

27th International Railway Safety Council

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

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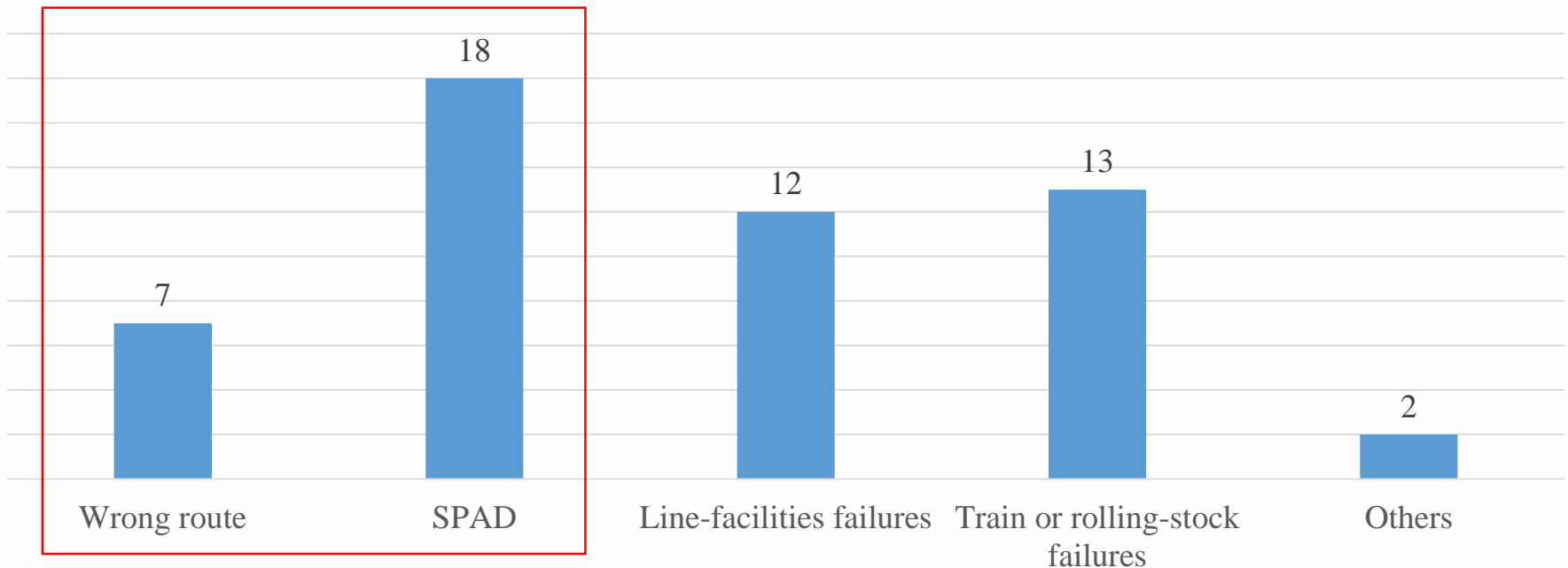
- **Human error accounts for a great portion of railway accidents.**
 - ▣ Developing technologies that reduce the risk of human errors made by drivers is a global issue.
- **If the cab-driver machine interface (DMI) of railway vehicles is not ergonomically suitable to drivers' physical characteristics,**
 - ▣ Hinders productivity and can cause accidents.
 - ▣ Critical to design an ergonomic driver cab.



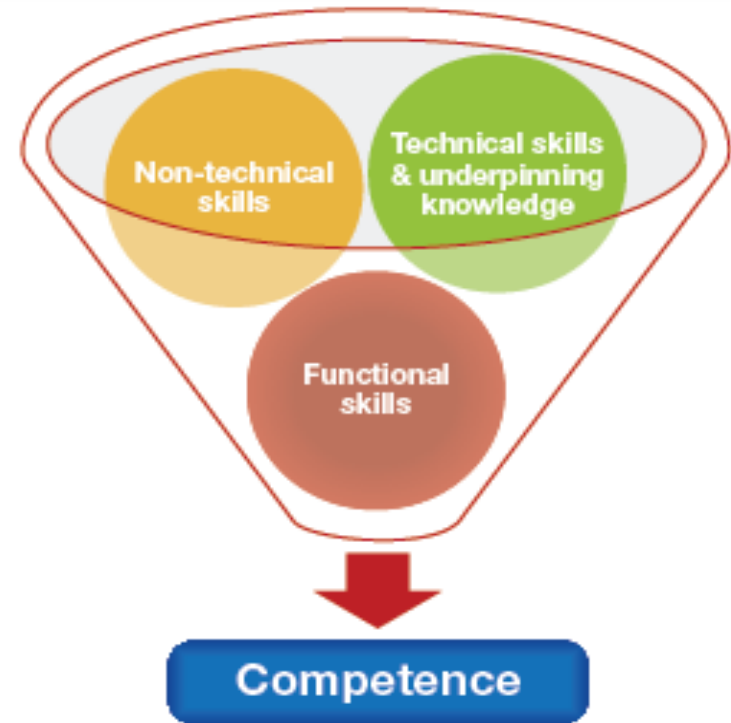
The human factor (error or violation) plays a key role in the recent Korea railway accidents

