Deliverable 3.7.4/T2.7.4

METHODOLOGY FOR USE OF RAILWAY SIMULATORS

Leading partner:

TTK / Tallinna Tehnikakõrgkool /TTK University of Applied Sciences

Project partners:

KRAO / Kouvolan Rautatie ja Aikuiskoulutus OY

TSI/TTI / Transporta un Sakaru Instituts / Transport and Telecommunication Institute

HAMK / Hämeen ammattikorkeakoulu /Häme University of Applied Sciences

RTU / Rigas Tehniska Universitate /Riga Technical University

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Content list

1. Introduction[1]

Simulators are safe and sustainable facilities for teaching students. Realistic scenarios can be created with them without endangering environment, infrastructure and people. Different malfunctions and faults can be simulated on them that may occur very seldom in real life. Thus, by using simulators, malfunctions and situations can be created when needed and can be thoroughly analysed and solved. The following deliverable has been prepared by TTK, KRAO and RTU, as partners having railway simulators and substantial simulation know-how.

The railway simulator in TTK University of Applied Sciences was founded to introduce the simulator users (students) to today's high-tech railway infrastructure and signalling solutions, and to teach the overall principles of this technology on real railway operation situation. The railway simulator enables to represent and simulate all the railway signalling components, starting from interlocking the main systems up to the whole subsystem, level crossing technology, Hot-Box detectors, ALSN code systems and on-board ATP systems. In the future, it is planned to upgrade the simulator with ERTMS/ETCS simulation technology. The simulator is designed for studying railway infrastructure technology, starting from beginner level up to cases when it is needed to increase the qualification of today´s signalling and automatisation engineers.

KRAO has, in its current training centre, renewed the old SR1 (VR Groups locomotive series) type electric locomotive simulators to new SR3 (VR Groups locomotive series, Siemens Vectron) electric locomotive type simulators. The new learning environment includes 6 new compact simulators, 6 Nano simulators and an observer wall. This new environment gives totally new possibilities for teaching and compiling the theoretical studies with tasks of the new simulator "world".

[1] Access to full text, which is reported in the Internal working document 3.4.1, may be applied from TTK UAS or from responsible partners – KRAO and RTU.

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RTU has the simulator of interlocking system Ebilock 950 and Siemens–MPC–MZ-F interlocking system. Students and trainees have the opportunity to work and perform several test tasks on simulators.

2. Use of Railway Simulators in Study Process in TTK

2.1 Railway Simulator in TTK

One part of the railway simulator is a model railway (1:87 scale) of one station of the main track. This model gives a good overview to students about the functionality of station route table and the functionality of outdoor infrastructure components in station. The station model can be simulated with interconnection to the main system for creating abnormal situations, component failures and their impact to the main functionality of the entire system.

With failure simulations, restrictions to traffic capacity can be evaluated, and the main activity rules in case of failures understood. It is possible to perform the following laboratory works:

1. interlocking system architecture and work principle
2. subsystem integration
3. interface, failure save interface
4. point machine and components
5. track vacancy detection systems functionality and function principles
6. level crossing system functionality, architecture and integration depending on system location
7. failures in subsystems
8. interlocking power systems
9. signals
10. Hot-Box system functionality
11. adjustment of the subsystems and restarts, rules and restrictions
12. radio and telecommunication systems on the railway infrastructure
13. high-speed railway

The study program in TTK University of Applied Sciences is built up so that beginners who have interest in railway signalling technology will get their initial knowledge and know-how of the railway automation environment. They will get the first overview of railway technology and begin to understand the practicalities of railway infrastructure. Through performing practical tasks in the laboratory, they will be introduced to the functionality of the system and the real size of railway environment. They will also learn to understand the main railway hazards and rules to avoid them.

For applied engineers, training courses at TTK UAS offer practical knowledge about subsystem integrations, finding failures and principles of localization, as well as knowledge on dealing with general errors, principles of system upgrades and new legal regulations in Estonia and in the EU.

