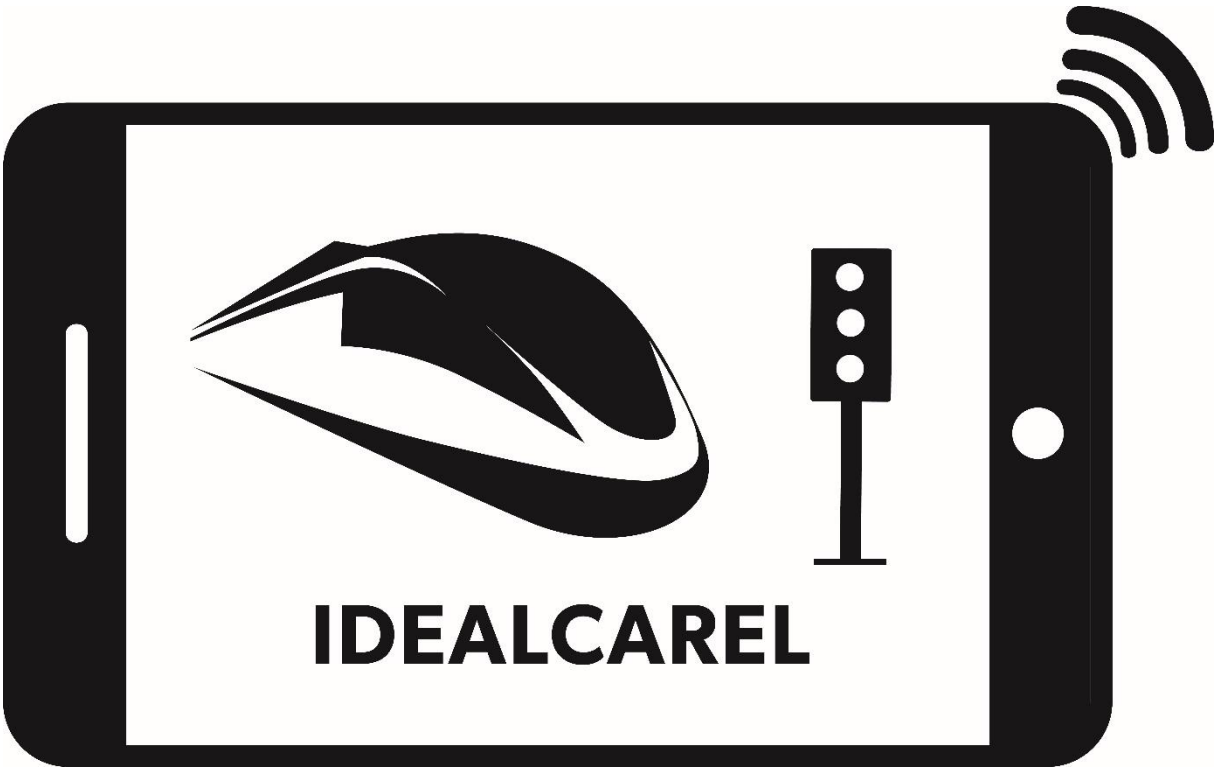
Institut für Eisenbahnwesen und Verkehrssicherung IfEV TU Braunschweig

ŽILINSKÁ UNIVERZITA V ŽILINE
Fakulta prevádzky a ekonomiky dopravy a spojov



Inclusive Digital Education and Laboratory training by Connecting Academic Rail Educational Laboratories

Erasmus + Strategic Partnership

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Intellectual Output: 03 Railway Laboratories

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Index

Organisation:

University	Institute	Abbreviation	Country
TU Braunschweig	Institute of Railway Systems Engineering and Traffic Safety	TUBS	Germany
University of Zagreb	Faculty of Transport and Traffic Sciences	UNIZG	Croatia
University of Žilina	Department of Railway Transport	UNIZA	Slovakia

Authors:

Name	Organisation
Jörn Pachl	TUBS
Simon Söser	TUBS
Kesting Volker	TUBS
Borna Abramović	UNIZG
Denis Šipuš	UNIZG
Martin Starčević	UNIZG
Jozef Gašparik	UNIZA
Jaroslav Mašek	UNIZA
Juraj Čamaj	UNIZA

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Introduction

This report explains the technical backgrounds of the developed teaching materials and how to use them. Furthermore the activities that have been carried out through Intellectual output are described. This document includes also a suggestion for a generic exercise about railway operations.

Intellectual Output 3 consists of the documents:

- Operational rulebook
- Generic introduction to interlockings
- Survey

The operational rulebook and the generic introduction can be downloaded from the IDEALCAREL homepage: www.idealcarel.eu

1. General and purpose of this document

The three documents of the Intellectual output 3 are public documents, they are published as OER teaching material on the Erasmus results homepage, the homepage of the IDEALCAREL project and via the participating institutions. This technical reports explains how the documents have been developed and tested. The understanding and background of the documents should be support the users of the documents. Furthermore all actions that have been carried out under IO 3 are described in this document.

2. Rulebook

2.1 Relevance of the rulebook for laboratory sessions

A railway system consists of three essential elements. The first is the infrastructure with the tracks, the signalling equipment, the stations, and - on electrified lines - the catenary or third rail system for power supply. Second, there is the rolling stock with all kinds of rail vehicles. Infrastructure and rolling stock represent the 'hardware' of a railway system. A third element of every railway is a system of operational rules and procedures for a safe and efficient operation. These rules and procedures may be regarded as the 'software' of a railway. Although it is not to be seen, this element of a railway system is of the same importance as infrastructure and rolling stock. The core element of the operational rules is the rulebook containing the train control rules.

This is also true for controlling train traffic in a laboratory session. Here, we have two essential problems. Firstly, the rulebooks have reached a very high degree of complexity. That degree of complexity is simply a result of the historical development. The operational rules are closely connected with the development of signalling technology. The introduction of a new generation of interlocking and block systems did never result in a complete replacement of the older systems. Today, on many European railways, the signalling technology in use represents a variety ranging from mechanical interlocking systems developed in the late 19th century, electro-mechanical systems mainly installed in the 1920s-1940s, relay systems from the 1960s and 1970s, up to the latest computer-based interlockings (CBI) from today. So, the systems still in use cover more than 120 years of railway signalling history. The requirement to have a rulebook covering all these technologies has significantly contributed to the current situation.

Secondly, the operational rules may differ extremely between individual countries. In particular, this is an issue in the Western and Southern part of Europe, while Eastern European railways achieved a higher degree in the harmonisation of operating principles. This is mainly a result of the membership of most East European railways (except the railways of former Yugoslavia) in the OSJD, which is the organisation of cooperation of railways (Russian: ОСЖД - организация сотрудничества железных дорог) of the former Eastern block countries. In Western Europe, a similar organisation did never exist, so the degree of standardisation in operating and signalling rules is lower than in the Eastern part of Europe. There are not even commonly accepted definitions for basic operating terms. These national differences make cross border operations complicate. While with the ETCS (European Train Control System), the railways will finally reach interoperability of the ATP systems, the operational rules are not harmonised. Even on ETCS lines, the operational rules would still change at national borders.

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2.2 Objectives and challenges

For international laboratory sessions, it's almost impossible to train the students in the complex operating rules of different national railway systems. For efficient international teaching, we need a common rulebook that can be used for sessions with different national laboratories. The rules may differ from the traditional rules used in a particular country but should allow to control train traffic in any of the laboratories. For efficient teaching, the rules should be kept as short as possible. This can be achieved by using a purpose-based rule design, which is quite different from the traditional action-based rule design still used today by many railways. The principle of action-based rule design is that for a given situation or for a task the user has to perform, all dos and don'ts are listed, i.e., all actions that must be taken and all actions that must not be taken. The idea behind that principle is that the dos and don'ts will always keep the user on a safe path. Even if the user has a limited understanding of the system, no accidents would occur as long the dos and don'ts are not violated. That often also leads to a teaching culture in the qualification of the operating staff that concentrates on providing rule knowledge.

Such a teaching culture does not fit to university teaching where the objective is to provide a profound understanding of the system. What students need is not rule knowledge but systems knowledge. This can be achieved by a purpose-based rule design. The idea behind purpose-based rule design is to explain the purpose of a rule, i.e., the hazard that is to be prevented by applying that rule. Then, the user is free to take appropriate action to meet the protective intention of the rule. The dos and don'ts are not directly given but left to decision making by the user. The idea behind that principle is that no accidents would occur as long the actions of the user do not violate the protective intention that is described by the purpose of the rule. This requires a completely different teaching culture. The training of the operating staff concentrates on providing a profound understanding of how the system works. It's not mainly about rule knowledge but about systems knowledge. The philosophy behind this approach is that the better the user understands the system, the fewer rules are needed. The rules more or less define just a safety relevant frame for the actions of the user. Also, by a purpose-based rule design, the size of the rulebook can be significantly reduced. That will save the students a lot of time for getting accustomed with the rules.

A specific challenge was to establish definitions for operating terms that would work in different national systems. Typical examples are the separation between station areas and the open line and the distinction between train movements and shunting movements. Since on many national railways, these traditional terms are a key element of the operating culture, they cannot simply be ignored. An example of how we solved that problem, is the solution we found for the separation between station areas and the open line. Railways that have that separation usually classify the operational role of signals that control train movement in conjunction with that separation. So, there may be 'home signal' to enter a station area from the open line, 'intermediate interlocking signals' to govern a train from one station track into another, 'station exit signals' to leave a station track onto the open line, and 'block signals' to protect train movement on the open line. The names for these signal may even differ in the rules of individual railways. To overcome this, we classified signals in just two categories: controlled signals and automatic signals. Controlled signals are all signals that are cleared by route setting of the operator. That are all signals that protect points and crossings. Automatic signals are

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controlled automatically by the trains moving along the line. Those signals just protect a section that does not contain any points or crossings. By that classification of signals, we can define a station track as a track protected by controlled signals on which trains may originate, terminate, pass, and turn. Then, a station area is simply a track layout consisting of station tracks. In this generic form, the definition would fit everywhere.

On many railways, the separation between station areas and the open line is relevant for shunting rules. Shunting movements may enter main tracks only in station areas and leave these areas only under specified conditions. So, the station areas also define the shunting limits. On railway that do not use station areas, shunting on main tracks may also be limited to specific areas. In the rulebook, that problem was solved by a generic definition of shunting limits. Shunting limits are just areas where shunting movements may enter main tracks. Whether the shunting limits of a particular railway equal the station areas or not is no longer relevant. The generic definition fits everywhere and allows to establish rules of how shunting moves must be protected when shunting beyond the shunting limits.

Another issue is the degraded mode operation on automatic block lines. It very depends on whether the stop aspect on automatic signals is absolute or permissive. So, the rulebook contains rules for both cases. For absolute block working, the German philosophy of performing a clearance check under staff responsibility (German: Räumungsprüfung) was not adopted. From an international point of view, that practice is not only very unusual but also quite risky. In our rules, when authorising a train to pass an absolute signal in stop position, the train must always proceed on sight up to the next signal. In contrast to a permissive signal, the train always needs an authority from the operator, however. If a particular railway used only absolute or permissive working, the other rules would simply be not relevant.

Since controlled signals are always absolute, this leads to an operational classification of main signals as shown in Figure x. This very generic classification allows to establish rules for all relevant situations.

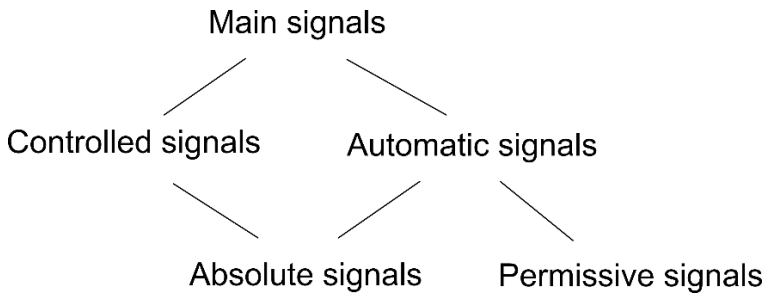

Figure 1 Classification of signals in the rulebook

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2.3 Constraints

A connected laboratory session is always kind of remote control. For that reason, the rulebook does not cover any old technologies that require stations to be locally staffed. It can only be applied on lines with continuous track clear detection and automatic block systems. Eliminating the need to cover all kinds of old signalling technology reduces the complexity of the rulebook significantly.

Also, since the rulebook is intended to be used in laboratories, it does only contain rules for the control operator working on the laboratory user interface. There are no rules for train crews.

In the current version, the rulebook only covers train control by lineside signals. This is still the operating procedure used in most laboratories. This way, it can also be used for ETCS level 1. However, the structure of the rulebook is open to add rules to govern trains by cab signalling on ETCS lines without lineside signals. Figure y shows the current structure of the rulebook.

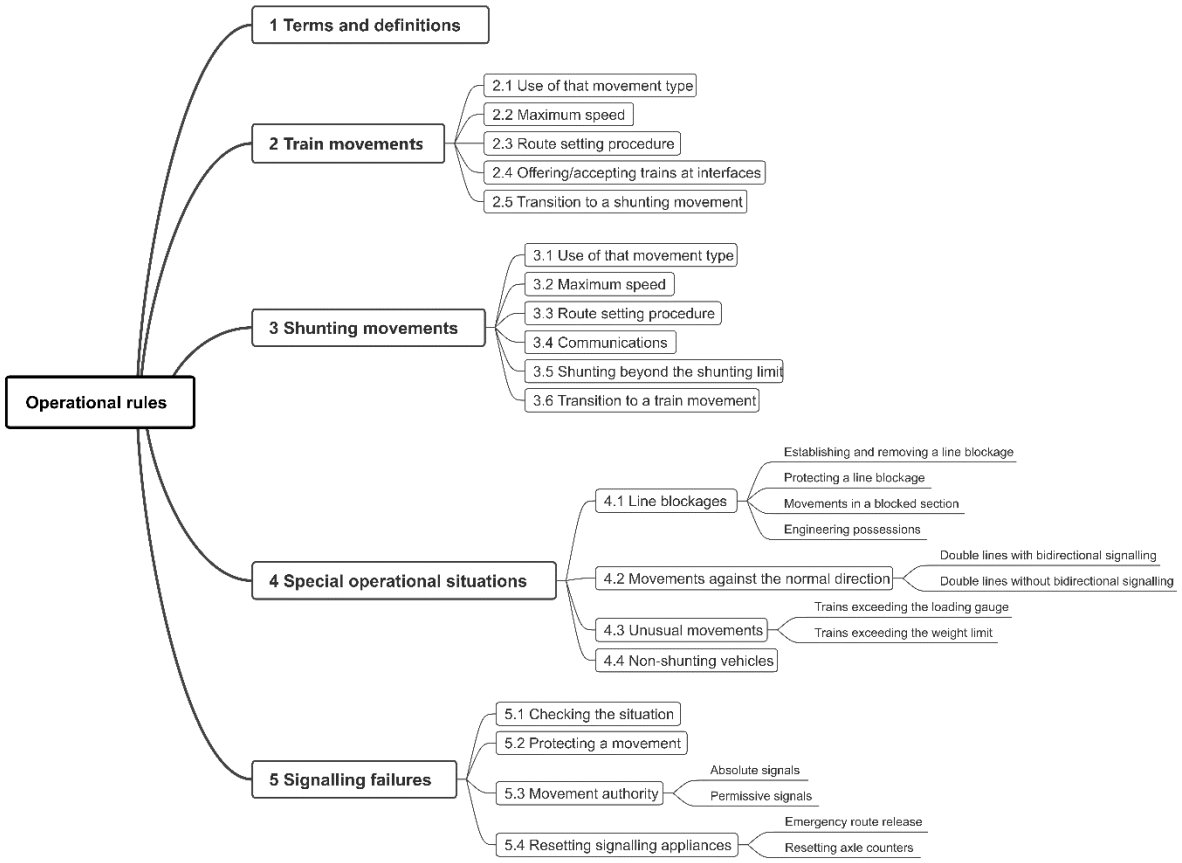

Figure 2 Overview on the rulebook structure

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3. Generic introduction for interlockings

This document is designed for students to use it for autodidactic revision to remember the functions of interlockings. It can also be also used by trainers as a systematic approach to explain the control of an interlocking. The guideline was developed in the context of digital education, but it can be also used in on side laboratories, as the guideline was also tested in different laboratories. The general approach was to design this document as generic as possible. However, according due the mentioned national differences it is possible that the guideline has to be adjusted by the users for their interlockings. The document can be used for electronic and relay interlockings. It is maybe also possible to use it for mechanical interlockings, but the original guideline was not designed for it. The method for this guideline was tested in railway laboratories of TU Braunschweig, University of Zagreb, University of Žilina and at CVUT Prague. Furthermore a team of TU Braunschweig tested this documents in the laboratories of TU Berlin (EBuEF) and also in the EBL in Switzerland. The introduction was tested in five laboratories on different types of interlockings. The types tested are described on each test sheet.

3.1. Design of the introduction

To find a generic approach to explain interlockings is a challenging task. This is caused by the national character of the railway sector and the technic that have been developed in the sector. Hence, the questions for the introduction are designed in the most generic way. The first design was based on the interlocking Rebenau. Based on that simulation the following 7 questions have been developed:

- Step 1: Explain the control area and limits of the interlocking and the power supply
  The first questions explains the entire area, that his controlled by
- Step 2: Explain how to set routes and the kind (e.g. train movement, shunting) that you can set
- Step 3: Explain how the routes are displayed at the interlocking
- Step 4: Explain how to release routes
- Step 5: If you have single line operations, then explain how the operation and dispatch on the single line
- Step 6: If you have any feeder lines in your area explain how the operations work with between your area and the line
- Step 7: If you have any change between tracks with and without catenary, then explain the special issues to set routes (if there are any)

A Step 8 was also considered, but during the tests it turned out that worked out 7 steps are the necessary tests for the introduction. Hence, it is possible that in a few test sheets a step 8 is explained.

