progress if they are not treated (Broll W.1998). The exercise should produce a high-level of immerse, where trainees feel like they are in the actual situation, and feel the stress that they would feel at an actual emergency. The exercise system should automatically score the trainees on defined objectives, as well as letting the instructors completely replay an exercise and view from any perspective. And also present a detailed, time-stamped action list, describing the scenario events and the actions that the trainees took.

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