trenolab

trenissimo

trenissimo is a new tool designed to make railway simulation more intuitive, accurate, and effective.

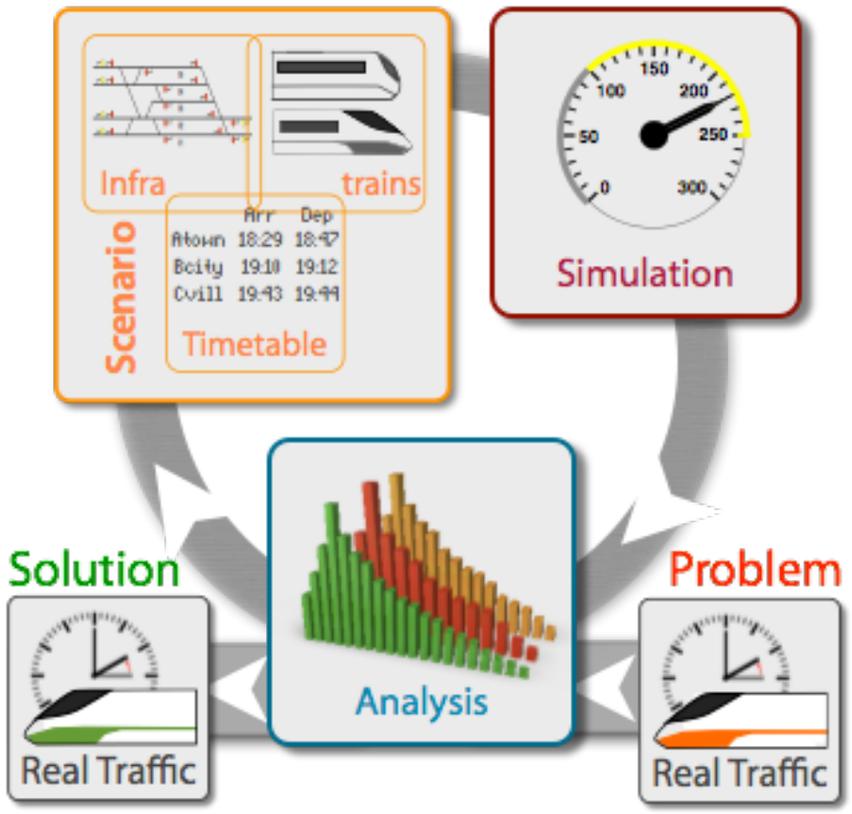
intuitive thanks to a smart, comfortable, state-of-the art user interface.

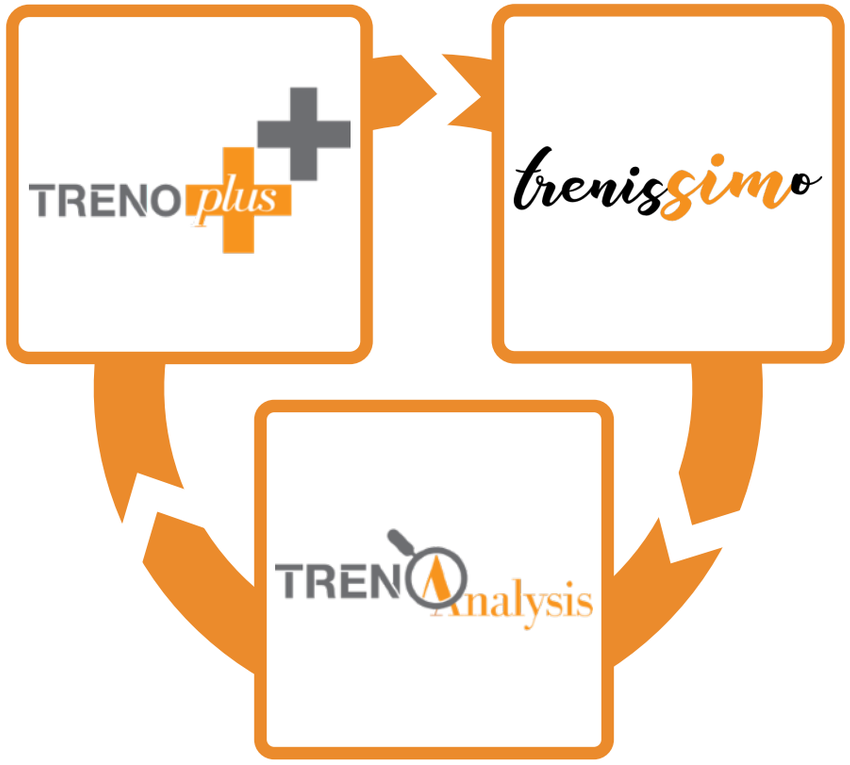
accurate thanks to its ability to fully consider everyday variations in railway operations.

