Railway Simulation and Timetable Planning

By Philipp Goetz, Managing Director
Rail Systems Engineering Sdn Bhd, Kuala Lumpur

New railway lines are being built in almost every country, the existing lines get improved or double-tracked and traffic gets denser everywhere. This makes it important that the operational performance of a track and signalling layout can be fully understood, not only by railway operators, but also by the supplying industry.

Computer simulation of railway operations offers the most comprehensive way to study the rail systems and operations in detail, even if the railways do not yet exist, the rolling stock is not available, or the daily operations do not allow access.

In this article I would like to describe the benefits of simulation, the principles of doing a simulation and what output can be expected.

History

Since the late 1990s European railway operators and the supplying industry in Europe started using simulation more and more as a tool to improve operations and verify track layout and signalling design. The railway simulation software "OpenTrack" which is used and described in this article started in the mid-1990s as a research project at the Swiss Federal Institute of Technology.

Today, the railway simulation tool OpenTrack is a well established railway planning software and it is used by railways, the railway supply industry, consultancies and universities. The tool is continuously improved until now to comply with the latest trends. developments and standards.It is used for all different types of railways, for example, but not limited to mainline, MRT, LRT, Trams, High Speed and Maglev. Continuous development allows the latest systems and operational approaches to be simulated.

The software runs on any standard PC or Mac with up to date specification. Systematical use of simulation started in Europe, but now simulation is used by operators, supplying industry and planners all over the world.

Use and benefits of a simulation

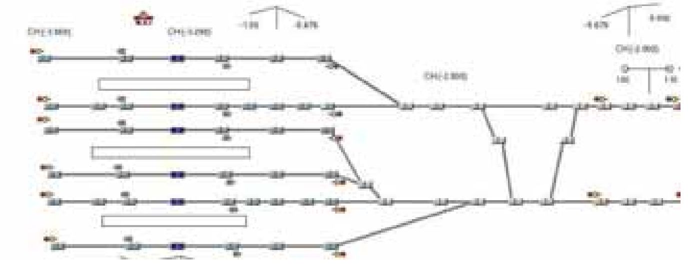
OpenTrack is a very flexible tool; it fulfils the needs of operators, suppliers and planning units. It is independent of the product or system specification.

The software supports the following tasks:

- Determining the requirements for a railway network's infrastructure
- Analysing the capacity of lines and stations
- Rolling stock studies (e.g. future requirements)
- Running and Headway time calculation
- Timetable construction and verification
- Analysing the robustness of timetables (single or multiple simulation runs)
- Bottleneck solving
- Prepare reduced service scenarios (e.g. line closures for maintenance)
- Analysing the effects of system failures (such as infrastructure or train failures) and delays
- Evaluating and designing various signalling systems and/or ATP systems, such as discrete block systems, short blocks, moving blocks, LZB, CBTC (communica tion-based train control), ATP, ATO, or different ETCS Levels
- Calculation of power and energy consumption of train services
- Analysing the contractual requirements and prove of compliance
- Feasibility studies for line extension projects

Running a typical simulation

For an accurate simulation track layout (incl. line speeds, gradients and curve radius), signalling information (e.g. location of signals, turnouts and ATP transponders) and rolling stock data is needed. Based on this information a simulation model of line and rolling stock is built up. Operational information like timetable (proposal), routing and dispatching information has to

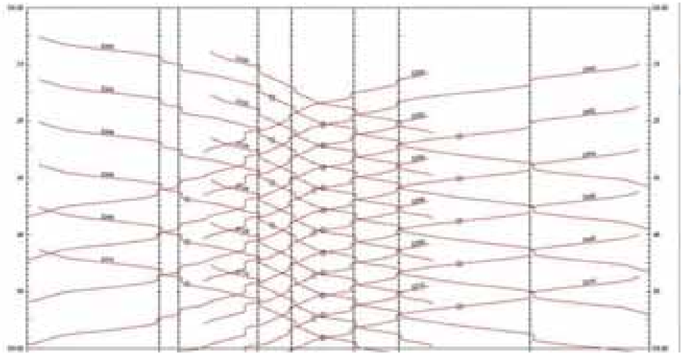


be added to start the simulation.

During the simulation the running activities will be displayed in graphical animation, data output will be logged in the respective log files and graphically displayed on the screens. In an interactive process input data will be modified (e.g timetable updated or signal positions modified) until the simulation shows the required results. Often a slow motion simulation will be needed to clearly show the detailed sequence of events. The final simulation output will be in graphical and tabular data. The simulation software allows many options of output to be produced.

Time way diagram

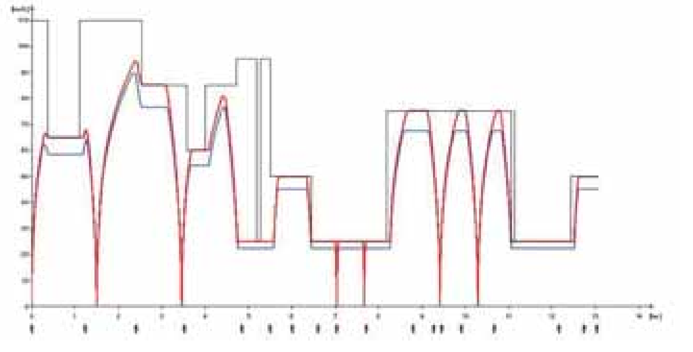
A time way diagram shows train operation on a specific section of the line. Trains of different categories may be displayed in



Time way diagram

different colours for easy interpretation. Colour coded circles indicate location and time of operational obstacles (like trains having to slow down or stop unplanned at a signal).