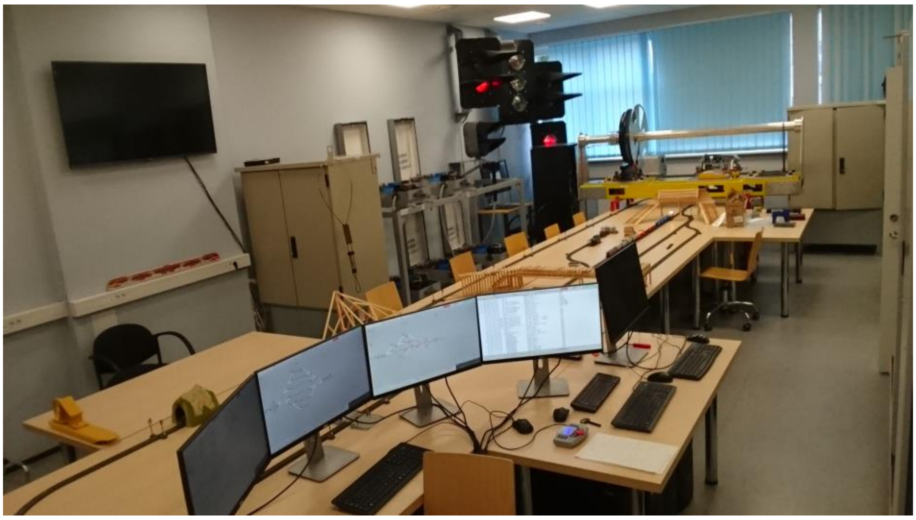

Fig 1. Main interlocking simulator

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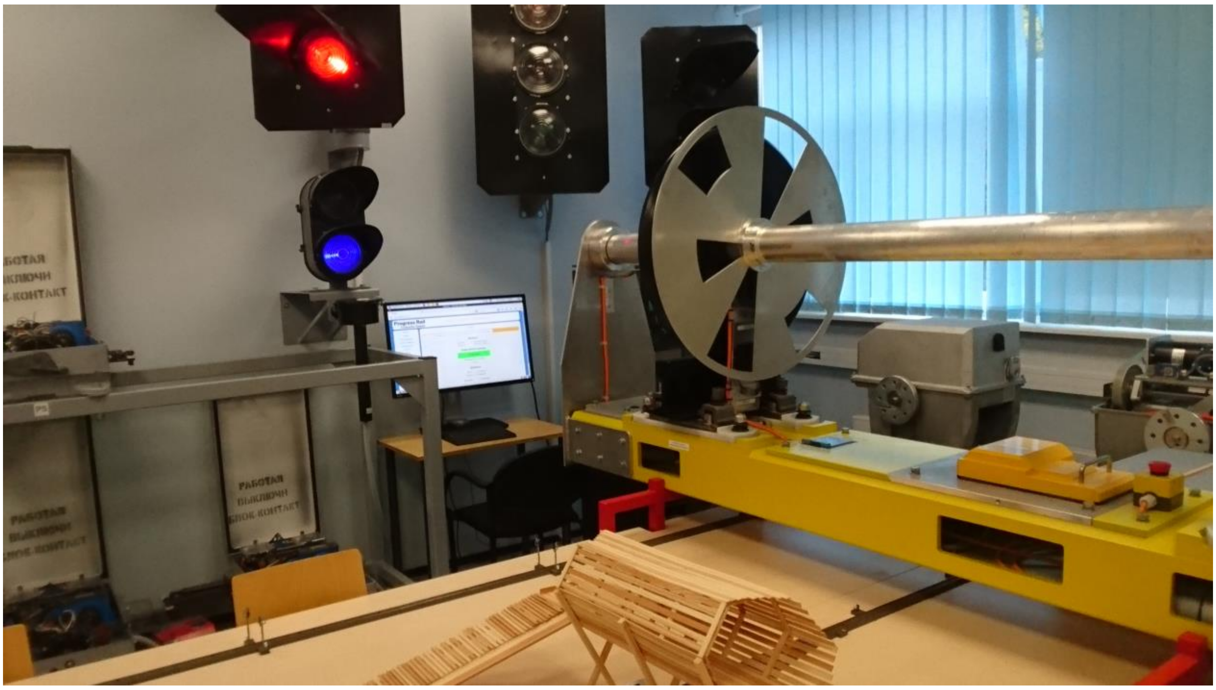

Fig 2 Hot/Box and Hot wheel detector

2.2. Learning the Signalling Manual and Principles of Railway Signalling

Required Prerequisites for Qualification and Education

As the main activities of a railway signalling engineer will be carried out in an electrified environment, it is required that the students of railway signalling and technology have fundamental knowledge about handling of low power electricity. They must have first basic knowledge about the hazards of the electrified environment and must understand the basic rules about electro-mechanical subjects.

The students who are interested in increasing their qualification should have previous practical experience and knowledge about railway signalling technology. The qualification can be raised according to the Estonian occupational qualifications system. The rise in qualification requires good knowledge about signalling roles and legal requirements, as well as of international standards like CENELLEC.

