

OPENTRACK

Simulation of Railway Networks

OpenTrack began a few years ago as a research project at the Swiss Federal Institute of Technology. The aim of the project, Object-Oriented Modeling in Railways, was to develop a user-friendly tool to answer questions about railway operations by simulation.

Figure 1 shows how the simulation tool works. Predefined trains run on a railway network according to the timetable. During the simulation, OpenTrack calculates train movements under the constraints of the timetable and the signaling system. After a simulation run, OpenTrack can analyze and display the resulting data in the form of diagrams, train graphs, occupation diagrams and statistics.

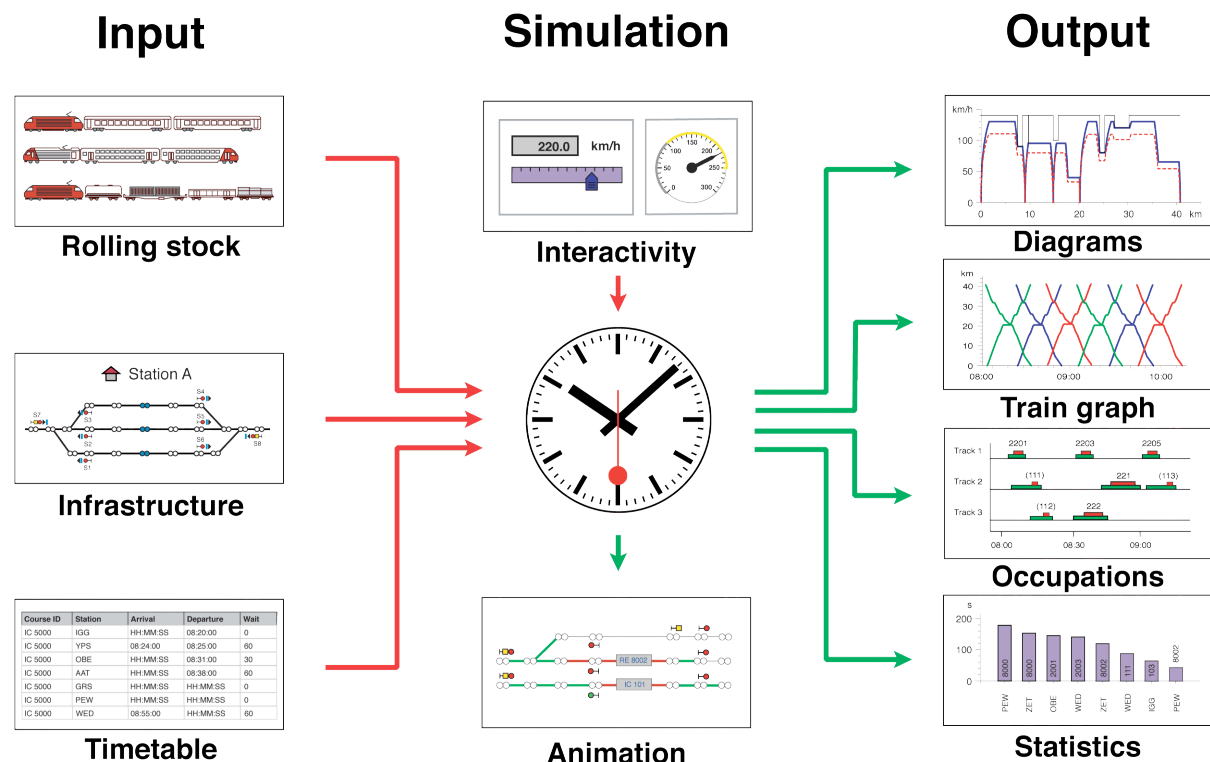


Figure 1: The modules of the simulation

Rolling stock data

OpenTrack stores each locomotive's technical characteristics, including tractive effort/speed diagrams, load, length, and adhesion factor. A database organizes locomotives into groups called depots. A simulated train consists of one or more locomotives from a depot together with a number of passenger or freight cars (carriages or wagons). Another database can store the simulated train.

