

APPLICATION OF OPENTRACK AT RAILWAYS OF REPUBLIC OF SRPSKA (RAILROAD TRACKS ŠAMAC – DOBOJ)

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***Abstract** – OpenTrack is a tool for planning and simulating railway operations. Developed at the Swiss Federal Institute of Technology in Zurich, Switzerland, and is currently supplied by OpenTrack Railway Technology Ltd. for over 230 organizations in 50 countries. Pre-defined trains run in accordance with the timetable data on the defined track topography. The simulation has both continuous and discrete parts. The continuous part calculates the differential equations for train speed and distance. The discrete part simulates processes such as the state of the signal system and possible delays. During the simulation, the user can view the track topography in animation mode showing trains, prepared routes and current aspects of the signal. The user can terminate the simulation at any time and, if necessary, enter OpenTrack and change certain restrictions. This work describes the application of OpenTrack on the Railways of the Republic of Srpska for the railway from Doboj to Šamac and the state border with the Republic of Croatia.*

Keywords - Simulation, Railway Operation, Timetable.

1. INTRODUCTION

Following the European and world trends in railway traffic planning and research of the relationship between the volume of traffic and traffic infrastructure on which it takes place, the Railways of Republika Srpska in 2017 decided to introduce a simulation method in their planning procedures, primarily for the development of timetable elements.

The software for traffic simulation on the railway network, developed by the Swiss Federal Institute of Technology in Zurich, is one of the generally accepted simulation software among experts engaged in planning and research in the field of railway transport. By 2019, this software was accepted by more than 230 organizations in over 50 countries. In the last ten years, it has also been used by railway experts from the neighbouring countries, ie Serbia, Croatia and Slovenia.

Although done as "user friendly", working in this software requires highly professional multidisciplinary knowledge of railway structural elements (stable and mobile capacities) and the way they function, as well as knowledge of the organization and technology of railway traffic.

The railway section from the Šamac station to the Doboj station was chosen for the pilot project of modeling and simulation of railway traffic in the OpenTrack software. The length of the railway Šamac - Doboj is 60.6 km and according to the category of the railway it belongs to the group of main auxiliary (M-P). The maximum speed on this section of the railway is 50 km / h from 2014. In the same year, Republika Srpska was hit by major floods that caused damage to the upper and lower parts of the railway, so that after the rehabilitation of the railway, the speed was reduced from 70 km/h to 50 km/h because the characteristics of the railway do not allow higher speeds. The reason why this section of the railway was chosen is because the railway is electrified and the closest connection with Croatia, and therefore with Europe. This section of the railway is also part of the Vc corridor.

2. MAIN CHARACTERISTICS OF THE OPENTRACK SOFTWARE

For modeling and simulation of complex multidisciplinary railway processes in the world today there are dozens of software and tools that allow the

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creation of macro, meso and micro simulation models, and the possibility of simulating discrete or continuous processes.

Simulation software OpenTrack is one of the few softwares that essentially allows the creation of macro-simulation models (there is no limit to the size of the railway network being modeled) with all the characteristics of micro-simulation models, because it allows modeling with a high attention to detail and monitoring of all structural and functional elements of importance for railway traffic. In addition, this software enables parallel simulation of discrete and continuous railway processes, as well as modeling and simulation of Maglev, metro and tram systems. OpenTrack has a complex modular structure that can be most simply described as a system consisting of an input data module, a simulation module, and an output data module (Figure 1) [1].

For process management purposes within the software, the data and information entered are classified into three different file types: documents, databases, and output. The software uses six different databases (on traction vehicles, train composition, official places, routes, train paths and timetables). All data, which is entered via the "user friendly" interface of these modules, is defined by the user [2].

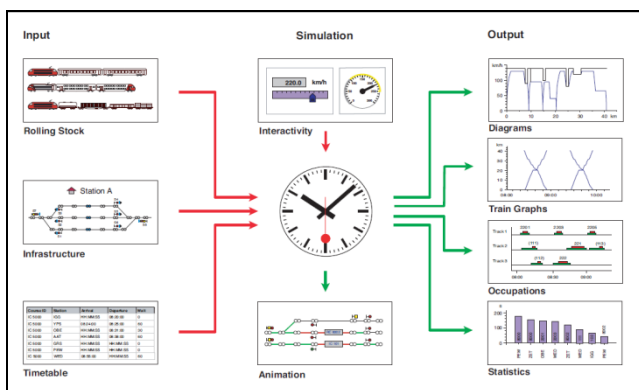


Fig.1. OpenTrack structure: Input - Simulation - Output

The vehicle module enables the entry, storage and management of vehicle data (towing and towed vehicles). The technical specifications of each individual towing vehicle such as towing force, towing force, diagram of change of towing force and power according to speed (towing passport), coefficients of adhesion, mass, length, acceleration and selection are entered into the database on towing vehicles (depot). are the formulas for calculating motion resistance. The required data on towed vehicles are length and weight, so they can be entered individually from the bill of lading or collectively for the entire composition. Accordingly, the train composition is modeled by selecting one or more traction vehicles from the base and attaching data on vehicle mass and length, braking percentage and train category (rank), which determines the priority when

moving through the infrastructure model in progress.