The training is divided into individual and group work. Individual study usually covers the acquisition of knowledge about unplugged safety system components and subsystems, and work with drawings and documentations. The group work tasks cover practical team works on the real system and on the study process.

By using the train driver simulator, it is possible for students to illustrate the signals given in the signalling role manual (https://www.riigiteataja.ee/aktilisa/1180/7201/5006/lisa1.pdf#), their location and meaning. In the simulation, it is possible to move the train to the desired location, to a signal or a mark, and to clarify why a particular signalling element is necessary. It can also be illustrated in the ALSN system, the signals of which light up in the driver's console depending on the signals outside on the track.

In addition, the simulation can illustrate the interdependence of signals. In other words, in the simulation, it is possible to see two traffic lights simultaneously and show how the traffic lights depend on each other. That is, what is the signal in a traffic light if there is, for example, a yellow signal in the next (or previous) traffic light.

If the illustrative part of the simulation is in a virtual environment and with variable routes, it is also possible to display different signals of the main traffic lights (entrance and departure traffic lights) depending on the train's route.

It is also possible to explain to the students the principles of train traffic and shunting, and how the shunting work is carried out in the railway station. In addition, it is possible to play different shunting scenarios and explain why the shunting process takes so much time.

Figure 3. Stadler FLIRT rail simulator in TTK

On the driver's desk, the ALSN on-board ATP system VEPS has been installed, which is a common ATP system used in Estonia. The ALSN code system ensures that the information about outdoor traffic signals will be converted to the driver cabin and that driver vigilance will be continuously monitored.

2.3 The Dependency Table for the Design of Railway Stations and the Illustration of Potential Traffic Hazard Situations

The teaching practice in design of railway stations has shown that simple presentations and illustrative schemes do not make the design requirements understandably clear for all students. This is especially true for students with non-railway background. Therefore, it is necessary to bring the students to the real environment, where it is possible to simulate different situations and possible traffic light layouts.

It is possible to illustrate in a driver's simulator why the train station dependency table complies with the requirements that it has. It is possible to outline the principle of hostile routes – e.g. why it is not possible to let two different trains through one track simultaneously and to receive or send trains on crossing routes, etc. In addition, it is possible to bring the student to the real environment of the station and to the station neck, where it is possible to explain in a graphic way why the traffic lights are intended to be located so far from the points. It can also be explained why the shunting signals must or should not be placed between the points in station necks.

In the subjects where electronic interlocking structure is explained, the students will get an overview of how the station field elements must be placed to ensure the traffic reliability and safety in case of the station's outdoor and/or indoor equipment failure. By using the simulator, route principles and hostile routes can be evaluated. The simulator also enables to learn about hazard situations and the methodology to avoid them.

