Training of Resilience Skills for Safer Railways: Developing a New Training Program on the Basis of Lessons from Tsunami Disaster

Shigeru HAGA[1], Osamu ONODERA[2], Tomoko YAMAKAWA[2], Akio OISHI[2], Yuichi TAKEDA[2], Ken KUSUKAMI[2], and Toshiko KIKKAWA[3]

[1] Department of Psychology, Rikkyo University, Niiza-shi, Saitama 352-8558 Japan

haga@rikkyo.ac.jp

[2] Research and Development Center of JR East Group, East Japan Railway Company, Saitama-shi, Saitama 331-8513 Japan

[3] Department of Business and Commerce, Keio University, Minato-ku, Tokyo 108-8345 Japan

Abstract. Railway operators such as drivers, conductors, and station staff faced difficult situations related to the earthquake and tsunami disaster in 2011. They had to decide by themselves what to do with limited information and to act quickly. They nevertheless performed remarkably and saved many lives of passengers as well as their own lives. We interviewed 104 such operators and found that (1) imagination, (2) sensitivity to risk, and (3) decision-making abilities are the most important for front-end operators to overcome a crisis. In order to enhance these abilities, we started to develop a new training program based on a serious game, “Crossroad”, that had been developed as a training tool to increase awareness of conflicts in the face of natural disasters. About 1500 railway practitioners from the East Japan Railway Company participated in experimental trials of the new training method. As expected, the program was found to be effective to enhance the ability of resilience, which would help front-end practitioners respond flexibly and adaptively to critical situations.

1 INTRODUCTION

The 2011 Off the Pacific Coast of Tohoku Earthquake (The Great East Japan Earthquake) was disastrous beyond imagination and more than 18,000 lives were lost in the Tohoku District in Japan. Most of the victims drowned in the tsunami that engulfed the Pacific Coast of Tohoku 30-60 minutes after the earthquake. As a consequence of the Earthquake, many people and organizations faced unanticipated problems that

required responses for which they were not trained, had not practiced, or that were not prescribed by manuals, rules, or laws. Some responses were successful and some ended in failure. Organizations and individuals who responded to the event flexibly and adaptively could provide great help to the people who were suffering or in danger. They displayed the competence that is considered in resilience engineering to be important for safety.

The East Japan Railway Company (JR-East) was one of the most successful organizations in this disaster. Their operators and local managers responded resiliently, saving many lives. The disaster has provided precious opportunities for us to learn from successful experiences and develop ideas on new training methods for resilience skills.

2 RESPONSES TO THE EARTHQUAKE AND TSUNAMI

At 14:46 hours on March 11, 2013, a massive earthquake with a moment magnitude of 9.0 occurred in the offing of the Pacific coast of the Tohoku District, Japan. The seismic centre was at about 130 km off the coast of Ojika Peninsula, Miyagi Prefecture, and at a depth of 24 km. The big tremor reached the coast within 1 minute. All the trains stopped quickly, automatically for Shinkansen trains and manually for trains on conventional lines, after receiving an automatic radio alert.

The Japan Meteorological Agency issued a tsunami alert 3 minutes later. Tidal waves attacked the coast several times, and the largest one came between 15:15 to 15:50.

Train drivers and conductors of 27 trains in service along the Pacific coast evacuated their passengers. Then the crews of 26 trains among them guided the passengers on foot to the nearest tsunami shelters before 5 of these trains were swept off the tracks. The crew of one train, which happened to stop on a hill, told their passengers to go back and stay on board according to the advice of a passenger who lived nearby. If they had left the train and moved downhill toward the shelter, the tsunami would have engulfed them. The decision to stay on board was against the dispatcher's instructions to evacuate the train, but owing to their noncompliance, all passengers and crew members survived to be rescued the next day.

Not only train crews on board, but also other front-end railway practitioners such as station staff, dispatchers, facility maintenance engineers, etc., showed remarkable reaction to the disaster. All of those on duty survived and many of them helped people in and near their workplaces.

Figure 1 shows the railway network of the JR-East. Squares represent the stations whose staff guided people to tsunami shelters and circles represent the trains from which train crews evacuated passengers on March 11, 2011.