- Lack of failure identification and risk monitoring for the railway vital safety equipment
- Insufficient sharing of safety information and changes such as a train service and maintenance schedule
- Insufficient communication among a train driver, traffic controllers and field workers
- Absence of practical training and assessment on human performance for train operation route check

Number of major collision and derailment accidents in Korea railway from 2007 to 2014



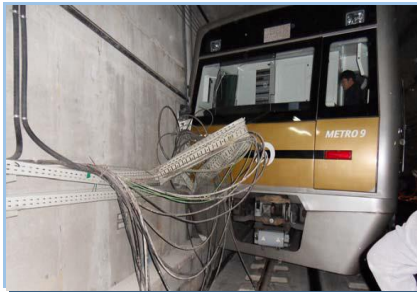
- **Technical skills and underpinning knowledge:** practical skills combined with the knowledge needed to practice them.
- **Non-technical skills (NTS):** cognitive, social and personal resource skills that contribute to safe and efficient task performance and complement technical skills.
- **Functional skills:** practical skills in language, numeracy, and information and communication technology (ICT).



*(in RSSB's Railway Safety Publication 1 (RSP1)
Developing and Maintaining Staff Competence)*

- **The hazard analysis consistently shows that absence of NTS actually plays a key role in railway accidents.**
 - ▶ NTS could be considered as a ‘thinking skills’ related to how risks can be managed.
 - ▶ In the process of developing the NTS skills, staff can learn how to deal with various hazardous situations, including situations that are more novel.

Non-technical skills (NTS)



Situational awareness

Conscientiousness

Communication

Decision making and action

Cooperation and working with others

Workload management

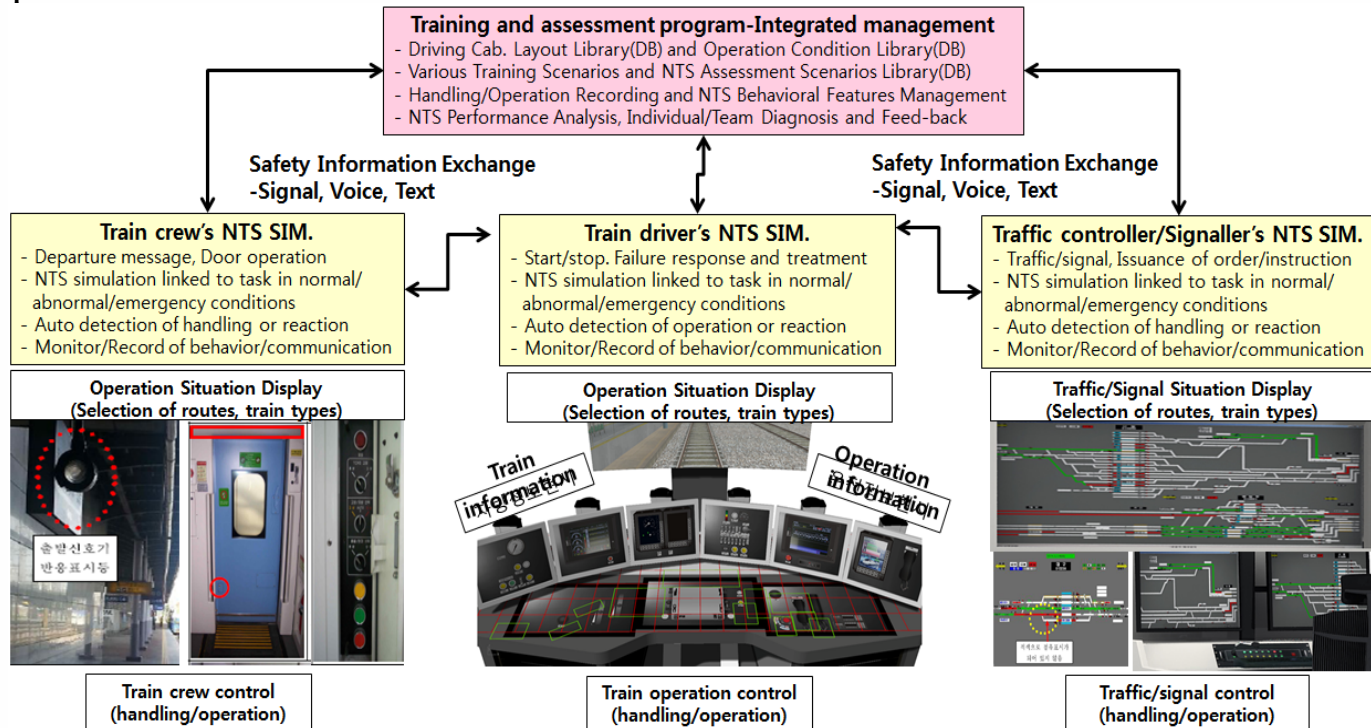
Self-management

- **Korea railway has a qualification system only for the driver and traffic controller.**
 - ▶ Qualification process contains a physical examination, aptitude inspection, task training and field placement.
 - ▶ But cooperative training program including NTS does not exist, such as mutual communication, exchange of information and collaboration with others, etc.

