DEVELOPMENT OF A HUMAN FACTORS EDUCATION PROGRAMME FOR TRAIN DRIVERS COMBINED WITH SIMULATOR TRAINING

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Speeding and SPADs are the two most common incidents which result from train drivers’ errors. Lapses tend to be involved in speeding while slips and mistakes are associated with SPADs. These incidents usually occur because drivers’ non technical skills (NTS) are limited rather than lacking necessary technical skills. To improve drivers’ NTS, a new education programme has been developed which focuses more on human factors perspectives compared to traditional training. The framework of the programme consists of three phases: (1) learning from error experiences, (2) understanding error mechanisms and coping strategies and (3) thinking of their own error-prevention actions. Driving simulators allow drivers to face speeding and SPAD inducing situations, enabling them to improve NTS from these experiences. Speeding inducing scenario has been developed first with this framework and showed positive effects on drivers. Based on this result, a SPAD scenario has also been developed and is now under a pilot test, showing positive reactions and learning effects as well.

Introduction

Speeding and Signals Passed At Danger (SPAD) have been the two most common but serious incidents which should be prevented as much as possible in order to achieve higher safety level. To reduce the occurrence of these incidents, train protection systems, such as Automatic Train Stop (ATS), have been installed in order to stop trains running over a speed limit or passing a signal at danger.
However, ATS is not always placed, especially for temporary speed restricted sections. Even when ATS stops a train, SPAD can happen if the driver mishandles the protection device. Therefore, speeding and SPAD still occur and drivers’ errors are often involved in these cases. Driver training has been reinforced along with other safety measures, but existing training seems to have a number of problems.

Driver training has put emphasis on technical knowledge and skills so that drivers can correctly handle emergency situations or car trouble. On the other hand, it has been pointed out in other safety-critical industries that safe operations cannot be achieved solely by improving technical skills (Fletcher et al., 2002). For instance, even a highly skilled surgeon can make terrible errors if s/he failed to have a clear communication with nurses or anaesthesiologists in the operation. Such ‘cognitive, social and personal resource skills that complement technical skills and contribute to safe and efficient task performance’ are called ‘non technical skills’ (Flin et al., 2008). Training programmes to support NTS improvement have also been developed and implemented in aviation and anaesthesiology (Fletcher et al., 2002).

The importance of NTS is the same in the field of rail operations. Serious incidents often occur because drivers’ non technical skills (NTS) are limited, i.e., easily distracted, not fully aware of the situation, making wrong assumptions etc., rather than as a result of a lack of necessary technical skills. Speeding can happen due to a lapse, where a driver was distracted by something near to the speed restrictions. SPADs can occur due to a slip or mistake, where a driver misperceived a signal and misunderstood the activation of a train protection device. Therefore, a new education programme has been developed which focuses more on human factors perspectives, compared to traditional training, in order to improve drivers’ NTS.

**Framework of NTS education programme for drivers**

Crew Resource management (CRM) training is a pioneering NTS training programme which has simulation as an important component and allows trainees to deal with error-inducing situations to receive effective feedback on their performance (Helmreich, 2000). Our education programme also uses simulators in order to raise drivers’ awareness to error-prone situations and motivate them to learn important NTS through the feedback on their performance.

The framework of this education programme consists of three phases: (1) learning from error experiences, (2) understanding error mechanisms and coping strategies and (3) thinking of their own error-prevention actions. First, drivers go through speeding and SPAD inducing scenarios in simulators, featuring Reason’s three error types (Reason, 1990): lapse in speeding and slip and mistake in SPAD. Then, instructors give a lecture of human factors along with introductory textbooks describing why
people make errors and how we can prevent them. After the lecture with the textbooks, train drivers get ready to discuss error prevention strategies and have a discussion with instructors and other drivers about their own error prevention actions. The detail of each step is described in the following.

Step 1. Learning from error experiences
The education programme has two error-inducing scenarios: Speeding and SPAD.

Development of the speeding scenario featuring a lapse
The speeding scenario is designed to simulate a lapse-inducing situation in driving simulators. The main features of this scenario are illustrated in Figure 1. A temporary speed restriction of 45km/h is set over a station, creating a lapse inducing situation due to interruptions by other tasks, i.e., stopping and departing a station in the middle of the speed restricted section. In addition, an on-demand switch box can make a variety of events happen, such as car trouble, heavy rain, and emergency alarm at station at any timing while a driver is running a train towards the speed restriction. All of these events also function as interruptions and divert the driver’s attention from the speed restriction.