Network data

OpenTrack describes a railway network in special graphs called double vertex graphs. A user can edit the network's topology graphically. Every element of the graph holds various attributes. An edge, for example, holds a track section's length, gradient, maximum speed for different train categories and much more. A user can create and manage objects for edges and vertices, and also signals, switches, stations and routes. Figure 2 shows an example for a station.

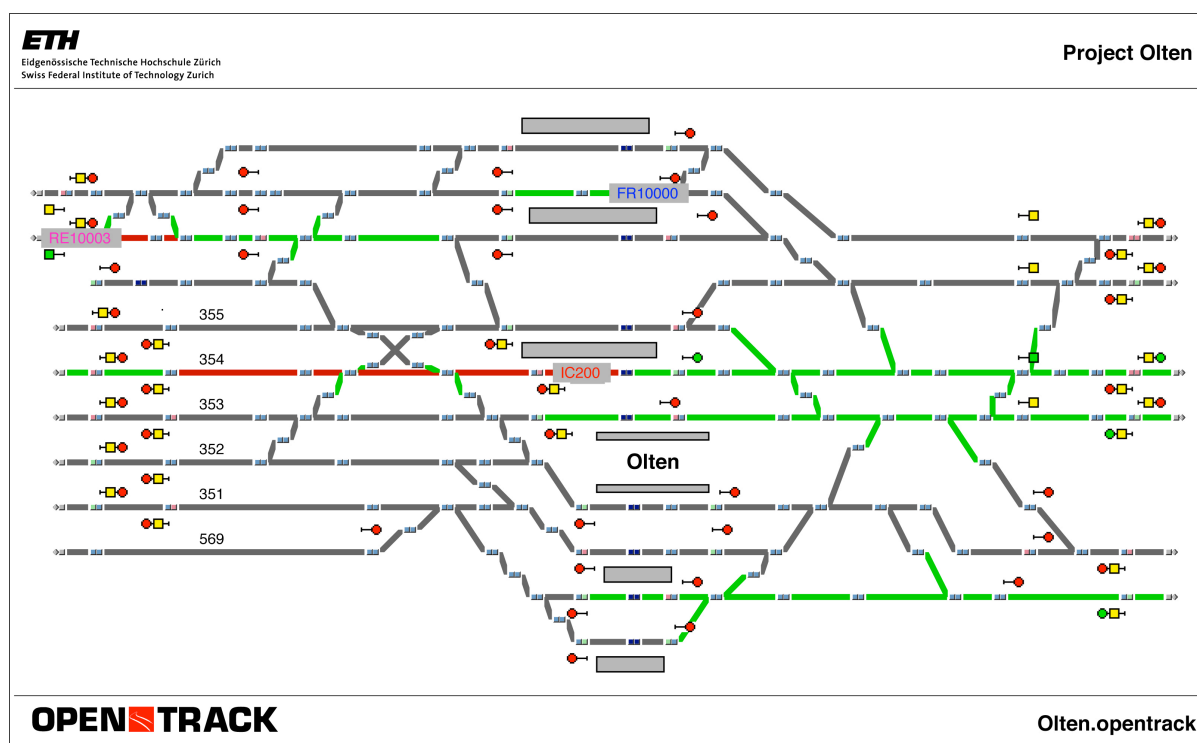


Figure 2: Layout of a station

Timetable data

The timetable database stores information for each train at each station, including arrival and departure times, minimal stop time, and connections to other trains.

Simulation

During a simulation, trains try to obey the given timetable. The differential equations for speed and distance are the basis for calculating a train's movement. The signaling system of the railway network poses constraints. Occupied tracks and restrictive signal aspects may impede a train's progress.

During the simulation, every train continuously stores its speed, acceleration, position, power consumption and other data. This data can be evaluated after the simulation as shown in Figures 3 to 7.