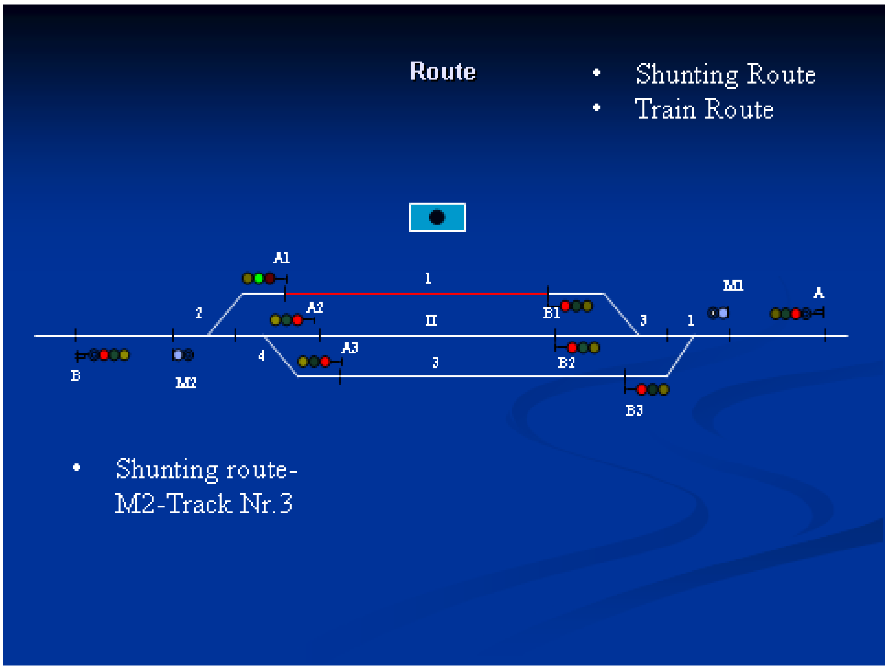

Fig 4 Routes and conflicts, hostile routes

2.4. Train Driver as the Ultimate Element of the Railway System, Who Should Prevent Possible Traffic Hazards

The driver must be extremely attentive and watchful during his entire work shift. This is especially the case in traffic disruptions where automation and traffic control devices fail and the train traffic is carried out through verbal and/or written permits and the point-signal interoperability dependence does not work. The driver is in the real environment and sees the actual position of the signals and turnout points. The actual signal indication or the turnout point position may be either invisible for the traffic controller or simply unnoticed for various reasons. There can be as many different hazardous train traffic situations as there are points and signals in a station. Therefore, two situations in which a driver can intervene and prevent a possible traffic hazard are outlined:

1. There is a train in the station and waiting for the departure. The train driver hears from the radio how the station manager/train dispatcher is contacting another train that is arriving, that the train will be taken into the station with a verbal permit because the entrance signal cannot be opened due to a malfunction. Due to the number of the train to which the command was issued, the train driver in the station understands from which direction the train is arriving to the station. If the driver sees that some of the station's departure lights are allowing departure for another train and the route is set to the same direction/track from which the train is arriving at the moment, the train driver should immediately interfere via the radio; inform the traffic manager and, in this case, the driver of the arriving train about the hazardous traffic situation. The case described is one example of a neglect by a traffic employee or a serious failure of a station interlocking device and it is one example how and when train drivers (even those that are not directly influenced) should interfere.
2. In a small railway station, where there are only the main and side tracks, it is necessary to do a manoeuvre for the train from one track to another. There are no shunting signals in the given station, or they cannot be used, and the shunting is carried out by voice communication transmitted by radio. The station traffic manager or dispatcher orders the driver to make a shunting carried out through the neighbouring "X" station's neck with passing the signal with the name "B2". In the actual situation, however, the signal at the neighbouring "X" station end is named "A2", and the signal

"B2" is at the "Y" station's neck. At first glance, this command is correct, but in this situation the driver needs to specify the command given by the traffic organizer. That is because the signal, which the driver was allowed to pass, is not in the station's neck that was discussed earlier.

3.1 Use of Railway Simulators in Study Process in KRAO[2]

KRAO has, in its current training centre, 13 driver simulators. KRAO has renewed 6 of old SR1 (VR Groups locomotive series) type electric locomotive simulators to new SR3 (VR Groups locomotive series, Siemens Vectron) electric locomotive type simulators.
KRAO has also renewed the learning environment in total. The new learning environment includes 6 new compact simulators, 6 Nano simulators and an observer wall. This new environment gives totally new possibilities for teaching and compiling the theoretical studies with tasks of the new simulator "world".

Fig. 5 Diesel engine simulator driver desk

[2] Full text is reported in Internal working document 3.4.1

Fig 6. Siemens Vectron driver desk

Fig 7. Nano simulator

3.2 Training Simulation

A training simulation is a virtual medium through which various types of skills can be acquired (see KRAO Module 2, deliverable 2.5.1, chapter 2.2).

The use of simulators is particularly useful for training in abnormal working conditions or for rules infrequently applied. They have a particular advantage in their ability to provide learning-by-doing capability for events that cannot be trained in the real world. Training simulations can be used in a variety of genres; however, they are most commonly used in different kind of scenarios which are made beforehand (KRAO has about 20 different scenarios in driver training). The word simulation implies an imitation of a real-life process, usually via a computer as Compact simulators and Nano simulators or other technological devices (i.e. Advance Notice System, in Finnish *Kupla* (kuljettajan päätelaite, see picture), in order to provide a lifelike experience. This has proven to be a reliable and successful method of training. They can be used both to allow specialization in a certain area, i.e. shunting yards, harbours, factory yards and to educate individuals in the workings of the sectors in main lines, making training simulations versatile. Training simulations are not just games, their aim is to educate and inform in an exciting and memorable way, rather than purely to entertain.

The Community’s railways require infrastructure managers and railway undertakings to establish their safety management systems in such a way that the railway system is at least able to achieve the common safety targets and comply with the national safety rules and safety requirements defined in the technical specifications for interoperability (TSIs) and that the relevant parts of the common safety methods are applied. These safety management systems provide, among other things, for staff training programs and systems, which ensure that staff competence is maintained, and that duties are performed in an appropriate manner. KRAO uses simulations as a tools to teach students. When a certain task is learnt in theory, it is also practiced with the simulator. It is important to practice the skills learnt immediately afterward in real (simulated) railway environment, so that the transfer of learning is more efficient. Some simulations are focused on making the right decisions in a particular area of the railway, especially when driving different kind of trains (e.g. passenger trains, freight trains, etc.), and on how to do shunting works, how to use brakes and brake trains in certain place, how to operate with or without ATP, different kind of malfunctions, hazards, accidents.