effective thanks to its integration in the TRENO suite - which significantly reduces the time needed to setup and perform railway planning and simulation.

trenolab

A unique planning suite

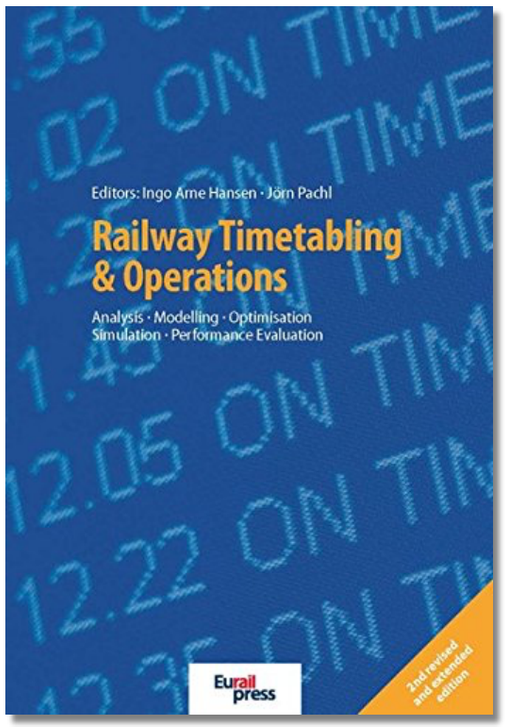


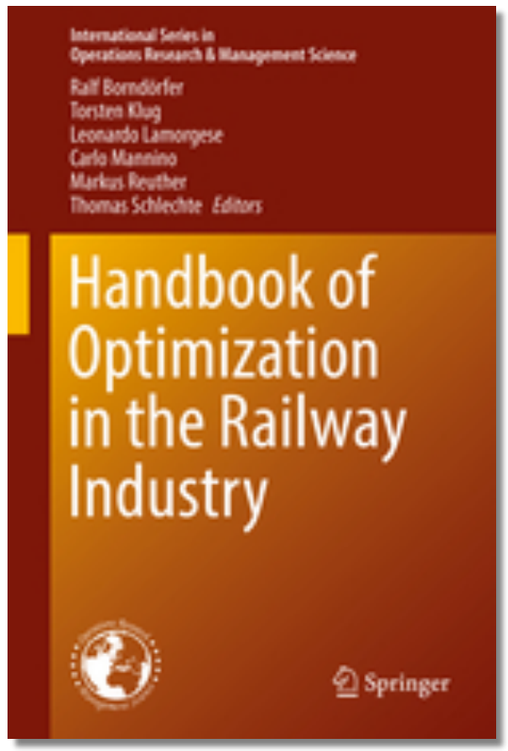


Our tools **TRENOAnalysis**, **TRENOPlus** and ***trenissimo*** are perfectly integrated with each other, forming a unique suite on the market covering *all key steps of rail planning*:
from the analysis of current operations, trough the definition of timetable alternatives and their validation to the design of new equipment and infrastructures.

A solid scientific background

- Since 2004 our funders have been active in research on timetabling and operation
- Selected scientific study, articles and papers:
  - "An implementation of stochastic blocking time to support timetable planning", Award 2011 IAROR International Association of Railway Operations Research (IAROR)
  - "Simulation", Railway Timetabling & Operations, EurailPress, 2014
  - "Simulation of Rail Operations", Handbook of Optimization in the Railway Industry, Springer, 2018
  - "Reducing Delays on High-Density Railway Lines: London–Shenfield Case Study" Transportation Research Record: Journal of the Transportation Research Board, 2020
- Lectures at ETH Zürich, 2018
- Lectures at TUDelft, 2018
- Lectures at SBB Master in Railways, 2020





Our references

NetworkRail

GWR

MTR

Jernbane-direktoratet

First

KEOLIS

ProRail

West Midlands Railway

RhB Rhätische Bahn

FGC Ferrocarrils de la Generalitat de Catalunya

DB

South Western Railway

RAMBØLL

SNCF TRANSILIEN

trenolab

Transport for London

Chiltern railways by arriva

ARRIVA

Why railway simulation ?

