ENHANCING CAPACITY ON ETCS LINES

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Abstract *– This paper presents the potential increase of capacity on the Austrian high speed line between Vienna and St. Pölten which has been opened in the year 2012 and is operated by ETCS Level 2. Trackside signals are only used as a fall back option. Simulation software OPENTRACK has been applied to calculate headways for different block layouts. Results are presented in this paper and look promising for an increase of capacity on railway lines.*

Keywords – ETCS, headways, simulation, operation

1. INTRODUCTION

OpenTrack was developed at the Swiss Federal Institute of Technology's Institute for Transportation Planning and Systems (ETH IVT). The project's goal was development of a user-friendly railroad simulation program that can run on different computer platforms and can answer many different questions about railway operations [1].

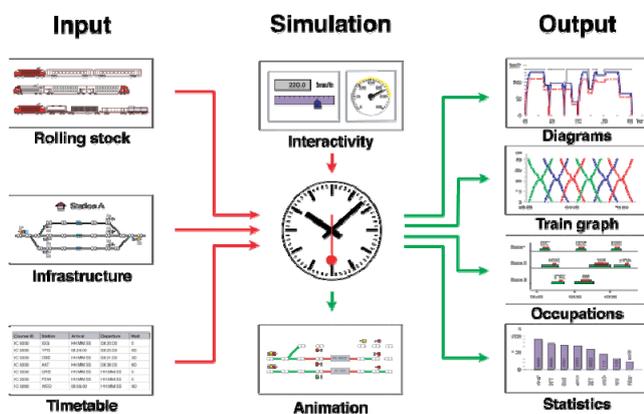Figure 1 illustrates the three main elements of OpenTrack: data input, simulation, and output.

Fig.1. Data flow in OpenTrack

OpenTrack is a microscopic synchronous railroad simulation model. As such it simulates the behaviour of all railway elements (infrastructure network, rolling stock, and timetable) as well as all the processes between them. It can be easily used for many different types of projects including testing the stability of a new timetable, evaluating the benefits of different long-term infrastructure improvement programs, and analyzing the impacts of different rolling stock.

2. SOFTWARE OPENTRACK

OpenTrack administers input data in three modules: rolling stock (trains), infrastructure, and timetable. Users enter input information into these modules and OpenTrack stores it in a database structure. Once data has been entered into the program, it can be used in many different simulation projects. For example, once a certain locomotive type has been entered into the database, that locomotive can be used in any simulation performed with OpenTrack. Similarly, different segments of the infrastructure network can be entered separately into the database and then used individually to model operations on the particular segment or together to model larger networks.

Train data (locomotive and wagons) is entered into the OpenTrack database with easy to use forms displayed using pull down menus. Infrastructure data (e.g. track layout, signal type/location) is entered with a user-friendly graphical interface; quantitative infrastructure data (e.g. elevation) is added using input forms linked to the graphical elements. Following completion of the RailML data structure for rolling stock and infrastructure, OpenTrack will be modified to enable train and infrastructure data to be directly imported from RailML data files [2].

Timetable data is entered into the OpenTrack database using forms. These forms include shortcuts that enable data input to be completed efficiently. For example, users can designate hourly trains that follow the same station stopping pattern an hour later. Since OpenTrack uses the RailML structure for timetable data, timetable data can also be entered directly from various different program output files as well as database files.

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In order to run a simulation using OpenTrack the user specifies the trains, infrastructure and timetable to be modeled along with a series of simulation parameters (e.g. animation formats) on a preferences window. During the simulation, OpenTrack attempts to meet the user-defined timetable on the specified infrastructure network based on the train characteristics. OpenTrack uses a mixed continuous/discrete simulation process that allows a time driven running of all the continuous and discrete processes (of both the vehicles and the safety systems) under the conditions of the integrated dispatching rules.

The continuous simulation is dynamic calculation of train movements based on Newton's motion formulas. For each time step, the maximum force between the locomotive's wheels and the tracks is calculated and then used to calculate acceleration. Next, the acceleration function is integrated to provide the train's speed function and is integrated a second time to provide the train's position function.

