Simulation of Railway Operation on the line from Zagreb to Karlovac by OPENTRACK

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Abstract

The application of simulation software in the planning process is state-of-the-art at many railway infrastructure managers. On the one hand software tools are used to point out the demand for new infrastructure and on the other hand they are used to optimize traffic flow in railway networks by support of the time table related processes. This paper deals with the first application of the software tool called OPENTRACK for simulation of railway operation on an existing line in Croatia from Zagreb to Karlovac. Aim of the work was to find out if the actual version of OPENTRACK able to consider the Croatian signalling system. Therefore the capability arises to use it also for other investigations in railway operation.

Keywords: railway operation, simulation

1. Introduction

The use of computing in railway-engineering is nowadays state-of-the-art. Project planning of train control and signalling technology is assisted by simulation of operation. Simulation allows statements of functionality by scenarios, without the assumption, that an application has to be realised in some location. The importance of simulation is pointed by the fact, that railway-enterprises demand simulation-outputs for new technologies which guarantee the efficiency, performance and utilisability of products.

Independently from the used software there are three different types of simulation inputs: railway infrastructure (e.g. gradient, signals, track switch etc.), rolling stock and timetable data. Outputs of simulation are e.g. graphical timetables and velocity-distance-diagrams.

Based on simulation-results the projecting of train control system can be made. Now the problem occurs that data of infrastructure are in the simulation-tool, but cannot be put automatically in every other tool for planning. For an efficient use of all tools it is necessary to define interfaces for the data-exchange e.g. RAILML [3]. For railway-enterprises it is also important to have data without redundancies in only one single data-base. This topic concerns data of infrastructure but also data of timetable. So for the planning of a train run in every state of the process, automatic data-exchange has to be installed between the different systems.

2. Software OPENTRACK

OPENTRACK was developed within a R&D project at ETH Zürich (Switzerland) [1]. The aim of the project, Object-Oriented Modelling in Railways, was to develop a user-friendly tool to answer questions about railway operations by simulation.

Today, the railway simulation tool OPENTRACK is used by railways, the railway supply industry, consultancies and universities in different countries. For simulation of a railroad network three groups of data are necessary independently of the used software (figure 1):

- infrastructure,
- rolling stock and
- time tables

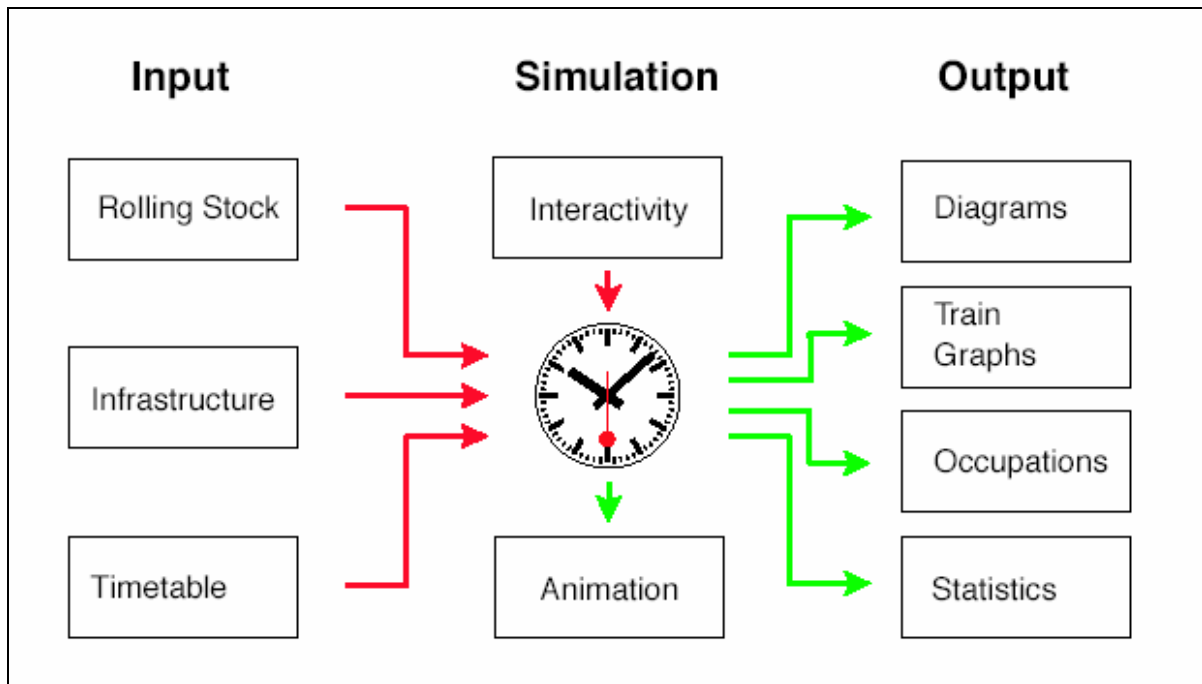A comparison of functionality of different software-tools can be found in [2].