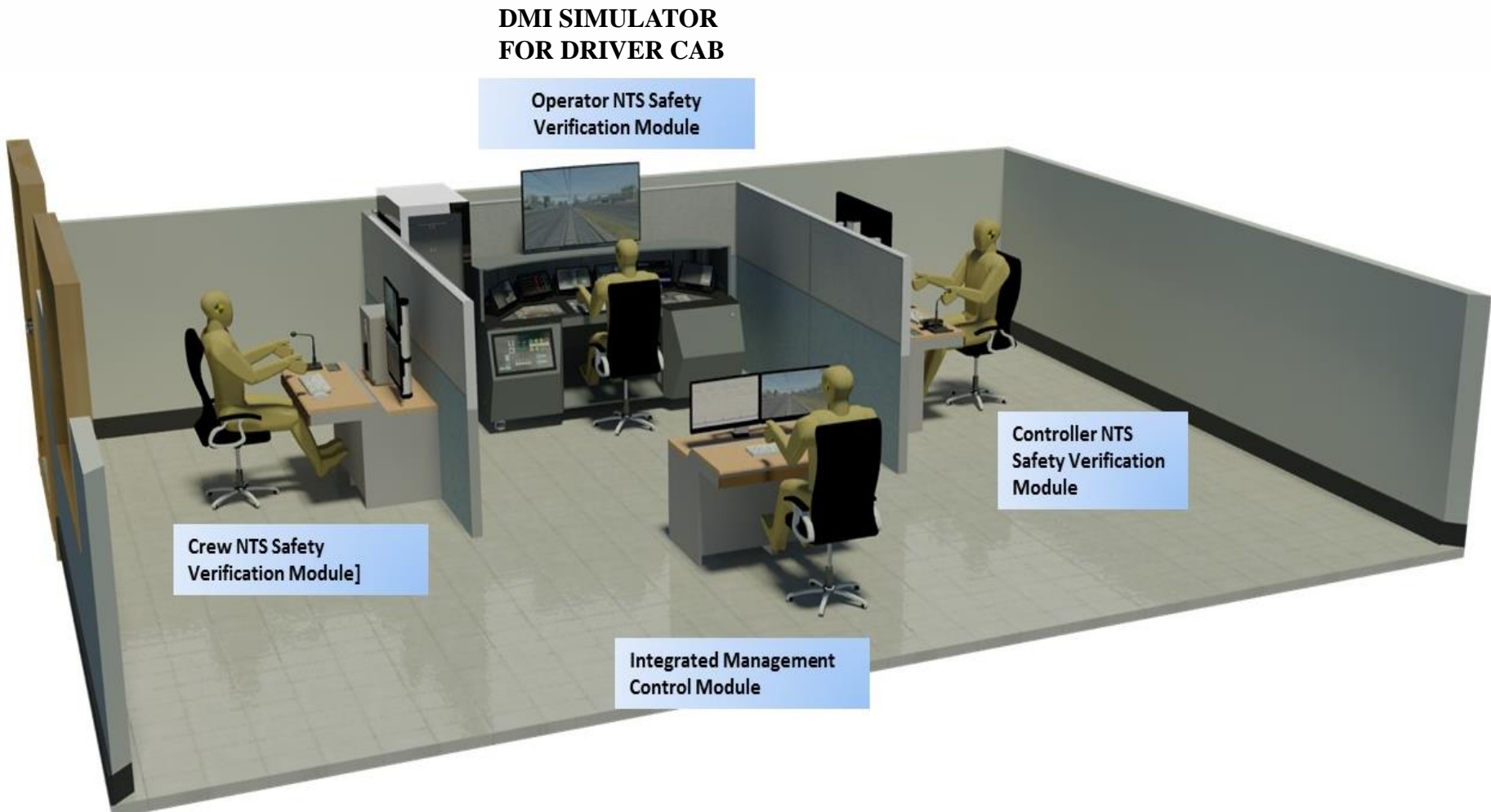


We develop...

- Virtual engineering-based railroad driver cab ergonomics verification simulator for international standards
- Simulator to assess individual and cooperative Non-Technical Skills
 - Scenarios for NTS training and assessment in the various accidents and hazardous situations
 - Simulation modules for NTS training and assessment in normal, abnormal and emergency response conditions



- The NTS training and assessment simulation system consist of three individual simulation modules and an integrated management program.



