Development of Simulator to Jointly Evaluate Train Non-Technical Skills of Railway Staffs using Ergonomics and Virtual Engineering Technologies

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SUMMARY

Railway accidents due to human error continue to increase, and developing technologies that reduce the risk of human errors made by drivers is a global issue. Korea Railroad Research Institute has developed a virtual engineering-based railroad driver cab ergonomics verification simulator for international standards. The simulator's capability has been expanded to jointly train and evaluate integrated Non-Technical Skills (NTS) of drivers, controllers and signalers, such as information exchange and communication in accident/abnormal/emergency situations, to improve railroad staffs' safety duty capabilities. As follow, the paper describes the results of the simulator and our findings.

INTRODUCTION

Railway accidents due to human error continue to increase (more than 60%), and developing technologies that reduce the risk of human errors made by drivers is a global issue. If the cab-driver machine interface (DMI) of railway vehicles is not ergonomically suitable to suitable to driver's physical characteristics, it hinders productivity and can cause accidents. Therefore, it is critical to design an ergonomic driver cab. Therefore, the Korea Railroad Research Institute has developed the virtual engineering-based railroad driver cab ergonomics verification simulator for international standards from 2001 to 2016, and it is have been applied to the field sequentially according to a development plan since 2013. Since 2014, the simulator's capability has been expanded to jointly train and evaluate integrated Non-Technical Skills (NTS) of drivers, controllers and signalers, such as information exchange and communication in accident/abnormal/emergency situations, to improve railroad staffs' safety duty capabilities, and it is currently testing in field by railroad operation organizations.

DEVELOPMENT OF SIMULATOR To JOINTLY EVALUATE TRAIN NON-TECHNICAL SKILLs OF RAILWAY STAFFS USING ERGONOMICS AND VIRTUAL ENGINEERING TECHNOLOGIES

Existing mock operation testers or simulators are designed and built to feature handling/control equipment/devices in actual vehicles, and as hardware and training cannot be modified due to the equipment being physically fixed, simulators for each vehicle must be prepared and operated. Existing mock operation testers or simulators are developed for the purposes driver training, so cannot perform DMI suitability or performance verification, and suitability verification is not possible during the design stage.

As a driver cab is not easy to modify when DMI issues are identified during the manufacturing stage, technology to evaluate and experience DMI in a virtual environment from the design stage is necessary. By utilizing railroad-specific virtual modelling (VE, Virtual Engineering) and human engineering methods to perform ergonomic designing of driver cabs including the driver-driver cab interface (DMI), visibility and equipment positioning, and technology verifying and evaluating design suitability on a simulator according to international standards (UIC, EN, ISO) and Korean railroad vehicle safety standards was developed (2011-13).

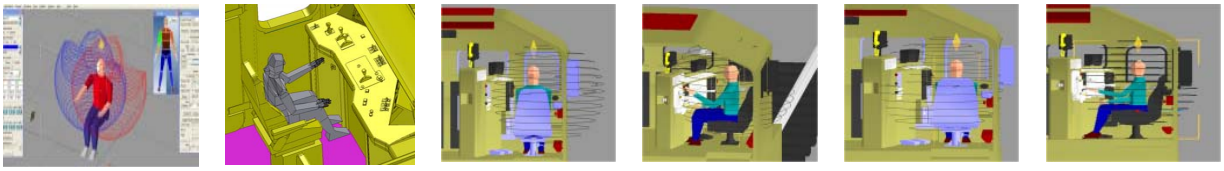

Figure 1. Examples for virtual modelling (VE, Virtual Engineering) and human engineering methods

The UIC international project (UIC Asia project on the layout of drivers' cab in Asian rail vehicle, 2013-2015) to establish a guideline for an ergonomic driver cab design suitable to driver's physical characteristics by utilizing this technology was conducted, and its research outcome is utilized.

[UIC APRA Study Result Verification]

Figure 2. Guideline for an ergonomic driver cab design

Vehicle driver cab design and verification technology with human engineering and virtual engineering technology is realized as a variable operation simulator via touchscreen panel to...