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3.2. Tests of TU Braunschweig

TU Braunschweig tested the guideline in the virtual rail lab of the IfEV and also in the ELA of the IVE (Institute of Transport, Railway Construction and Operation.(TU Braunschweig has to railway institutes the IfEV and IVE). In the IfEV laboratory the interlockings are entire online simulations similar to electronic interlockings. Whereas ELA offers classic interlockings from Germany for training purposes. The generic introduction was tested on every interlocking in the ELA and also with the *"Signalsoft"* and *"SimSig"* software. Signalsoft is a simulation with a generic interface with a fictional railway network developed for IfEV. SimSig is simulation software of British interlockings.

3.2.1. Test with Signalsoft

The first test of this guideline was developed with the station Rebenau. Hence, this document is the basic design for every other interlocking.

Generic introduction for controlling interlocking's

This introduction is a briefing for the control of an interlocking. It is generic designed, that means that you can use it on every training interlocking.

Hint: This introduction is designed for the academic training purpose and not for infrastructure managers.

Test with Rebenau

Step 1: Explain the control area, signals and limits of the interlocking and the power supply

The station Rebenau is part of the IfEV generic network. In Rebenau is on the double track main (with catenary) Wenden (XWN) – Schlossberg (XSBG) in right hand traffic. From Rebenau starts the single track line Rebenau – Abzw. Bülten (without catenary).

End of the controlled area:

- In the direction of Wenden is Signal 12 only a target signal so set the route (comment: I don´t know if the term target signal is correct)
- Signal 13 in the direction of Okerbach
- Green coloured marks in the directions Pockelsdorf, Okerbach and Wenden
- In the direction Wenden and Okerbach only on the opposite track

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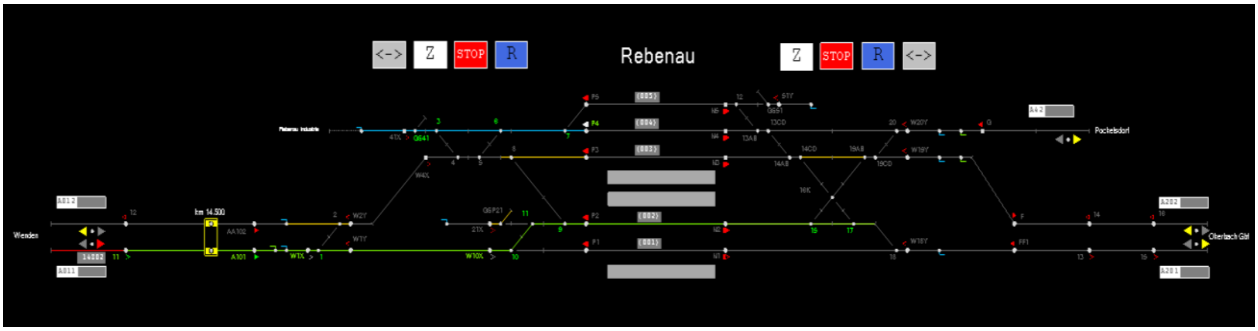

Figure 3 Rebenau Interlocking

Signals:

- Signals with a full triangle a main signals
- Signals with a full triangle and a square are main and shunting signals
- Signals with small drawn roof are shunting signals e.g. W20Y
- Signals with an empty triangle are in ARS mode
- The yellow triangles e.g. A 42 are the direction, if the triangle is red, the direction is locked

Step 2: Explain how to set routes and the kind (e.g. train movement, shunting) that you can set

You can set train and shunting routes. In this software you have a start – target setting.

When you want to set you route, you have to click on the starting signal and den on the target signal. In this simulation you have also to click on the button to set the main route.

You can change the direction (after you offered a train) with a click on the point between the triangles and the grey button with the arrows.

Step 3: Explain how the routes are displayed at the interlocking

- Green: Set main route
- Blue: Set shunting route
- Yellow: Flank protection
- Red with train number: Occupied main route
- Red without main route: Shunting movement

Step 4: Explain how to release routes

If you set a wrong route and you want to release it, then you have to set a stop aspect at the signal. Do to that you have to click in the green signal / or white shunting aspect and click stop. In the second step you click on the same signal and click the button release train / shunting route.

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Step 5: If you have single line operations, then explain how the operation and dispatch on the single line works

The line between Rebenau and Pockelsdorf is one track line. For that line you need the generic train describer. You can get offers from Pockelsdorf and offer trains to this station. For an offer the train number will occur and you can accept or decline the offer (depending on the current traffic in your station). For an offer you have to input the train number, the track number and station. The track number is in that case A 42.

If you want to set a route it is also necessary, that the block direction must be correctly set.

Step 6: If you have any industrial siding in your area explain how the operations work with between your area and the line

In Rebenau you have the industrial siding to Rebenau Industrie (without catenary). You can only set shunting routes inside and outside, there are now other issues for operations.

Step 7: If you have any change between tracks with and without catenary, then explain the special issues to set routes (if there are any)

In Rebenau there are no special issues to set a route to track without catenary.

Step 8: If you have call on signals, explain how to set one

If you have to set a call on signal. Only in degraded mode operations. Then you have to close the signals that can be in the route. You have also to lock the points zone.

To set the call on, you have to click on the signal and the call on button

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3.2.2. Test with the SimSig Simulation

The guideline was also tested at the SimSig simulation with the Wembley Suburban network. SimSig is a simulation that is also used by Network Rail for training purposes.

Generic introduction for controlling interlocking's

This introduction is a briefing for the control of an interlocking. It is generic designed, that means that you can use it on every training interlocking.

Hint: This introduction is designed for the academic training purpose and not for infrastructure managers.

Software SimSig, Interlocking Wembley Suburban

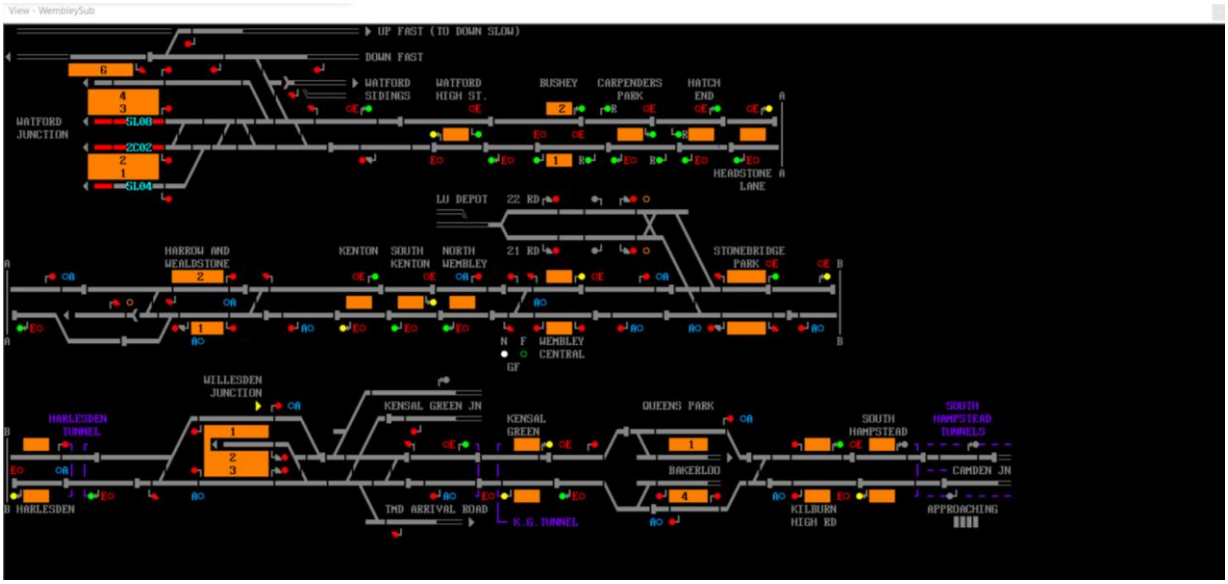

Figure 4 Wembley Suburban

Step 1: Explain the control area and limits of the interlocking and the power supply

Control area = several stations

Watford Junction - Harrow and Wealdstone – Wembley Central – Stonebridge Park – Willesden Junction – Queens Park

Between the stations you have block signals (OE), they work automatically.

You only control by yourself the signals in the several stations (OA).

For checking the timetable, you have to click on the train with the right mouse key.

For change a train number you have to click on the right mouse key and chose interpose and right the new number in and click ok. The new train number you can see in the timetable.

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Step 2: Explain how to set routes and the kind (e.g. train movement, shunting) that you can set

Train movement: click on the start signal (red circle) with the mouse and click the target signal.

Shunting: start is a main signal (red circle) or a red triangle symbol as shunting signal and the target is a main signal or a grey triangle at the end of the track.

Step 3: Explain how the routes are displayed at the interlocking

Grey = no main route set

White = main route set

Red = occupied track

Step 4: Explain how to release routes

Release routes by click at the start signal with the right mouse key.

Step 5: If you have single line operations, then explain how the operation and dispatch on the single line works

/

Step 6: If you have any industrial siding in your area explain how the operations work with between your area and the line

When a train is entered your control area you get a message in the “Messages”-Window or there open a new window with a message. And the train number stand on the junction.

If you get a call on the “Telephone Calls” window from the train. You have to answer them.

Step 7: If you have any change between tracks with and without catenary, then explain the special issues to set routes (if there are any)

/

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3.2.3. Test in ELA -Braunschweig

The ELA is a classical on side laboratory with real interlockings and a model railway that is uses as a medium to experience the railway operation. The ELA is used by the IVE (Institute of Transport, Railway Construction and Operation) of TU Braunschweig and also the DB Netz AG for teaching purposes. In this facility students of TU Braunschweig and employees of DB are trained.

Generic introduction for controlling interlocking's

ELA – IVE Braunschweig

This introduction is a briefing for the control of an interlocking. It is generic designed, that means that you can use it on every training interlocking.

Hint: This introduction is designed for the academic training purpose and not for infrastructure managers.

In this test all tested interlockings are summed up in every question. The interlockings are named with their fictional station names: Wuppertal, Neustadt and Ruhleben.

Step 1: Explain the control area and limits of the interlocking and the power supply

Wuppertal:

Signal A to F ; control area ; policy discussion→ block signal u. entrance and exit signal reach

No catenary

Neustadt (DtSt):

- Entry signal (Blocksignal) A-F
- side track key dependent local

Ruhleben:

Geographically two interacting parts

Signal A bis P

- Fdl-Stw head "A" mech. Stw. (A, P, W1)
- "Weichenwärter-Stw." head "P" electronic Stw. W2 + 3; W1 + 2

Boundary between the two signal boxes

Clearance by inspection

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Answers to all stations:

Ruhleben:

Station area (including entrance signal) splitting in two signal boxes

Neustadt:

Station area (including entrance signal and one “Sbk-Signal” at main tracks in the direction of Wuppertal)

Wuppertal:

Station area (including entrance signal and multiple “Sbk-Signale” in both main tracks)

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Step 2: Explain how to set routes and the kind (e.g. train movement, shunting) that you can set

Wuppertal:

Main routes and shunting routes:

Start → in setting

Red → occupied

Yellow → route set

Touch protection is visually with pointe zone

Setting main route main signals out

Neustadt (DtSt):

Push buttons (entrance signal-target); points by pushing the target button

No shunting routes (signal + points) shunting local based and key depended

By change direction and overtake push FRGT (route dissolve automatically)

Ruhleben:

1) Set points
2) Block the points
3) Check for free overlap (by "Weichenwärter")
4) Set the route
5) Block the route
6) Check the train is complete

Answers to all stations:

Ruhleben: only main routes:

- Check the route is free (visually), including overlap and junctions
- Set the route elements, including the overlap and flank protection
- Establishing the necessary dependencies between all interlockings involved (by blocking the command or consent fields of the station block)
- Set the route (signal dependence)
- Block the route (block-electrical)
- Set Signal

Neustadt: only main routes:

- (Check the route is free by technic)
- Set the route elements, including the overlap and flank protection
- Setting and blocking the route and setting the signal by start-target-condition

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Wuppertal: main routes:

- The same as Neustadt (no manual setting of the route elements; setting automatically including overlap and flank protection)

Shunting route:

- Equivalent to main routes (no overlap, flank protection and checking the route in the target track)

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Step 3: Explain how the routes are displayed at the interlocking

Wuppertal:

Flash points zone is visible with the points main route → main and shunting signals in movement

Shunting signals with MA and main signals no MA

Neustadt (DtSt):

White+ red + signal

Ruhleben:

Motion detector

At the colour panel

Points lever

Answers to all stations:

Ruhleben:

- (Condition check of the control elements and block fields possible)
- (electrical motion detector of the main signals)

Neustadt:

- Yellow = locked route elements (without overlap)
- "Festlegemelder" at entrance signal ore in the target track

Wuppertal:

- Yellow = locked route elements (including overlap and flank protection)
- "Festlegemelder"

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Step 4: Explain how to release routes

Wuppertal:

Press FRT with a 6 sec. shout and in → Shunting route

Main route: FHT + target main + Overlay DHT + main signal hold

Neustadt (DtSt):

FHT + start button → Entry

FHT + target button → exit

Ruhleben:

regular → setting backwards

help operation

Answers to all stations:

Ruhleben: regularl:

- Release by driving the section by train and release contact
- Do step 2 in the other direction

Not regular (documentation required)

- Basic position of the block field of the route definition by signal book, then as above
- (eventual setting the signal in stop position)

Neustadt: Regelfall:

- Release by driving the section by train in the correct order
  … by exit routes completely
  … by entrance routes only prepared
  Complete resolution by additional setting of the following exit or by participation via FRGT.
- Signal stop position self-acting when clearing the 1st subsequent section

Not regular (count- and documentation required):

- Total resolution and signal hold with help button (FHT)

Wuppertal: regular:

- Einzelelement-Auflösung nach Belegung und Räumung
- Signal stop by occupied the 1st subsequent section

Not regular (count- and documentation required):

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- same like Neustadt

Step 5: If you have single line operations, then explain how the operation and dispatch on the single line works

Wuppertal:

Just in degraded mode and only verbal

Neustadt (DtSt):

/

Ruhleben:

/

Step 6: If you have any industrial siding in your area explain how the operations work with between your area and the line

Wuppertal:

lock main track → Frage 6 ?

Neustadt (DtSt):

Key-depended + manual point setting

Communication by phone

Ruhleben:

/

(is possible by using the key lock in Neustadt or the "Hebelbauchschlosses" in Ruhleben)

Step 7: If you have any change between tracks with and without catenary, then explain the special issues to set routes (if there are any)

Wuppertal:

No issues

…live Line with catenary

Neustadt (DtSt):

/

Ruhleben:

/

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3.3. Tests of the University of Žilina

The University of Žilina tested the guideline in their own laboratory on three different types of interlockings. This includes an electronic mechanical interlocking, an electric relay interlocking and an electronic interlocking.

Test 1 with Hričov

Generic introduction for controlling interlocking's

This introduction is a briefing for the control of an interlocking. It is generic designed, that means that you can use it on every training interlocking.

Hint: This introduction is designed for the academic training purpose and not for infrastructure managers.

Test with Hričov (electric relay interlocking system)

Step 1: Explain the control area, signals and limits of the interlocking and the power supply

The station Hričov is part of the UNIZA laboratory track line circuit.

Station Hričov is located at km 29.265 of double-track line no. 100 and in km 0.000 of single-track line no. 101. The station layout includes 7 traffic and 1 handling track, 20 switches, 26 signals (17 main, 6 shunting and 3 warning signals). The station is equipped with a category 3 station safety device - relay station device type AŽD 71 with route selection method. The station is controlled by means of an inclined control table, on which all the necessary control and indicating elements are placed. The control table is intended for monitoring the operation of the safety device in operational and fault conditions. On the control table there is a plan of the track with transparencies and mock-ups of signals. Mock-ups of signals simply indicate the signals lit on the signals located in the track. Just as the station's track is divided into individual isolated sections (station tracks, switches), the track plan also includes transparencies (status indicators) of these sections. In the light image of the track, there are three-position indicator buttons for entering the start and end of travel routes.

In the interstation section Hričov - Žilina and in the interstation section Hričov - Čadca, is a 3rd category of line safety device - a two-way three-character automatic block with a complete block condition introduced automatically by the train. The controlled area of the station is delimited by entrance signals, from the direction of Žilina they are 1L and 2L and S from the direction of Čadca. The layout diagram of the Hričov station track is shown in fig. 1.