The user can watch the simulation in an animation mode, which shows the trains running and lets the user analyze occupied tracks, reserved tracks and signal aspects.

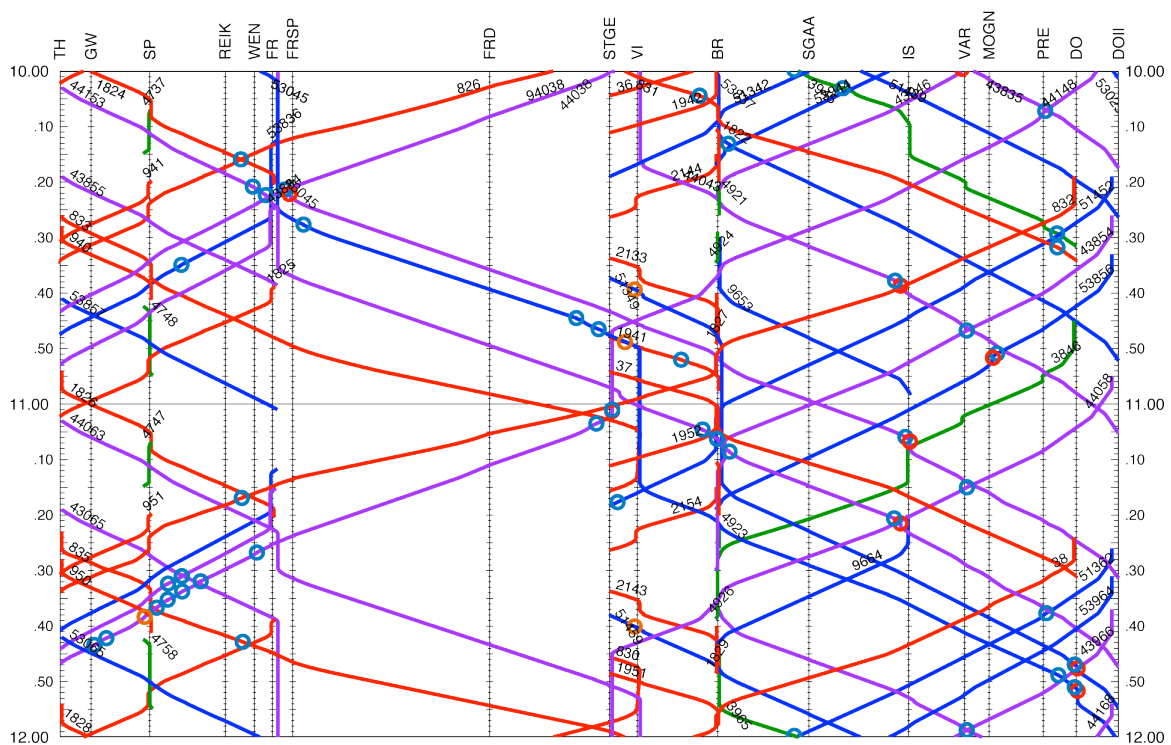


Figure 3: Train graph (train diagram)

Output data

After a simulation, OpenTrack offers output data in a number of forms. Evaluations of a train, line or station are possible. For a train, OpenTrack offers diagrams such as acceleration vs. distance, speed vs. distance (Figure 4), and obstructions. For a line, there are evaluations in the form of diagrams of train movements (Figure 3), track occupation (Figure 5) and line profiles. Every station produces output about all the trains that used it, including arrival, stopping and departure times.

The user can view output data in either a diagram or an Excel table, or export it as a readable ASCII table.