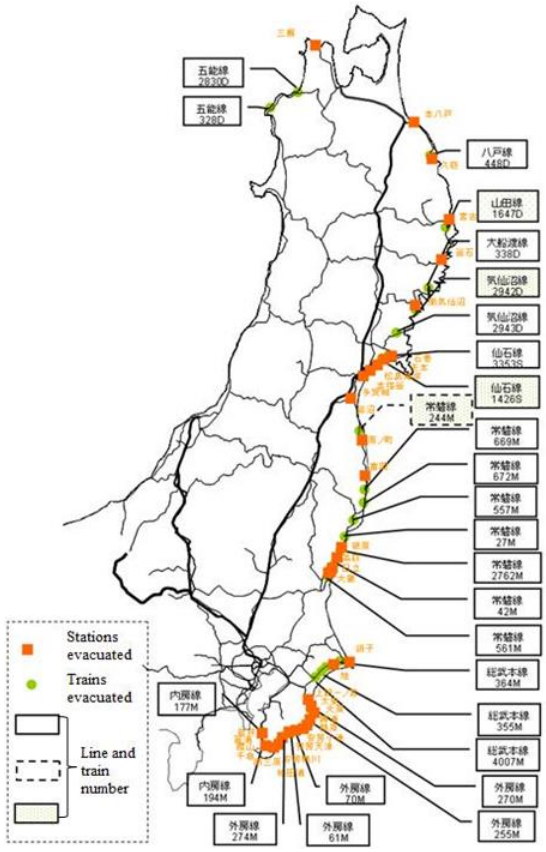

Fig. 1. Railway network of the JR-East and its stations (squares) and trains (circles) from which station staff and train crews helped passengers move to or stay at safe places on March 11, 2011

3 INTERVIEWS

3.1 Purpose

The purpose of the interviews was to find factors that contributed to successful responses by front-end railway practitioners.

3.2 Method

In May and June in 2011, a total of 14 interviewers visited 48 workplaces of the JR-East in the areas affected by the tsunami. Most of the interviewers were human factors specialists working for the Research and Development Center of the JR East Group and

the remaining were risk managers in the headquarters of the JR-East. They interviewed 104 railway personnel consisting of 26 train crews (drivers and conductors), 24 station staff members, 19 dispatchers, 10 facility maintenance engineers, and 25 local managers. Each interview session was performed by two interviewers for each interviewee.

In an approximate 30-minute semi-structured interview, we asked the interviewee about his/her behaviour, decision-making, and content and sources of information that was utilized. Local managers were also asked about preparation and anticipation for natural disasters before the event.