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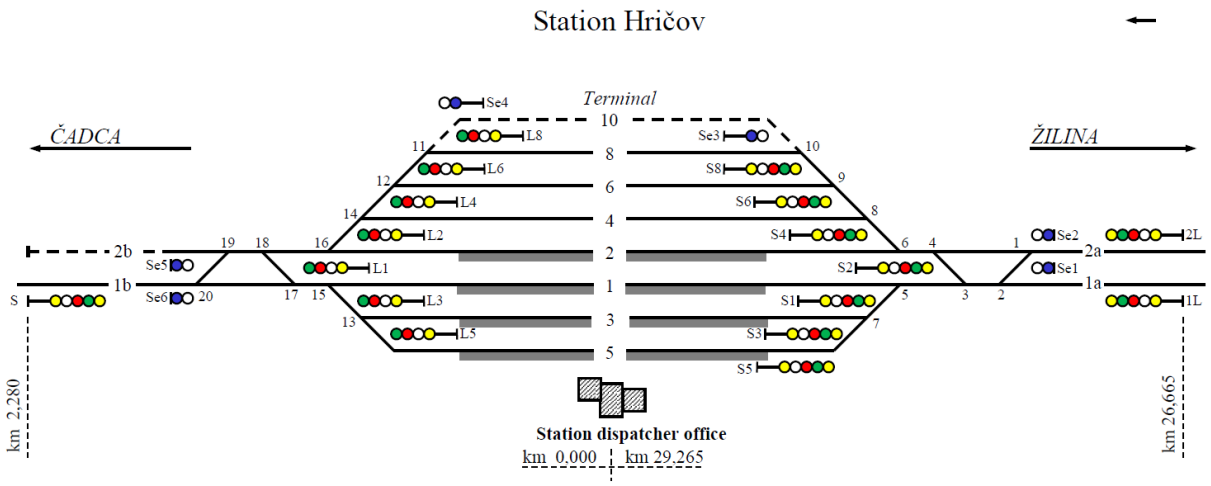

Figure 5 Track layout of the Hričov station

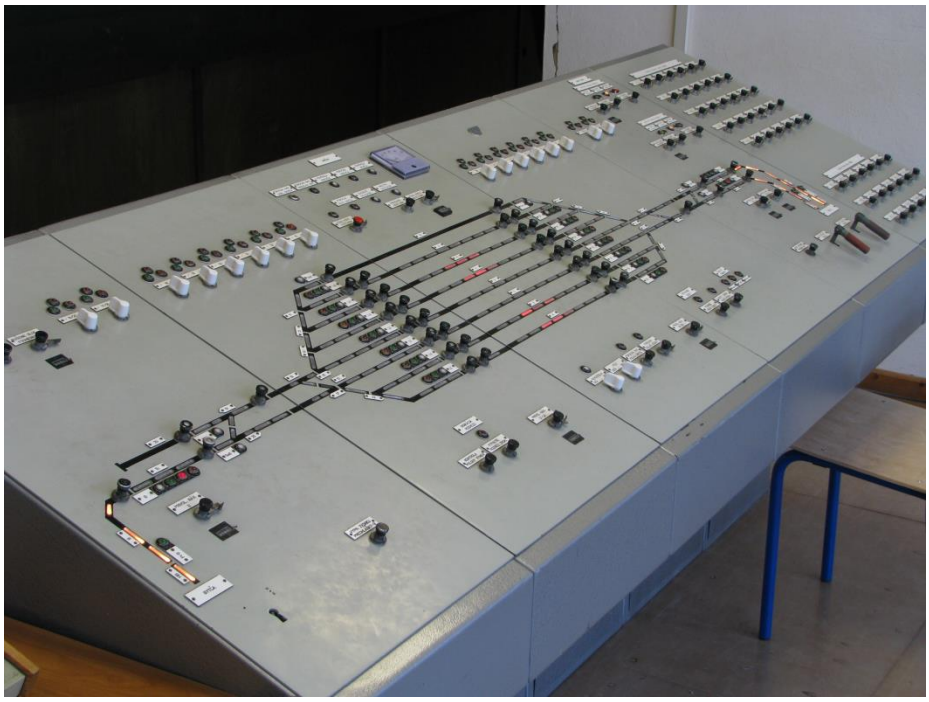

Figure 6 Control table of relay safety device type AŽD 71 with route selection method

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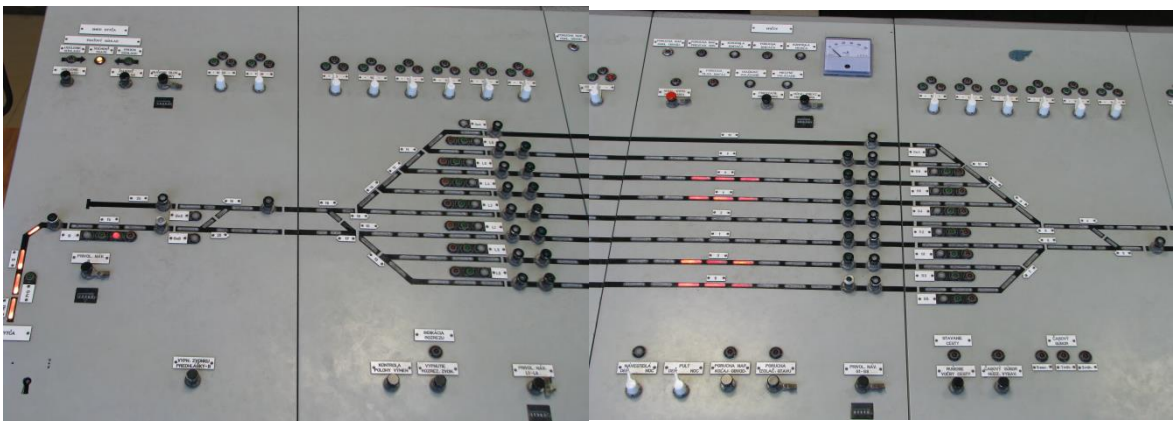

Figure 7 Control elements on the control table of relay safety device type AŽD 71

Step 2: Explain how to set routes and the kind (e.g. train movement, shunting) that you can set

On the relay station safety device with the route system, the routes (entrance, departure, transitive, shunting) are set by determining their beginning and end. The beginning and end of the driving routes is determined by operating the indicator buttons on the inclined control table.

Entrance main route: The main route start button for the train entrance is pressed.

Departure main route: The signal button for the start of the main route is pressed. Subsequently, the signal button for the end of the main route is pressed. After approaching the train, the dispatcher have to press "Switching off the announcement bell".

Transitive main route: Position of the entrance and exit main route (in any order).

Shunting route: Pressing the shift path start button and then pressing the shift path end button.

Step 3: Explain how the routes are displayed at the interlocking

Entrance main route: When the train path start button is pressed, the green light in the button lights intermittently, and at the same time, the red light of the "Route setting" indication lights up. Next, the signal button for the end of the main route is pressed. After pressing it, a white light flashes intermittently in the button, which goes out after the end of the main route. At the same time, the intermittent green light in the signal button for the start of the main route will stop shining, and at the same time, the red light of the indication "Setting the route" will go out. All other signaling buttons in the setted main route light up until the end of the train path is completed with a white light, after it is completed, they go out. After the repositioning of passing and switches, the setted main route will come to an end and the signal allowing the train to run will be lit on the entrance signal (the transoms of the light image of the track in the entrance main route shine with a constant white light). After the train has occupied the first approach section, the colour of the transom will change to red, which means the complete end of the main route and the acoustic announcement of

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the announcement will sound. The dispatcher turns off the acoustic signal of the pre-registration by pressing the button "Turning off the pre-registration bell".

Departing main route: After pressing the signal button for the start of the main route, the green light in the button lights up intermittently, and the red light of the indication "Setting the route" lights up at the same time. After pressing the button indicating the end of the main route, a white light flashes intermittently in the button, which goes out after the end of the main route has been completed. At the same time, the intermittent green light in the signal button for the start of the train journey will stop shining, and at the same time, the red light of the indication "Setting the route" will go out. All other signaling buttons in the prepared main route light up until the end of the main route is completed with a white light, after it is completed, they go out. After the repositioning of passing and diverting switches, the constructed main route will be completed, and in the case of granted track approval, the signal allowing the train to run will be lit on the departure signal (the transoms of the light image of the track in the departure main route shine with a constant white light).

Transitive main route: Transit main route consists of an entrance and an exit main route. When setting it, it does not matter whether the entrance main route is built first and then the departure route or vice versa. The procedure is according to the principles described above.

Shunting route: After pressing the shunting start indicator button, an intermittent white light will light up in the button, and the red "Setting a route" indicator will light up at the same time. After pressing the button indicating the end of the shunting route, a white light in the button lights up intermittently, which goes out after the end of the shunting route is completed. At the same time, the intermittent white light in the indicator button for the start of the shunting route will stop shunting, and at the same time, the red light of the indication "Setting the route" will go out. All other indicator buttons in the constructed shunting route light up with white light until its completion, after which they go out. After repositioning the passing and diverting switches, the set shunting route will be completed, and the signal permitting the shunting will be lit on the shunting or departure signal (the transoms of the light image of the track in the shunting route shine with a constant white light). The completion of the setted shunting route will occur by occupying by moving part the station track with the track circuit.

Step 4: Explain how to release routes

The train gradually occupies and subsequently vacates the track circuits in the main route with its movement, and at the same time cancels the complete end of the main route and resets the safety device to the basic state, except for the position of the crossing and turning switches in the original train path.

In the case of a shunting route, the moving part gradually occupies and subsequently releases the track circuits in the shunting route with its movement, and at the same time cancels the complete conclusion of the shunting route and brings the safety device to the basic state except for passing and turning switches in the shunting route.

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Step 5: If you have single line operations, then explain how the operation and dispatch on the single line works

On the single-track line in the direction of Čadca, there is an automatic block for two-way operation without block signals. The device brings dependencies between neighbouring traffic points (stations), checks the availability of entire track sections.

In order for the train to leave the station, the dispatcher must obtain a line consent. The departure signal can only be set by the dispatcher who has been granted track approval. He can send trains in an unchanged direction as long as he does not return the consent of the neighbouring station. If a train is to be dispatched to a neighbouring station and the station dispatching the train does not have track consent, the dispatcher will ask the neighbouring station to grant consent. The track consent can only be changed when the entire inter-station section is free (the "Track free" indicator is on). During train breaks, the dispatcher on the single-track line must set the automatic block to a non-consent state.

Step 6: If you have any industrial siding in your area explain how the operations work with between your area and the line

Does not apply.

Step 7: If you have any change between tracks with and without catenary, then explain the special issues to set routes (if there are any)

In Hričov station there are no special issues to set a route to track without catenary.

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Step 8: If you have call on signals, explain how to set one

Call sign setting by dispatcher:

- makes sure by looking at the control table, whether it is possible to secure the main route with a lock, no track circuit must be occupied between the main (entrance and exit) signals and passing and turning switches must not be in malfunction. When this condition is met, he will set the entrance or the departure main route, which will result in the closure of the main route. The green light on the signal button for the start of the main route lights up intermittently, which means that all the conditions for the train to run are not met and the signal allowing the train to run does not light up on the main signal;
- set the replacement controllers of passing and turning switches according to the Dependency table and mark the translated controllers with a suitable memory aid;
- by pressing the "Check position of switches" button, he checks the correct position of the switches;
- if he has control of the end positions of passing and turning switches on the indicator table, he presses and holds:
    - at the train entrance, the corresponding call signal two-position return button (after unlocking the safety lock). After this operation, the sign "Beware of the call sign" (white intermittent light) lights up on the entrance signal and in the model of the entrance signal in the light image of the track. On the device control table, the white calm light "Oscillator check" will also light up, and the attendant counter will record its use;
    - when the train departs, the respective two-position returnable common call button (after unlocking the safety lock) and at the same time pulls out the three-position returnable button for the start of the main route of the track from which the call button wants to light up. After this operation, the sign "Beware of the call sign" (white intermittent light) lights up on the departure signal and in the mock-up of the departure signal in the lighting image of the track. On the device control table, the white calm light "Oscillator check" will also light up, and the operator's counter will record its use. A common two-position return call button can release;
    - call button, or the three-position return button for the beginning of the main route must not be released before the train clears the rear guard (at the entrance train path), or the front of the train does not enter the boundary (on the departure train path) - deviating from the provisions of service regulation ŽSR D 101/T 101. If this condition is not observed, the call button is canceled, the train stops and the entire procedure must be repeated.

The train cancels the end of the main route, if it has been completed. The dispatcher presses the button "Cancel route selection" and the intermittent green light in the start button of the main route goes out. It secures the call buttons with a safety lock. If the end of the train journey has not been completed, the dispatcher moves the exchange controllers to the basic position and removes the reminders from them.

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Test 2: Vrútky

Generic introduction for controlling interlocking's

This introduction is a briefing for the control of an interlocking. It is generic designed, that means that you can use it on every training interlocking.

Hint: This introduction is designed for the academic training purpose and not for infrastructure managers.

Test with Vrútky (electro-mechanical interlocking system)

Step 1: Explain the control area, signals and limits of the interlocking and the power supply

The station Vrútky is part of the UNIZA laboratory track line circuit.

Station Vrútky is located in km 0.000 of double-track line no. 100 and in km 17,383 of single-track line no. 101. The station track contains 4 traffic tracks, 12 switches, 15 signals (11 main, 1 shunting and 3 warning signals). The station is equipped with a category 2 station security device (electromechanical safety device model 5007 with light main signals dependent on each other with a speed signal system and with central adjustment of turnouts by adjusters controlled by switch levers). The "Oil Products" industrial siding (direct continuation of track No. 2a) is connected to the station. In the interstation section Vrútka - Bytča, a 2nd category track safety device (relay semi-automatic block without block signals) has been built. In the Vrútka - Púchov interstation section, a category 3 track security device has been built (automatic gate for two-way operation without section signals). The layout diagram of Vrútky station is shown in fig. 1.

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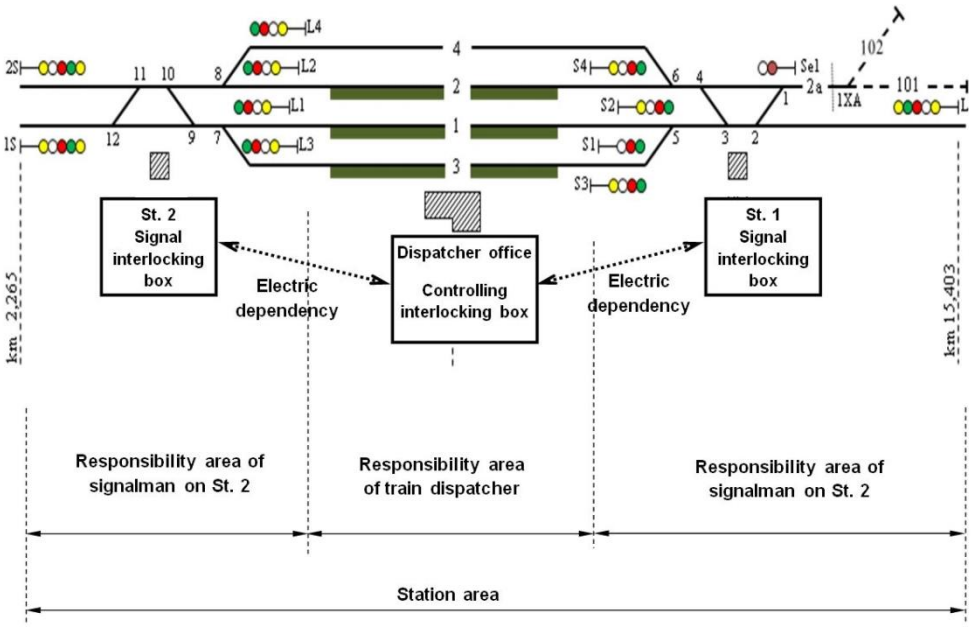

Figure 8 Track layout of the Vrútky station and schematic assembly of electromechanical safety device

The basic assembly of the station's electromechanical safety device consists of a controlling interlocking box located in the traffic office and signal interlocking boxes located on the signal box. Dependencies between control elements, directional shutters and gate buttons on the controlling interlocking box, as well as between track shutters, signal controllers and gate buttons on the switching device, are mechanical. The interconnection between the controlling interlocking box and the signal interlocking boxes is made through electrical dependencies.

Such a set of safety device arose from the need to divide the operation of the devices in the station trackside, point switches and signals, into several signal boxes (mainly in larger stations), when the capacity and technical solution of the central mechanical interlocking box no longer allowed the aforementioned devices to be operated in the track from one place.

The controlling interlocking box, which is located in the dispatcher's office, consists of a mechanical (lower) and electrical (upper) part. The mechanical part consists of the switching and closing device, which is placed in a metal closing box, on which the gate device is mounted. On the top plate of the closing box is a picture track layout, on which there are as many sliding knobs for each station head as there are tracks. By moving the sliding knob in the cut-out across the image of the traffic tracks, the designated entrance or departure track is set. On the front wall of the closing box, there is a directional shutter for each sliding knob, which closes the sliding knob on the specified track of the track layout for entry or departure (against the intended direction of main route). You cannot set mutually threatening main routes with sliding knobs and directional shutters. The electrical part of the controlling interlocking box consists of an inductor, a group of gate latches, an entrance signal gate and an departure signal gate, an switch gate, a consent gate, a bell button, a release button, emergency release devices for gate releases (emergency release device of the signal gate, emergency release device of the gate bolt and emergency equipment for the consent to use shunting signal Se 1) and the gate bell.

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Each gate bolt from this group has a coloured aperture and a label with the name of the bolt. The colour of the label corresponds to the basic position, and the colour of the letters corresponds to the opposite position of the gate shutter aperture.

Figure 9 Control elements on the electromechanical safety device (controlling interlocking box)

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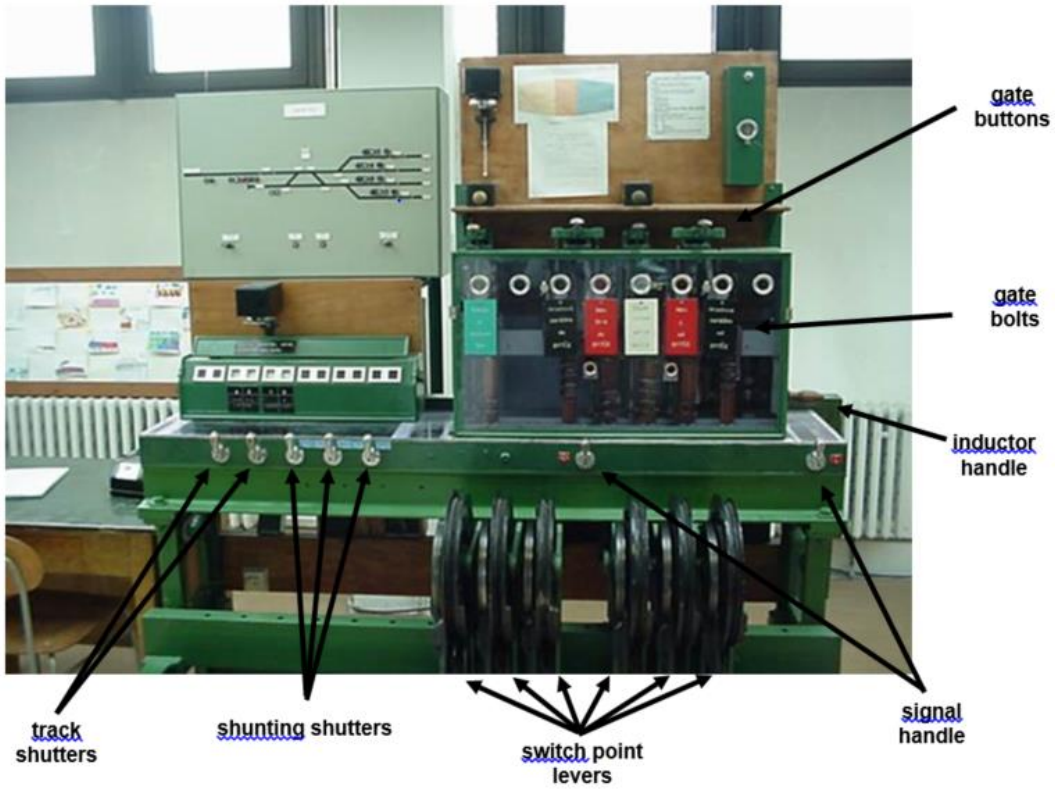

Figure 10 Control elements on the electromechanical safety device (controlling interlocking box)

The signal interlocking box enables the operation of the specified elements of the safety device, while it does not allow the signalman to electrically close the main route, unless it was ordered by the dispatcher from the controlling interlocking box and properly set by the signalman. It consists of a mechanical (lower) and electrical (upper) part.