![Speeding Scenario](image)

**Figure 1: Main features of Speeding scenario**

Development of the SPAD scenario featuring slip and mistake
The SPAD scenario is designed to simulate slip and mistake inducing situations. Before describing the SPAD inducing scenario, it would be better to explain an issue on the interface of ATS-P system, identified as an underlying factor for some recent SPAD incidents. ATS-P is widely used in JR East and has a function similar to ETCS level 1 with trackside signals, which sets a brake curve to automatically stop a train and prevent a SPAD even when a driver ignored the stop signal. This system
applies two different types of brake when a train speed exceeded a brake curve: maximum normal brake and emergency brake. The emergency brake is applied for all departure signals but its application to a home signal is limited. It is partly because drivers need to move forward as quickly as possible once it turns green (“proceed”) or yellow (“caution”) after being stopped by a home signal. The brake curve is cleared or updated only after a train passes a beacon, therefore, the ATS-P system sometimes stops a train even after the signal aspect turned green or yellow from red because of the lingering brake curve. Train drivers are allowed to reset the maximum normal brake by themselves while the reset of emergency brake always requires permission by dispatchers in the control room. Before resetting the maximum normal brake, drivers are supposed to reconfirm the signal aspect and other relevant indicators to make sure they can move forward. However, they sometimes misperceive the signal, e.g. seeing a neighbouring signal, and reset the maximum normal brake activated by ATS-P, letting the train pass the signal at danger.

To make a similar situation in a driving simulator, additional line and home signals have been put in next to the original training route (Figure 2). Home signals usually stand at the left side of the line but these are built on the right side because they are located at the end of a left curve, where right-side construction gives better visibility of the signal for drivers passing the curve. This situation entices drivers to see the neighbouring signal and results in confusion with the signal that they are supposed to see. Furthermore, upcoming train movement is added in order to induce an assumption that their signal will turn green or yellow as soon as the train leaves the station. In this scenario, when drivers passed the signal at danger, a neighbouring train approaches from behind. If drivers don’t stop the train immediately after seeing the neighbouring train, the two trains are designed to collide and derail. The detail of the scenario development is described later.
Figure 2: Main features of SPAD scenario

An example of the scenario during simulator training is as follows.

1. A driver receives a call from a dispatcher saying “your train will stop at the next station’s home signal due to a delay of another train dealing with an emergency passenger at the platform you are supposed arrive at.”
2. The driver stops at the next station’s home signal and waits for the other train departing (the driver can see the other train staying at the platform from her/his position).
3. The other train leaves the platform (at this point, the driver tends to expect that her/his route will be cleared as soon as possible).
4. A home signal for the neighbouring line turns yellow (“caution”).
5. The driver misperceives the signal and moves forward.
6. ATS-P activates a maximum normal brake and stops the train.
7. The driver believes that this automatic brake is due to a lingering brake curve and resets it.
8. The driver restarts the train at lower speed so that it won’t be stopped by ATS-P again.
9. The driver passes the home signal at danger.
10. Another train running on the neighbouring line appears from behind and the driver hits an emergency brake to avoid a collision.

For drivers who didn’t make an error, instructors praise their cautious checking and calm handling in the error-prone situation, and encourage them to improve such NTS furthermore. Then, those drivers are asked to run the train on the assumption that they somehow misperceived the signal and think how they would have reacted to ATS-P activation. By letting them go through the situation toward SPAD, instructors can evaluate drivers’ relevant technical and non-technical skills and teach them important points to prevent a SPAD if necessary.

Step2. Understanding error mechanisms and coping strategies
After facing error-inducing situations and having error experiences, drivers learn why they made such errors and how they can avoid them. This step is designed to introduce fundamental human factors behind these errors and coping strategies for each error types. To facilitate their understanding and willingness to learn, HF education materials have been developed in the style of comic books.

Development of HF education materials
Figure 3 shows a part of the HF education materials. They include the following contents to support drivers in understanding human factors issues and tips to take error-prevention actions by themselves:

- Human vulnerability to errors
• Types of human errors and mechanisms
• Coping strategies to each error type

These materials are designed to be used after simulator training to make drivers realise the aim of the simulator training and to be ready for the subsequent discussion with instructors and fellow drivers on error prevention techniques. For example, special emphasis is placed on dangers of assumptions and potential countermeasures to recover from the assumptions in SPAD education. Instructors explain that it becomes difficult to get away from assumptions that they are seeing the right signal and that it is the lingering brake curve that is stopping the train, which can be well understood based on the simulator experiences (Step 1). Then, drivers learn that it is important to change their viewpoints to get away from assumptions and it can be achieved by asking themselves “Am I seeing the right signal?” or by contacting a dispatcher, i.e. having someone else’s viewpoints, to make sure they are doing the right thing.

In addition, drivers learn that there are several opportunities to prevent accidents. The structure of these opportunities can be described in a Swiss Cheese Model (Reason, 1990) with three phases: preventing errors (phase 1), noticing and recovering from errors (phase 2) and mitigating the impact of errors (phase 3). Preventing errors is the most straightforward goal but not the only way to prevent accidents. Even when they commit an error, nothing happens if they immediately notice and recover from it. In case of a SPAD, even when a driver misperceives a signal, a SPAD will not happen if the driver notices that s/he was gazing at a wrong signal by correctly interpreting the activation of ATS-P. Furthermore, even when a SPAD incident actually occurs, it will cause no harm if drivers correctly handle the situation, such as hitting emergency brake and protecting other trains. This lesson widens drivers’ perspectives on error-prevention strategies. In fact, drivers tend to think too much about preventing errors and are not ready for error management without this kind of education.

