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ANALYSIS OF TECHNICAL MEANS USED IN EU FOR TRAINING OF RAILWAY TRANSPORT EMPLOYEES

Summary. Experience in training specialists of various professions in railway transport in European and CIS countries shows that the training consists, as a rule, of several basic stages: theoretical preparation, practical training and examinations or testing. Specific feature of practical training for railway transport employees is the usage of technical means, which to the maximum extent approximate the training conditions to those of further professional activity. For creation of new technical means of training, analysis of structures of simulators intended for training of railway transport specialists of various professions would be interesting. Below we will examine the most specific means being used in railways, underground railroads and in educational institutions.

АНАЛИЗ ТЕХНИЧЕСКИХ СРЕДСТВ ИСПОЛЬЗУЕМЫХ В ЕС ДЛЯ ОБУЧЕНИЯ СОТРУДНИКОВ ЖЕЛЕЗНОДОРОЖНОГО ТРАНСПОРТА

Аннотация. Опыт подготовки специалистов различных профессий железнодорожного транспорта в европейских странах и страны СНГ показывает, что обучение состоит, как правило, нескольких основных стадий: теоретической подготовки, практического обучения, экзаменов или тестирования. Определенной особенностью практического обучения служащих железнодорожного транспорта является использование технических средств, чтобы в максимальной степени приблизить учебные условия к аналогичным из дальнейшей профессиональной деятельности. При создании новых технических средств обучения интересен анализ структур тренажеров, предназначенных для обучения специалистов по железнодорожному транспорту различных профессий. Ниже мы исследуем наиболее специфические средства, используемые на железных дорогах, метро и в образовательных учреждениях.

1. ANALYSIS OF TRAINING MEANS

The Higher Military Technical School ‘T. Kableshkov’ (Bulgaria, Sophia) has developed and produced a simulator for training of locomotive drivers [1]. It was produced according to principle of

modularity. As a spatial model it uses experience of locomotive control, where all the devices and equipment necessary for training purposes are installed. Dynamic system of the simulator creates vertical and horizontal vibrations of driver seat (maximum horizontal and vertical movement is 0.015 m, vertical acceleration – up to 1 m/s^2, and lateral acceleration – up to 1.5 m/s^2). The simulator is equipped with acoustic system for recreation of noises emitted by train driving, also a PC and printer, as necessary for modelling the functions of main locomotive systems, movement of train, signals, etc. During the training, permanent control of changes of speed, current and stress of traction engines is ensured, just as of pressure in the main air tank, mileage and energy consumption. Six topics were prepared for formation of habits in adjustment of traction force and braking at standing start, for maintaining given speed of movement and traction and braking modes, etc. Description of criteria is supplied and methodology for evaluation of trainee activities. After completion of training, the trainee activities are assessed with the help of a single aggregate criterion.

Article [2] provides data on preparation of employees in German railways. Thus the system of vocational training provides that training of train locomotive driver must last for 11 months, and at first the trainees receive qualification of locomotive driver-shunting master. A new concept of staff preparation was accepted, with broad use of electronic simulators and methods of imitational modelling of train handling modes. Measures are taken to replace the train movement schedule books with respective databases in on-board computers.

Article [3] presents a brief history of creation and provides analysis of the main structures of the simulators for driver's training. It concludes that the passive full-scale simulator of driving is able to assure actually full-scale training of locomotive drivers, including duration, physical and psychological loads, and interaction with track staff and passengers.

For drivers of high-speed electric trains Paris–Berlin and Paris–London, an electronic simulator was developed [4], where all the movement conditions in respective track are simulated. Price of such a simulator amounts to 1.7 million pounds; first sample of the simulator is installed in depot London-Waterloo in England, and the second one – in depot Hellems-Lille in France. The driver training programme includes exercises on the simulator with total duration of 20 h at least; in addition to this, classroom lessons are held, just as trips on electric train with trainer at the end of the training. Specific to work of international train drivers is the obligation to perform operational negotiations with traffic controllers using language of the country they are in. Therefore the simulator helps developing regulations for negotiations with traffic controllers of France, Great Britain, Germany, Belgium and the Netherlands. In the course of driver training on the simulator, entire group of 10 persons can monitor his work over individual displays.