The s signal interlocking box allows the signalman (switcher) to:

- close electrically only a properly setted and designated by the dispatcher, as long as the signal interlocking box has an gate bolt (switch gate), and for this main route, set up the main signal (announcement) on the signal allowing jorney,
- close the main signals with the signal "Stop" only after the shutter of the gate relay changes from red to white, or after the red indication goes out, if the signal interlocking box has this device.

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Figure 11 Control elements on the electromechanical safety device (signal interlocking box)

By operating the safety device, the traffic employees always set a main route for a specific train. During normal operation, the main route can be canceled, and the safety device set to the basic position only after the arrival or departure of this train from the station. The actual arrival of the train at the station or departure from it is recorded by special devices, which we include among the means of cooperation between the train and the security device as are insulated rail, gate relay and gate stop.

The controlled area of the station is delimited by entrance signals, from the direction of Púchov they are 1S and 2S and from the direction of Bytča L.

The layout diagram of the Vrútky station track is shown in fig. 1. The specific elements are shown on figures 2, 3 and 4.

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Step 2: Explain how to set routes and the kind (e.g. train movement, shunting) that you can set

The setting of train or shunting routes is ordered by the dispatcher and he set them in cooperation with signalmen using controlling interlocking box and signal interlocking box. First step is the checking of the freedom of the track sections in their station area of responsibility (human factor).

In the following points, the procedure for preparing the main route is summarized:

a) entrance,
b) departure,
c) transitional.

1. The dispatcher will determine the availability of the track in his area of responsibility.

2. The dispatcher calls both signalmen´s by phone and waits for the signalmen to report to him with the name of the station: "First box", "Second box".

3. The dispatcher reports:

a) "Train 2800 to the second track."
b) "Train 2800 from the second track."
c) "Train 2800 to and from the second track."

4. The signalmen write down the data in the Record of clearance and correct position of the train paths, when the train enters and passes the signalman at the entrance station head, when the train departs the signalman repeats it at the exit station head, and both add that they understood:

a) "Train 2800 to the second track, the first box understands." "The second box understands."
b) "Train 2800 from the second track, the second switch understands." "The first switch understands."
c) "Train 2800 to and from the second track, the first switch understands." "The second switch understands."

5. After hanging up the phone, the signalmen will check the availability of the track in their area of responsibility.

6. The signalman, who will not operate the safety device, but the main route extends into his area of responsibility, calls the dispatcher, who announces: "Dispatcher", and informs him that the track is free in his area of responsibility:

a) "The second box. Free for train 2800 on the second track. Your_surname."
b) When the train departs, availability is not announced by telephone, but by the operator of the security device.
c) When the train passes, availability is not reported by telephone, but by the operator of the security device.

7. If the availability of a track was reported by phone:

a) The dispatcher in the Traffic book and the signalman in the Record of clearance and correct position of train tracks enter in the relevant column the time when the clearance was reported.

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b) When the train departs, availability is not announced by phone, but by the operator of the security device, and therefore the time data is not even recorded in the transport documentation.
c) When the train passes, availability is not announced by telephone but by the operator of the security device, and therefore the time data is not even recorded in the traffic documentation.

8. The dispatcher starts setting the main route by operating the safety device (controlling interlocking box).

Summary of procedures by dispatcher:

1. determines the freedom of the track in its area of responsibility,
2. by phone, orders the signalmen to prepare the train path,
3. moves the slider,
4. translates the directional shutter,
5. releases the signal gate,
6. rings the gate bell.

Summary of procedures by signalmen:

1. Determines the availability of the track in its area of responsibility, checks the correctness of the track number,
2. rings the gate bell,
3. lifts the drop plate of the gate bell,
4. sets the switch point levers to the desired position,
5. translates the rail shutter,
6. close the switches (gate bolt),
7. folds the signal handle,
8. is waiting for the train.

The shunting routes in the Vrútky station are unsecured. This means that the safety devices enables signaling the "Shunting allowed" on any departure or the shunting signal without the switches being properly adjusted for the intended shunting.

The leader of the shift is always the dispatcher. The dispatcher and the signalmen mutually agree on the intended shunting movement in the station and inform them of the direction of the shunting (e.g. "From the third track to the second track" and the work with the shunting vehicles (e.g. "Hook up the locomotive" etc.). By allowing a shunting on the traffic tracks, the dispatcher also allows the occupation of these tracks by vehicles, but only for the duration of the shunting. The end of the shunting and the release of the traffic tracks will be announced by the signalmen to the dispatcher by telephone immediately after its end.

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Step 3: Explain how the routes are displayed at the interlocking

The dispatcher sees a diagram of the station's track on the display board.

Also on this scheme are:

- buttons and light indications of track approvals;
- buttons for canceling the block condition with an operator counter (only in the direction of Púchov);
- button "Grant track approval" (only from Bytča direction),
- three-position return buttons of call signals with a safety lock, supplemented with counters for operators. In the basic position, they are secured by a cap;
- red indications of the status of insulated rails (IR). In the basic state, the IR transparencies are turned off;
- light indications of signal signs of traffic lights. In the basic state, except for the entrance lights, they are off, the red indication is lit on the entrance lights;
- a controller for switching the intensity of the signal lights, complete with a white indicator light;
- red fault indication and white oscillator check indication. In the basic state, they are extinguished;
- red indication of emergency power off of the device with a two-position reversible sealable red button. In the basic position, the button is secured by a safety lock and sealed, the indication is off.

According to the position of the elements, the dispatcher sees the following facts on the controlling interlocking box:

The sliding button determines the track on which or from which the main route will be set, and at the same time, after it is moved to the relevant track, the exclusion of mutually threatening main routes is established. In the basic position, it is marked with the number "0".

The directional closure determines the direction of main route on the respective track, i.e. entrance or departure. It is always translated against the direction of travel of the train and secures the sliding knob on the assigned track. In the basic position, it is in the center of the guide arc (in a vertical position).

After the shutter of the approval gate is folded to the label of the shutter (on the right), the exclusion of mutually threatening shifting and train paths is established. In the basic position, it is in the center of the guide arc (in a vertical position).

Each gate bolt from this group has a coloured aperture and a label with the name of the bolt. The colour of the label corresponds to the basic position, and the colour of the letters corresponds to the opposite position of the gate shutter aperture.

Entrance signal gate and departure signal gate - by releasing them, the dispatcher secures the directional shutter on the control device and at the same time allows the signalman to place the main signal on the signal allowing the train to run. The dispatcher releases this gate, the signalman closes it. The basic position of the aperture is red, the opposite is white.

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The switch gate bolt electrically secures the position of the closures, after its closure the signalman can no longer rearrange the switches arbitrarily. The signalman closes this gate, the dispatcher releases it. The basic position of the aperture is white, the opposite is green.

With the consent gate, the dispatcher authorizes the operation of the establishment signal "Se 1" from the siding "Oil products". The narrator loosens this conclusion, the signalman closes it. The basic position of the aperture is green, the opposite is white.

By operating the gate bell with a tilting plate, the signalman gives the dispatcher various bell signals specified by the regulations. The meaning of these acoustic signs is posted on the control and switching devices. The folding plate folds down after ringing as proof that the bell button has been operated. In the basic position, the folding plate of the gate bell is raised (in a horizontal position).

He does not see the occupation of the track. The insulated rail (IK) and the gate relay record whether the train has passed through the specified section and prevent premature closure of the train path. They help that when a train passes a signal and affects the IK with its movement, the signal sign on this signal changes to the signal "Stop". The basic colour of the IK transom is white (the transom is off), the opposite is red (similarly, the basic position of the shutter of the gate relay is white, the opposite is red).

The signalling interlocking box allows the signalman to:

- close electrically only a properly set and designated by the dispatcher, as long as the signal interlocking box has an switch gate (gate bolt), and for this main route, set up the main signal (announcement) on the signal allowing running,
- close the main signals with the signal "Stop" only after the shutter of the gate relay changes from red to white, or after the red indication goes out, if the signal interlocking box has this device.

Exchangeable adjustment levers are used for the adjustment of switches. When the lever is in the upper position, the turnout is usually adjusted to the turn (so-called minus position), if the lever is in the lower position, the turnout is usually adjusted to the straight direction (so-called plus position or basic position).

The number of the designated track will be shown in the track number table. After moving the track shutter to the number of the track determined by the track dial, the shutter mechanically blocks the switch setting levers, which can no longer be adjusted from this moment (only if the switches (points) are in the correct position according to the label of the track dial or the closing table). In the basic position, it is in a vertical position.

Each gate bolt from this group has its own-coloured shutter and a label with the name of the bolt. The colour of the label corresponds to the basic position, and the colour of the letters corresponds to the opposite position of the gate lock.

The double gate button of the entrance signal gate connected to the gate stop - releasing the entrance signal gate from the control device allows the signalman to set the main signal to the position allowing the train to run. The narrator releases these conclusions, the signalman concludes them. The basic position of the aperture of the signal gate is red and the opposite is white, the basic position of the aperture of the gate stop is black and the opposite is white.

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The switch gate (gate bolt) electrically secures the position of the switches, by closing it, the signalman can no longer rearrange the switches arbitrarily. The signalman concludes this conclusion, the storyteller releases it. The basic position of the aperture is white, the opposite is green.

Consent gate - located only on signalling box no. 1. With it, the shipper authorizes the operation of the establishment signal "Se 1" from the siding "Petroleum products". The narrator loosens this conclusion, the signalman closes it. The basic position of the aperture is green, the opposite is white.

The spare latch of the signal gate prevents the corresponding signal handle of the main signal from being reset to the signal allowing the train to run if the signal gate could not be closed electrically due to a malfunction. With a white-blinded window, the replacement latch is released, with a red-blinded window, the corresponding main signal is mechanically closed with a replacement latch in the "Stop" position - this is the basic position of the replacement latch of the signal gate.

The insulated rail (IK) and the gate relay record whether the train has passed through the specified section and prevent premature closure of the train path. They help that when a train passes a signal and affects the IK with its movement, the signal sign on this signal changes to the signal "Stop". The basic colour of the IK transom is white (the transom is off), the opposite is red (similarly, the basic position of the shutter of the gate relay is white, the opposite is red).

Step 4: Explain how to release routes

Train:

1. By entering the isolated rail, the gate relay turns red, the indication of occupation of the isolated rail on the indicator box lights up, equips the gate stop and resets the signal to the signal prohibiting driving.
2. By releasing the insulated rail, the gate relay is released and the indication of occupancy of the insulated rail on the indicator box goes off.

Signalman:

1. Moves the indicator handle to the basic position.
2. Closes the signal gate connected to the gate stopper.

Dispatcher:

1. Releases the closure of switches.
1. Moves the directional shutter to the basic position.
2. Moves the sliding knob to the basic position.

Signalman:

1. Moves the track shutter to the basic position.
2. Resets the switch point levers to the basic position.

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Step 5: If you have single line operations, then explain how the operation and dispatch on the single line works

There is a relay semi-automatic block in the single-track interstation section Bytča - Vrútky. The device requires the cooperation of operating employees in stations. The granting of consent is operated from the dispatcher's display board at Vrútky station. The dispatcher must have track line approval for the train to leave the station. The departure signal can only be seted by the dispatcher who has been granted track approval. He can send trains in the direction of the granted track approval as long as he does not return it to the neighboring station.

In the double-track section Vrútky - Púchov, there is an automatic gate for two-way operation without block signals. The device mediates dependencies between neighbouring stations, checks the availability of entire track sections. For the train to leave the station, the dispatcher must have a track consent. The departure signal can only be seted by the dispatcher who has been granted track approval. He can dispatch trains in an unchanged direction as long as he does not return the consent to the neighbouring station. If a train is to be dispatched to a neighbouring station and the station dispatching the train does not have track approval, the dispatch dispatcher will ask the neighbouring station to grant approval. The track approval can only be changed if the entire inter-station section is free and no departure train path has been built in a neighbouring station.

Step 6: If you have any industrial siding in your area explain how the operations work with between your area and the line

Service of the siding "Oil products" (track 102):

- The dispatcher informs the signalman at signalling box no. 1 direction of movement and the work of the rail vehicles set, if necessary, the signalman will hang or split the relevant set of vehicles according to the dispatcher's instructions.
- The dispatcher moves the shutter handle of the approval gate to the right, located on the front wall of the shutter box of the control device, releases the approval gate by pressing the gate button and turning the inductor handle at the same time. The colour of the shutter of this gate on both the switchgear and the control device will change from green to white (the shutter will go to the opposite position), operate the bell button above this gate shutter by pressing and turning the inductor handle will give the signalman an acoustic signal "Call for service" (one short ring).
- The signalman, by pressing the bell button and turning the inductor crank, gives the dispatcher an acoustic signal "Confirmation of the call to service" (one short ring). The dispatcher and the signalman each raise the drop board on their own gate bell. The signalman resets the respective passing and turning back switches according to the stated principles, resets the handle of the shunting signal "Se 1" towards the label. He makes sure by looking at the display board whether the sign "Movement allowed" has been lit on the signal.

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- After stopping the moving part, the signalman resets the signal handle of the establishment signal to the basic position and closes the approval gate by pressing this gate button and turning the inductor handle at the same time. This will return the dispatcher's approval, and the colour of the aperture on the control and switchgear will change from white to green.
- The dispatcher on the control device moves the shutter of the approval gate to the basic position.

Note: When consent is granted to the signalman on the signalling box no. 1, the safety device prevents the setting of all entrance main routes.

Step 7: If you have any change between tracks with and without catenary, then explain the special issues to set routes (if there are any)

In Vrútky there are no special issues to set a route to track without cateanary.

Step 8: If you have call on signals, explain how to set one

Emergency cancellation of the main route and the running of the train at the call sign are among the special features when operating the electromechanical device.

Emergency disruption of the main route must be carried out if the dispatcher has accidentally released the wrong signal gate (entrance or departure) and at the same time announced the number of the track (entrance or departure) to the signalman with the bell button. The correct main route can only be set by the dispatcher after the interlocking has been put in its basic condition. Another case may be a situation where the dispatcher of a neighboring station changes the sequence of trains or will cancel the scheduled departure of the train at a time when the main route is already set. Running a train on the call sign is used in the event of malfunctions of main signals, malfunctions of isolated rails in the train track, malfunctions of track safety devices and other extraordinary conditions (e.g. main power failure, switch section, etc.). The dispatcher gives the order to operate the call sign to the signalmen, when all the conditions for running the train are met.

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Test 3 with Čadca

Generic introduction for controlling interlocking's

This introduction is a briefing for the control of an interlocking. It is generic designed, that means that you can use it on every training interlocking.

Hint: This introduction is designed for the academic training purpose and not for infrastructure managers.

Step 1: Explain the control area, signals and limits of the interlocking and the power supply

The station Čadca is part of the UNIZA laboratory track line circuit.

The Čadca railway station is in kilometer 8.829 of single-track line Hričov – Vrútky no. 101 and at the same time in kilometer 0.000 of single-track line no. 102 Čadca – Žilina. The station's track contains 10 traffic tracks (of which two are head) and two turnout shunting tracks. In the station, there are 19 switches, 38 electric signals - of which 24 are main signals (of which 1 block signal as an entrance warning signal), 2 separate warning signals and 13 shunting signals. At km 7,119, the level crossing is secured by a category 3 light crossing security device with double barriers with sequential folding and opening of the barriers. The station is secured by category 3 safety equipment (AŽD ESA 44 electronic interlocking).

End of the controlled area are main entrance signals L, S, RS.