This step is important because without emphasising human factors issues surrounding drivers’ errors, the main focus of the simulator training could be simply upon whether a driver made an error or not rather than what s/he can do to prevent such errors. If drivers only feel they have been deceived to make an error, they will never be willing to learn from their own errors.
Step3. Thinking of their own error-prevention actions

By this stage, drivers are ready to discuss effective countermeasures to prevent errors from occurring. Instructors facilitate the discussion by asking a series of questions such as what kind of actions they can take to prevent misperception of signals, what could be done to get away from wrong assumptions, why the current rules and procedures are important to follow, and so on. Each driver is encouraged to think of their own error-prevention strategies and put them into their actual behaviours. Since instructors play a key role as a facilitator during the discussion, their understanding of HF is essential. Therefore, we have also developed education materials for instructors as well, which include more detailed descriptions of this education programme and various examples of drivers’ errors.

Effects of this education programme

The education programme for speeding and SPADs has been developed and evaluated in a training centre of JR East. The programme for speeding has been developed first and pilot-tested in 2012. Two hundred forty drivers participated in the pilot test and seventy four drivers (31%) actually experienced speeding in this scenario.

The programme for SPADs is now under construction and in a stage of a pilot test. Sixty two drivers have so far been involved in this simulator training and twenty five drivers (40%) misperceived the home signal, resulting in SPAD in eighteen cases (29%). There were several dangerous cases where drivers misperceived the signal, moved forward, misunderstood the activation of ATS-P maximum normal brake, reset the brake, ran the train at low speed in order not to be stopped again by the lingering brake curve, then passed the signal at danger. It was also revealed how difficult it is to get away from an assumption. Even after drivers noticed that
something was wrong by seeing another train coming from behind, they still tend to believe that they checked the home signal correctly.

Kirkpatrick’s framework for training evaluation (Kirkpatrick, 1979) was used to determine the effectiveness of this education programme, which consists of four evaluation steps: Reaction (Step 1), Learning (Step 2), Behaviour (Step 3) and Results (Step 4). Since Behaviours (Step 3) and Results (Step 4) require a long-term evaluation, this study has measured mainly the first two steps and confirmed the effectiveness of this education programme. A questionnaire for speeding was distributed to drivers before and after (one to two months later) the training. Meanwhile, a questionnaire for SPADs was distributed to drivers on training days, due to time constraints. Self-reported responses were collected in both questionnaires.

**Step 1: Reaction**

For SPADs, a four point Likert scale (1 = agree, 2 = slightly agree, 3 = slightly disagree, 4 = disagree) was applied to two questions measuring drivers’ reactions. The results were very positive with the average of 1.4 (n=42) for a question saying “Do you think you get motivated to learn human errors after this training?” and 1.3 (n=42) for “Did you understand dangers of assumptions?” Some drivers made comments on this education programme as follows: “I realised dangers of making assumptions simply based on my past experiences”, “I learned the importance of asking operators when I am not sure about the situation”.

**Step 2: Learning**

For Speeding, drivers were asked to describe their own speeding prevention actions and human factors experts judged the effectiveness of their actions in terms of error prevention. For example, putting reminders, setting alarms and double-checking were counted as effective measures while keeping themselves alert or disciplining themselves were judged as unrealistic or less effective. The proportion of drivers who take effective measures went up to 69% from 47% after the education (n=32). This effect appears to go beyond learning and bring about behavioural changes. Instructors actually observed some drivers begin to repeatedly speak to themselves about a speed restriction when it comes close, trying to keep reminding themselves of a speed restriction while others changed their confirmation style at a speed restriction to raise their awareness.

For SPADs, two multiple-choice questions were set to measure learning effects of this education. According to the response to a question “What cause will come up to your mind when ATS-P maximum normal brake was activated?”, drivers’ attitudes changed a lot. After training, the proportion of drivers who responded that they would think they might have misperceived a signal went up to 72% from 26%.
while drivers responding that they would assume it as the result of lingering brake curve went down to 26% from 69% (n=24).

As for a question about drivers’ likely reactions to ATS-P activation, a majority of drivers (54%) reported that they were highly likely to reset the maximum normal brake without careful checking before the training and only 18% reported that they were highly likely to confirm the signal aspect and its location once again before resetting the brake (n=42). However, this landscape has dramatically changed after the training, where a vast majority of drivers (67%) responded that they will be highly likely to confirm the signal aspect and the location (n=42).

Conclusion

The education programme for speeding has been rolled out in all twelve training centres of JR East after this evaluation while the SPAD scenario is now under development. This programme provides a good start to make drivers recognise the importance of human factors issues for safe operations and drive them to improve their non-technical skills. To facilitate their learning, feedback from instructors and local managers on error-prevention actions is critical. Thus, it is important to provide further support for those in charge of drivers’ competence to have a deeper understanding of human factors and non-technical skills.

References