Article [5] describes a typical simulator intended for training of locomotive teams in depot and realised on the basis of typical PC, locomotive control panel and a unit of video-recording for creating effect of train movement on track. The PC memory contains system of software, including programs for making traction calculation, readout of information from locomotive control panel and control of the process of reproduction of videos synchronously with train movement. The simulator can also be used for group sessions; for this it uses a separate trainer panel and additional workplaces with individual displays. The simulator is basically used for in-service training of locomotive teams and for mastering of economic methods of locomotive control.

Simulators for training of drivers are widely used in locomotive depots of German railways. [6]. Modern simulator units are implemented on the basis of universal PCs, which allows realising substantial didactic possibilities in training with the help of corresponding development of software. Usually they follow the principle of software training with gradual increase of task complexity and stage-by-stage control. This process in its pure form is applied in initial stage of training or at preliminary control. Subsequent stages usually need participation of trainer; they also realise complex interactive mode with simultaneous participation of the trainee, the trainer and PC, which registers the training process and later can repeat it without participation of trainer. Simulator unit for 16 persons is examined in detail.

CORYS Company (France) has developed for London Underground Railroad a simulator of LUCAS type, with computer generation of visual information [7]. Memory of the simulator is loaded with parameters of Anniversary Line with total length of 38 km. With the help of the simulator, a

trainer can train a driver not only driving the train under normal conditions but also in case of technical faults in train equipment, and in total 130 technical faults and 15 non-standard situations can be simulated, such as delay of passenger entry in station, fire on train and in tunnel, disconnection of traction substation, etc.

Article [8] presents development of a new simulator for driver training, with simulation of traffic and use of DBAG for training of locomotive drivers and even for examinations. Berliner Verkehrsbetriebe (BVG) Company has started operation of a simulator with electronic part delivered by Bremer STN ATLAS Electronic GmbH. The simulator consists of separate modules, such as driver cabin GT6. Digital video system projects onto display a 30-degree segment of panoramic view of traffic situation in real time. The computer has view of 64 km of Berlin railway track. The system can simultaneously control 40 participants of traffic. Additional training programs are available. A brief description is provided about 'Computer Based Training' trainer from Ustra Hannoversche Verkehrsbetriebe AG.

Article [9] examines assumptions for use of simulators in railway transport, in particular for training and certification of drivers, requirements raised thereto, and currently accepted structural concepts. Descriptions of simulator functional models are provided.

Simulation devices start playing increasingly important role in methodology for training of operators who plan and control traffic of trains. A new multifunctional simulation system 'Messina' [10] was developed by Vossloh Technical Systems Company (Germany) in cooperation with Hungarian company TSTS and consulting company HC from Hamburg. The first simulator was delivered to railway centre in Hamburg at the end of 1998.

Design and informational company 'Sydac' (Australia) has developed a mobile simulator [11], intended for training of drivers in Queensland rail (QR) railway company, when its fleet was augmented with 38 new diesel-electric locomotives of Class 4000. When necessary, the simulator can be transformed into a car semitrailer and easily transported to any depot or QR's training centre. Databank of the simulator contains information about 30 different types of wagons and 5 types of braking equipment.

Public company 'German Railways' (DB AG) has ordered from Krauss-Maffei Wegmann GmbH & Co. KG (Munich, Germany) additional six simulators for training of drivers of suburban and local trains [13]. The order stipulates two simulators for locomotive 143/112, two ones for 423-426 and one simulator per diesel trains 628 and 612 each. The simulators reproduce real situation, including acoustic accompaniment.

In 1996, city of Fulda (Germany) saw commissioning of new training centre of German Railways (DB AG), where training preparation of locomotive drivers is organised on the basis of computerised system of training (CBT) [14]. The basis of the system includes simulators, which, by means of modelling, simulate conditions of locomotive and train movement. Presently, training of locomotive drivers is carried out in 10 training centres specialised according to types of locomotives. Such centres are located in Hamburg, Munich, Berlin and other cities.