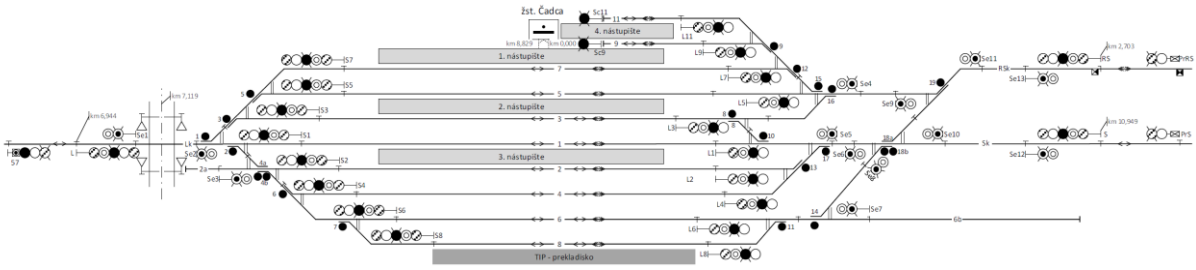

Figure 12 Track layout of the Čadca station

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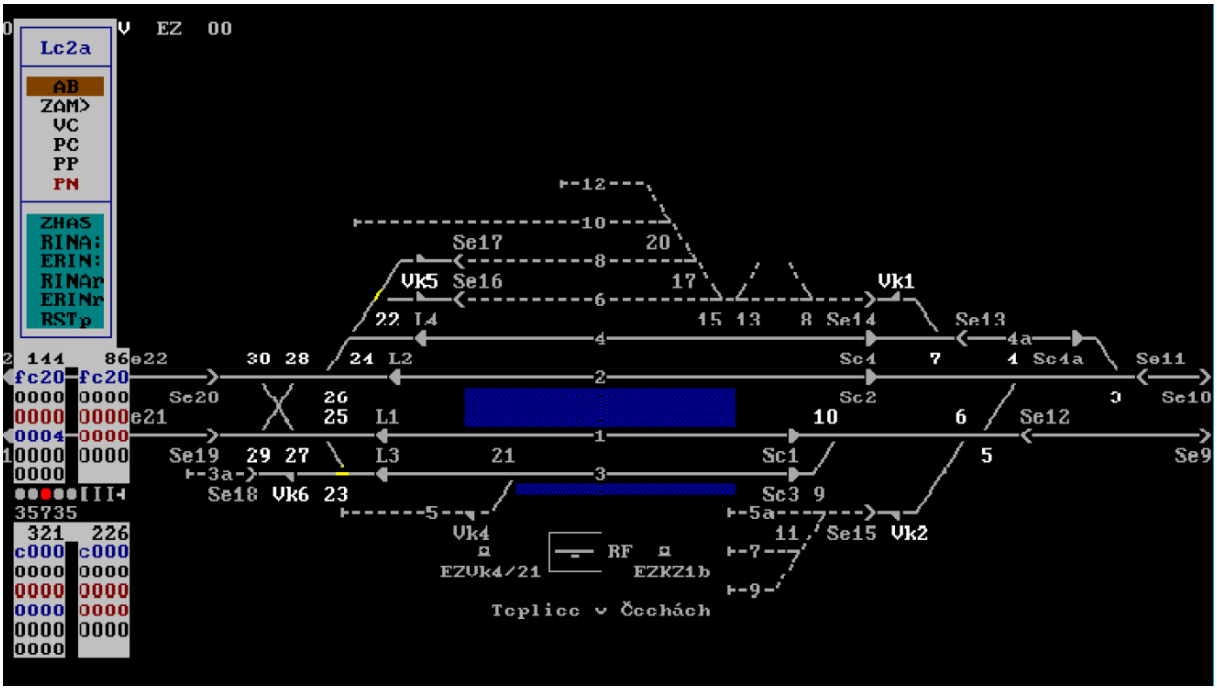

Figure 13 Controlling menu for signal Lc2a

Step 2: Explain how to set routes and the kind (e.g. train movement, shunting) that you can set

Main routes and shunting routes are set by pressing the mouse button on the signal symbol, or from the signal menu and by clicking on the track circuit behind the signal, where the route should end. After the rolling stock passes, the journey is canceled automatically. The dispatcher can use the command stack for preselection of traffic routes, the traffic routes will be selected sequentially according to the specified order.

Command tray - indication on the monitor:

VZ……setting routes (issuing a command) from the stack

PV....choice of preferred route

EZ... stack editing

Step 3: Explain how the routes are displayed at the interlocking

- Green: Set main route
- White: Set shunting route
- Red with train number: Occupied main route
- Red without main route: Shunting movement

Step 4: Explain how to release routes

If you set a wrong route and you want to release it, then you have to set a stop aspect at the signal. Do to that you have to click in the green signal / or white shunting aspect and click stop. In the second step you click on the same signal and click the button release train / shunting route (STOP).

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Step 5: If you have single line operations, then explain how the operation and dispatch on the single line works

In the interstation section Čadca - Hričov, a track security device of the 3rd category has been built - a two-way three-character automatic block with a complete block condition introduced automatically by the movement of the train.
In the interstation section Čadca - Bytča, a track security device of the 3rd category has been built - an automatic block for two-way traffic without a section signal.

Command tray - indication on the monitor:

ZTS> ..... request for granting line approval

ZTS< ..... cancellation of the request for approval

UTS ..... granting line approval

STIT ..... insertion / withdrawal of warning label

ZAK> ..... registration of departure ban

ZAV> ..... introduction of emergency conclusion of line approval

STOPPING ..... repositioning all signals of the track section in the direction of the granted consent to the STOPPING position

UBP> ..... introducing full block condition

STATUS ..... display of text information about the status of the

TZZ ODHL ..... sending unsubscribe

ZAK< ..... cancellation of departure ban registration

ZAV< ..... cancellation of the emergency conclusion of the line approval

UBP< ..... cancel complete block condition

AŽD interlocking may not contain some functions in the mentioned menus, on the contrary, it may also contain other types of service menus according to local needs – auxiliary signal, power supply, etc.

Step 6: If you have any industrial siding in your area explain how the operations work with between your area and the line

In Čadca is connected no special feeder (industrial) line.

Step 7: If you have any change between tracks with and without catenary, then explain the special issues to set routes (if there are any)

In Čadca there are no special issues to set a route to track without catenary.

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Step 8: If you have call on signals, explain how to set one

The train will be allowed to run on an emergency paved main route at a call sign (conditions are set by the relevant regulations). Before the call signal is lit, the dispatcher is alerted to unfulfilled conditions. The act of lighting the call sign is a compulsorily documented command, the dispatcher must confirm its execution with the "asdf" confirmation sequence. The lighting of the call signal is time-limited for a period of 60 to 180 s. The dispatcher's device notifies the dispatcher of the automatic termination of the summoning signal 30 s before the end of the lighting (also an acoustic signal), the dispatcher can extend the lighting time from the menu of the relevant signal with the PPN command. The call signal can be terminated at any time by the STUJ command from the menu of the relevant signal. After the automatic termination of the call sign and after its termination by command, the emergency conclusions of the individual units are preserved.

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3.4. Tests of the University of Zagreb

The University of Zagreb tested the guideline in the Laboratory for Rail Traffic Safety with the railway model of the railway network. Also, the guidelines were tested with models of railway locomotives, electric and diesel motor units (EMU/DMU), and passenger and freight wagons. In the University of Zagreb laboratory the interlocking is not included in the software for regulation of Railway traffic because the idea is that students do everything manually and allows students to understand the organization and management of railway traffic from the basic knowledge to the complicated situations which can be simulated on the model. The University of Zagreb Laboratory plans to include electronic interlocking on all four stations with Croatian national rules for operating the trains.

Generic introduction for controlling interlocking

In the University of Zagreb, laboratory the interlocking is not included in the software for regulation of Railway traffic, and students need to understand the Railway procedures to work in the model but the part of the line on the Railway model works like electronic interlocking. This is a part of the Absolute-Permissive Block (APB) that ensures the safe movement of trains in the inter-station area. The APB control device is a signaling and safety device that enables safe traffic of consecutive trains between two neighboring stations on the same track and prevents the setting of train paths for simultaneous trains running in the opposite direction on the same track between two adjacent stations. Each block signal sign must depend on the control of the freedom and occupancy of the corresponding block section and the signal signs of the previous and next block signal. Signal signals change automatically when a train encounters certain elements on the track.

Exit signals in the set direction from the station show the signal sign "Stop", and block signals may show the signal signs "Free, expect Free or Caution", "Caution, expect Stop" and "Stop" but as a rule, until the train starts, block signals are "Free, expect Free or Caution" or extinguished, except for the distant signal of the neighboring station which shows the signal sign "Caution, expect Stop".

When the train operator sets the exit train path, the corresponding sign for permitted running will appear on the exit signal, and the train can start. After the train occupies the first isolated section behind the exit signal and after 2 seconds, a "Stop" signal sign will be indicated on the exit signal. The signal sign "Free, expect Free or Caution" on the same exit signal will be shown again only after the end of the previous train leaves the second block section in the direction of train movement.

The train ride will cause the change of signal sign on the block signals to the "Stop" signal sign 2 seconds after the block section is occupied behind that signal. The release of the block section will cause the change of signal sign "Stop" (red) at the signal that protects it to "Caution, expect Stop" (yellow), and the change of signal sign "Caution, expect Stop" on the signal in front of this to the signal sign "Free, expect Free or Caution "(green).

As soon as the block section is released, it is possible to make the next consecutive run.

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Test with Station A

Step 1: Explain the control area, signals, and limits of the interlocking and the power supply

Station A is the simplest station on the railway network with an intersection function. Passenger and freight trains in this station can be stopped or pass it and/or cross, pass, or overtake each other if necessary. The station is connected to Station D by a double-track line equipped with automatic block protection. On the other side towards Station B is a double-track line with interstation dependency. Station A is fitted for this purpose with four tracks (2 main passing tracks), two sidings, and two home and eight exit signals.

The end of the controlled area in Station A is the space between the home signal on one side and the home signal on the other side.

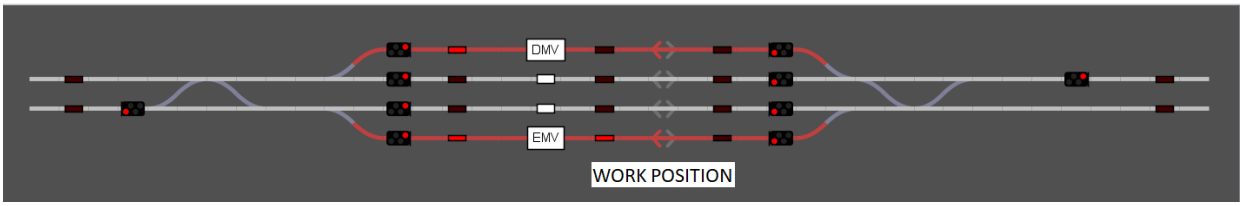

Figure 14 Schematic view template of Station A

Home and exit signals may be set so that they show the signal sign for permitted driving only when it is previously determined that the train's path is secured and that there is no obstacle to the safe entry or exit of the train.

Step 2: Explain how to set routes and the kind (e.g. train movement, shunting) that you can set

Track routes behave like the Memory module. Students can set a list of turnouts or signals to a specific state and they will be set and reserved as long as the track route is active. That means that they cannot be set manually anymore by clicking or by other track routes, and they are not used by main routes. Blocks provide some basic protection against collisions by not allowing two trains to be in the same block. Main routes allow you to automate the path a train is following on your layout. Main routes can be defined on their own and attached to a train.

Creating a new shunting route in iTrain software defaults to a normal route, but there is also the option to shunt the whole or part of the route. When shunting, the following things are different:

- There is a separate maximum speed for shunting defined globally and/or per block.
- Reservations are made in different teal colors instead of yellow/orange color.
- Direction changes in single-direction blocks are allowed.

Students can either choose to make the whole route of type ‘Shunt’, or create a ‘Mixed’ route in which case the shunting parts are explicitly marked via the extra option ‘Shunt’ per item in the route.

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Step 3: Explain how the routes are displayed at the interlocking

- Yellow: Set main route
- Yellow/orange: Set shunting route
- Yellow: Flank protection
- Red with train number: Occupied main route
- Red without main route: Shunting movement

Step 4: Explain how to release routes

Releasing of track routes are released by the train or manually only if we are sure that no part of the train is occupying (parts of) the reserved turnout. A train is normally in one block and we call this the 'Control' block. This block is coloured red and the name of the train is displayed in black letters in the block element. Sometimes the tail of the train is still in another block or even in multiple other blocks. These are called the 'Release' blocks, as they will soon be released when the train has moved to the control block. These blocks are also coloured red, but the name of the train is grey. When the direction of the train changes, the last release block will become the new 'Control' block and the previous 'Control' block will become a 'Release' block.

When you want to extend an existing train, you might end up covering an extra block for the train. To manually extend this in the switchboard you can hold the Command and Alt keys and click on a block element to add a 'Release' block to a train. This way you prevent other trains to use this block. By holding the Shift, Command, and Alt key and clicking on a block element, a 'Release' block will be removed.

There is one more method to remove a train from a block, by holding the Shift key and clicking on a block element. This will not necessarily remove the train from the clicked block, but it will first remove the reservations in order from the front back to the 'Control' block and then remove all the 'Release' blocks from the tail back to the 'Control' block, and finally, it will remove the train from the 'Control' block. So by repeatedly clicking on the 'Control' block, while holding the Shift key, you will remove the train from the switchboard.

Step 5: If you have single-line operations, then explain how the operation and dispatch on the single-line works

The line between Station B and Station C is one track line. Station B is connected to the passenger part of Station C by a single track, where traffic runs at a distance between stations. For that line train signaller need offers trains to the neighbor station and the train signaller from the neighbor station can accept or decline the offer (depending on the current traffic in the station).

Step 6: If you have any industrial siding in your area explain how the operations work between your area and the line

At the University of Zagreb Laboratory an industrial sidings doesn't exist.

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Step 7: If you have any change between tracks with and without catenary, then explain the special issues to set routes (if there are any)

In the University of Zagreb Laboratory there are no special issues to set a route to track without a catenary.

Step 8: If you have called on signals, explain how to set one

In the University of Zagreb Laboratory there is no call on signals.

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3.5. Tests ČVUT Praha

Generic introduction for controlling interlocking's

This introduction is a briefing for the control of an interlocking. It is generic designed, that means that you can use it on every training interlocking.

Hint: This introduction is designed for the academic training purpose and not for infrastructure managers.

Station Strančice

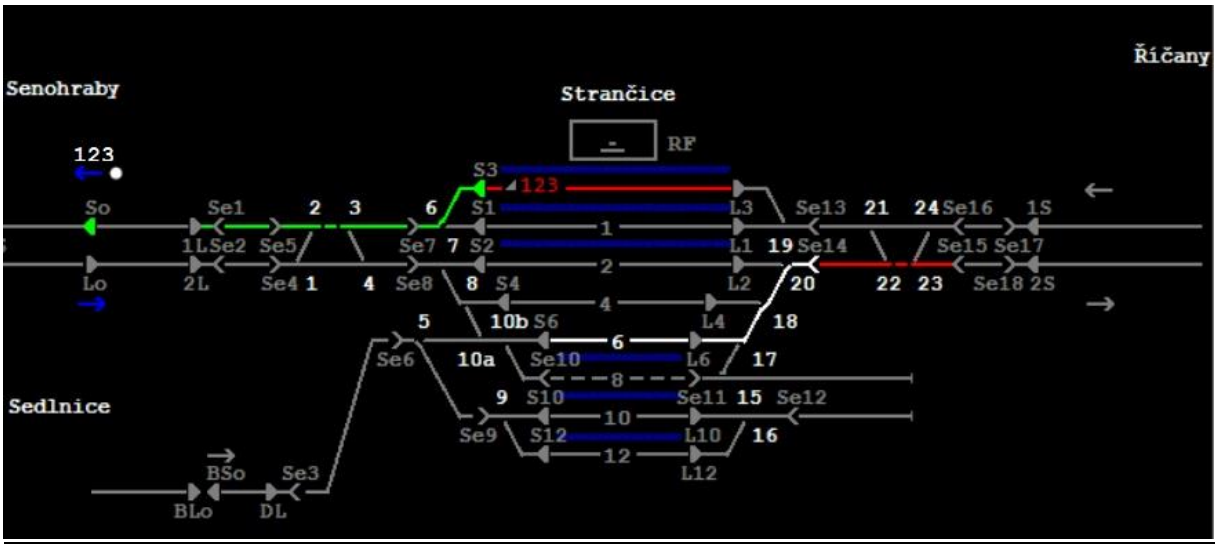

Figure 15 Electronic interlocking of Strančice

Step 1: Explain the control area and limits of the interlocking and the power supply

The station Strančice is part of generic network in the Railway Laboratory of Faculty of Transportation Sciences in Prague.

Strančice is on the double track main line (with catenary) Říčany – Benešov in right hand traffic. From Strančice starts the single track line (without catenary) to Čerčany (via Sedlnice).

End of the controlled area:

- home signals 1L and 2L from direction of Senohraby – open line is equipped by one direction block system (block signals So and Lo are controlled from Hr. Mnichovice), departure from Strančice to Senohraby is allowed by exit signals S3, S1, S2, S4 or S6 to open line track number 1;
- home signals 1S and 2S from direction of Říčany – open line is equipped by both direction automatic block system with permissive block signals (there are no indications of block

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signals), departure from Strančice to Říčany is allowed by exit signals L3, L1, L2, L4 or L6 to both open line tracks depend on direction locking (track number 2 is preferred);

- home signal DL from direction of Sedlnice – open line is equipped by both direction automatic block system with absolutive block signals (block signals BSo and BLo are operated automatically, only in emergency block signal BLo can be controlled from Strančice), departure from Strančice to Sedlnice is allowed by exit signals S6, S10 or S12;
- shunting signal Se101 from feeder.

Signals:

- signals with a full triangle are main signals (combined with shunting signals);
- signals with small drawn roof are shunting signals.

Step 2: Explain how to set routes and the kind (e.g. train movement, shunting) that you can set

You can set main route or shunt route.

If you want to set main route, you have to click on the main signal (where the route starts) by left button and then to final track section (station tracks or open line tracks).

If you want to set shunt route, you have to click on the shunting signal or main signal by middle button and then to final track section.

Step 3: Explain how the routes are displayed at the interlocking

Track section:

- grey: free
- red: occupied by train / vehicles (the train number can be assigned to occupied section)
- green: main route locking
- white: shunt route locking

Signals:

- grey: stop signal
- green: cleared for main route
- white: cleared for shunt route

Step 4: Explain how to release routes

Routes are released automatically section by section when vehicle pass it.

If you want to cancel route, you have to click on signal (where the route starts) by middle button and select RC from menu. Stop signal is set immediately, route is released with delay.

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Step 5: If you have single line operations, then explain how the operation and dispatch on the single line works

Signals can be cleared only in direction, which is showed by direction arrow. When you need to direction change, it must be initiated by station that is requesting direction. When direction arrow is grey, you have to click on direction arrow and select ZTS> from menu. The direction arrow starts flashing. The other station have to accept it by clinking on direction arrow and selecting UTS from menu.

When direction arrow is blue, then direction is locked.

Step 6: If you have any industrial siding in your area explain how the operations work with between your area and the line

(It is not implemented)

Step 7: If you have any change between tracks with and without catenary, then explain the special issues to set routes (if there are any)

There are no special issues to set a route to track without catenary.

Step 8: If you have call on signals, explain how to set one

Call on signals can be used only in degraded mode operations. You have to check correct position of switches (and use emergency locking – you click on switch symbol by left button and select ZAM>), freedom of track sections and status of other necessary elements. Then you click on main signal by middle button and select PN. Finally you click on flashing square to confirm it.