Figure 1 Date flow in a simulation tool

Infrastructure layout data consists of a description of the physical infrastructure that is being simulated. This includes actual infrastructure such as track segments like edges, signals, stations, vertices and routes. Vertices mark points where at least one route attribute changes (gradient, radius, speed, etc.) or where there is a signal, a switch. Other vertices are signals (shunting, main, distant, halt position indicators) and software specific vertices (connectors). In OPENTRACK vertices always appear in pairs.

Rolling Stock consists of locomotives and wagons which are combined to form trains (model trains). In fact it is much more complex due to defective locomotives or additional load. The number of model trains depends on outlay. It is useful to create two different extreme compositions for every species (Freight, IC). For example one light and one heavy freight train or one fast (IC) and one slow train (Regio). It is recommended to consider different traction forms like single and multi traction.

Every model train composition consists of

- one or more locomotives
- trailer loads

There are only few attributes which characterize a model loco. Locomotive characteristics are

- tractive-effort-diagram,
- adhesion weight,
- safety equipment, signalling equipment, balise reader, onboard equipment
- length

Open Track has a database of locos which is available for use in the simulation process. From this database the requested train can be chosen and extended by

- the length
- and the weight of the trailers

100 % utilization of the tractive-effort-diagram is supposed to accelerate the model train. Further on a deceleration of 0.6m/s² is supposed.

Open Track is able to read automatically time tables which have a specific schema. The structure of the file contains following information

- course number,
- departure time at the first station
- minimum stop time in station
- running time between two stations

3. Application on line from Zagreb to Karlovac

The line from Zagreb to Karlovac is part of the Paneuropean Corridor Vb which is coming from Hungary via Koprivnica and Zagreb to Rijeka. This corridor is very important for Hungarian cargo traffic because of its connection to the Adriatic Sea. The section from Zagreb to Karlovac is a single line with a speed limit up to 160 km/h. Within the next years the whole corridor shall be renovated according to the European standard. For the simulation of railway operation passenger train paths representing a backbone of the timetable and remaining time slots were filled with cargo trains to evaluate the capacity of the line.
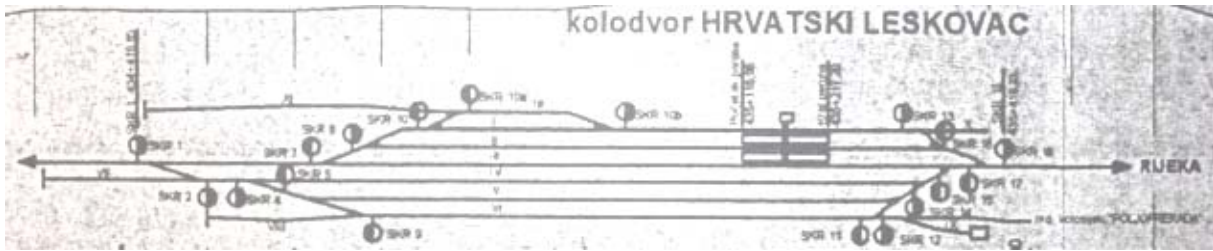
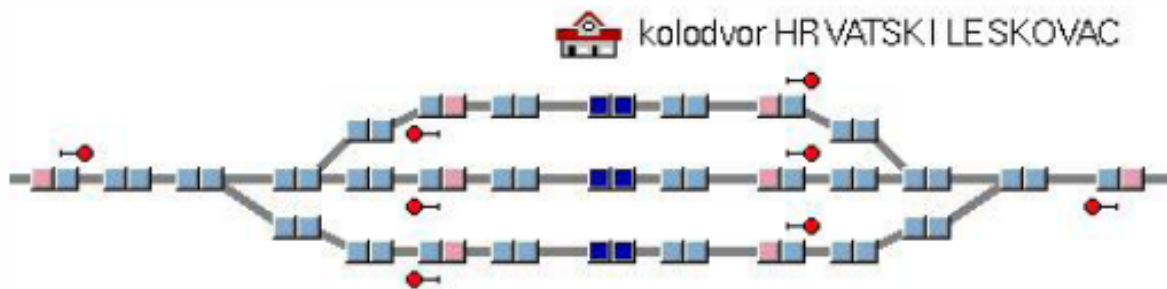**Figure 2 Map of station "Hrvatski Leskovac"**