- •Stage 1: Model driver cabs on a simulator using a design library
- •Stage 2: Perform design verification of driver cab simulator based on international standards and Korean railroad vehicle safety standards
- •Stage 3: Feedback technology reviewing driver cab suitability through test operations using the simulator

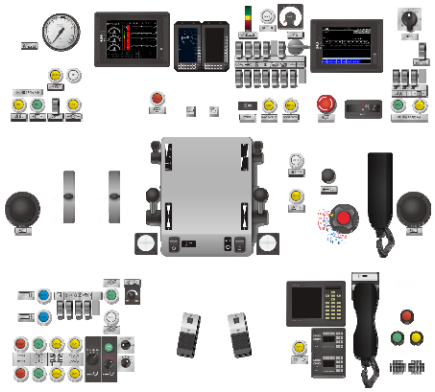

Figure 3. DMI design library of driver cab simulator

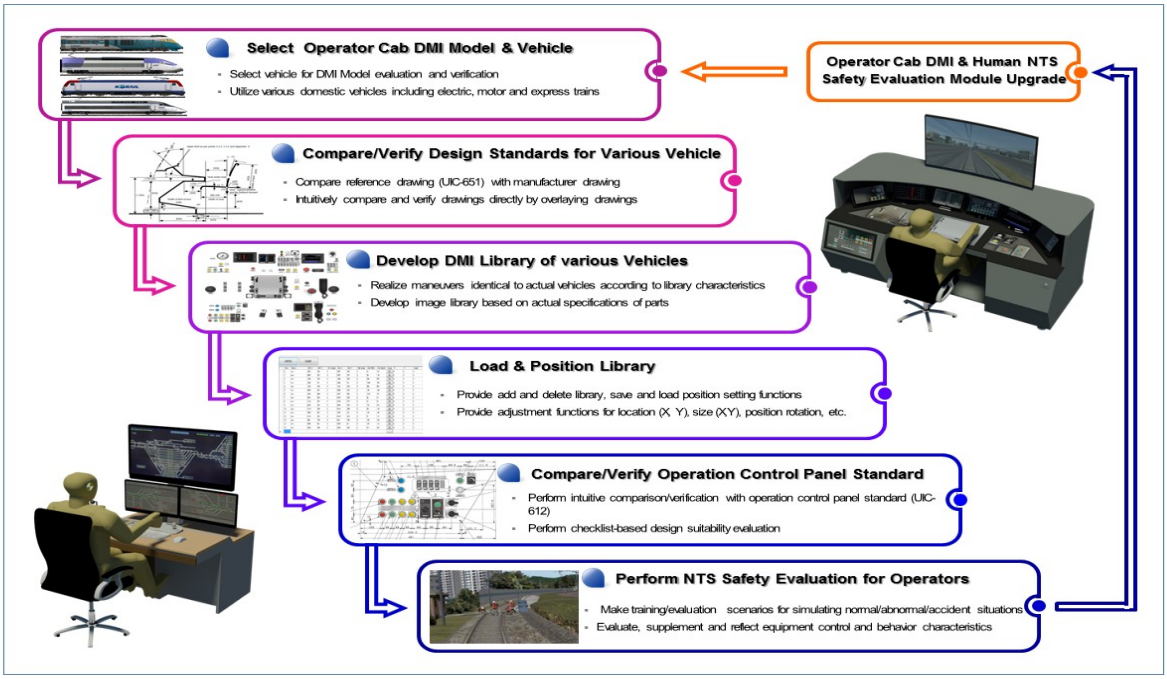

Figure 4. Vehicle driver cab design and verification with human engineering and virtual engineering technology

Through the stages above, the design completeness is improved in the design stage by conducting test operation and virtual engineering before development, and a technological solution capable of verifying vehicle driver cab design suitability against international standards was developed (2015), and the developed technology is currently utilized to evaluate the ergonomic design suitability of vehicle driver cabs according to Korea's Railroad Safety Act.

Figure 5. Train Vehicle Type Approval Operator Cab Design Standard Acceptance Limit Interpretation

Various handling/control equipment/devices are modelled as objects with virtual engineering (VE) based on a vehicle driver cab component library (DB) and route operation status library (DB), allowing a wide range of operation simulation scenarios with various routes and vehicle type combinations. Existing driver cab devices can be utilized or new driver cab devices can be designed and stored by utilizing the driver cab DMI library on the simulator, and stored models can be loaded to develop a new driver cab model. Ergonomic design suitability of driver cab layouts based on international standards (UIC, EN, ISO) can be evaluated in the design stage, allowing easy identification of nonconformities and prompt improvement. The selection/handling/operation of various equipment/devices through touchscreen operation are automatically recorded, objective evaluation of safety response capabilities according to layout based on acknowledgement/response data analysis can be performed, and human error/violations can be characterized.