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3.6. Test in EBL Switzerland

The generic introduction was also tested in the EBL Switzerland in Dübendorf. The generic introduction was tested at the former ETH operating field at every interlocking. EBL Switzerland owns two operating fields the first is as mentioned the former laboratory of ETH Zürich and the second one is the former training field of SBB. The ETH field is equipped with different interlocking types whereas the former SBB field is only equipped with the Domino interlockings. The ETH side is also equipped with two interlockings of the Domino type. For that reason it was not necessary to test guideline on both facilities. Furthermore the EBL plans currently to equip the SBB field with new equipment. The research activity was planned for two day, however after one day in the test was finished. The types of interlockings were:

- Mechanical interlocking in a death end terminal
- Domino 67
- Domino 57
- Electro mechanical interlocking
- Electronic interlocking based on the ILITS software

The question that have been tested are at every interlocking are summed up under every step.

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Generic introduction for controlling interlocking's

This introduction is a briefing for the control of an interlocking. It is generic designed, that means that you can use it on every training interlocking.

Hint: This introduction is designed for the academic training purpose and not for infrastructure managers.

Step 1: Explain the control area and limits of the interlocking and the power supply

Wedorf (ILTIS-Oberfläche kein Stw.):

Control area = limits

No catenary

Igswill (mechanical):

Limit = control area

No catenary

Ypslikon (Domino 67):

Control area on a table

No catenary

Zetthausen (electromechanically stw.) :

112*

D*→ entrance pre signal

B* → exit pre signal at mast ES

B/C group exit signal

A → entrance signal

Yellow = "Gleisfreimeldung"

White = no "Gleisfreimeldung"

Control area = limits

No catenary

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Pewald (Domino 69):

Wedorf/Zetthausen – Pewald – Utal

Control area = limits 212/215 and 112/115

Item signal and track

No catenary

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Step 2: Explain how to set routes and the kind (e.g., train movement, shunting) that you can set

Wedorf (ILTIS-Oberfläche kein Stw.):

Train: Start → target, Drag and Drop green line

Pull to the target! Confirm the proposal.

Shunting: Same proceed with shunting signal.

Iggswill (mechanical):

Signal → red

Points → blue

By shunting signalising manual by hands

Ypslikon (Domino 67):

Routes and shunting:

Start → target route runs in from target

Blue = shunting

Red = signal

Zetthausen (electromechanically stw.):

Shunting with setting points

Train movements:

Direction of the main route is precondition

1. Set points
2. Direction button

Points with malfunction = “Auflösungsfreigabe”

Pewald (Domino 69):

Shunting movement: arrangement between engineer and operator

Blue buttons = points

No shunting signals

Points button + single lock (“Einzelverschluss”)

Track buttons with red ring

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Step 3: Explain how the routes are displayed at the interlocking

Wedorf (ILTIS-Oberfläche kein Stw.):

Green → main routes

Blue → shunting

Red → occupied track

Iggswill (mechanical):

Entrance: example: 304 → III

1. Check free
2. Decision
3. Set points
4. Block the route
5. Set signal

Exit the station:

1. III is blocked
2. Decision
3. Set points
4. Determination
5. Check the “Streckenblock”
6. Set signal “Vorblocken”

Ypslikon (Domino 67):

Red = occupied track

White = main route runs in

Main and shunting signal …

Zetthausen (electromechanically stw.) :

Look at page 1

Pewald (Domino 69):

White = main route runs in

Red = occupied track

Only shunting route

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Step 4: Explain how to release routes

Wedorf (ILTIS-Oberfläche kein Stw.):

No regular action

"Signalhaltfall" → YHZ-Button

With right click on the mouse to the target and "Auflösung"

Iggswill (mechanical):

Regular: V → I

Points 1/2 with relay

Ypslikon (Domino 67):

Only in special case

1. Reset signal → stop
2. Operation dissolving from target

Main route:

1. Reset signal
2. Emergency dissolving with protocol

Zetthausen (electromechanically stw.) :

Fst-Signalschalter in regular position

1. Emergency dissolving
2. All switches in regular position

Pewald (Domino 69):

1. Emergency dissolving → emergency dissolving button (only main routes)
2. "Restfharstraßenauflösung" (as example: last point occupied) operation dissolving and start button

By remote control at Domino 69 operation dissolving → from start

Step 5: If you have single line operations, then explain how the operation and dispatch on the single line works

Wedorf (ILTIS-Oberfläche kein Stw.):

No Change of permission

Iggswill (mechanical):

/

Ypslikon (Domino 67):

Directional operation

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Permission from neighbour

Zetthausen (electromechanically stw.) :

Request the direction

If direction of the track is locked the neighbour have to submit

Pewald (Domino 69):

With a timetable …

Zugnummermeldeanlage mit ILTIS fernmündlich

Accept button → Blue white button → automatic change

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Step 6: If you have any industrial siding in your area explain how the operations work with between your area and the line

Wedorf (ILTIS-Oberfläche kein Stw.):

/

Iggswill (mechanical):

/

Ypslikon (Domino 67):

/

Zetthausen (electromechanically stw.) :

/

Pewald (Domino 69):

/

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Step 7: If you have any change between tracks with and without catenary, then explain the special issues to set routes (if there are any)

Wedorf (ILTIS-Oberfläche kein Stw.):

/

Iggswill (mechanical):

/

Ypslikon (Domino 67):

/

Zetthausen (electromechanically stw.) :

/

Pewald (Domino 69):

/

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3.7. Tests in EBuEF Berlin

In January 2023 the guideline was tested in EBuEF Berlin this is the laboratory for railway operations of TU Berlin. The introduction was tested on the entire laboratory. The test tooked place during a common lecture and after the lecture. The guideline worked also as well in the interockings. One point of discussion was the issue of the term control area again. As one electronic interlocking controls the station Walfdorf and the junction Leopoldsgrün (test xx). On the other side the difference was clearer at the mechanical interlocking as in the ELA of TU Braunschweig.

Generic introduction for controlling interlocking's

This introduction is a briefing for the control of an interlocking. It is generic designed, that means that you can use it on every training interlocking.

Hint: This introduction is designed for the academic training purpose and not for infrastructure managers.

Step 1: Explain the control area and limits of the interlocking and the power supply

Berg (Befehlsstellwerk):

Mechanical Interlocking between "Walfdorf" and "Berg Wärterstellwerk"

Block Signalling

points and Signals from and to "Walfdorf"

Berg (Wärterstellwerk):

Mechanical Interlocking between "Berg Befehlsstellwerk" and "Derau"

Block signalling

points and signals from and to "Derau"

Derau (doubletrack mainline):

SPDtS

Bhf: entrance signal bis block signal + siding

To "Berg": automatic track block

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To “Cella”: “Blockstelle Alp” pre-block

Walfdorf (ESTW):

Control area = station area

“Walfdorf” station + junction “Leopoldsgrün”

To and from “Cella”

To and from “Leopoldsgrün”

From junction to and “Leopoldsgrün”

Pörsten:

STw EZMG:

Station area: from signal A to signal D

Power supply not necessary

ESTW:

No signals on the tracks

Cella (E43):

Entire station controlled by interlocking

Catenary not necessary

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Step 2: Explain how to set routes and the kind (e.g. train movement, shunting) that you can set

Berg (Befehlsstellwerk):

- points are set
- Blocking the route
- Signals can be set

Berg (Wärterstellwerk):

- get commands
- set points
- set the route
- block the route
- set signals

Derau (doubletrack mainline):

Start button: signal (red)

Finish button: track (grey)

Shunting only in yard (points + signal, no route)

Walfdorf (ESTW):

Start → target (blue) + button "Verarbeiten"

Main signal → direction main routes

Shunting signal also start → target+"Verarbeiten"

Pörsten:

STw EZMG:

Points are moved with buttons

Pre e. g. $1^N - 3$

$1^\mu - 1$

$1 - 1^s$

$3 - 1^s$

The routes are select by controlling the pointer

The signal hast to be set by the signal

Shunting signal while frames green

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ESTW:

Main routes are set with a start → target click from signal to XDI or same

Shunting signals are set with start → target

Green → main route set

Red → occupied track

Shunt routes are blue

All with the button “Verarbeiten”

Cella (E43):

Routes are set with the buttons

Points and signals are controlled by the blue and red buttons

Blue → points

Red → signals

Step 3: Explain how the routes are displayed at the interlocking

Berg (Befehlsstellwerk):

“Fahrstraßenhebel” no illumination

Berg (Wärterstellwerk):

Set the “Fahrstraßenhebel” to no illumination

Derau (doubletrack mainline):

Coloured lights

Red: occupied track

White: route set + points (no overlap)

Walfdorf (ESTW):

Green: main route set

Red: occupied track

Blue: shunting route

Yellow: controlled track → with “Gleisfreimeldung”

White: track without “Gleisfreimeldung”

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Pörsten:

STw EZMG:

the status of the points is displayed white

red light

ESTW:

red → occupied

blue → shunt route

green → main route

yellow → track

Cella (E43):

Routes not are displayed.

The status of the signals is displayed red and green.

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Step 4: Explain how to release routes

Berg (Befehlsstellwerk):

Standard: train release block; all points and signals can be released manually

wrong block: break the lead seal (documentation is necessary and maintenance has to be informed)

points and signals can be released manually

Berg (Wärterstellwerk):

Standard: moving train release block, switches and points released manually

Wrong block: break the lead seal by activate of “Befehlsstellwerk” (documentation necessary; maintenance has to be informed)

Switches and signals released manually

Derau (doubletrack mainline):

Standard: automatic

Fall back: button “Fahrstraßenhilfstaste”

Walfdorf (ESTW):

Only for degraded mode

Click with the right mouse button → click the order → Button ILF1 + ILF2 + “Verarbeiten” + documentation

Pörsten:

STw EZMG:

SH = Signalhilfsblock

FH = Zählpflichtig

SH→ brings signals on the north or south

SH Nord; SH Süd; FH Nord, FH Süd

ESTW:

Only for degraded mode operations with a click of the right mouse and the correct command

Cella (E43):

The release of routes is regular process, all button has to be removed in the basic status.

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Step 5: If you have single line operations, then explain how the operation and dispatch on the single line works

Berg (Befehlsstellwerk):

/

Berg (Wärterstellwerk):

/

Derau (doubletrack mainline):

/

Walfdorf (ESTW):

But block → "Cella"has to block back that a new route is possible

From "Leopoldsgrün" junction to "Tessin"

Right click

Chose EA + Button "Verarbeiten"

Pörsten:

STw EZMG:

To "Tessin" → Streckenblock → semi-automatic block

Enl → A button

Drewitz ZWP 801

ESTW:

The signaller controls an entire line, so there is no need for the change of direction

Cella (E43):

There are no single line operations. Between there is a block. Block to Alp and Walfdorf and vice versa there.

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Step 6: If you have any industrial siding in your area explain how the operations work with between your area and the line

Berg (Befehlsstellwerk):

/

Berg (Wärterstellwerk):

/

Derau (doubletrack mainline):

Siding; passenger train yard

Shunting signal + switches (no route setting)

Walfdorf (ESTW):

No feeder / siding

But tracks shunting operation with shunting routes

Pörsten:

STw EZMG:

There are no sidings only tracks

ESTW:

No siding

Cella (E43):

Only station area!

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Step 7: If you have any change between tracks with and without catenary, then explain the special issues to set routes (if there are any)

Berg (Befehlsstellwerk):

/

Berg (Wärterstellwerk):

/

Derau (doubletrack mainline):

/

Walfdorf (ESTW):

No catenary to “Tessin”

1. start → target right click
2. chose “Andere” + “XTS F-“
3. chose “Verarbeiten” + in Bft. Spenevkasse

Pörsten:

STw EZMG:

Not applicable / necessary

ESTW:

Not necessary

Cella (E43):

Not applicable

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3.8. Optimised template

After the tests and the discussion of the results in the consortium the following optimised version has been developed. The main issue during the tests was the terminology as every European railway has historically developed their own. As the introduction should be useable for every railway system/laboratory the terminology had to be optimised. For that reason it is a very difficult task to find a generic description. Furthermore it was also discussed for what interlocking types the guideline should be used. As it was tested on almost every type of interlocking. Hence, the guideline works for almost every type of interlocking in the European railway system. However, there are limits especially if it comes to the type of mechanical interlockings. It is also the case that this interlockings aren't state of the art anymore. For that reason the recommendation of the consortium is to use the guideline started from the type of relay interlockings. So it is in the scope of the users, if the use in guideline also for mechanical interlockings.

Another major issue is the definition of the term control area and interlocking limits. This is term is now changed to the term control area and the differentiation between controlled in and automatic signals in the control area of a dispatcher. The new definition was necessary because the definition interlocking limits is already used in the British railway terminology. For that reason another definition hat to be found.

In the first version the term feeder line was used. However, this term was not the correct term. The correct wording is "industrial siding", hence step 6 was optimised in the wording after the tests and further research.

- Step 1: Explain the control area and controlled and automatic signals in the area. Explain also tracks with and without catenary
- Step 2: Explain how to set routes and the kind (e.g. train movement, shunting) that you can set
- Step 3: Explain how the routes are displayed at the interlocking
- Step 4: Explain how to release routes
- Step 5: If you have single line operations, then explain how the operation and dispatch on the single line
- Step 6: If you have any industrial siding in your area explain how the operations work with between your area and the line
- Step 7: If you have any change between tracks with and without catenary, then explain the special issues to set routes (if there are any)

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4. Test in week 49 and survey

During week 49 (2022) a test of an online exercise was held, with students of the project partners from Žilina and Zagreb. Furthermore a group of CVUT Prague participated in the tests. This test was done with the software *"Signalsoft"* from IfEV (TU Braunschweig). The reasons to choose this software were that the IfEV gained experience in digital exercises during the Covid pandemic, the availability of the software and the knowledge of how to use and to connect the software online. Furthermore Signalsoft was a supporter of the IDEACAREL project ("Letter of Support"). However, it is not necessary to use this particular software. It is also possible to use another software for a digital railway exercise.

In addition the project staff also gained already experience with Signalsoft as on the one hand the software was used for the try of digital exercise for team members and on the other hand every team member knows the software from the first on side meeting in Braunschweig. CVUT Praha also had already gained that knowledge. Hence, this was also an argument to choose Signalsoft.

The test for the IDEALCAREL project with the students was a test only for online teaching and also to try out the developed materials. In the test only experienced students with knowledge of railway operations participated, e.g. Master and PhD students from all partners. The test took place in one week. On the first day a lecture about how to use the software was held online, this lecture was streamed to the class rooms to the partners or students could join from home the online meeting. After the introduction the students had two days to work individual with the software to train the handling with it.

On the fourth day the first exercise was held in local groups with an international trainer from another faculty. Hence, every group has to use English for communication and the trainers could also experience their aspects about online exercises. The last day was held in international groups with three students from different faculties. The test with the software worked in different ways. For two groups the software worked well and the full function was possible whereas some groups had the problem that the software didn´t worked. The results and the experience of the students can be seen by the results of the survey.

For the trainers the test was also a good experience to improve the digital and common teaching skills. During the test it was the idea that every group has a trainer. For the first test it was the idea that the local groups work with an international trainer from another faculty. With that approach the trainers and students should gain experience in new digital lecture skills and also in working with international groups.

For the test Cisco Webex was used as communication platform in every step. TU Braunschweig owns licenses for that software that was the reason to choose it. Furthermore the entire consortium has experience with the software as it was used for online meetings. The introduction lecture for the software was given via Webex in the common online lecture. The main idea for the first exercise was that the international trainer support the local groups. However, this concept didn´t worked very well, because the local trainers were supporting the local groups with the software. Hence, this

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approach was not the best in for the internationalisation and digitalisation of the exercise. In the international groups and with the fact that every student was at a different location the concept worked well.

During and after the test one result was that for the support of the exercise a big staff of trainers is required. The number of the trainers depend of how many groups are participating in the test. First of all every group needs a trainer for question about the handling of the software. Furthermore a result of the test was that a technical support is also necessary for the successful exercise. The technical support focused on the questions of how to connection could works and how to solve problems, if the connection disappears etc.

After the test an online survey was done with the students and also the trainers. The survey was filled out by 9 (of 16) students and 4 (of 4) trainers that participated in the test. The survey consisted of closed-end and open-end questions. For the closed end question 1 was the worst and 5 the highest/best rating. Students were asked about each part of the test. The first statistic is the students' feedback on the introductory lecture of day 1 (05.12.2022). The students were asked about the lecture, the quality of the developed teaching material, the improvement of their knowledge and also about their general satisfaction with the lecture. It can be seen that the students' satisfaction is above average to very high.

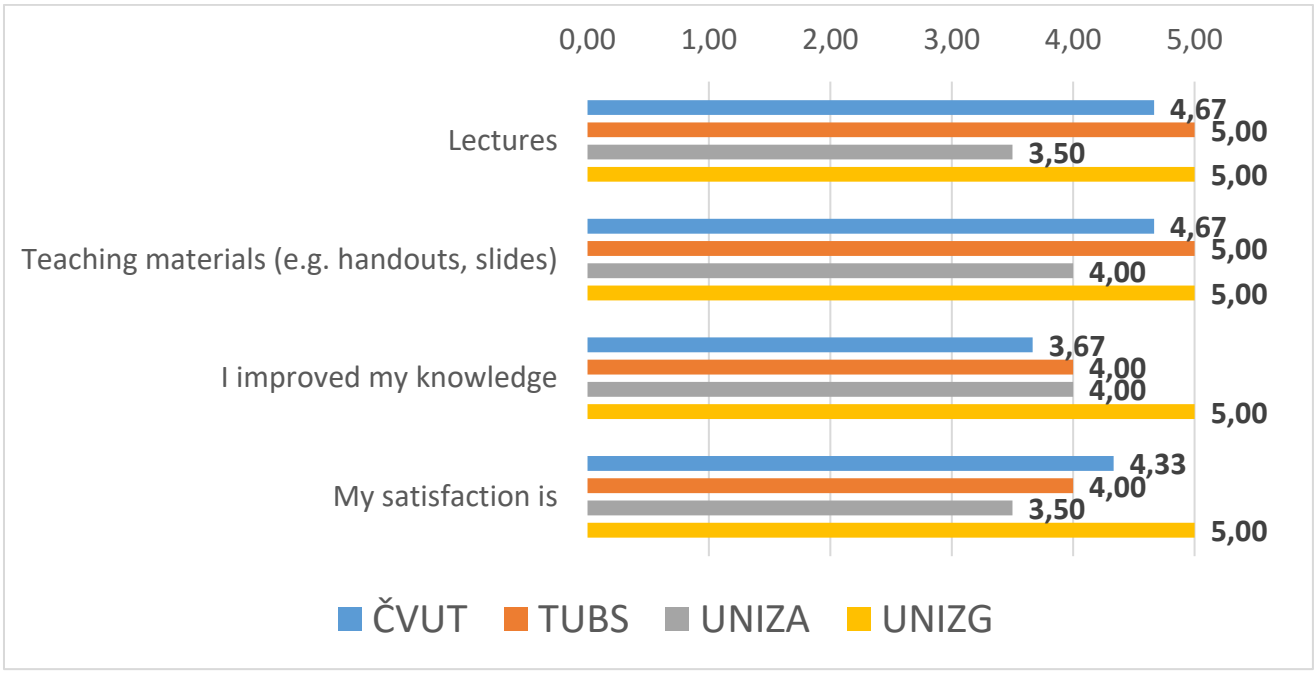

Figure 16 Student feedback on the lecture

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The next feedback from the students was about the exercise in local groups with the trainer from another faculty (activity on the 08.12.2022. Here the feedback was a little different then on the first activity.