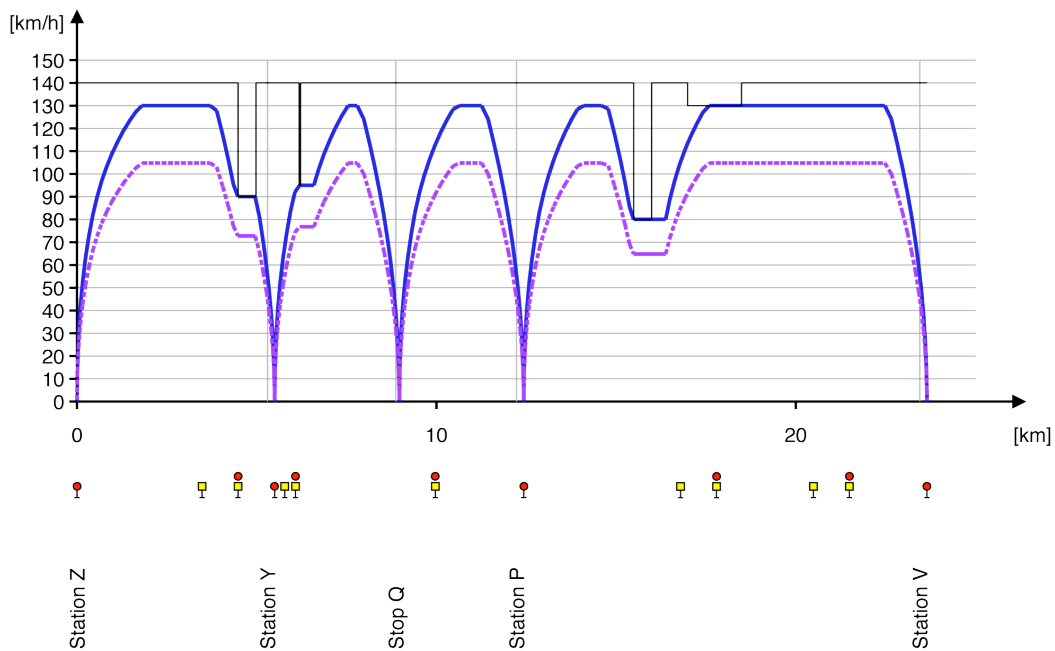


Figure 4: Speed/distance diagram

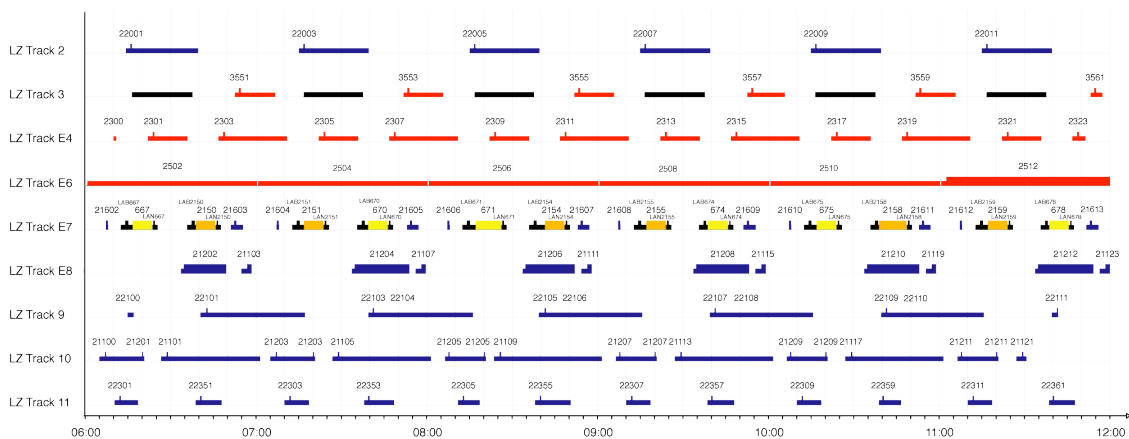


Figure 5: Occupation of selected platform tracks

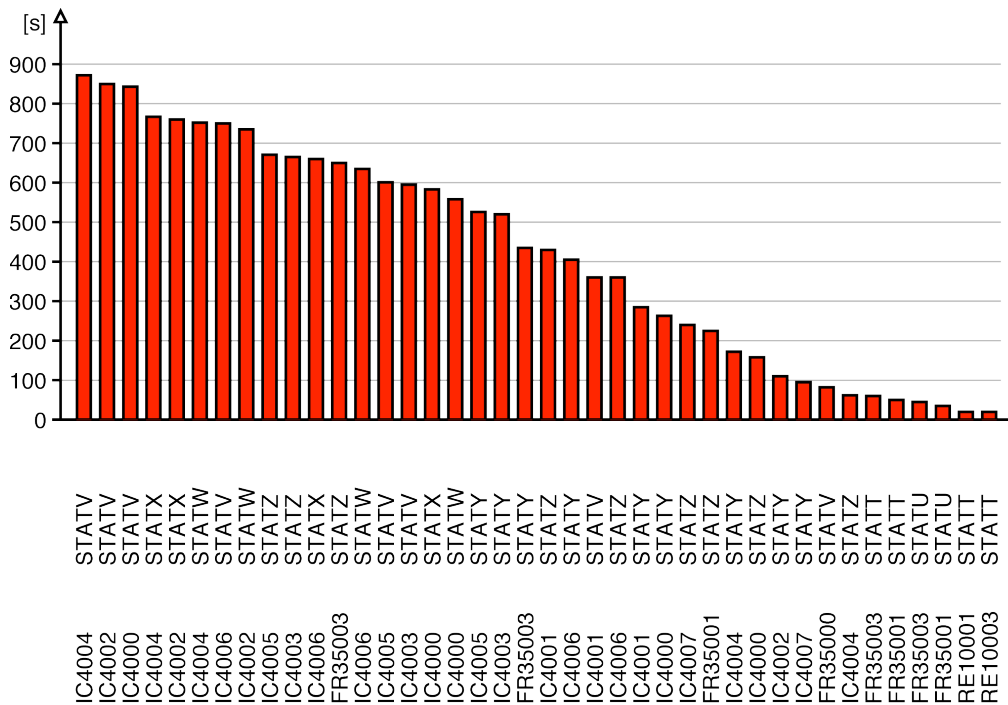


Figure 6: Delay statistics

| Course | Station | Arr. Planned | Dep. Planned | Arr. Actual | Dep. Actual | Arr. Del. | Dept. Del. |
|--------|---------|--------------|--------------|-------------|-------------|-----------|------------|
| | | [HH:MM:SS] | [HH:MM:SS] | [HH:MM:SS] | [HH:MM:SS] | [s] | [s] |
| 18021 | ZMUS | 07:04:00 | 07:05:20 | HH:MM:SS | 07:07:00 | 0 | 100 |
| 18021 | ZMUO | HH:MM:SS | HH:MM:SS | HH:MM:SS | 07:07:26 | 0 | 0 |
| 18021 | ZSTH | 07:09:00 | 07:10:30 | 07:09:04 | 07:10:30 | 4 | 0 |
