Modernization of the Transport Laboratory

Ondrej Karpiš, Peter Ševčík, Veronika Olešnaníková

***Abstract*—**The education of students at universities is based not only on the transfer of theoretical knowledge, but also on its application in practice. During the teaching of students at the Faculty of Transport and Communications Operations and Economics of the University of Žilina, the transport laboratory has been used for more than 25 years to practise practical skills. Since 2020, its complete reconstruction has been underway. This article describes the main changes implemented during the modernization, particularly the change of the topology of the model railway, its digitisation and the renewal of conventional types of interlocking equipment.

***Keywords*—**laboratory modernization, practical education, railway model

I. INTRODUCTION

In the process of education of students at the university it is important not only to acquire theoretical knowledge but also its practical application. Employers are also interested in graduates with practical experience. Connecting education with practice is possible in various ways - in the form of lectures by people from practice, excursions or internships directly in companies. Thanks to the development of digital technologies, it is sometimes possible to try out working with real equipment through virtual reality. But it is best if students can work on the same equipment as is used in practice. In some cases, it is not possible to make a life-size copy of the system - then a scale model must be used. Such systems include railway traffic control.

To improve the quality of teaching of students in various fields of study, a transport laboratory was built at the Department of Railway Transport at the Faculty of Operation and Economics of Transport and Communications of the University of Žilina. It was put into operation in 1994. For 25 years it allowed students to get acquainted with the construction and operation of railway interlocking equipment used in the network of the Railways of the Slovak Republic (ŽSR) and to practice theoretical knowledge related to the management of railway transport - the organisation of train running in stations and inter-station sections, train formation, management of local work in stations, etc. The laboratory is also used in the preparation of ŽSR employees for the theoretical part of qualification professional examinations and in regular retraining of employees. Moreover, the laboratory has been used extensively for marketing purposes of the department, faculty and the entire university practically since its construction. Numerous excursions of children and students of primary and secondary schools have taken place in the laboratory when presenting the possibilities of studying at the University of Žilina, especially within the framework of the Open Day and the regular Žilina Children's University.

Since its inception, the laboratory has been heavily used. Thanks to regular maintenance, most of the control systems were still functional after almost 27 years. The increased failure rate of the systems in the laboratory, as well as the need to extend the laboratory technology with new modern systems, which at the time of the laboratory construction had not yet been developed and deployed in the ŽSR network, led to a complete reconstruction and modernization of the laboratory.

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II. THE ORIGINAL TRANSPORT LABORATORY

The original transport laboratory consisted of five stations and their respective track sections. The following station interlocking equipment (SIE) were emulated in the stations:

- Hričov station: relay SIE type AŽD 71 with travel option,
- Púchov station: relay SIE type AŽD 71 with digital selection,
- Vrútky station: electromechanical SIE model 5007,
- Bytča station: relay SIE type TEST 14,
- Žilina station: electronic interlocking of unspecified type.

The following systems were emulated as track interlocking equipment (TIE): two-way automatic TIE type AH 71, two-way automatic TIE type AB 3-82 and two-way semi-automatic TIE type RPB 71.

In addition to the stations, a dispatcher's station was also implemented, which enabled remote control and remote operation of the stations - construction and cancellation of simple paths and simulation of faults.

The movement of the trains in the model track was realized by connecting traction voltage to the track sections. This method of motion control did not allow to realize all traffic activities that take place in real stations (e.g. driving of working trains on the line with return to the starting station). Two levels of traction voltage were used, corresponding to two different vehicle speeds. Thus, the system did not allow a smooth voltage control, and it was not possible to achieve a faithful dynamic of the trains movement on the track.

The control system of the transport laboratory was conceived as a distributed system - each station had its own control computer, which controlled the components of the model track (control of the position of exchanges, control of light signals, control of the model vehicles and detection of the presence of vehicles in individual track sections) and at the same time modelled the behaviour of the relevant type of station or track interlocking equipment in the station or inter-station section. The basic task of the control system was to model the behaviour of control and indication elements of all interlocking systems in accordance with the specification of individual signalling devices and the requirements of the valid ŽSR regulations.