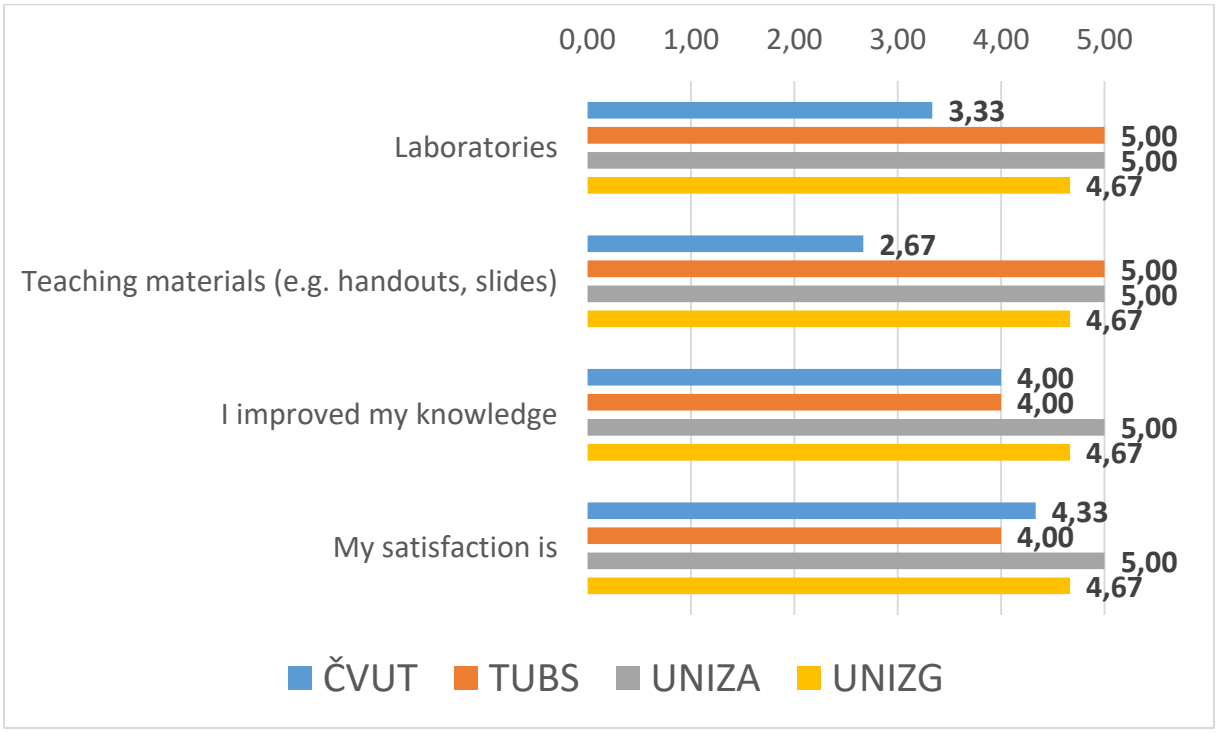

Figure 17 Student feedback on the first exercise

Some students were very satisfied and some students were just satisfied under the average. This could be also be due to the fact that the simulation didn´t work in every group.

The last feedback from the students also includes poor ratings. It should also be mentioned here that the software did not work for some students. Therefore, not everyone could work with the simulation. This could be a reason for the poor feedback.

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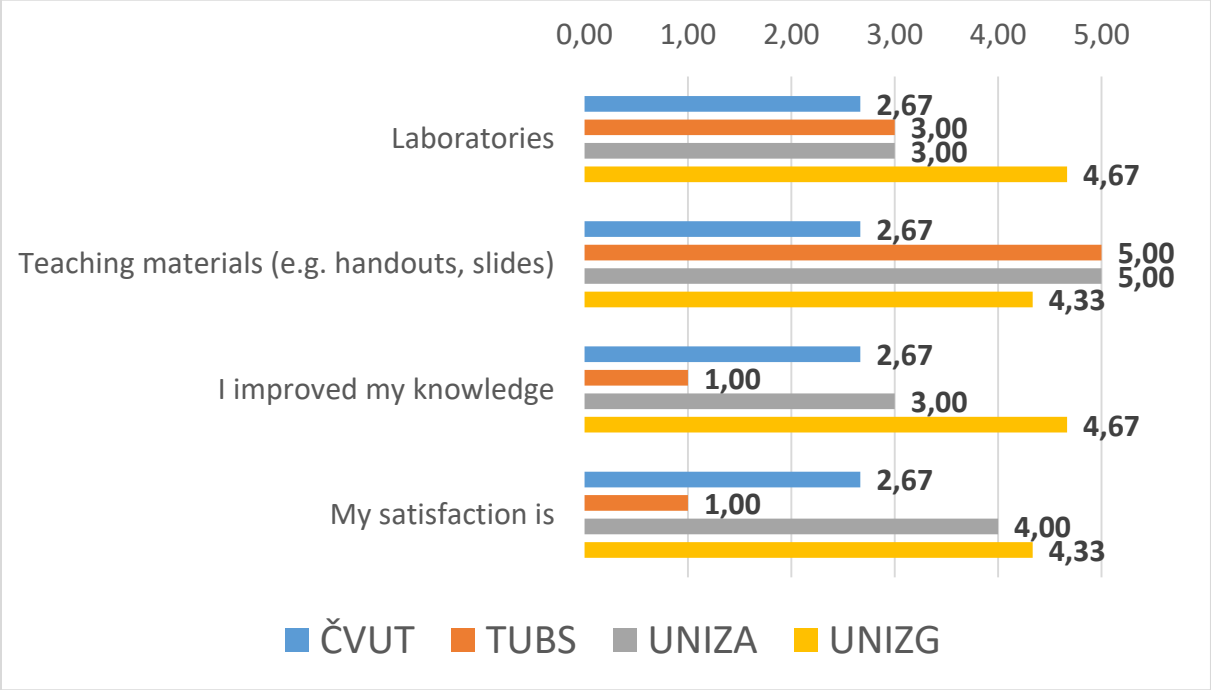

Figure 18 Student feedback on the second exercise

The last feedback from the students was related to the feedback on interesting questions. Here it can be seen that the students were not only able to acquire professional skills with the simulation, but that it was also a good opportunity to improve their social skills.

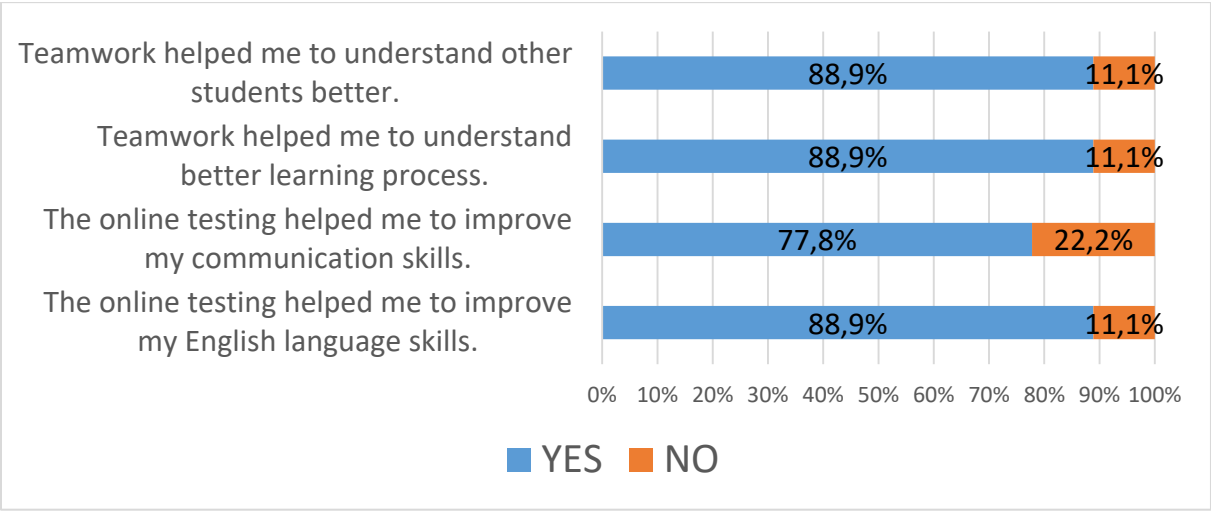

Figure 19 General feedback from the students

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As mentioned earlier, the feedback was not only collected from the students, the trainers also gave their feedback on the activities. The trainers were also asked about their feedback of the introduction lecture on day 1. This rating shows that the trainers were average to very satisfied with the online lecture. Regarding the question about improving the trainers' knowledge, it is worth mentioning that this was the first time that all trainers worked together in an international online exercise.

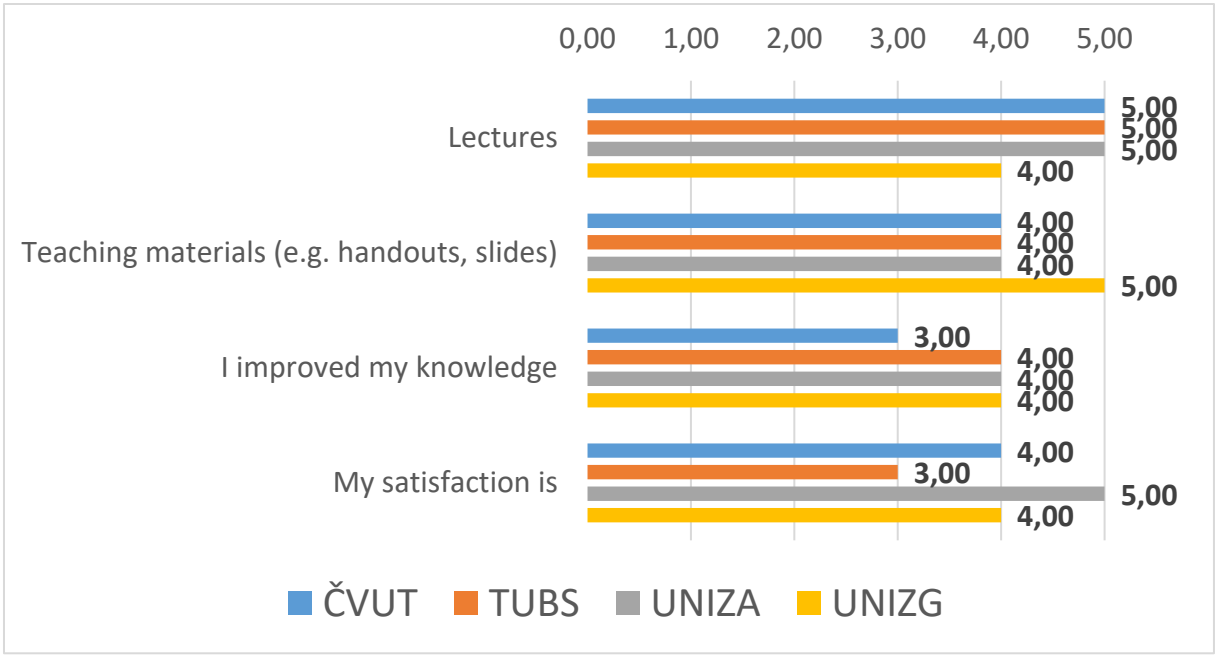

Figure 20 Feedback from the trainers on the lecture

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The results of the test on the fourth day were mixed from the trainers' point of view. This could also be due to the fact that the simulation did not work for some students.

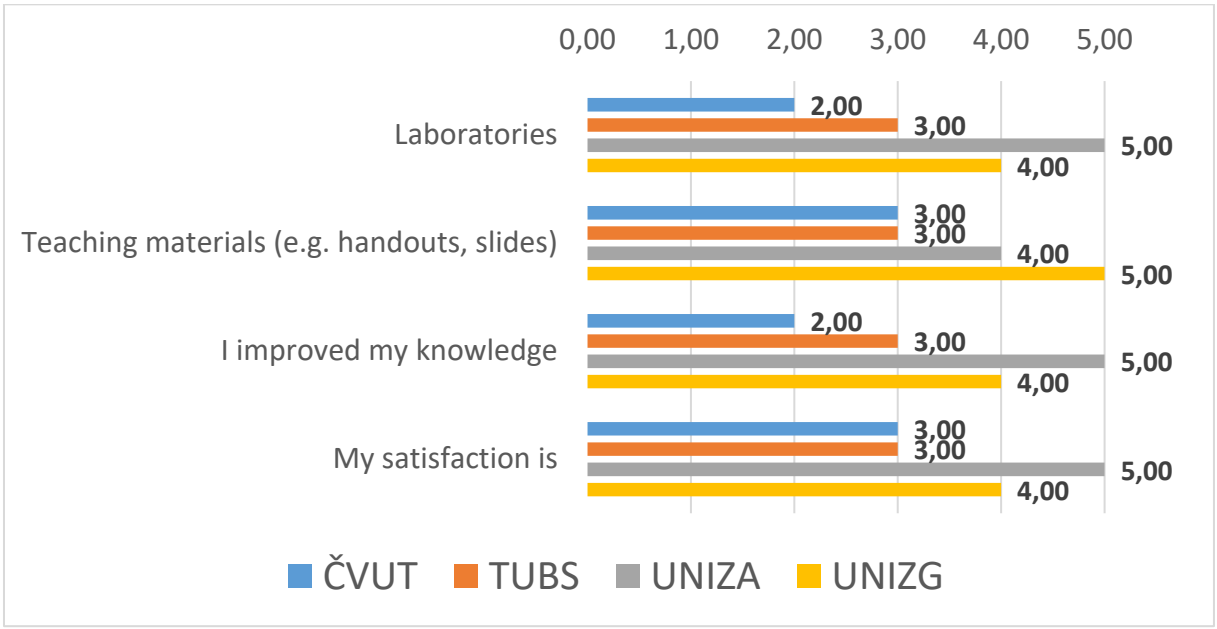

Figure 21 Feedback from the trainers on the first exercise

On the last day, the trainers worked with the students in mixed groups. Again, the results are mixed, which could also be due to the technical problems with the software and the technical support needed from the students.

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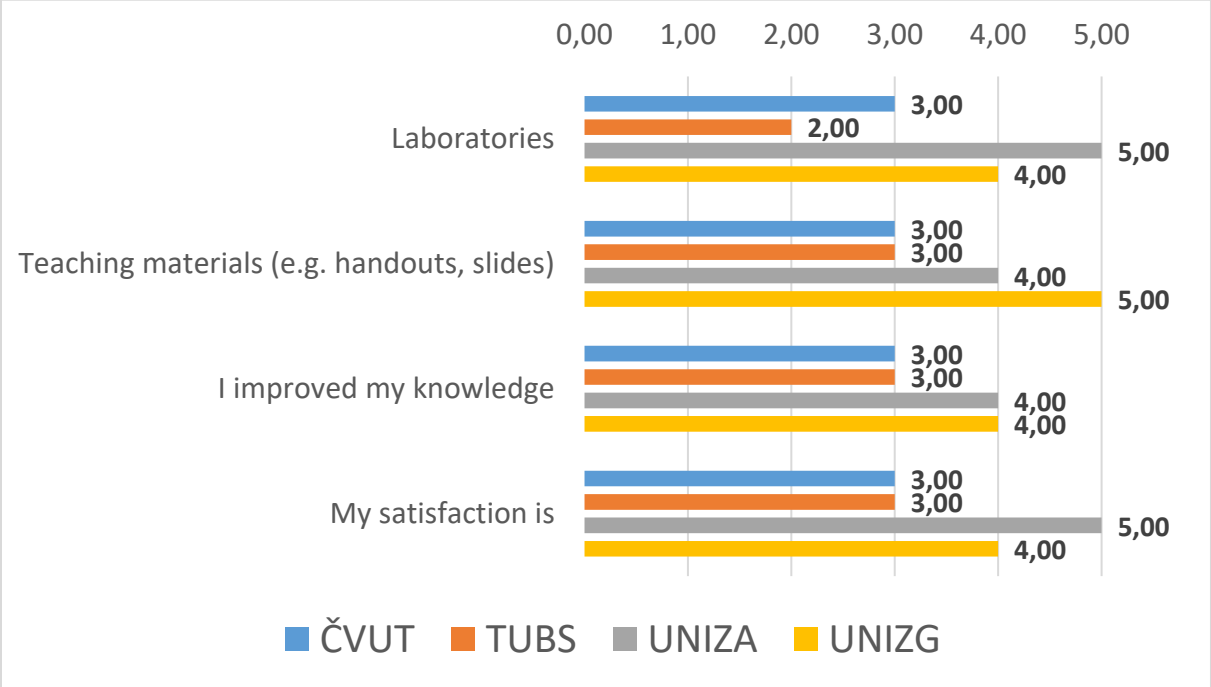

Figure 22 Feedback from the trainers on the second exercise

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5. Template for a laboratory course or distance learning environment

The course is designed for distance or hybrid learning. Furthermore the design of the course has to be as generic as possible. However, it is to mention that the course is designed for the understanding of railway operations and signalling systems. Hence, potential study field for the application of the course are: railway engineering, traffic and transport engineering, logistics, environmental engineering, civil engineering, urban and regional planning etc. The suggestion for the design of the course is based on the results of the practical test in week 49.