Stochastic microscopic simulation is the most accurate way of evaluating the impact on operations of any change in the rail system: timetable, infrastructure, rolling stock or even in the organisation of processes such as train dispatching.

However, microscopic simulation was also known until today for its weaknesses:

- time consuming & expensive,
- inaccurate in representing delays,
- dispatcher not always correct,
- risk of not obtaining usable results, …

… which have limited its practical applicability.

➔ **but with trenissimo, we're at a turning point !**

What is trenissimo ?

- ❑ simulation → calculates the position of all trains second by second by solving the motion equation and considering the signalling and interlocking constraints.
- ❑ microscopic → its infrastructure model includes all elements that are relevant for railway operations.
- ❑ synchronous → all trains are in the model at the same time, and are calculated together.
- ❑ dispatching-driven → the trains are driven by their drivers, but the home and exit signals are operated by a dispatcher.

trenolab

Is it accurate?

One of the key goals in the development of trenissimo was to make it as accurate as possible.
We have obtained this result combining (1):

- **Dispatcher**
  As in the real world, a dispatcher decides which train has the highest priority and opens the home and exit signals. A growing number of dispatching criteria is being implemented in trenissimo to cover the widest range of real operations.

- **Driver Behaviour**
  Based on a large-scale analysis of the way real drivers drive the trains, we demonstrated (and published in an award-winning scientific paper) that a set of at least three parameters is needed to represent accurately the behaviour of drivers. In trenissimo we implemented these parameters.

Is it accurate?

One of the key goals in the development of ***trenissimo*** was to make it as accurate as possible.
We have obtained this result combining (2):

- **Delays**
  We represent the human factors and other delay sources as suggested in the most respected scientific literature as a combination of four parameters (driving style, initial delays, dwell times, departure inaccuracy).

- **Signalling Systems**
  We implement directly the various signalling systems, in order to ensure the highest accuracy in their modelling, including icons that represent their real aspects.

trenolab

Is it intuitive?

graphical user interface
trenissimo uses a state-of-the-art graphical interface, which allows keeping all models, animations, outputs and messages tidy and clean on the desktop both when working with a single or multiple monitors. The desktop(s) can be divided in any number of panels, to keep all relevant inputs, animations and outputs under perfect control.

replay
In trenissimo it is possible to save the replay of the entire simulation, recording the position (and all other data) of all trains.

identification of deadlocks.
Our dispatching algorithms prevent deadlocks. But they might still happen as a result of inaccurate modelling or combination of heavy delays. trenissimo saves the last screenshot of the animation of all files, allowing a quick identification of the critical point.

Is it intuitive?

automatic itineraries

Creating the itineraries of trains is one of the most time consuming steps when setting up a large simulation model. In trenissimo the user defines only the routes from signal to signal, and an algorithm combines them to obtain the complete itinerary.

output management

One of the key advantages of simulation is the variety of outputs. In order to make them as accessible as possible, and easily achievable as well, in trenissimo the outputs are stored directly in the project folder, and it is extremely easy to navigate among them.

project-based

In trenissimo the scenarios covering different timetable/ infrastructure cases are managed directly from within the app: no file or folder to move, no setting to update and, additionally, the possibility to add comments and have a clean overview of all simulations.

Is it effective?

We are aware that simulation is time consuming and that the *available time must be used as efficiently as possible*. We strive to make trenissimo as effective as possible through:

- **Timetable pushed from TRENOPlus**
  No need to import timetables and other files in trenissimo.
  The timetable is pushed from TRENOplus, where it can be imported, stored and managed extremely easily at a macro level.
  And you can decide to simulate a small part of a network by just drawing the corresponding area on a map!

- **Delays from TRENOAnalysis**
  Setting up a stochastic simulation can be extremely time consuming.
  Real or user-defined delays, dwell times, and train performances are pushed from TRENOanalysis

Is it effective?