EXISTING MOCK OPERATION TESTERS & SIMULATORS

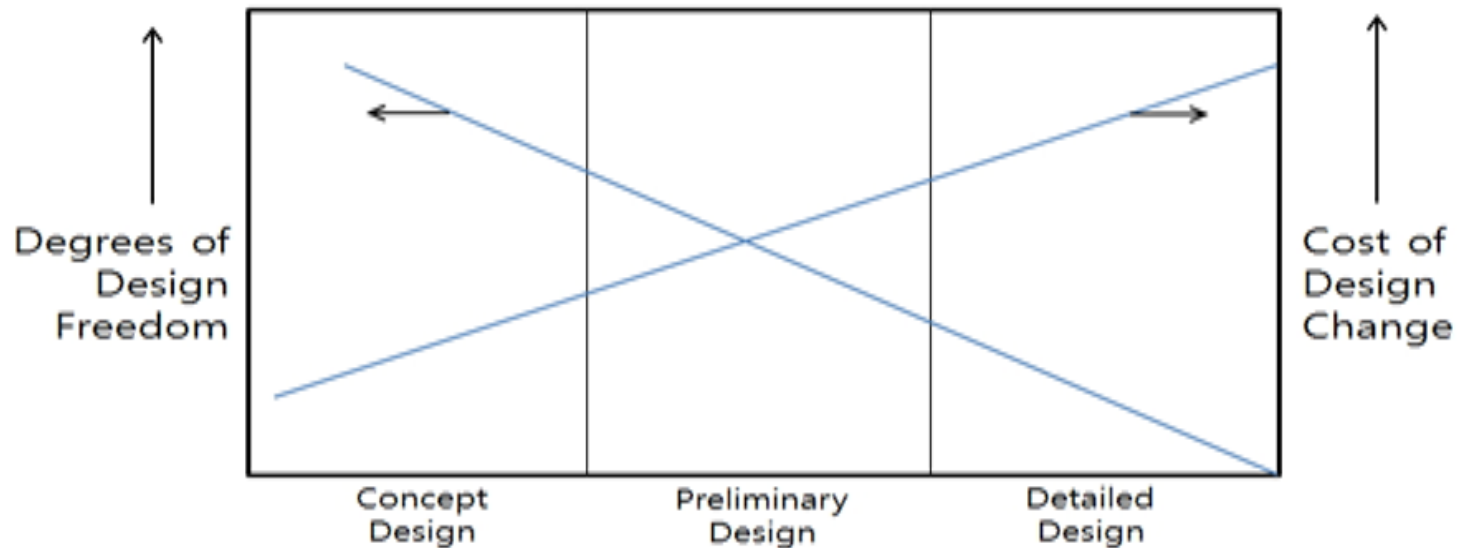


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- Designed and built to feature control equipment and devices in actual vehicles
- Difficult to be modified due to the equipment being physically fixed
- Developed for the purposes of driver training
 - ❑ Cannot perform DMI suitability or performance verification
 - ❑ Suitability verification is not possible during the design stage.



“Design alternatives cost less and have a great potential influence during concept design”

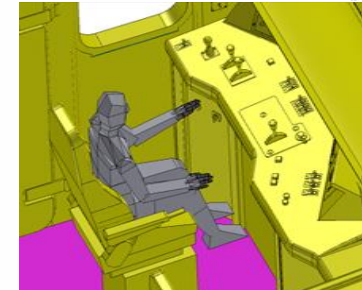
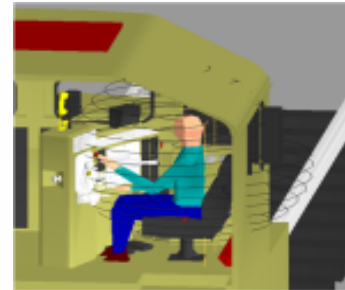
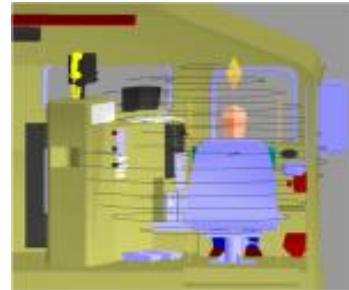
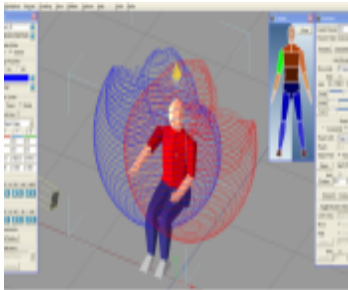


▣ **“Technology to evaluate and experience**

DMI (Driver Machine Interface) in a virtual environment

from the design stage is necessary”

- Developed according to
 - Korean railroad vehicle safety standards
 - International standards (UIC, EN, ISO)
- Utilizing
 - Railroad-specific virtual modelling (VE, Virtual Engineering)
 - Human engineering methods



- Performs
 - Ergonomic designing of driver cabs including the driver-machine cab interface (DMI)
 - Visibility test and equipment positioning
 - Technology verifying and evaluating design suitability