Figure 3 OPENTRACK infrastructure layout of station "Hrvatski Leskovac"

Based upon signalling maps given by HŽ the OPENTRACK infrastructure layout was created. The provided maps start at Zagreb Glavni kolodvor (km 424,432) and stop at station Karlovac (km 476,218). In this study, the information about power supply and special buildings along the line is not taken into account. The most relevant information is about existing slopes and curves on the track. Therefore the speed limits are given and used for the calibration of the model. Moreover the positions of all relevant signals were introduced in the model. In the stations Zagreb Glavni kolodvor, Hrvatski Leskovac (figure 2 & 3), Zdencina, Jastrebarsko and Draganići only three tracks were implemented because of the low occupation by trains. The possibility for crossing trains was also realised in station Horvati.
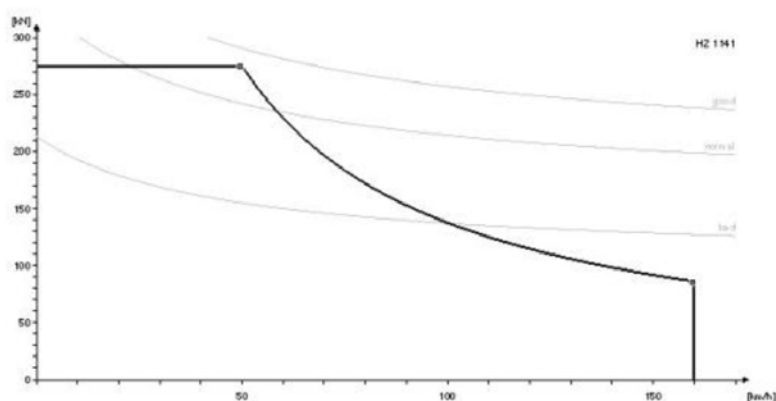
Figure 4 HŽ type 1142 traction-speed-diagram

For the rolling stock the typical engine from HŽ type 1142 was taken (figure 4). This engine has a maximum speed of 160 km/h and a power of 3860 kW. The acceleration of the engine is given by the traction-speed-diagram. In the simulation this engine is used for the intercity and the cargo train. The intercity has 8 cars and therefore a weight of 400 tons and a length of 210 metre. The cargo train has a total weight of 800 tons and a length of 500 metre. The deceleration for cargo train was set to 0,2 m/s² due to weaker breaking behaviour. For regional trains (4000, 4055 and 4057) the type 6111 was modelled. This train has a maximum speed of 120 km/h and a length of 72 metre.

The implemented timetable was taken from the internet timetable application for a time slot of two hours in the peak period. Within this time slot three passenger trains are operated on the line. Two of them are region trains from Rijeka to Zagreb. The third one is an intercity from Rijeka via Zagreb to Osijek. The intercity has the ID 703 and leaves Karlovac at 9:00 and arrives in Zagreb at 9:37 without any commercial stop. On one part of the section there is also a local service with the ID 4057 from Moravice to Zagreb.