First of all it is to mention that the course is an exercise that supports the understanding of the lecture. For that reason a lecture part is required, because the students have gain the theoretical basics before the exercise. It depends on the institution and on the requirements of the students and the course of how to gain basic knowledge. First of all it could take place as a classical lecture. Another option to integrate lecture in one or two week course. The form could be also hybrid with audience in the class room and online. Furthermore it is also a possibility that the students can watch videos with the basics in an asynchronous form. In that case it should be considered that students have to take test before the exercise. In that case the trainer could check, if the students have understood everything. This is very necessary for a fluent exercise.

The second part is the introduction to the software. In that part students should be introduced to the handling of the software and the basic principles should be explained. The form of the lecture could be also synchronous or asynchronous, if the introduction will be online and asynchronous e.g. with video that explains the handling of the software, then a test before the exercise should also be considered.

The third part is the individual study time for the students to gain to skills for controlling the software. The duration of this part depends on the students´ skills and how long the need to understand and use the software well. Furthermore it depends also on the level of difficulty chosen by the trainers.

The fourth and last part is the connected simulation with the online software or the remote controlled laboratory. There should be no technical problems with this exercise. In addition, the students should already be familiar with the remote control of the software (or the software of the laboratory). In order for the exercise to serve its purpose and for the students to practice the principles of railway operation.

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Step	Form	Suggestions	Duration
Gaining basic knowledge	Classical classroom teaching Hybrid Online	Synchronous or asynchronous	Classical during the semester or intensive course in a week
Gaining the knowledge to control the interlockings	Lecture that could	Synchronous	Depending on the used software. Lecture of three hours could be done
Individual study of the simulation	Home exercise	Self-study by the students	One or two days
Simulation	Connected exercise	Synchronous	Depending on the requirement of the lecture and students.

Table 1 Suggestion for the structure of the generic course

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6. Technical Requirements and lessons learned

During the online-sessions with the students some technical issues and problems occurred. Most of them are caused by the so called “embedded” Version of the used software Signalsoft. Also not many students are familiar with online-gaming and the necessary settings of internet routes. During the session one of the students had to start the software and his hardware works as a server. Therefore he has to do some customizing in his router port settings. The used software only works with ipV4 addresses which is no longer standard for all internet access points.

Also the access to the server is restricted to the neighbouring stations in the simulated railway network, so only three students can connect and work together.

As a result of this, the following suggestions are for future online lessons independent on the used software:

- The Server should be centralized and accessible for all participants.
- The hardware of the server should not be used as a client
- All stations of the simulated railway network must have the possibility to connect
- The client software should use the standard Internet-Access, so there is no need for customizing the participants hardware

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Appendix

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Operational Rules for Railway Laboratories

For international student sessions in railway operations laboratories

June 2022

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This rulebook was developed to support students in operating sessions in railway operations laboratories. In particular, the rules established in this rulebook should enable students from different countries to participate in common operating sessions. Since it is not intended to be used for training of the operating staff of a particular railway, it is written in a generic form not referring to the rules of a particular railway. The main target group are students at universities that may later start a career in different national rail systems.

The rulebook contains only the rules for operators. Rules for train and shunting crews are not covered. The use of this rulebook requires the controlled network to be equipped with continuous track clear detection and an automatic block system. Outdated legacy systems as leverframe interlocking machines, and manual and semi-automatic block systems are not covered.

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Contents

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1 Terms and Definitions

Absolute signal
A signal that must not be passed in stop position without authority from the operator. Same rule applies, when the signal is dark.

ARS, Automatic Route Setting
A system for setting routes automatically without action from the operator.

Automatic signal
A signal that is controlled automatically by the trains moving along the line.

Block section
A section between two successive main signals on which train movements are protected by a block system.

Block system
A system that protects trains against following and opposing movements outside of station areas.

Controlled signal
A signal that is cleared by setting a route by action of the operator or by ARS.

Derailer
A flank protection device that would derail an inadmissible movement before it could join the protected route.

Direction locking
A function of a block systems that locks out opposing movements on lines with bidirectional operation.

Engineering notice
A notice issued by the operations management on the operational procedure during planned construction or maintenance works.

Engineering possession
A section protected by a line blockage for maintenance or construction work on which responsibility for controlling movements is transferred to the engineering staff.

Flank area
The track section between a flank protection device (flank point, derailer, signal) and the point to be protected.

Flank protection
The protection of a route against inadmissible movements on converging tracks.

Line blockage
The temporary state of a track section that must not be used for normal train movements.

Main route
A route governed by a main signal.

Main signal

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A signal that provides movement authority for a train movement. A main signal may also have a shunt aspect.

Main track
A track that may be used for train movements.

Non-shunting vehicle
A light vehicle that is not safely detected by track clear detection devices.

Normal direction
A direction to be used for all normal train movements on a double line.

On sight
A mode in which a movement must run cautiously not exceeding a speed to be able to stop short of any vehicles or obstructions.

Operating notice
A notice issued by the operations management of how to handle specific operational situations.

Operator
The person in charge for authorising movements.

Permissive signal
An automatic signal that may be cautiously passed in stop position without authority from the operator after the train has stopped at the signal. After having passed the signal, the movement up to the next main signal must be made on sight. Same rule applies, when the signal is dark.

Points
The movable parts of a turnout by which different routes through the turnout are set.

Reminder
A marker manually applied at the user interface to lock a signal in stop position, to lock a point or derailer, or to prevent route setting into a track section.

Route
The path for the safe passage of a movement through a point zone.

Shunting limits
An area where shunting movements may occupy main tracks.

Shunting movements
Movements running on sight without a timetable for making up trains, moving vehicles between tracks and similar purposes.

Shunting signal
A signal used to authorise shunting movements.

Shunt route
A route governed by a shunting signal or the shunt aspect on a main signal.

Siding
A track other than a main track that may only be used for shunting movements.

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Station area
A track layout consisting of station tracks.

Station track
A track protected by controlled signals on which trains may originate, terminate, pass, and turn.

Supervising technician
A person supervising a construction or maintenance site responsible for the operational communication with the operator.

Train describer
A system by which train descriptions are displayed in the track chart of the user interface and by which trains are offered and accepted between adjacent operators.

Train description
A number or an alphanumeric code to identify a train and its train path.

Train movements
All movements on main tracks that have been assigned a train path in the timetable.

Train path
A pre-defined time-distance line in the timetable for the conflict-free passage of a train.

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2 Train Movements

2.1 Use of that Movement Type

All movements on main tracks that have been assigned a train path in the timetable are authorised to run as train movements. In normal operations, trains have to use the station tracks assigned in the timetable. On double lines, trains run in the normal direction. The operator may decide to change the track for operational reasons. Train movements must not enter sidings.

2.2 Maximum Speed

The speed limits along the line are given in the timetable. The timetable speed may be reduced by signal aspects, temporary speed restrictions, or written orders.

2.3 Route Setting Procedure

To authorise a train movement, a main route is set. If the main signal governing the route has been cleared, the interlocking system guaranties that the following conditions are in effect:

- All points and derailers are locked in the proper position.
- The route, the overlap, and the flank areas are clear.
- Conflicting movements are locked out.
- Flank protection is in effect.
- For routes leading into a block section, the correct block direction is set.
- Level crossings protected by the route are closed for road traffic.

If route setting cannot be completed or the main signal doesn't clear as expected, the operator has to follow the failure mode procedure of section 5.

The same rule applies if a train has to be authorised to enter a track where a main route doesn’t exist. This is only allowed if ordered by an engineering notice or if the regular track has become unavailable by a line blockage.

2.4 Offering/Accepting Trains at Interfaces to adjacent Control Areas

Before a route is set for a train to leave the control area on a single line or against the normal direction on a double line, the train must be offered to the operator in charge of the adjacent control area. The train must not leave until having been accepted. The offering and accepting procedure is normally done by the train describer system. In the following cases, it has to be done by telephone communication with manual recording:

- If the train describer is not working
- If the block system is in a failure mode
- If a train has to be authorised to pass the signal protecting the line in stop position
- For trains exceeding the loading gauge if prescribed in an operating notice.

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After a train has been accepted, the operator who is in charge to change the block direction has to check that the direction is correctly set and, if needed, initiate a direction change.

If the train describer is not working, the departure of a train leaving the own control area must be reported by telephone to the adjacent operator.

2.5 Transition to a Shunting Movement

When, after the arrival of a train, the movement should proceed in shunting mode, the train must have stopped before the shunting movement may be authorised.

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3 Shunting Movements

3.1 Use of that Movement Type

All movements in sidings and movements running on main tracks without a timetable are shunting movements. Shunting movement on main tracks in station areas must normally not leave the shunting limits marked by shunting limit boards or signals or stated in operating documents. If shunting beyond the shunting limit is necessary, the procedure of section 3.5 applies.

3.2 Maximum Speed

Shunting moves run on sight not exceeding a speed of 25 km/h.

3.3 Route Setting Procedure

To authorise a shunting movement on a main track or on a siding controlled by an interlocking system, a shunt route is set. When the shunt aspect is shown at the signal governing the route (main signal or shunting signal), the interlocking system guaranties that the following conditions are in effect:

- All points and derailers are locked in the proper position.
- Conflicting movements are locked out.

If a shunt route is not available, the points must be set manually and the movement gets a verbal authority to pass the signal or to start moving from a position without a signal. The operator must not authorise a shunting movement by verbal authority that could put other movements into danger. In sidings not controlled by an interlocking system, all shunting moves are verbally authorised by the person controlling the points.

3.4 Communications

The operator will authorise a shunting movement only on request of the shunting crew. Before authorising the movement, the operator has to notify all involved staff members. If the destination of the shunting movement is not a signal or a shunting limit board, the shunting crew and the operator have to agree on the location where the movement has to stop. The operator may order the shunting crew to report that the movement has cleared a specific track section or has stopped at the destination track. If a shunting movement should pass the border between two control areas, the operator must not authorise the movement before the operator of the adjacent control area has agreed to receive the movement.

3.5 Shunting beyond the Shunting Limit

If there is an urgent need to shunt beyond a shunting limit, the movement needs a written order from the operator. The operator may authorise that movement only after having guaranteed that no train is approaching on that track by setting the block direction or by applying reminders at relevant signals. At the border to an adjacent control area, the adjacent operator has to confirm to protect the section. After the shunting movement has cleared the shunting limits, the adjacent operator has to be notified that the protection is no longer needed.

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3.6 Transition to a Train Movement

A shunting movement approaching a clear main signal may pass the main signal and proceed as a train movement without stopping at the signal.

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4 Special Operational Situations

4.1 Line blockages

Establishing and removing a line blockage

A line blockage is established for the following reasons:

- The track is interrupted or blocked by an obstruction.
- The section is occupied by a disabled train or by lost equipment.
- The section must be blocked for construction or maintenance work.
- The section must be kept clear to enable a movement that exceeds the loading gauge on an adjacent track.

A line blockage is established and removed by the operator in charge for that section. On a section at the interface between two control areas, the adjacent operator has to agree to establish and to remove a line blockage.

After construction or maintenance work, the supervising technician has to confirm that the track is in a safe condition before the line blockage may be ended.

Protecting a line blockage

The operator has to protect the section by applying reminders that would prevent route setting into the section. If this is not possible, signals protecting the section must be locked in stop position. The operator has to notify all involved operating and engineering staff that the line blockage is in effect.

Movements in a blocked section

The operator may authorise movements to cautiously enter a blocked line section. Train movements must get a written order to run on sight. Several movements may be authorised to enter the same section at a time. Train movements are allowed to reverse in a blocked section. Before starting a reverse movement, the driver has to call the operator for permission to reverse. The operator has to keep track of all movements that have entered and left the blocked section by manual recording. This does not apply for engineering possessions.

If movements have been made in the blocked section, the first train passing through this section after the line blockage has ended, must be ordered to run on sight.

Engineering possessions

An engineering possession is only established on the basis of an engineering notice. Before the engineering possession is established, the line blockage must be in effect. With establishing the engineering possession, the responsibility for controlling movements in the blocked section is transferred from the operator to the supervising technician. All movements in the blocked section are shunting movements. Shunting limits are not in effect during an engineering possession. The operator does not keep track of the movements within the blocked section but just arranges movements entering and leaving the section together with the supervising technician. Before the line blockage is

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removed, the supervising technician has to confirm that the track is in a safe condition and that all movement have left the section.

After a line blockage protecting an engineering possession has ended, the first train passing through the section must be ordered to run on sight.

4.2 Movements against the normal Direction

A normal direction is in effect on double lines outside of station areas.

Double lines with bidirectional signalling

On double lines equipped with bidirectional signalling, trains may at any time run against the normal direction on decision of the operator. At the interface to an adjacent operator, trains running against the normal direction must be offered and accepted.

Double lines without bidirectional signalling

On double lines not equipped with bidirectional signalling, trains must only be authorised to run against the normal direction if a line blockage is in effect on the regular track.

In that case, the routes for entering and leaving the section on which the train is running against the normal direction must be protected under staff responsibility as described in section 5.3. The movement authority is issued by a written order under the conditions described in section 5.4. If the train should stop in the section in front of a point zone not protected by a main signal, the stopping location must be stated in the written order. When having stopped at this location, the train needs another written order to proceed.

At the interface to an adjacent operator, trains of both directions must be offered and accepted as long the line blockage is in effect.

4.3 Unusual Movements

Trains exceeding the loading gauge

A train exceeding the loading must only run in accordance with an operating notice describing the specific conditions for that movement. The operating notice may prescribe the following constraints:

- The tracks that may be used for that movement,
- The requirement to keep adjacent tracks clear of vehicles,
- Restrictions for passing other trains exceeding the loading gauge on adjacent tracks,
- The requirement to offer and accept the train at the interface to an adjacent operator,
- The requirement to disable ARS for that movement.

Trains exceeding the weight limit

A train exceeding the weight limit must only run in accordance with an operating notice describing the specific conditions for that movement. The operating order may prescribe the following constraints:

- The tracks that may be used for that movement,

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- The requirement to disable ARS for that movement.

4.4 Non-shunting Vehicles

A track section occupied by non-shunting vehicles must be protected by applying reminders preventing route setting into that section. A train movement passing through a section directly after a non-shunting vehicle has left the section must be ordered to pass through the section on sight.

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5 Signalling Failures

5.1 Checking the Situation

If the route is rejected or the signal doesn't clear as expected, the operator must not immediately assume a signal failure but check if any of the following issues prevents the signal from being cleared:

- Reminders applied to prevent signals from being cleared for this route,
- Reminders applied to prevent points or derailers from being moved to the proper position,
- Reminders applied to block track sections for route setting,
- Conflicting route set,
- Track section occupied by a previous movement or by parked vehicles,
- Conflicting movements not yet finished,
- For a route into a block section with bidirectional signalling: direction not correctly set,
- A level crossing protected by the signal not closed for road traffic.

If all these conditions can be excluded, the operator has to identify the route element or track section that prevents the signal from being cleared. If a route element was not released or an axle counter section was not cleared by a previous movement, the operator has to perform a resetting procedure as described in section 5.4.

5.2 Protecting the Route

Before authorising a train to pass a signal in stop position or to leave from a track with no signal, the operator has to establish a safe route under staff responsibility. This depends on the state the route has reached.

If route locking is indicated, the interlocking guaranties that all points and derailers are locked in the proper position and all conflicting moves in the interlocking area are locked out.

If route locking is not indicated, all points and derailers must be locked in the proper position by applying reminders. If flank points or derailers cannot be moved to the protective position, the operator must not authorise any movements toward these elements. Signals of conflicting routes that are not locked out by point positions must be locked in stop position by applying reminders.

If the position of points in the path of the train is not indicated on the user interface, manual locks must be applied on site. This must be confirmed by the person in charge to the operator. On the user interface, the points must also be secured by a reminder.

If route locking is not in effect, automatic point setting must be switched off.

For a route leading into a block section with bidirectional traffic, direction locking is to be set for the proper direction. If the direction cannot be set, or, in case of running against the normal direction on a line without bidirectional signalling, signals protecting opposing movements must be locked in stop position by applying reminders.

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5.3 Movement Authority

Absolute signals

Movement authority to pass an absolute signal in stop position is issued either by a call-on signal or by a written order. Same rule applies to pass a dark absolute signal. When a train is going to leave from a track with no signal, a written order is always used. The train has to run up to the next main signal on sight.

The movement must not be authorised before the following conditions are in effect:

- The route is protected as described in section 5.2.
- No opposing route is set into the destination track.
- No conflicting movement is authorised by a call-on signal or written order.
- On sections where trains have to be offered to an adjacent operator, that operator must have accepted the train.

Permissive signals

A permissive signal may be passed in stop position without authority from the operator. The movement through the block section protected by that signal must be made on sight. Same rule applies to pass a dark permissive signal.

5.4 Resetting Signal Appliances

Emergency route release

A route that was accidently set with no train approaching may be released without further precautions. The same rule applies if an approaching train has not yet reached a location from which the driver could have seen that the signal has been cleared.

If a route is to be released with a train approaching, the signal must at first be restored to stop. Route release may be initiated after the train driver has confirmed that the train has come to stop.

If automatic route release failed after the passage of a train, the operator has to check that the train has left the route before initiating the route release. The next train passing through the route elements for which the automatic release failed, must be ordered to pass through this route on sight. After the route was correctly released behind this train, on-sight running is no longer required for following trains.

Resetting axle counters

Before resetting an axle counter, the operator must order the next train to pass through the section on sight. That order must be issued before the resetting command is executed.

If the last train that has passed through the section cannot be clearly identified, the axle counter must not be reset. The next train must be authorised to pass the signal in stop position and to pass through the section on sight. After this train has left the section and the next train has been ordered to pass through the section on sight, the resetting command may be executed.

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