| 18021 | ZHOT | HH:MM:SS | HH:MM:SS | HH:MM:SS | 07:11:40 | 0 | 0 |
| 18021 | STET | 07:14:00 | 07:14:00 | HH:MM:SS | 07:13:52 | 0 | -8 |
| 18021 | NGUT | HH:MM:SS | HH:MM:SS | HH:MM:SS | 07:14:20 | 0 | 0 |
| 18021 | CHRI | HH:MM:SS | HH:MM:SS | HH:MM:SS | 07:14:50 | 0 | 0 |
| 18021 | DUE | HH:MM:SS | HH:MM:SS | HH:MM:SS | 07:15:22 | 0 | 0 |
| 18021 | SCWE | HH:MM:SS | HH:MM:SS | HH:MM:SS | 07:16:56 | 0 | 0 |
| 18021 | NAEN | HH:MM:SS | HH:MM:SS | HH:MM:SS | 07:18:16 | 0 | 0 |
| 18021 | UST | 07:21:00 | HH:MM:SS | 07:20:26 | HH:MM:SS | -34 | 0 |
| 18022 | UST | HH:MM:SS | 07:37:20 | HH:MM:SS | 07:39:00 | 0 | 100 |
| 18022 | NAEN | HH:MM:SS | HH:MM:SS | HH:MM:SS | 07:40:46 | 0 | 0 |
| 18022 | SCWE | HH:MM:SS | HH:MM:SS | HH:MM:SS | 07:42:06 | 0 | 0 |