The infrastructure module enables graphical modeling of all elements of infrastructure important for train movement on the principle of the graph method with double points of change of value ("vertex")¹ and lines connecting them ("edge")². These points and lines are the basic elements for modeling tracks, switches, signals, security systems, road crossings, power supply systems, train stops, etc. and their individual attributes. Attributes are added via menus in whose fields are entered: object name, stationing, level slope, radius of curvature, maximum speed of train traffic over each individual element of the line by train categories. In this way, the railway is modeled according to the real parameters of the longitudinal profile and stationations of buildings, tracks, track plants and devices. Signaling is modeled according to all functional specifications [1].

In order to perform the simulation of train movement in the model, it is necessary to enter, store and manage train traffic data, ie it is necessary to define the route for each train (by track and station tracks) and timetable elements, at least departure time from the departure station, minimum time of dealing in stations and at stops or other places where it is necessary, places of crossing and overtaking trains, turns of locomotives and sets, etc.). During the simulation, the equations of train movement are calculated and the driving time is obtained as one of the results. The output results of the simulation can be displayed in several different ways, and are most common by train, route or station. During the simulation, a virtual tachograph is created for each train, as an output file, which contains data on acceleration, speed and distance traveled. Also, the output results can be presented in the form of timing diagrams, timetable graphs, station track occupancy schemes and various statistics shown both graphically and tabularly.

3. MODELING AND SIMULATION OF THE SAMAC-DOBOJ RAILWAY

The application of modern tools in scheduling planning is extremely important, especially when it comes to railways where there are several factors in planning, which requires a long process of harmonization. Railway: Šamac - Dobož (Figure 2) is single-track, electrified 25 kW and 50Hz and provided with inter-station dependence devices. The traffic of successive trains on the line takes place at the station distance. The track is of category D4, capable of a load per axle of 22.5 kN and 80 kN per meter [5].

¹ The point of change of parameter values.

² A line that connects the points where the parameter values change.



Fig.2. Scheme of the railway Shamac - Doboje

There are:

- o 5 stations: Šamac, Modriča, Osječani, SrpskaKostajnica and Doboje.
- o 2 crossroads: Vranjak and KoprivnaGornja,
- o 9 stops: Miloševac, Garevac, Brvno, KoprivnaDonja, Kožuhe, Vasiljevići, Bušletići, KostajnicaDonja, KostajnicaGornja.

The maximum allowed speed on the railway (according to the timetable for 2019/2020) is 50 km / h. The stopping distance is 1000 m, the minimum radius of curvature is 250 m while the maximum radius of curvature is 40,000 m. The relevant resistance on the railway is 7 ‰ and is located between the intersections KoprivnaGornja and Vranjak [4].

4. DATA PREPARATION AND MODELING IN OPENTRACK

Data for model development are provided from databases and records of company services, namely: Sector for construction works (written longitudinal profile of the railway, data on stationing and radius of curves and transition curves in tabular form, station schemes, data on limited speeds and easy rides and etc.), Sector for electrical engineering (data on signaling and safety devices on the line and in stations by type and stationing, stationing and level of securing road crossings in the level), Sector for towing trains (data on towing vehicles in the active park and their technical exploitation characteristics), Sector for exploitation (Timetable booklet and STU with timetable), etc. [5].

The modeling of the railway was done in phases, filling in the required database one by one. Thus, a model of infrastructural elements was first made: station and railway tracks, signals, etc. with the entry of their attributes in the databases (Figures 3, 4, 5, 6 and 7) and the creation of a database of official places [3].

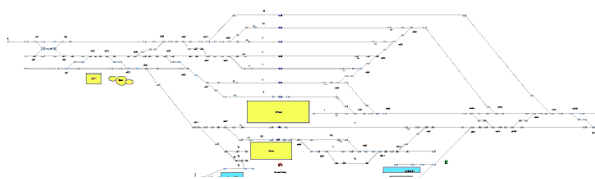


Fig.3. Model of the Doboje station in OpenTrack

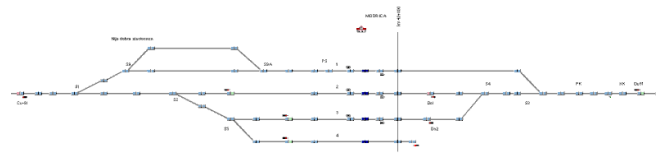


Fig.4. Model of Modriča station in OpenTrack

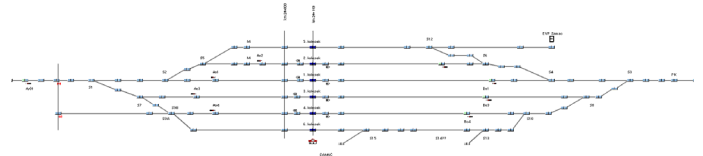


Fig.5. Model of the Šamac station in OpenTrack

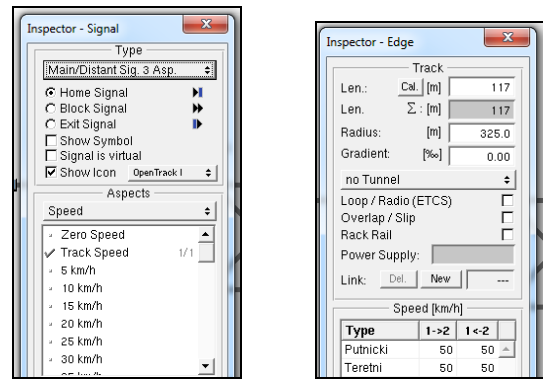


Fig.6. Attributes of the input signal and the part of the track behind the input signal to the Doboje station

Then the construction elements are grouped into safety elements: paths, routes (Figure 7) and itineraries (Figure 8).