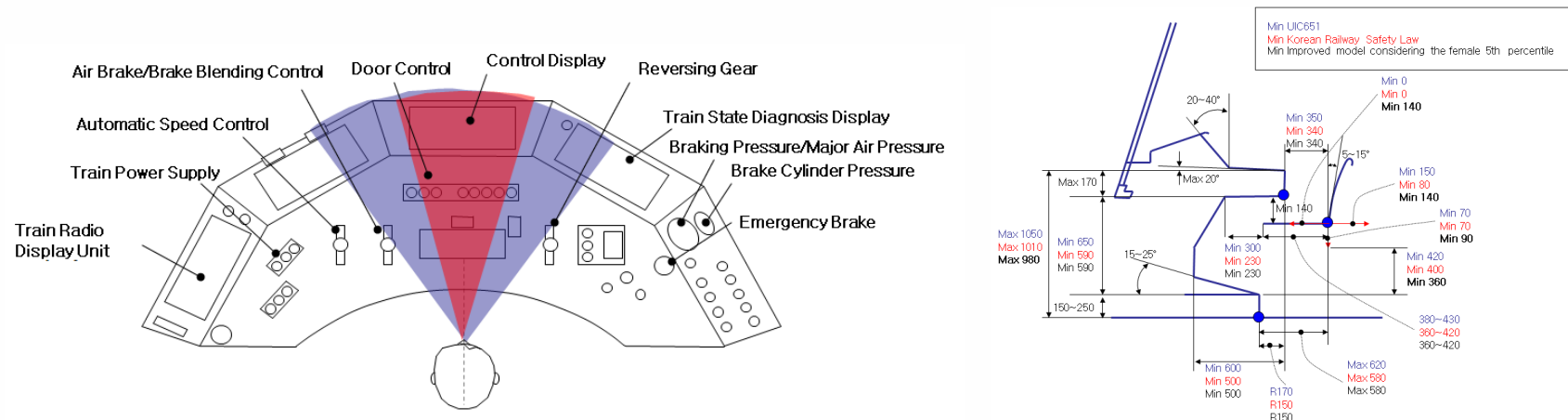
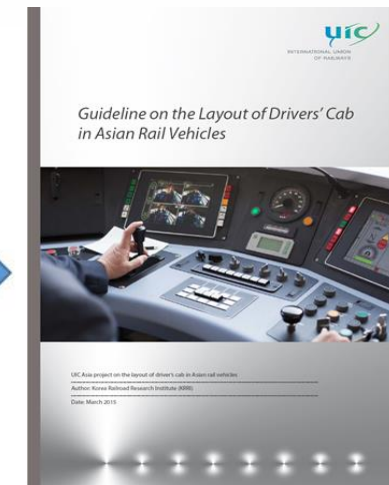
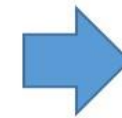
GUIDELINE FOR AN ERGONOMIC DRIVER CAB DESIGN



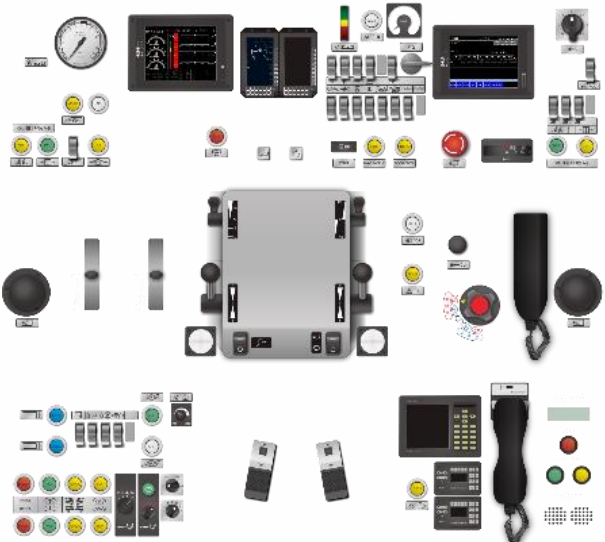
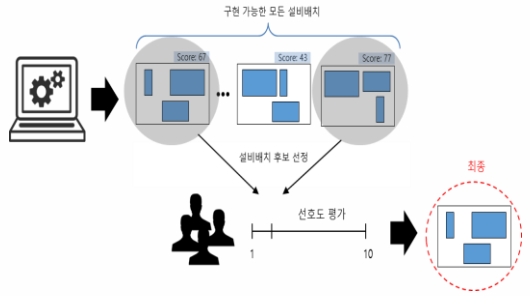
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The simulator's technologies

- Used in “UIC Asia project on the layout of drivers' cab rail vehicle”
- Establish a guideline for an ergonomic driver's cab design suitable to driver's physical characteristics



- Using human engineering and virtual engineering
- Realized as the DMI simulator for driver cab 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
 - Korean railroad vehicle safety standards
 - Stage 3: Feedback technology reviewing driver cab suitability through test operations using the simulator