Training centres in Germany implement new methods of training, based on use of special simulators-modulators [15]. When working with the simulator, a trainee is located as if in virtual space, which is approximated to reality to the utmost. The simulator has a full set of devices for locomotive control, simulating its route, with possible scenery in the process of movement control and a possibility of overview. For closer similarity to real conditions, the work simulator is accompanied with noise analogous to real noise during movement of trains. The use of simulators-modulators significantly increases quality of training.

Thorough training of drivers working in tram lines and municipal railways is a precondition of safety in operation of street transport and suburban communications. In Moring, a new centre is being built for training of drivers with emulator of driving and movement [16], which allows increasing efficiency and reducing costs of training by 25 and 10 % respectively. The developed emulator is a simulator located in sound-insulated premise, with lower floor containing a computer complex, and the upper one equipped as audience hall. The emulator consists of: video system for simulation of exterior environment in driving direction; system for simulation of longitudinal and transverse acceleration, and vibrations; processor simulating dynamic conditions, impact of surrounding

environment, functional logics of actuating, controlling and protecting devices, indicating devices, driver cab models and parts of passenger compartment: devices for reproduction of emergency braking. The emulator allows performing: primary training of drivers, in-service training, assimilation of behaviour methods in standard and high-stress situations, development of responses to changes of working conditions, and skill refreshment after sickness periods.

Mass introduction of simulators realised on the basis of computer technologies started in 2000 in Munich, when 6 installations were introduced for permanent operation for training of drivers of 423 and 426 models. These simulators used two-level training programmes – for primary training and for subsequent control and in-service training [17]. Typical simulator usually has two workplaces – for the driver trained and for trainer, who controls the training process in real-time mode. During the second stage, simulators were developed for training and regular control of drivers of high-speed electric trains ICE. Special attention was granted to interaction with system of automatic direction and to evaluation of driver's speed in response to changes of situation in railway line. In total, the German Railways have spent 36 millions USD for simulators developed on the basis of typical PCs, and a significant portion of the amount was spent for creation of track visualisation system, as it is seen from the driver's cabin (CGI-Technic system). The view is adapted to particular conditions (time of year and day, meteorological conditions, etc.), which are set by driver-trainer from his panel.

Article [18] examines specifics of new information technologies used for development of computer simulators and training systems. It provides examples of realisation of new information technologies in design of simulator sets.

Article [19] emphasises that the train simulator released by Microsoft Corporation provides scenario of trip over 1 000 km in various climate conditions (including simulation of wheel slip) and authentic noise, meeting requirements of the instruction. Usage of simulators conforms to the concept of staff preparation on computer basis, including reduction of non-production costs, increase of efficiency of training time usage and coherence of staff activities. Such major operators as Amtrak, BNSF in USA and JR Kyushu Odakyu Electric Railway in Japan use simulators for staff training.

In April 2002 in Lille (France), annual international conference on issues of training and preparation of railway transport staff was held (RTIC) [20]. One of the main problems discussed there was the problem of integration of training simulators into existing system of staff preparation. Traditional training of train drivers is quite costly in respect of price and time. Presently, for basic preparation of one driver 40 thousand pounds are spent in the course of 11 months. Under present conditions of continuous growth of costs and the requirements towards efficiency of train driving, perfection of the training process becomes increasingly necessary.

Describes possibility to solve the task of raising the driver preparation quality with the help of experience gained while developing simulating-modelling sets, elaborated for preparation of astronauts and pilots [21]. Such a set for preparation of drivers of 3rd generation electric locomotives includes integrated and specialised simulators and functional-modelling stands for pre-simulator preparation.

To illustrate the main directions in development of visualisation means in railway simulators, survey was performed of simulators for underground railway drivers from 'Technokomplekt' Company as used in Vladykino Depot (Moscow), simulator for drivers of trunk trains as developed in cooperation with Sector Research and Development Laboratory of Dynamics and Durability of Rolling Stock (Dnepropetrovsk National University of Railway Transport), and simulator from Research, Development and Training Centre for Problems of Transport Medicine (KharHAZHT) for Railway Employee Training Centre (Teheran).