The discrete simulation process models operation of the safety systems; in other words, train movements are governed by the track network's signals. Therefore, parameters including occupied track sections, signal switching times, and restrictive signal states all influence the train performance. OpenTrack supports traditional multi-aspect signalling systems as well as new moving block train control systems (e.g. European Train Control System – ETCS signalling).

Finally, dynamic simulation enables users to run OpenTrack in a step-by-step process and monitor results at each step. Users can also specify exactly what results are displayed on the screen. Running OpenTrack in a step-by-step mode with real time data presented on screen helps users to identify problems and develop alternative solutions.

One of the major benefits of using an object oriented language is the great variety of data types, presentation formats, and specifications that are available to the user. During the OpenTrack simulation each train feeds a virtual tachograph (output database), which stores data such as acceleration, speed, and distance covered. Storing the data in this way allows users to perform various different evaluations after the simulation has been completed.

OpenTrack allows users to present output data in many different formats including various forms of graphs (e.g. time-space diagrams), tables, and images. Similarly, users can choose to model the entire network or selected parts, depending on their needs. Output can be used either to document a particular simulation scenario or as an interim product designed to help users identify input modifications for another model run.

3. SIMULATION OF ETCS

Regarding the equipment of the lines, ETCS specifications distinguish five application levels: the levels 0, 1, 2, 3 and STM [3]. Level 0 just describes the situation where a vehicle which is equipped with ETCS moves in an unequipped area. Level STM (Specific Transmission Module) is designed for situations where a train which is equipped with ETCS moves on a line without ETCS, but with a national train protection system. This level has been developed for the migration period.

In ETCS Level 1 the main transmission medium are so called Balises which transmit movement authorities and profile data to the train. Balises can be fix data or switchable balises. The former store the data content in the balise itself (only static data), whereas the latter, a Lineside Electronic Unit (LEU) selects the data according to input information (e.g. signal aspects). Besides the balises, linear infill devices can be used locally to transmit changes of signal aspects beyond. These are Euroloops (cable loops in the rail) or radio infill units. Therefore Level 1 provides continuous guidance functions by movement authority.

In ETCS Level 2 and 3 information can be continuously and bidirectionally transmitted by Euroradio, a radio standard based on GSM-R. The central trackside unit is the Radio Block Centre (RBC). In contrast to Level 1 the trains are individually known in the RBC. The train requests new movement authorities in regular time intervals or at particular events. A difference between Level 2 and 3 is that in Level 2 ETCS only takes the responsibility for signal and train protection functions, whereas Level 3 also replaces the interlocking-based track clear detection by continuously checking train completeness on the train and transmitting this information to the RBC.
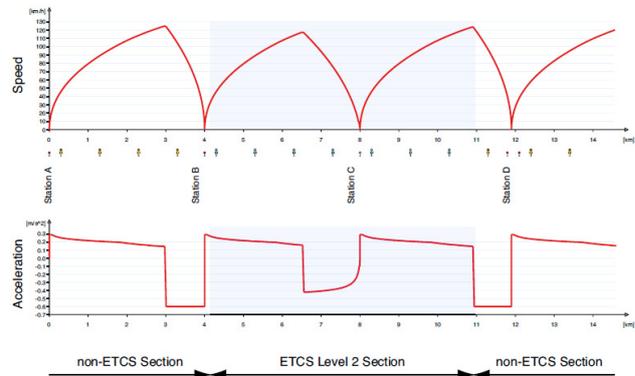

Fig.2. Speed-distance and acceleration-distance diagrams for non-ETCS and ETCS Level 2 sections

The interesting investigation of non ETCS and ETCS Level 2 sections is the behaving of trains in terms of speed and acceleration. Finally the running time is influenced and thereby the timetable has to be

modified. The maximum speed achieved by the train is lower and the braking procedure has to start earlier due to reduced deceleration.