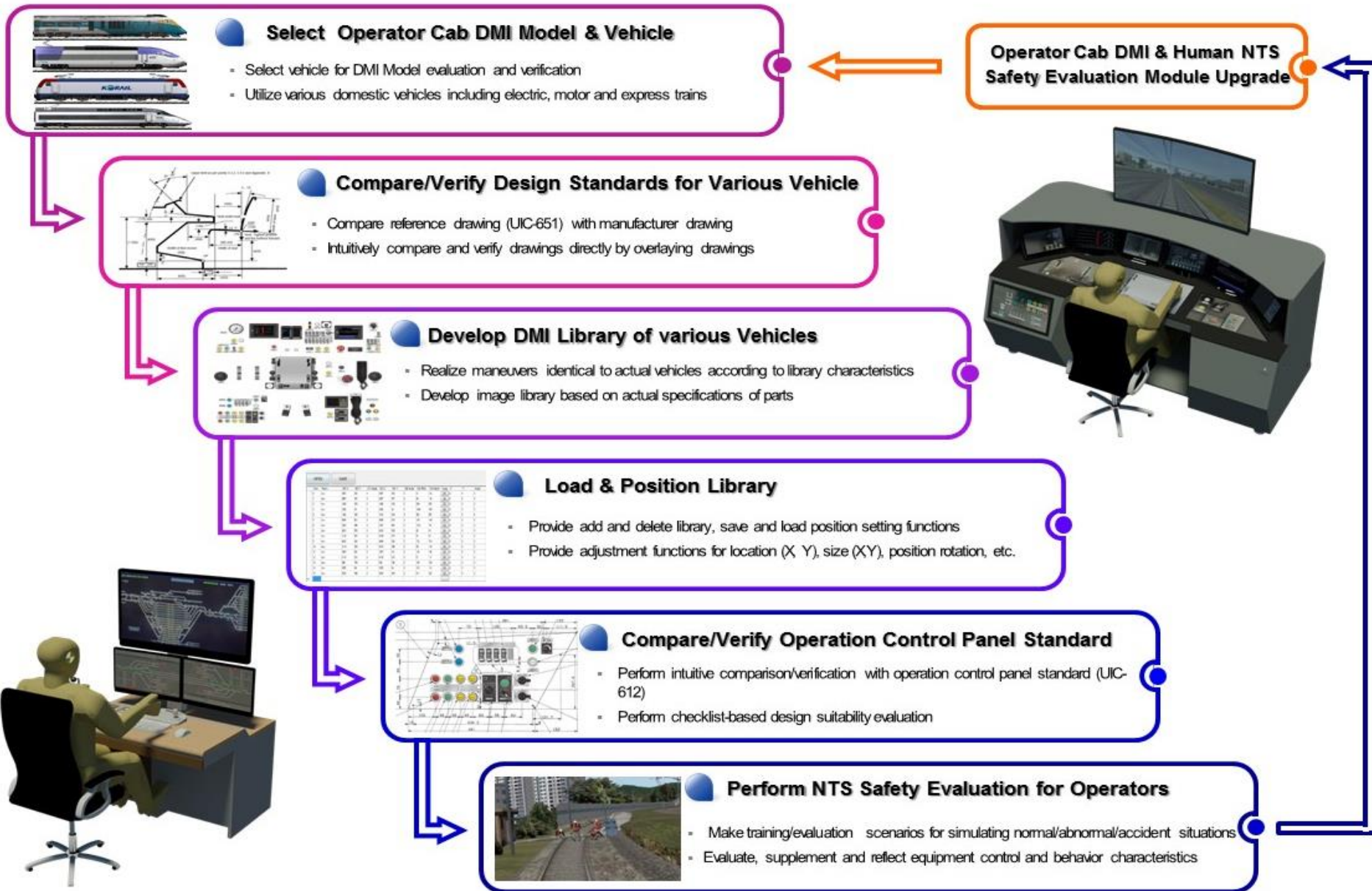
DMI design library



DRIVER CAB DESIGN & VERIFICATION TECH.