Both simulators are realised on the basis of PCs, have layouts of actual cabins, full set of full-scale control devices, linked to PCs, and in front of the cabins projections screens for visual simulation are arranged. The main difference of the said simulators is the method used for visualisation of movement. Underground railway simulator employs digitalised video recording of actual underground rail-way line in Moscow, and in other case an interactive graphic model is used as created on the basis of video recording of actual section of railway line Andimeshk-Gorun (Iran) with length of 200 km.

CORYS T.E.S.S Company (Grenoble, France) is a leading manufacturer of simulators [22], which are realised for specific types of locomotives and allow, by means of program change, simulating profile and plan of track, also provide video display of line as previously filmed using video camera.

Vossloh System-Technic Company has developed a system, which simulates all the functions of electronic signalisation control centre, as necessary for operator training. The main principle demands the most accurate possible recreation of actual operation environment, including rules of signalling in given railway and detailed scheme of tracks in each station.

Article [25] examines experience of French National Railways (SNCF) in vocational training of staff with the help of computer simulator, which allows detailed reproduction of situations possible for a train driver. The simulator offers a wide selection of hardware, tracks, weather conditions and times of day.

Tooling of track facilities with high-performance equipment, including automated control systems with computer devices, requires a new approach to preparation of qualified employees [26]. It is inadmissible to train persons, as it often happens, directly in production during spring-autumn periods. This also requires additional costs for fuels and oils, track repairs are interrupted, and errors in operation of machines are unavoidable, which results in breakage of systems and mechanisms and incorrect track surfacing.

Article [3] provides a general description of modular simulators for railway controllers, developed and offered by Vossloch System-Technic (VST) Company for instruction and training of railway controllers in Germany and Austria, and for employees of local public transport companies. The modular simulator can reproduce features of all the important new electronic devices for electronic centralisation and interlocking, while recreating all the realities of practical work of railway controllers.

The Sector Research and Development Laboratory of Dynamics and Durability of Rolling Stock (ONIL DPPS) of Dnepropetrovsk National University of Railway Transport of Academic V. Lazarian (DIIT) has also developed a specialised simulator. The simulator is a software-hardware set with full-scale devices of locomotive control for various series of electric locomotives, diesel-electric locomotives, diesel and electric trains [29-40]. The simulator also contains models of locomotive and wagon braking system, system simulating vibrations and movements of locomotive cab depending on driving mode, plan, track profile and butt irregularities of rails. Specific feature of the simulators developed in DIIT is the presence of software for modelling longitudinal dynamics of train with account for traction-energetic characteristics of locomotives. Refinement of locomotives' passport characteristics is made by means of driving and traction-energetic tests, using original methodologies and special measurement sets. Software part of the driver simulator can also be supplemented with software for modelling spatial oscillations of locomotive, wagon, wagon coupler and train in its entirety. This allows, in addition to acquisition of professional skills in train driving, to per-form modelling of transient conditions of movement and non-standard (emergency) situations in order to assess indices of driving safety on the basis of particular conditions. One more characteristic feature of the simulators is the fact that visualisation of landscape is not digitalised according to available video record, but is created in details and formed from available library of objects, which allows creating interactive image, which ensures possibility for driver-trainer to make operative changes in driving situation and to maximally approximate training conditions to real ones.

CONCLUSIONS

The provided survey of designs of technical means of education for specialists of railway transport allows reaching the following conclusions.

1. It is expedient to include simulators into programme of training and certification of specialists;
2. Application of simulators reduces time and costs of preparation of specialists and allows developing professional skills both in standard and non-standard situations;
3. In addition to professional selection during preparation of specialists, there is a possibility to develop progressive methods of operation (for drivers – especially safe and resource-saving driving

techniques, for traffic controllers – rational behaviour in various operational situations). Basically all the surveyed simulators were developed usi ng PCs, and for a version of group training local information networks are used.

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Received 27.04.2009; accepted in revised form 22.12.2009