The control system of each station consisted of a PC AT 286 control computer, expanders and input/output modules. The expanders allowed up to 16 I/O modules to be connected to the computer bus. The input module allowed the input of 24 binary information, with an input voltage magnitude in the range of 5-24 V representing logic 0. All inputs were optically isolated. The output module allowed the output of 24 binary information. Each output was controlled by an optically isolated transistor and allowed switching voltages up to 32 V with current up to 75 mA. The power version of the output module allowed to permanently switch currents up to 500 mA. The traction voltage control was implemented by a power module with current protection. The module allowed to control 12 isolated sections by connecting positive or negative voltage for forward and reverse motion of trains.

III. THE ORIGINAL TRANSPORT LABORATORY

The original technology used in the transport laboratory has been in operation for over 25 years. In that time, it has become morally and technically obsolete. The physical obsolescence of the control system was manifested by increasingly frequent failures, which eventually caused the complete non-functionality of the Púchov station and the partial non-functionality of the Vrútky station. During the operation of the laboratory, flaws in the original design of the track topology were also identified:

- insufficient number of inter-station sections,
- the absence of a model of the level crossing interlocking equipment,

- the use of a model of an unspecified type of electronic interlocking,
- the absence of a system for remote control of traffic in the intermediate station section.

During the modernization of the transport laboratory, the topology of the model track was modified by adding additional railway stations and inter-station sections, while maintaining the concept that individual railway stations are controlled by a different type of station interlocking equipment. Figure 1 shows topology of the modernized track.

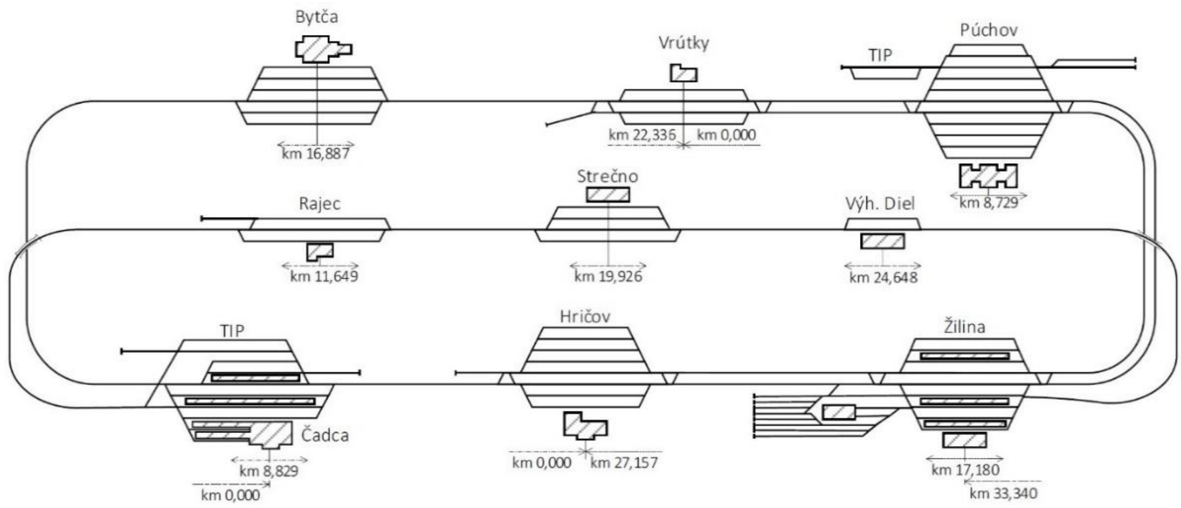

Figure 1 Topology of the modernized track

To enable the training of traffic dispatching, a new single side track was built between the stations Čadca and Žilina, which is centrally controlled by the system of remote control and checking of interlocking equipment. In addition to the increase in the number of stations, the modernization also changed the type of some interlocking equipment. The stations with relay and electromechanical station interlocking remained unchanged. The following types of station interlocking equipment are used in the other stations:

- Žilina station: SIMIS W electronic interlocking with ILTIS supervisory system of SIEMENS Mobility. The ILTIS supervisory system allows to display the station track on one to eight colour monitors, depending on the size of the station, while the used catalogue of symbols of the elements in the track and the displayed traffic situations is implemented in accordance with the valid regulations of ŽSR [1-3].
- Čadca station: a newly built railway station with ESA 44 electronic interlocking of AŽD Praha. The method of controlling the interlocking by means of a mouse and displaying the operating statuses is implemented in accordance with [4].
- Rajec station: newly built railway station secured by electronic interlocking type ESA 44 remotely controlled from the control station Strečno.
- station Strečno: newly built railway station secured by electronic interlocking type ESA 44. The station will remotely control both Rajec station and Diel switching station.
- Switching station Diel: a newly established transport station secured by electronic interlocking
- type ESA 44 remotely controlled from the control station Strečno.

Track interlocking equipment has also been updated to match the most used types of interlocking equipment in Slovakia. Currently the following systems are implemented: automatic block ESA-ITZZ, automatic gate ESA-ITZZ, automatic block AB3-88, automatic block AB3-74/88, relay semi-automatic block RPB 71 and centralized automatic block ABE-1.

A. *Model railway*

The model railway has been fully digitised. It is built on commercially available equipment using DCC and XpressNet communication protocols. The model railway uses switch control modules, feedback modules, signal modules and DCC signal boosters. All turnouts in the model railway are electromagnetic. The modelling of the lower speed of the real turnouts is implemented by delays in the control computers. The communication of the control computers with the station elements is provided by Ethernet/XpressNet converters. The digitisation of the track and trains allows not only to model more faithfully the behaviour of the trains (smooth starting and braking, lights and sounds) but also to model situations that could not be realised in the original system (e.g. two trains on the same track).

B. *Renewal of conventional types of interlocking equipment*

Conventional interlocking equipment (i.e. relay and electromechanical) is characterised by the use of a specialised control and indication panel. The control system shall provide a faithful simulation of the response of the system to the operation of the controls located at the control panel, to the operation of the controls in adjacent stations related to the operation of trains in the inter-station section, and to the various operational situations in the model track of the station and adjacent track sections, with the response of the indicating elements corresponding to the type of station or track interlocking equipment modelled. A faithful simulation of the behaviour shall also be ensured by the control system when simulating selected fault conditions of the relevant type of interlocking equipment.

The renewal of conventional interlocking equipment, including the software, was carried out by the Department of Technical Cybernetics at the Faculty of Management and Informatics. Due to the very good condition of the original cabling in the control panels, it was decided to replace only the input/output boards and the communication subsystem. To minimize the required cabling between the operator panel and the control computer, the CAN bus was chosen as the communication interface. The input and output boards are based on the XYZ microcontroller, which contains enough I/O pins and has built-in support for CAN communication. Dimensions, location of connectors, and mounting holes of developed boards are compatible with the original boards.

The new boards also contain indicator elements (LEDs) that allow visual control of the current status of all inputs or outputs. Instead of screw terminals, plug-in connectors have been used to simplify the replacement of the board in case of failure. Each board also contains a small EEPROM memory in which the board settings, especially the board address, are stored. Address configuration is accomplished by sending a defined CAN message when a user button is pressed.

The control program was created in C++ and is designed for the Windows operating system. It mainly provides modelling of the relevant type of station and track interlocking equipment, as well as simulation of fault conditions. The software also allows testing of all elements in the model railway and in the control panel. In a separate window it is possible to monitor the status of station elements, i.e. the status of turnouts, occupancy of sections and the status of signals. In another window, a digital copy of the control panel can be displayed (Figure 2), which shows the status of all indicating and control panel elements and allows to emulate the use of the controls. Thus, control of the station is possible even in the event of a control panel failure. The program also allows the activation of the simulation mode, in which it is possible to simulate the behaviour of the model station, including the train running. The software can therefore also be used independently as a simulation tool for students to practice their practical skills individually.