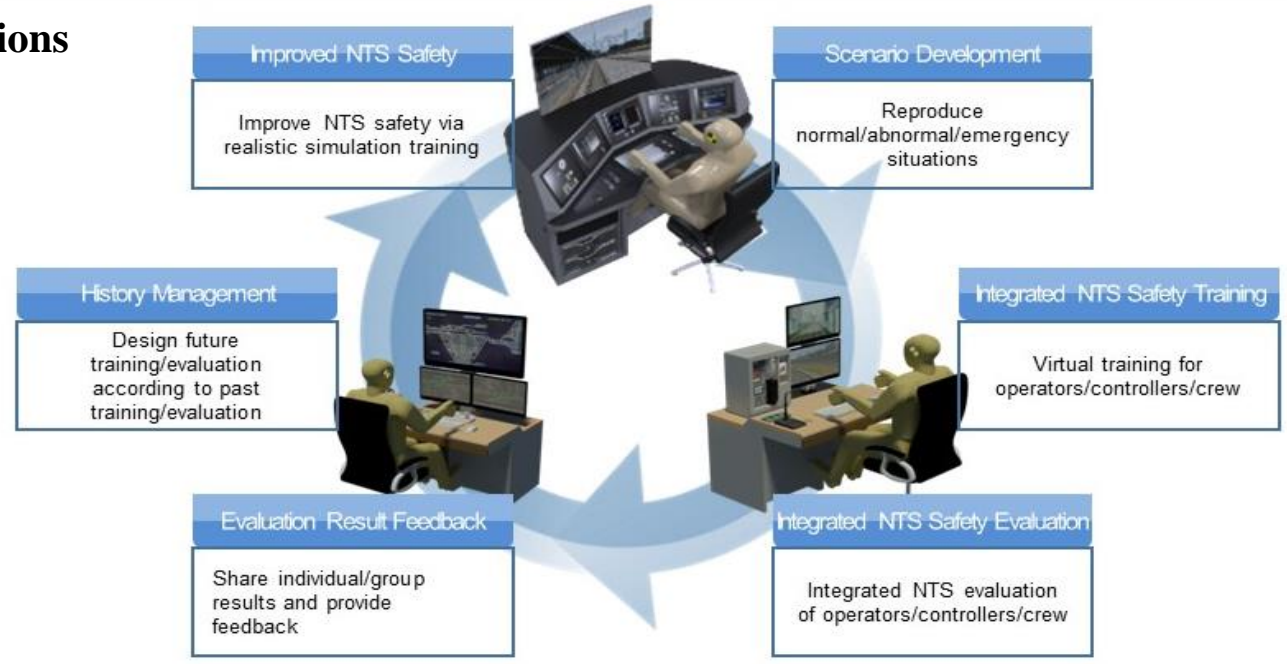


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The simulator's capability has been expanded

- ▣ To jointly train and evaluate integrated NTS of drivers, controllers and crews
- ▣ To improve railroad staffs' safety duty capabilities
- ▣ Such as information exchange and communication in accident/abnormal/emergency situations



- Feedback Reference**
- Train operation status
 - Track and signal conditions
 - Equipment control/behavior characteristics
 - Normal/abnormal/emergency situation conditions

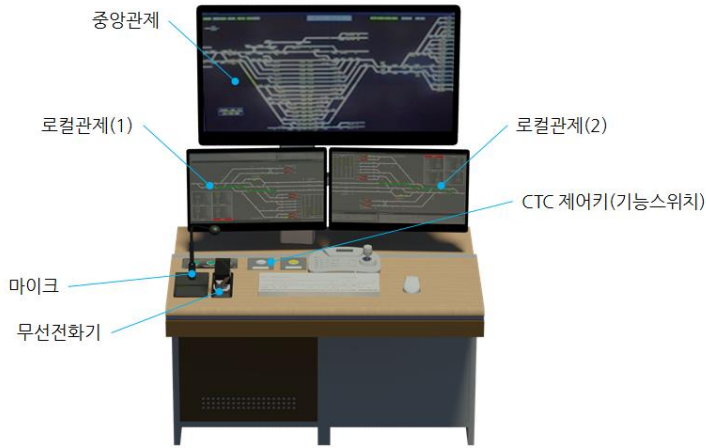
- History Management**
- Instructor/trainee information
 - Training/evaluation schedule
 - Training/evaluation content

- Operator NTS Training**
- Normal/abnormal situation report during train operation

- Controller NTS Training**
- Normal/abnormal situation report on tracks, signal, turnout, neighboring trains, etc.

- Crew NTS Training**
- Normal/abnormal situation report on cabin interior, station platform, etc.

- Implementation of Virtual-Engineering Objects (shape, function and effect) for equipment or display in driving cab, traffic control installation and for train crew's devices
 - Driving and control equipment in driving cab, operation state and related information display
 - Train crew: train departure message (signal post, sign, marker, response lamp, etc.), door operation handling
 - Traffic and signal control, confirm and deliver of operation order, instruction or message