On the one hand the timetable is an input but on the other hand it is also an output (figure 5). The input timetable can be interpreted as the vision how the operation shall run and the output timetable shows the capability of the infrastructure to realise the vision. Therefore the graphical timetable is an important instrument to evaluate the quality of a simulation run. The planned timetable from the input is drawn in black and the dynamic profile coloured purple for passenger trains and violet for cargo trains. On the left side of the graphical timetable a schematic overview on the track layout is given. Therefore crossing opportunities can be

recognised easily. So if the operation is not disturbed by delays, all the trains are arriving before the scheduled arrival time due to the running time reserves given by UIC leaflet 451-1. In case of delay trains are therefore able to reduce their delay.
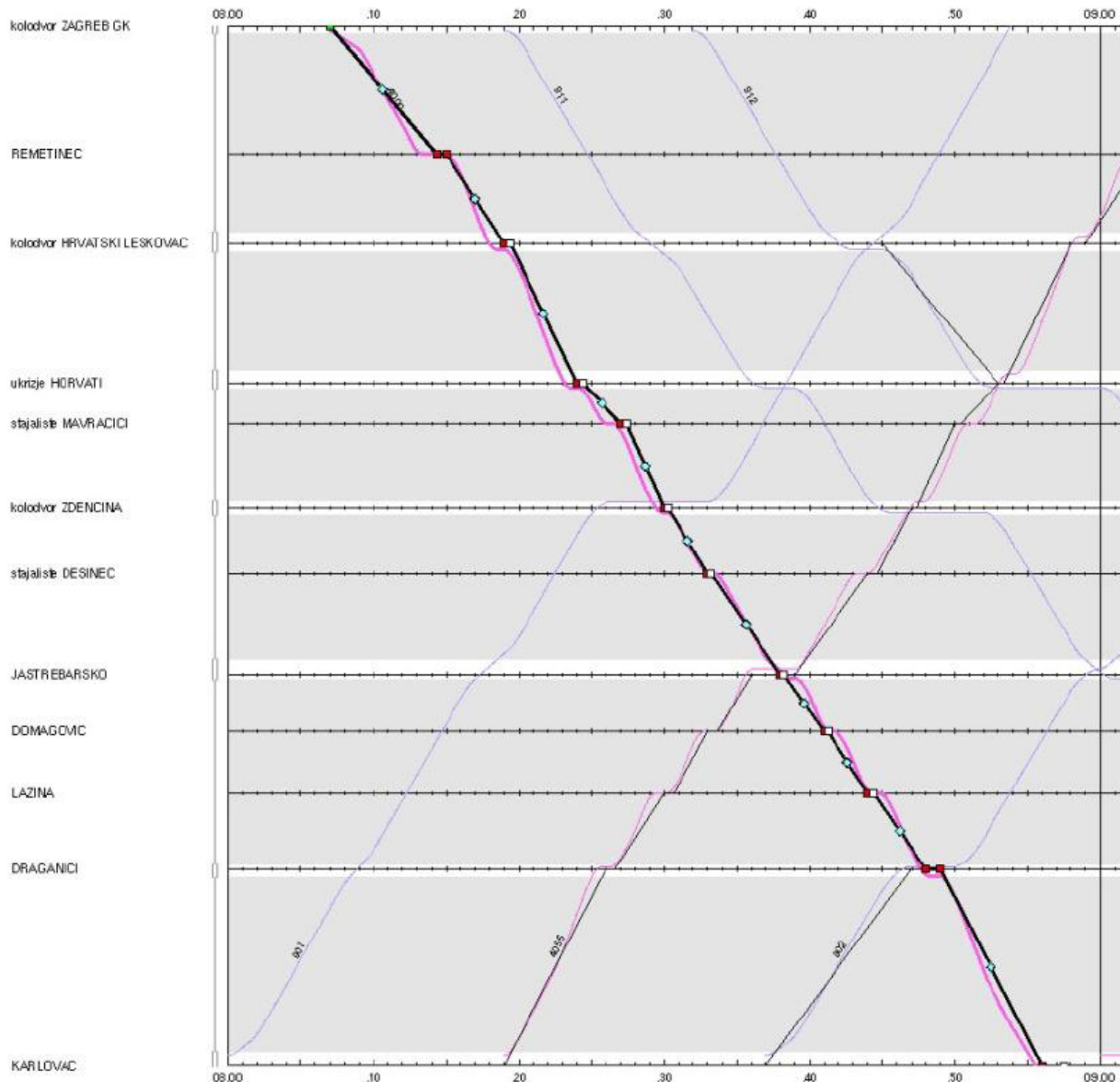