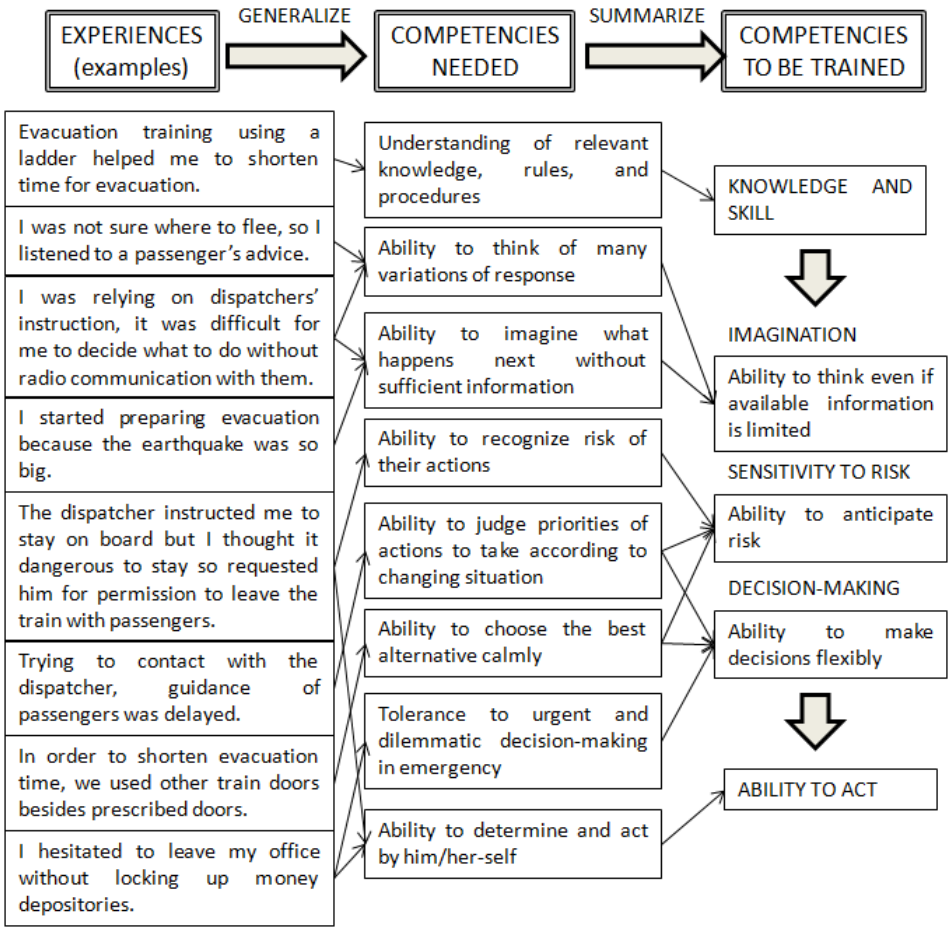

Fig. 2. Summary of results of the interview

3.3 Results

As shown in Figure 2, both from successful and defective experiences by front-end practitioners, we extracted general competencies that would contribute to overcoming not only a crisis as a consequence of natural disasters but also overcoming various other emergency situations. These competencies are summarized as (1) professional knowledge and skill, (2) imagination, (3) sensitivity to risk, (4) decision-making ability, and (5) ability to act.

Additionally, from these interviews we identified three requirements for an adequate response to an imminent crisis: (1) immediate and reliable information should be available to frontline operators, (2) onsite decision-making should be done promptly, and (3) both passengers and operators can if deemed reasonable immediately leave the train or station in danger and move to a safer place. For requirement 1, operators should not only passively wait for reliable information but actively seek it from various sources. For requirement 2, operators should be able to make decisions by themselves. Lastly, for requirement 3, operators should be encouraged to leave their workstations, if necessary, for safety rather than to stay at their posts and perform duties there.

4 THE TRAINING PROGRAM

4.1 Need for a New Training Approach

From the interviews, we identified five competencies required in emergency situations. However, the company had not trained its employees to acquire those competencies. Traditionally, education and training in railway companies in Japan in general put stress on compliance to written rules and standard procedures. However, to act after making independent decisions was found by the present study to be very important in overcoming the crisis.

Japanese railways have a reputation for safety, as well as punctuality, but in order to enhance safety to a higher level, we concluded that a new training program should be developed and introduced as part of the regular training course.

Since the JR-East already has training programs for professional knowledge and skill, among the five competencies summarized above our focus of concern in developing a new training program was put on (2) imagination, (3) sensitivity to risk, and (4) decision-making abilities.

4.2 Method of Training

The training program utilizes a modified version of a serious game named “Crossroad”, which had been developed as a training tool to increase awareness of interpersonal and intrapersonal conflicts in the face of natural disasters (Kikkawa, Yamori, Ajiro, and

Hayashi, 2004; Yamori, Kikkawa, and Ajiro, 2005; Kikkawa, Yamori, and Sugiura, 2009). In our training program, the chairperson of a group of four to six trainees reads aloud a short description of an irregular event (scenarios) on the railway. For example, “The train stopped at a red signal in a tunnel, and, at the same time, smoke arose in a carriage. A few passengers were trying to open the door and escape.” Then each group member is told to think about the situation and decide what he or she should do. After intensive discussion with experts in railway operations and front-end practices, we tentatively created 64 scenarios for the training.

In one version of the training procedure, members are given a question such as “Do you tell passengers to stay on board until instructed to evacuate?” Each member chooses one of two cards, “YES (tell them to stay)” or “NO (let them leave)” and puts the card on the table face down. In the other version, each group member writes down the answer on a blank card. In both versions, after all the participants make their decisions, they simultaneously flip the card face up.

Next, the chairperson asks members the reason for their decision and starts a debate between the supporters of decision alternatives. This inevitably leads to a discussion of trade-offs that must be made in decision-making in an unstable situation.

4.3 Trial of the Training Program

The new training program was put into practice experimentally in various local workplaces of the JR-East. About 1500 railway personnel in total participated in the experimental trial of the new training method. They were comprised of station staff, train crews, maintenance engineers, and construction supervisors. Through discussions in the training, participants discovered that there were different ways of thinking and many factors to consider, and that there was no “correct answer”. They found that alternative responses were numerous, but that each alternative involved trade-offs. They learned that to make better decisions they should anticipate what could happen as a result of their decisions. Using YES/NO cards was found to be more suitable for novice trainees because some of them could not think of possible alternatives and were unable to think out trade-offs.

4.4 Evaluation of the Program

We asked the participants for comments on the new method right after each trial. The evaluation was quite positive. Qualitative analysis of the comments showed that there are two major advantages in the new program compared to traditional approaches.

Firstly, participants found it effective for trainees to think by themselves about various emergency situations before they actually faced such a situation. Without an opportunity to receive this kind of training, they would not think of or imagine such critical situations. Many participants in the trial program expressed thanks for the opportunity given to them. They found difficulty in dilemmatic decision-making but

they understood its necessity.