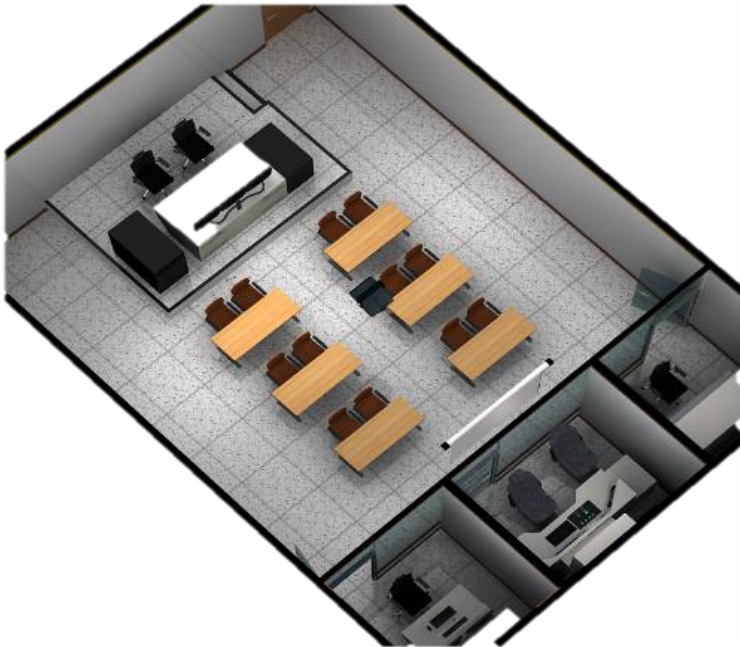


Controller NTS Safety Verification Module

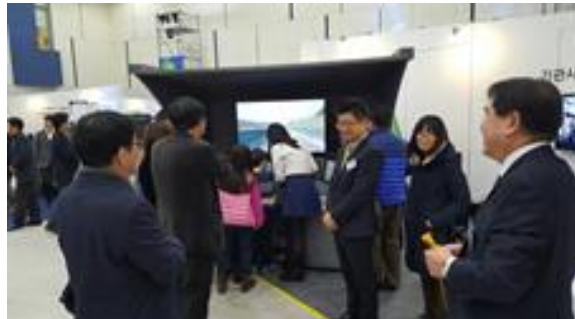


Crew NTS Safety Verification Module

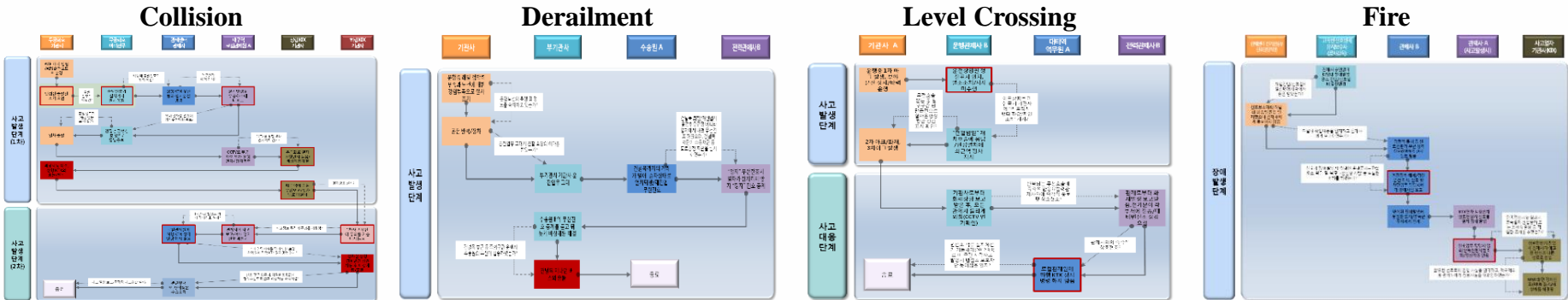
- **Implementation of Auto-detection and recording for operation, handling, reaction and information exchange**
 - ▣ **Auto detection of operation and handling and recording of confirm and reaction by touch screen**
 - ▣ **CCTV monitoring of all behavior and voice recording for communication or information exchange**



- **Driving Cab Layout Library (Data-base)**
 - ▣ Select a type of train, depending on for training purpose
 - ▣ For example, high-speed train (KTX), urban-transit train (VVVF), Diesel or Electric Locomotive, etc.
- **Line Operation Condition Library (Data-base)**
 - ▣ select a route, operation situation or safety equipment etc., depending on for training purpose
 - ▣ Operation route or line: selection of track, station, switch, level-crossing etc.
 - ▣ Occupation and protection for train or work
 - ▣ Blocking (automatic or alternative), interlocking (entry and exit, branch or crossing)
 - ▣ Signal or instruction for start, stop, shunt, delay, stand-by, change of route or order etc.

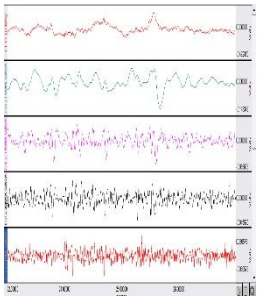


- **Scenarios** for NTS training and assessment for various accidents and hazardous situations
 - ▣ In normal, abnormal and emergency response conditions
- NTS training and assessment **simulation modules** for each and team staffs
 - ▣ Individual training modules
 - deal with situational awareness including hazard identification
 - ▣ Team (joint) training module
 - address an information exchange, communication and work cooperation etc.
- Human performance **verification and management** program
 - ▣ Performance measurement for individual and team
 - ▣ Vulnerability analysis
 - ▣ Proposal for improvement, competence verification and feed-back management etc.



< Examples of NTS training scenarios for train accidents >

- The human error reduction effect was quantitatively and qualitatively measured by the NASA Task Load Index method and the Trace-R method
 - ▣ Achieve a significant reduction in human error
- 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



평가 방법 및 지표	기존 배치	개선 배치
AOI에 대한 시선 고정 비율	15.8%	11.2% (개선)
속도를 위반한 상태로 주행한 시간	10.2분	8.8분 (개선)
속도를 위반한 상태로 주행한 거리	35.7km	24.9km (개선)
신호를 놓친 횟수	1.2회	0.9회
NASA-TLX	86.3	74.1 (개선)
SART	6.62	7.02 (개선)

The developed NTS simulator ...

- **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**
- **Performs training and evaluation of performance of collaborative works such as**
 - ▣ **Risk anticipation, information exchange, communication**
 - ▣ **In normal/abnormal/accident situations**
- **Verifies the human performance of NTS such as**
 - ▣ **Situational awareness, risk acknowledgement, decision making, regulation compliance and work load management**
- **Improves the individual/group capacity of work safety performance**

Thank you for your attention !!