Individual train run diagrams



Many different variations of diagrams may be shown for the individual train runs like speed-distance, speed-time or acceleration by distance or time diagrams. Data of several trains may be overlaid for easy interpretation, or influences of driver's performance or delays may be shown.

Braking curves for the individual train may be shown to verify the braking distances or transponder locations. Time distance diagrams with signal stepping information may be used to determine the headway and showing the locations of the headway limiting elements. This allows the line capacity to be shown according to the UIC recommendations.

Diagrams with Power and Energy consumption of each individual train or by geographical area (e.g. the area of a substation) allow evaluating the power consumption of a system. This gives an early indication on how much power has to be ordered from the power supplier. On the other side it allows to study the impact on energy consumption if power saving driving principles (e.g. speed restrictions or coasting) is applied.

In addition the graphical display of simulation output are all stored in numerical form (text or excel) and may be used for further processing. Infrastructure data (track layout) and Timetable data may be exported and imported in standard RailML format (and many other formats) for easy data interchange with other software.

Scenarios and delays

The possibility of adding random delays to trains allows studying operations in different situations than the ideal scenario. Random delays can be added to trains in general or just on specific sections. Delays can be added for running times or for dwell times. This feature together with the possibility to run a simulation multiple times, with statistical variations of delays, allows evaluation on the timetable stability.

Different ATP systems

Modern ATP systems and an increasing number of fully automated train operation systems overlay the signalling systems to achieve the needed safety. Modern signalling systems with Cab signalling and shorter signal distance, including CBTC, are widely used. All these systems have their impact on operations. The simulation system caters for all these systems and takes into account its parameters; this allows verifying the design of these systems (e.g. including transponder location) and the impact on operations.

In early conceptual stages of a new railway project, simulations with different ATP systems may help to evaluate the best suitable system (unless international standards require a specific system).

Simulation projects

There are many reasons to do a simulation. Depending on the type of organisation, different aspects of the track/signalling layout – rolling stock – operations interface may be under investigation.

Typical simulation tasks for operators are detailed investigations of impacts on timetable caused by changes on the system. Usually only a limited section of the system is investigated, in particular sections with lines crossing each other or in terminal stations where trains are changing directions. In these locations sometimes seconds saved on a route release may have a big impact on the timetable and its operational stability.

Timetables scenarios for reduced service periods e.g. due to a line closure for maintenance can be tested in advance. Revised time table derived from the simulation can be preloaded into the traffic management system and allow smooth operations during such periods.

When line capacity reaches its limits changes on the infrastructure may be needed to increase the capacity. Any change of infrastructure always comes with a cost consideration. Simulation of different improvement scenarios allows verifying the best solution. This allows minimising the construction efforts. A smaller solution particularly designed to cater for the planned services saves cost and ensures uninterrupted service.

Large scale simulation projects

Railway networks of large cities often consist of a complex mash of lines. Lines cross or jointly use sections of track. With short train intervals on all the lines simulation is often the only way to see the limits of a timetable. In several big cities simulations have been performed to evaluate the new timetables. This includes running different timetable proposals and verifying their stability by running them hundreds of times with statistical delays imposed.

Small and simple simulations

Not every simulation has to be a large scale simulation study that needs a big budget. In many cases a simple simulation can give the answers needed. Very often such simulations can be done with simplified data input. A graphical output of a simulation may already be enough to solve the question without giving the need of a long report.

At the beginning of a big construction project only limited data might be available to run a simulation, but with regards to the stage of the project this is often enough to verify the early design. At a later stage the data may be brought up-to-date with more details, without having to start from scratch.

Conclusion

A simulation might look like a big task (and cost) at the beginning. The resulting output, its accuracy and the impact of understanding operational behaviour of a line and proper verification of data will deliver a pay back for all earlier efforts. If a simulation model is built up early during a project it can be used throughout all the stages of building a railway line and during operations. Once simulation data is ready, further simulation for subsequent tasks can easily be done and needs considerably less time. Computer based railway simulation is a proven and accepted method in planning and verification of railway construction and railway operation.

For more information on this article contact:
Philipp Goetz at philipp.goetz@railsystemsengineering.com
www.railsystemsengineering.com

tdhrail

THE ASIAN RAILWAY MAGAZINE

ISSUE 53 SEPTEMBER 2014

NEWS - ROLLING STOCK OPERATIONS - SIGNALLING PERMANENT WAY

ASIAN RAILWAY OPERATORS ASSOCIATION

The Official Magazine of the Asian Railway Operators Association and Rail Solutions Asia 2015

Rail Solutions Asia
KUALA LUMPUR
APRIL 22 - 24
2015