Figure 5 Graphical timetables as input and output of simulation

Another important output of the simulation is the speed-way-diagram (figure 6) where the dynamic speed profile can be seen. This graph is important for check of the sight distance of signals. In case of punctual operation it is not necessary to drive at maximum speed limit of

the line. Here the opportunity arises to use time reserves for saving energy by driving a little bit slower than allowed. On the other hand in case of delay, the train will follow the maximum speed profile to reduce its delay.
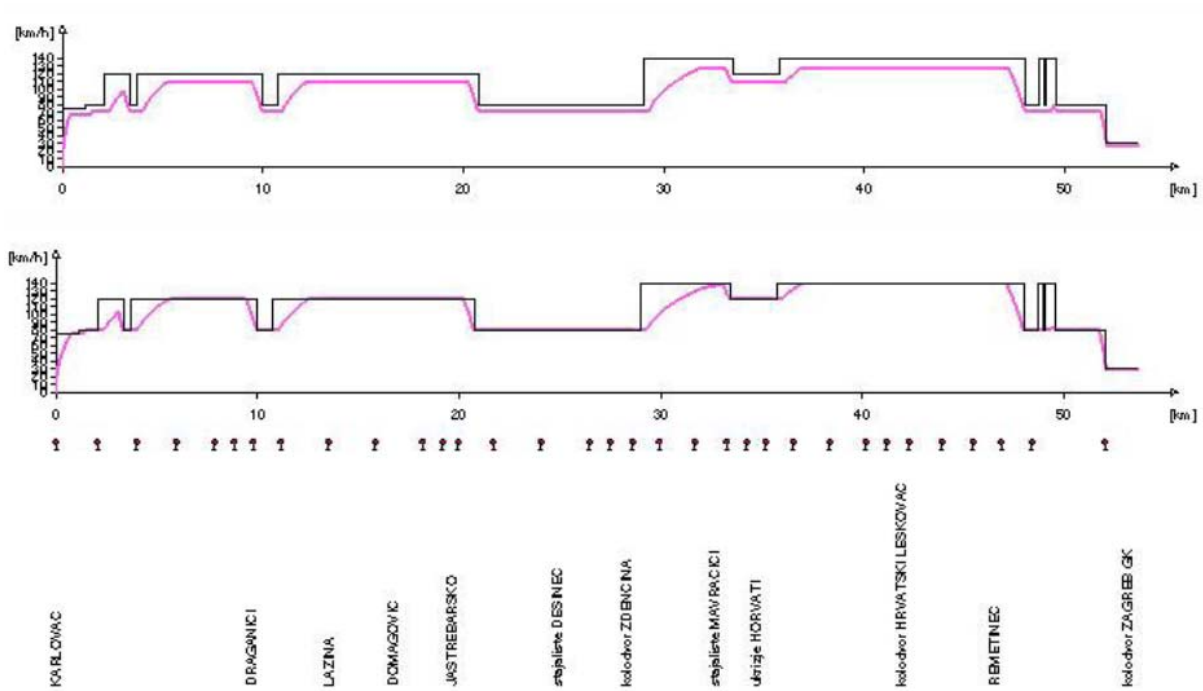

Figure 6 Speed-way-diagram of intercity

4. Outlook

The results from this work clearly show that OPENTRACK is able to fulfil the requirements of HŽ signalling system. For future work it would be helpful to have infrastructure data and timetable data in some XML schema to improve the import of data.

References

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[2] Warninghoff, C.R., Ferchland C. (2004): *Nutzung von Simulation zur Unterstützung der betrieblichen Infrastrukturplanung*, Eisenbahntechnische Rundschau, H.7/8 - Juli/August, S. 490-498, Eurailpress Tetzlaff-Hestra

[3] http://www.railml.org