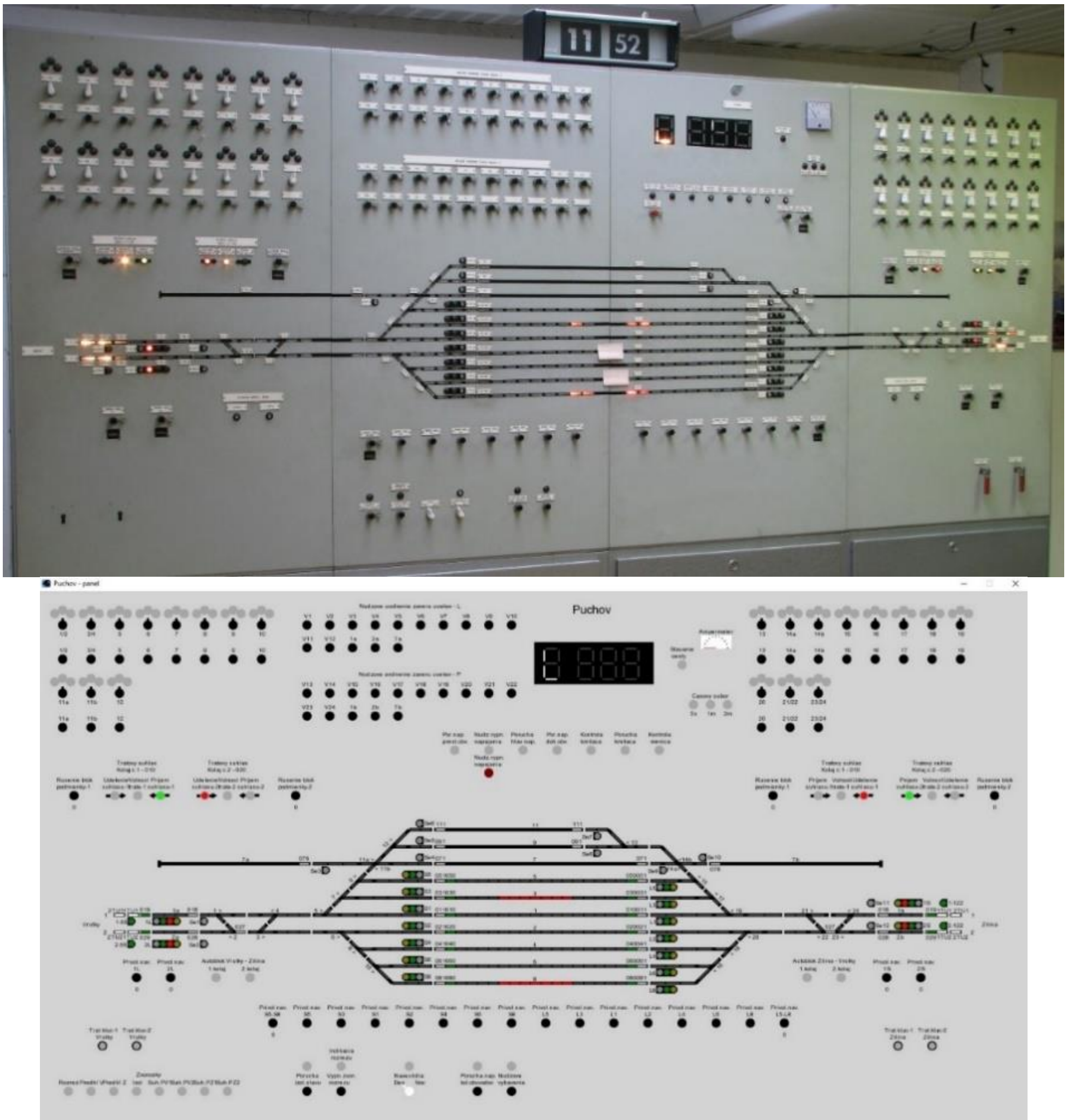

Figure 2 Control panel of the station Puchov and its digital copy

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