Recent railroad accidents occur mainly due to human factors (error/violation) caused by a lack of non-technical skills such as situational awareness, risk acknowledgement, safety regulation compliance, communication, collaboration, etc., rather than mechanical defects/breakdowns or lack of skills/techniques in operation and control. Currently, training and work practice is performed according to a system focusing on individual work classified by drivers, crew, controllers and signallers selected to take charge of operation safety in their respective sector. Evaluation and joint training in group (team) for situational awareness, risk acknowledgement, decision making, regulation compliance, information exchange, communication and work collaboration in various accident/abnormal/emergency situations are not performed, and there is no program that verifies NTS-based human performance. Independent simulators for driver license and controller qualification procedures are used, but only training and evaluation of technical subjects such as handling/controlling and measures for operating or controlling based on their individual functions. There is no mock experience simulator and human performance verification program capable of performing joint training and evaluation of NTS-based safety work such as information exchange, communication and work collaboration among railroad operation staff (drivers, crew, controllers, and signallers).

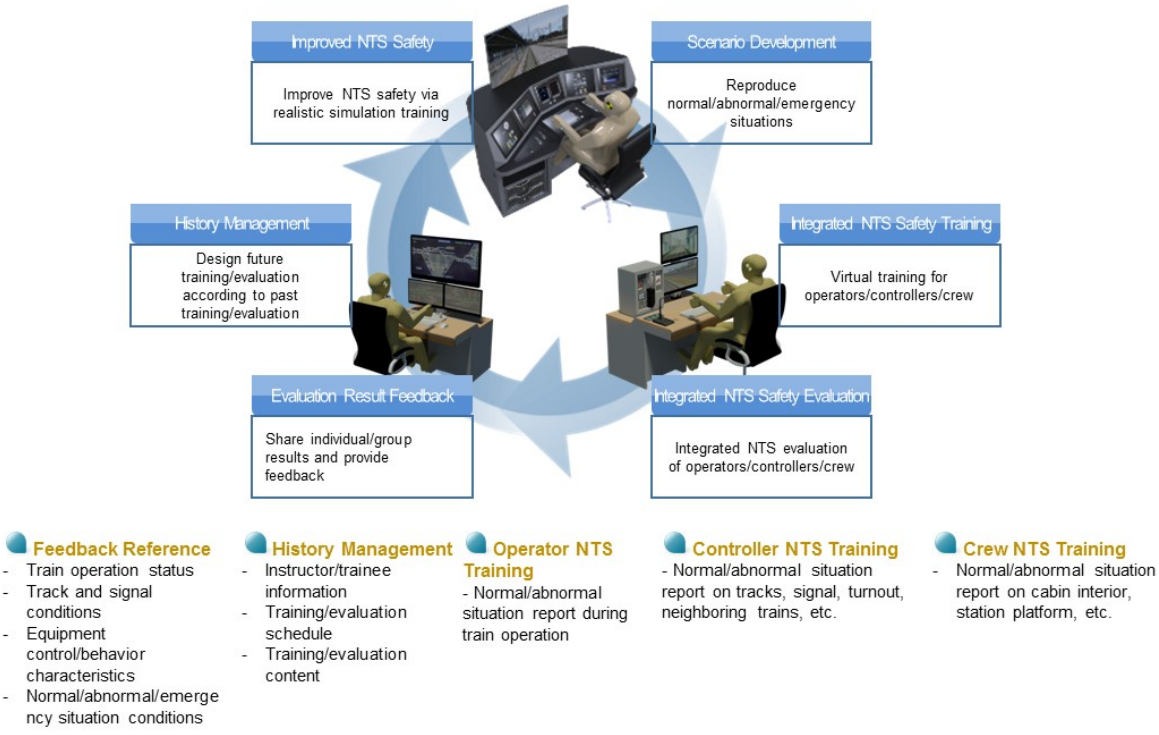

Figure 6. Simulator to Jointly Evaluate Train Non-Technical Skills of Railway Staffs

Since 2014, the simulator's capability has been expanded to jointly train and evaluate integrated non-technical skills of drivers, controllers and signallers, such as information exchange and communication in accident/abnormal/emergency situations, to improve railroad staffs' safety duty capabilities, and it is currently testing in field by railroad operation organizations.