4. SHOW CASE IN AUSTRIA

Since 2012 the new high speed line between Vienna and St. Pölten is in operation. The line is designed for speeds up to 250 km/h. Unfortunately, there is no train in Austria available to reach this speed limit. Nevertheless, Austrian Railways use their RailJet services with a speed limit of 230 km/h. RailJet consists out of a Taurus engine and seven trailers. Taurus engines are also used for freight trains with a maximum speed of 100 km/h. For both headway scenarios the headway calculator of OpenTrack has been used to compare headways with ETCS Level 2 vs. ETCS Level 3.
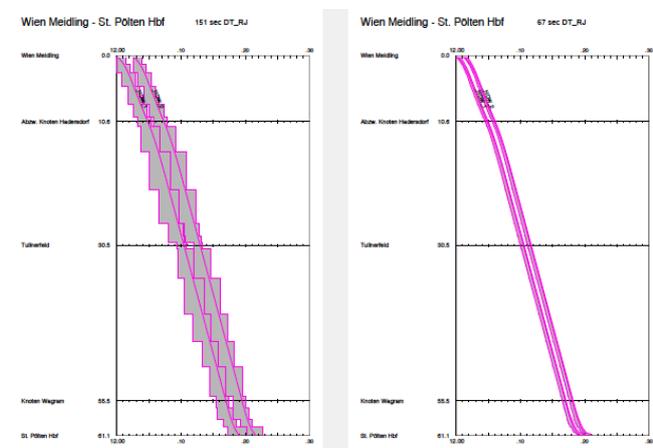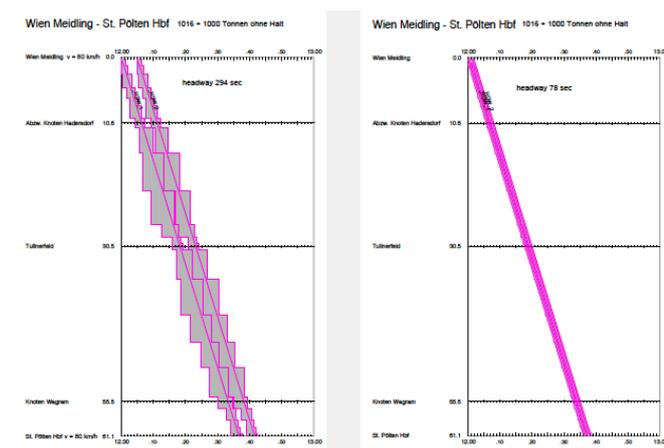

Fig.2. Headway for two RailJets with ETCS Level 2

(left) and 3 (right)

Fig.3. Headway for two Cargo trains with ETCS Level 2 (left) and 3 (right)

Results are promising since ETCS Level 3 would allow to shorten the headway from 151 to 67 seconds for two RailJet services and from 294 to 78 seconds for two cargo trains. During day time this would allow to double the frequency of passenger services. Even more interesting is the possible increase of capacity during night time for cargo trains. ETCS Level 3 with moving block would allow to have almost four times more cargo trains. Of course, ETCS Level 3 is currently not available as a solution on the market but with short blocks in ETCS Level 2 headways can be pretty close to the ones possible in ETCS Level 3. Signals can be only virtual in ETCS Level 2 while axle counters have to be physically placed wayside wherever a short block ends. Results from the headway calculator show that it is a promising topic worth to be investigated as a business case for railway infrastructur managers. Since axle counters are a relatively cheap component of railway infrastructur it should be economically feasible to install them frequently to increase capacity on ETCS Level 2 lines.

5. CONCLUSION

OpenTrack is an efficient and effective railway simulation program. It has been used successfully in many different railway planning projects throughout the world. The program's use of object oriented programming and the RailML data structure makes it particularly effective since the program can be modified relatively easily to address specific applications and since data can be transferred easily to and from other programs based on RailML. Therefore it seems to be highly recommended to apply it also for the evaluation of the operation performance for the planned introduction of ETCS in the network of Croatian Railways. As the Austrian show case has clearly shown an increase of capacity even on high speed lines is possible. Another field of application is the implementation of ETCS Level 2 on existing lines with shorter blocks than in the existing layout.

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