DESIGN OF RAILWAY INFRASTRUCTURE WITH OPENTRACK IN AUSTRIA

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Abstract

This paper describes how software OpenTrack has been applied for the design of railway infrastructure in Austria. Software OpenTrack allows railway engineers to simulate railway operation on different infrastructure layouts. Typically, there is a demand for a certain type of railway services (e.g. an integrated timetable). To enable these services several scenarios of topology can be developed. By simulating railway operation on these scenarios the stability of the timetable can be evaluated. Extensions of existing topology can be justified by running such a simulation. For the realisation of an integrated timetable on the Zillertalbahn from Jenbach to Mayrhofen additional crossing stations are required. In OpenTrack different locations for the crossing stations have been simulated and evaluated. Additionally, upgrades of signalling system can be analysed in detail which is applied at Salzburg AG.

Keywords: integrated timetable, railway infrastructure, railway topology, simulation of railway 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]. In Austria, software OpenTrack is in commercial use by railway companies Zillertaler Verkehrsbetriebe AG and Salzburg AG.

2 Functionality of Software 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. Figure 1 illustrates the three main elements of OpenTrack: data input, simulation, and output.
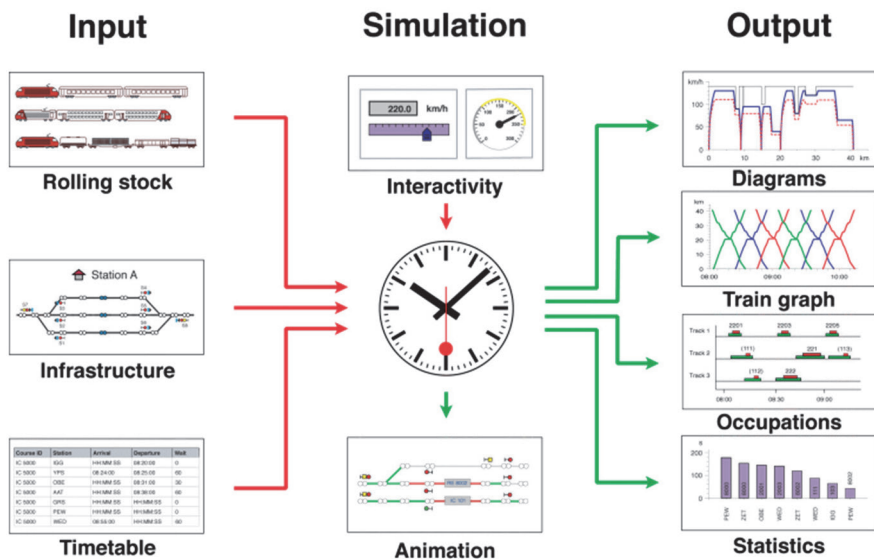
Figure 1   Data flow in a simulation project

2.1 Input data

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 desig-nate hourly trains that follow the same station stopping pattern an hour later. Since Open-Track uses the RailML structure for timetable data, timetable data can also be entered direct-ly from various different program output files as well as database files.

2.2 Simulation

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 character-

istics. 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.

2.3 Output

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 Show Case Zillertaler Verkehrsbetriebe AG

3.1 Topology

The Zillertaler Verkehrsbetriebe AG operates the narrow gauge line from Jenbach to Mayrhofen [3]. At Jenbach there is the connection to the network of Austrian Railways (ÖBB) where all regional, national and several international have a commercial stop. Figure 2 shows the graph for the topology of an upgraded design of the infrastructure to fulfill future requirements of service quality and density. Today there are already two double track sections in operation between Kaltenbach-Stumm and Aschau as well as between Zell am Ziller and Ramsau-Hippach.
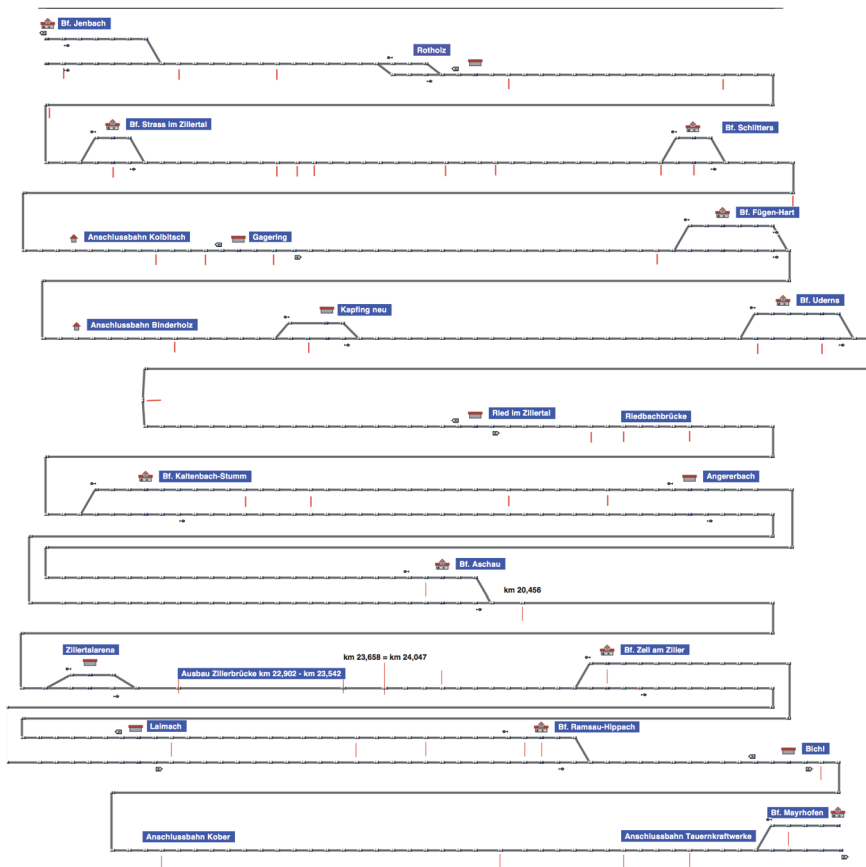
Figure 2 Scenario of infrastructure layout for the timetable study 2014