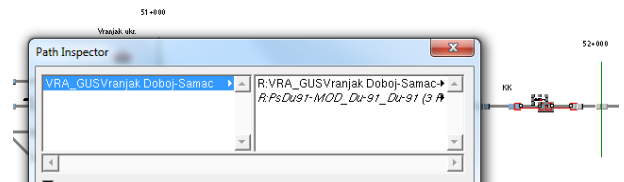


Fig.7. Entrance routes to the Vranjak intersection

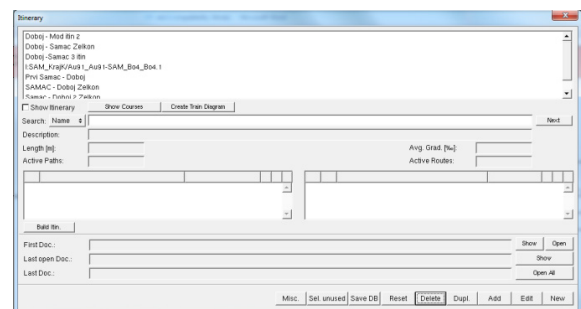


Fig.8. Itineraries for train movement on the Shamac-Doboje line

Then the base of towing vehicles was made (Figures 9 and 10).

After that, the base of rolling stock was made at the end of the train base by assigning numbers and itineraries to the rolling stock.

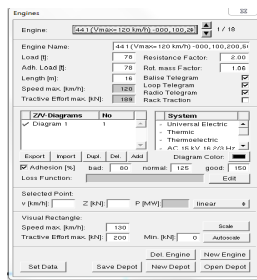


Fig.9. Data on locomotive 441 in depot base

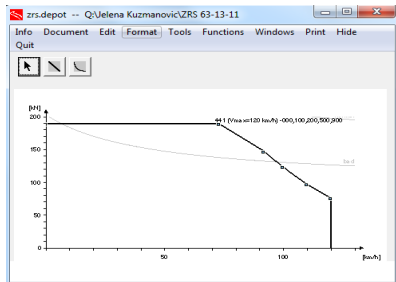


Fig.10. Towing passport of locomotive 441 in depot base

Finally, the trains are assigned the basic elements of the timetable (departure time from the departure station and time spent in official places on the line) so that during the simulation calculations of train equations get the travel times and arrival times at each station and departure from each station. located in output databases.

5. CALIBRATION VERIFICATION AND MODEL VALIDATION

The model was verified by zero simulation. It was determined that the model behaves according to all principles and rules that apply in railway traffic, ie. active infrastructure elements (switches, signaling devices) react to the given train paths and the train movement through the model is identical to the train movement in the real system [3].

Validation, ie evaluation of the validity of the model was done by comparing the output data of the simulation on the driving time of the passenger train 6451 and the freight train 48820 with the data from the real system, ie with the data from the actual chart. The driving times were found to be very close to the driving times recorded in the actual graphs. Then, a simulation of all trains for good and bad operating conditions was planned and done, for a period of 24 hours. Simulation experiments were performed several times to confirm the identity of the output results.

6. CONCLUDING REMARKS

For traffic planners and traffic infrastructure (track capacities, signalization, electrification, etc.), the application of modern sophisticated methods and tools is very important, and above all the application of the

simulation method on the model. By applying the OpenTrack software, it is possible to create various traffic scenarios in the present and future in a simple and fast way on the built model. Also, it is possible to make a model of planned modifications of the elements of the existing infrastructure or a completely newly designed infrastructure and monitor the relationship between the volume of traffic and the traffic infrastructure on which it takes place. In addition, this software enables the simulation of various traffic disturbances, which enables other "if-then" research. The results of the research are, above all, considered as additional arguments for decision-making in the development of various operational, tactical and strategic plans. It has been shown that the method of simulation on the model is especially suitable in the conditions of market liberalization, where the relationship between the operator and the owner of the infrastructure is based, primarily on the lease of the route. So simulation software can benefit both infrastructure owners and operators. As the timetable is an act of the infrastructure manager, and the calculation of route elements should be based on real data on train composition (towing and towed vehicles) owned by the operator, it is necessary for both parties to provide data on order elements in a simple and fast way driving which can only be realized by simulating the traffic of the desired train through a defined infrastructure. Also, for the section of the railway that has been selected and tested, it is possible to place in the program all those elements that are planned to be installed on the corridor Vc and see the effects that are achieved, which is extremely important for our small railway.

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