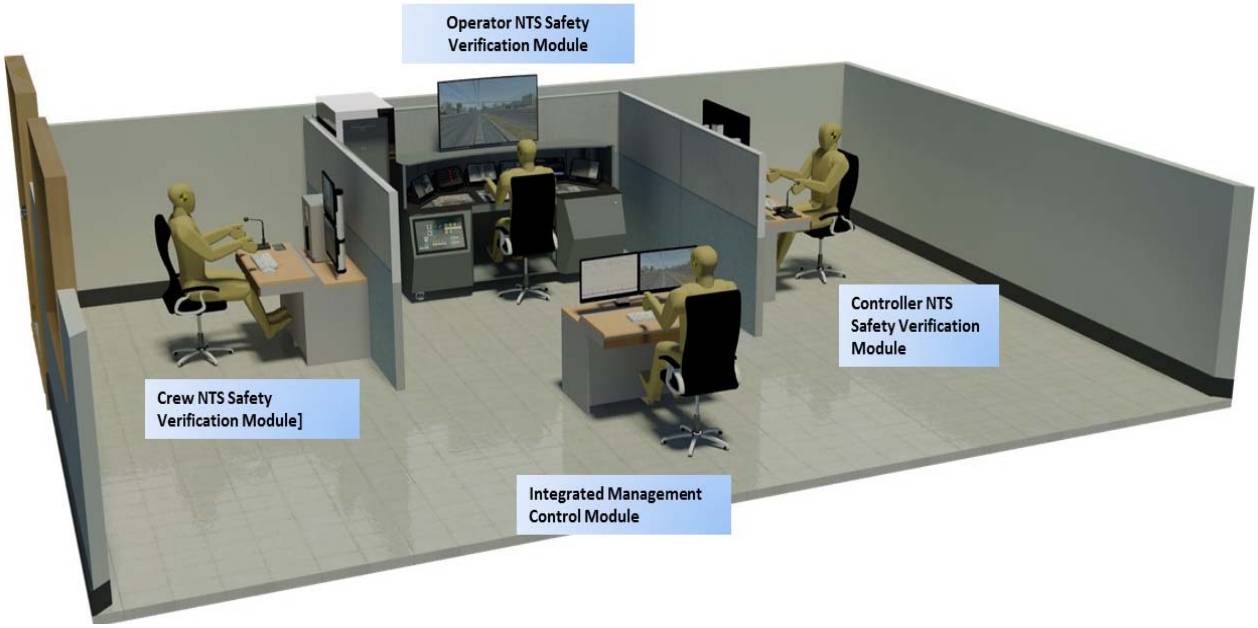

Figure 7. Modules of Simulator to Jointly Evaluate Train Non-Technical Skills of Railway Staffs

This technology provides the following to railroad operation staff (drivers, crew, controllers, and signallers). It provides mock experiences and training for railroad accidents and hazards with a desired vehicle type and route simulated using virtual engineering of the training and evaluation simulator. It performs joint training and evaluation of collaborative work performance of group (team) risk anticipation, information exchange, communication and work collaboration in normal/abnormal/accident situations. It verifies the human performance of non-technical skills such as situational awareness, risk acknowledgement, decision making, regulation compliance and work load management during individual work performance. The technology aims to improve the individual/group capacity of work safety performance.

CONCLUSION

Ergonomic Design Suitability Evaluation Technology, driver Cab Ergonomic Design Suitability Evaluation Technology based on International Standards developed starting from 2011 and Variable Operation Simulator Technology are installed in the Korea Railroad Research Institute, and they have been used since 2015 in the driver-driver cab interface (DMI) evaluation during railroad vehicle type approval according to Korea's Railroad Safety Act to identify ergonomic design nonconformities, and they have been receiving high regards from railroad operation organizations and developers. In addition, the technology has contributed to securing safety against human error based on virtual engineering in railroads with various demonstrations, including a Ministry of Science, ICT and Future Planning demonstration event in 2016.

The human error reduction effect of 2015 achieved by this technology was quantitatively and qualitatively measured by the NASA Task Load Index method developed by NASA in the United States and the Trace-R method developed in the UK. In case of the diesel-electric vehicle improvement plan, it was able to achieve a significant reduction in human error (an 82% reduction), and new electric vehicles also achieved a reduction (a 66% reduction). Human engineering equipment, such as eye trackers, is used to measure improvement effects, and in practice, significant improvement is achieved in eye movement, cognitive load, situational awareness, etc. compared to existing designs. In 2016, joint training for railroad operation staff (drivers, crew, controllers, and signallers) was implemented, and its outcome is continuing to prove the excellence of the technology.

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