3.2 Timetable study 2014

To offer an integrated timetable on a regular and symmetric basis another crossing opportunity between Aschau and Zell am Ziller is required where there is a plan to realize a new commercial stop close to a skiing center (Figure 2). For the calculation of the running time new electrical train units where assumed as well as an increase of the track speed limit towards 80 km/h where ever reasonable. This allows to shorten the running time from Jenbach to Mayrhofen from 55 to 45 minutes. Figure 3 shows the graphical timetable for the morning peak hours from 8 to 11 during winter season where additional services run to provide a 15 minutes interval. The blue lines represent the courses providing the 30 minutes interval during the entire day while the green lines indicate the additional services for the 15 minutes interval.
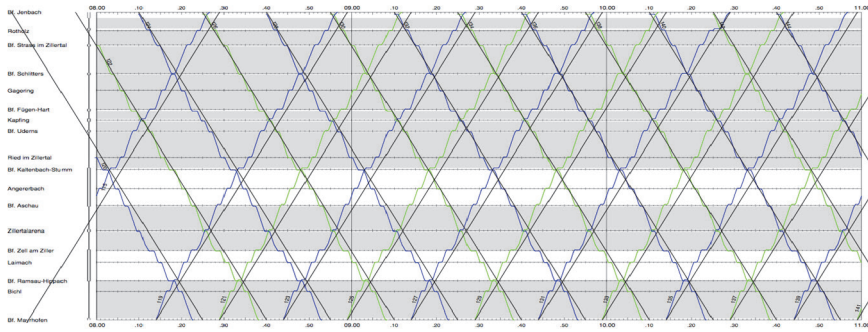
Figure 3   Integrated timetable in the time slot 8:00 – 11:00

3.3 Timetable study 2021

Recently, the decision has been taken to purchase hydrogen-powered trains. Moreover, the design of infrastructure topology will be changed in a different manner than planned in 2014. Therefore, an update of the timetable study was required.
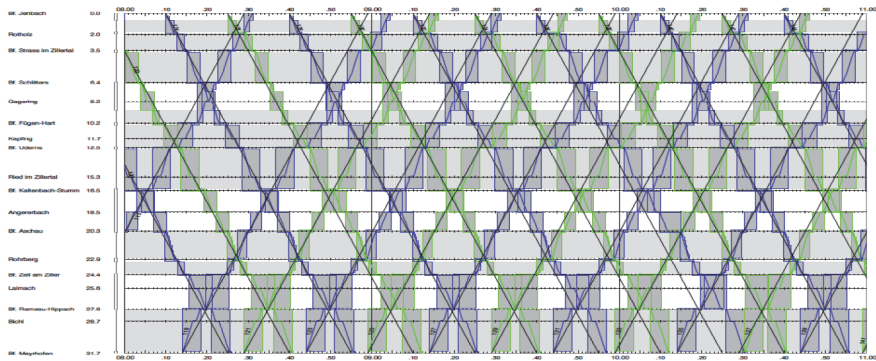

Figure 4   Integrated timetable in the time slot 8:00 – 11:00

4   Show case Salzburg AG

The local railway company operates a network of 38 km which consists out of one line from Salzburg Lokalbahn to Lamprechtshausen over Bürmoos where there is a junction to Ostermiething [4]. Passenger trains operate in a 30 minutes interval while express trains are additionally running in peak time period. Existing infrastructure has been successfully modelled in OpenTrack (see figure 5). This is now the starting point for further research when implementing a new signalling system.
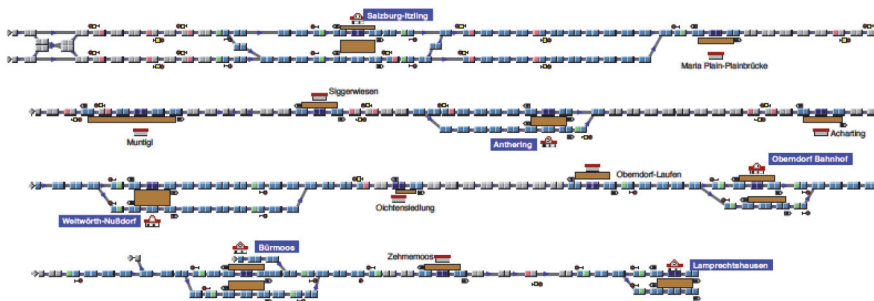
Figure 5   Part of the infrastructure operated by Salzburg AG

5 Conclusions

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. Recent applications in Austria underpin the value of modelling railway infrastructure in a very early stage of planning extensions of existing railway infrastructure. Investments in railway infrastructure always have to be justified by a proof of operational concepts by simulation of railway operation.

References

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