The focus should be directed towards everyone gaining some useful and relevant knowledge that they can take away and use in their daily lives.

Driver courses that contain a training simulation integrate it into an existing training program. This allows the participants to get the maximum value from the experience, as well as review the sessions to improve them for future use. The structure of a training session would normally be as follows:

Briefing/ Introduction:

Instructor or administrator of the program (plus sometimes a specialist in the training simulation) will meet the trainees and give them a brief explanation of the purposes behind the training and what they should hope to achieve.

Scenarios:

In KRAO, a new learning environment – an observer wall, gives the instructor a possibility to supervise (see picture: observer wall) every trainee's progression in simulator training. Sometimes the trainees will also receive one or more scenarios around the topics that the simulation will be based on, to give them an idea of the type of skills they will need. This is especially important in training centre, when students will be examined on this section after the event. Normally the instructor makes his/her own remarks during driving session, and gives feedback after the session. If necessary (not after every driving session), the instructor asks a trainee to give his/her own feedback. Usually the feedback is given after the content of the entire module or task has been learnt.

Fig 8. Observer wall

Pop-Up Resources

When creating an exercise, the instructor or administrator can make different kinds of pop-up windows into the exercise, as explained below:

The R^3 program also allows you to add as much pop-up content as you wish to your exercises, either via:

- Movies,
- Sounds,
- Pop-up windows,
- quizzes or
- slideshows

This pop-up layer will help be particularly useful to:

- share information with trainees
- introduce the context of an exercise
- warn trainees
- test trainees' knowledge
- show them procedures
- etc.

To easily manage all these pop-up resources, we developed a dedicated menu aptly called *Resources*. The chapters below will help you manage this database from A to Z.

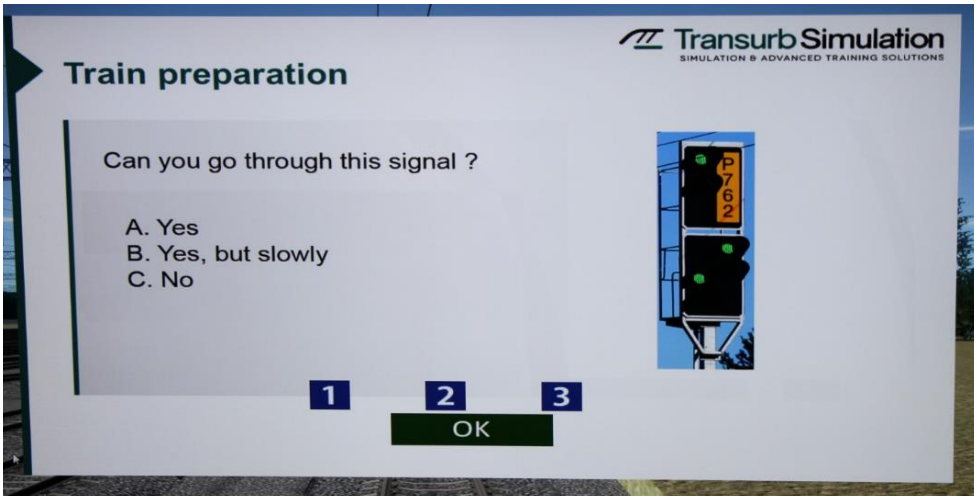

Fig 9. Example

The simulation will then be played, allowing newly acquired knowledge to be tested and skills practiced. A positive atmosphere is vital here to maintain enthusiasm.

3.3 Evaluation

KRAO has its own evaluation process and file in Optima environment. It is currently used in/after a practical training, but is going to be used also in simulator training.
Once the simulation has been completed, it is important to summarize what has been learnt and the effectiveness of the training. Presenting results to others may provide a means of internal assessment, as well as showcasing student achievements. This integrated training will allow everyone to take part in the simulation to get the maximum experience, at the same time being entertaining, exciting, and giving learners a new perspective on the railway world.

4. Use of Railway Simulators in RTU

RTU has developed the simulators for the interlocking system Ebilock 950 and Siemens–MPC–MZ-F interlocking system. The students and trainees have opportunities to work on the simulator and perform test tasks.

Fig 10. Interlocking simulators in RTU

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