Secondly, participants evaluated group work as a good practice. They said that listening to other trainees' opinions helped them to expand their own imagination and behavioural variations. They learned there were various alternative ways to respond to a single event and that there was no "correct answer". In spite of this uncertainty, they must make a decision and choose the best alternative, taking trade-offs into account.

Before finishing the development of our training program, we must increase both the number and quality of scenarios available. In addition, we will need to collect quantitative evaluations by trainers and trainees, not only right after the training but also some time later (say a year) to ensure the effectiveness of the training.

5 DISCUSSION

Several previous training techniques have aimed at enhancing front-end practitioners' ability of resilience. For example, the National Patient Safety Agency in the United Kingdom developed a training program named "Foresight Training", and put it into practical use. The program aims to develop mental skills of nurses and midwives to identify, respond to and recover from the initial indications that a patient safety incident could take place (National Patient Safety Agency, 2008). Dekker, Dahlström, van Winsen, and Nyce (2008) suggested that an efficient use of low fidelity simulation could serve as an important complement in the creation of resilient crews in aviation and shipping. Bergström, Dahlström, Dekker, and Petersen (2011) developed a program for Swedish fire safety engineers engaged in rescue services. Using scenarios involving escalating situations, they tried to force trainees beyond their learned roles and routines and to force them into proactive thinking and articulation of their expectations of what might happen.

The approach of our new training program is in line with these preceding attempts at resilience engineering. Hale and Heijer (2005) admitted that railways have achieved remarkably high level of passenger safety without resilience, but claimed that safety management in railway track maintenance was not sufficient and needed to be improved by incorporating the strategy of resilience. However, It is obvious from our experience of the 2011 earthquake and tsunami that railways surely need resilience to achieve a higher level of passenger safety.

In an emergency situation, professionals working at the frontline face the dilemma of deciding how to respond to a critical event. Each reaction alternative has its own trade-offs between risks and advantages. Railway practitioners of the JR-East faced difficult situations related to the earthquake and tsunami disaster in 2011. They had to decide by themselves what to do with limited information and to act quickly. Tsunami alerts had been issued many times in Japan but railways had never been flooded before. Evacuation of trains and stations could be useless and could be more dangerous or risky than staying in carriages or buildings. Practitioners experienced the dilemma of making trade-offs among their choices. Ultimately, they made the best decisions and

saved many lives of staff and passengers.

The training program that we are developing is expected to improve operator's ability to manage trade-offs in a crisis and enhance resilience of individual workers as well as groups of workers. It is the first attempt to apply resilience engineering to the field of practical operations in Japan. It will contribute to the development of resilience engineering and add new findings in the application of the theory.

REFERENCES

Bergström, J., Dahlström, N., Dekker, S., and Petersen, K. (2011) Training organisational resilience in escalating situations, In E. Hollnagel, J. Pariès, D. D. Woods, and J. Wreathall (Eds.) *Resilience Engineering in Practice: A Guidebook*. (Pp. 45-57). Farnham, U. K.: Ashgate.

Dekker, S., Dahlström, N., van Winsen, R., and Nyce, J. M. (2008). Crew resilience and simulator training in aviation. In E. Hollnagel, C. P. Nemeth, and Dekker, S. (Eds.) *Resilience Engineering Perspectives.* (Pp. 119-126). Farnham, U. K.: Ashgate.

Hale, A. and Heijer, T. (2005). Is resilience really necessary ? The case of railways. In E. Hollnagel, D. D. Woods, N. Leveson (Eds.) *Resilience Engineering: Concepts And Precepts*, (Pp. 125-147). Farnham, U. K.: Ashgate.

Kikkawa, T., Yamori, K., and Sugiura, J. (2009). *Crossroad and More...*, Kyoto, Japan: Nakanishiya Shuppan. (in Japanese)

Kikkawa, T., Yamori, K., Ajiro, T., and Hayashi, H. (2004). 'Crossroad: Kobe': A training tool for disaster preparedness and response. In W.C. Kriz & T. Eberle (Eds.), *Bridging the Gap: Transforming Knowledge into Action through Gaming and Simulation.* (Pp.245-253). Munich, Germany: SAGSAGA

National Patient Safety Agency (2008). *Foresight Training Resource Pack*, NHS Reference Number 0721, www.nrls.npsa.nhs.uk/resources/?entryid45=59840, accessed on 06-05-13.

Reason, J. (2008). *The Human Contribution: Unsafe Acts, Accidents and Heroic Recoveries.* Farnham, U. K.: Ashgate.

Yamori, K., Kikkawa, T., and Ajiro, T. (2005). *Crossroad*. Kyoto, Japan: Nakanishiya Shuppan. (in Japanese)