Figure 7: All outputs can be viewed in Excel

The OpenTrack application

The OpenTrack application is available for the following operating systems: *Windows* (2000, XP, Vista, 7, 8, 10) and *Mac OS X*.

The application is available in two versions. The full version of OpenTrack offers an unlimited number of running trains per simulation. The limit of the OpenTrack Light version is two trains per simulation.

Figure 8 shows an example of the application during a simulation run. OpenTrack animates the running trains on the screen.

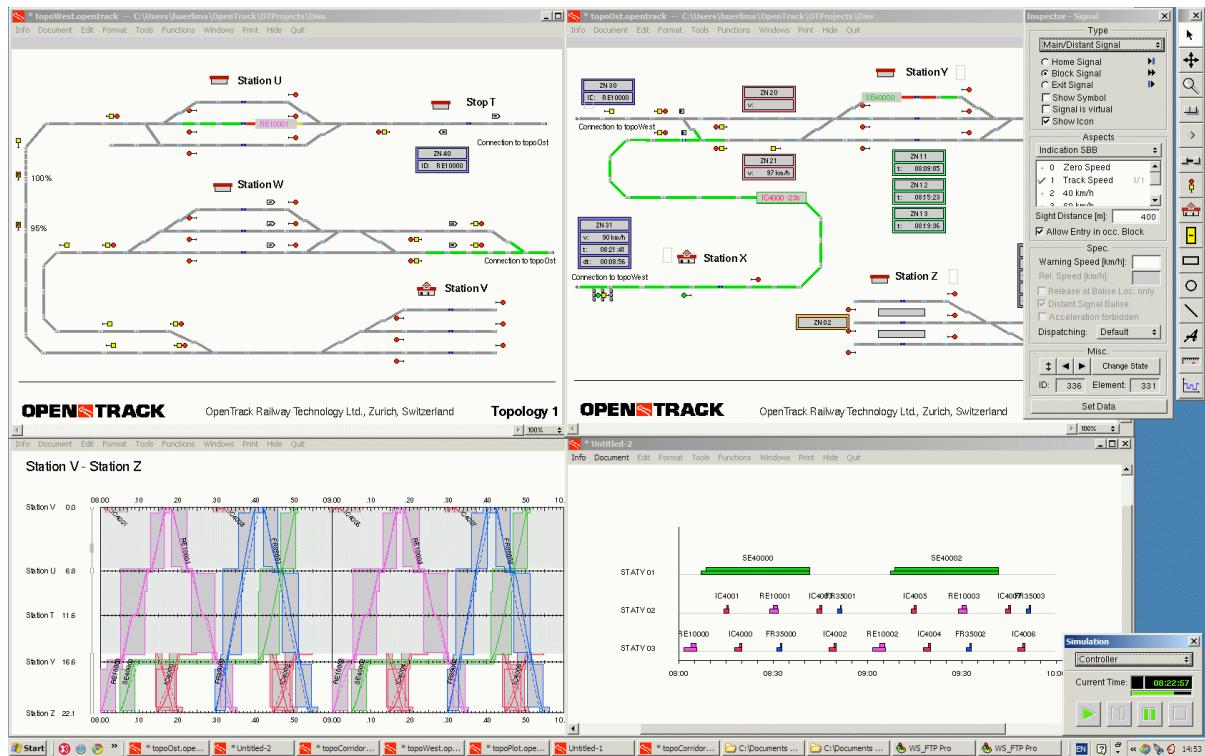


Figure 8: Screenshot (OpenTrack for Windows XP)

For more information

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