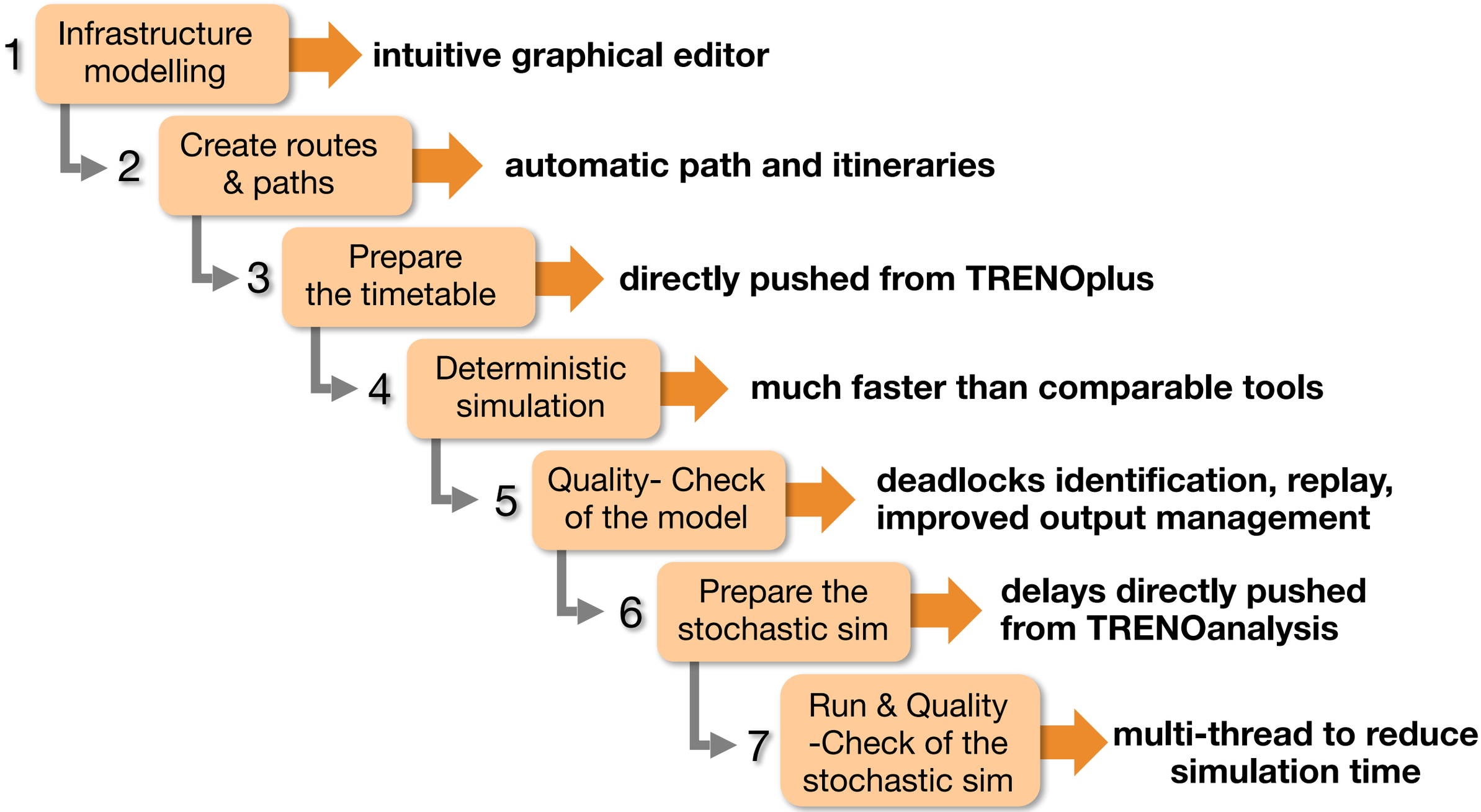
To optimise the available working time, we make the simulation in trenissimo more efficient and effective:

- **No need to move files**
  The project-based approach keeps all data clean and tidy in a folder, with no need to move files, duplicate or rename folders, etc.

- **Faster**
  We used at best the power of new computers, to make *trenissimo* as fast as possible through:
  - **Separation of animation and calculation**: the CPU is used for the simulation, and the GPU for the animation.
  - **Stochastic simulation on multi-core computers**: when running stochastic simulations trenissimo runs a number of runs in parallel corresponding to 2x the number of cores of the CPU.
  - **Through command line execution**. Already when using trenissimo through its graphical interface, it is not need to open all files to run a simulation. And the script mode is available to power users.
  - **HPC ready.** An add-on package allows to seamlessly run simulations on other computers in just one click, creating a High Performance Computing (HPC) unit using desktop computers available in the office

Streamlined workflow

We have streamlined the entire simulation process to make it as efficient as possible:



trenolab

trenissimo

more in detail..

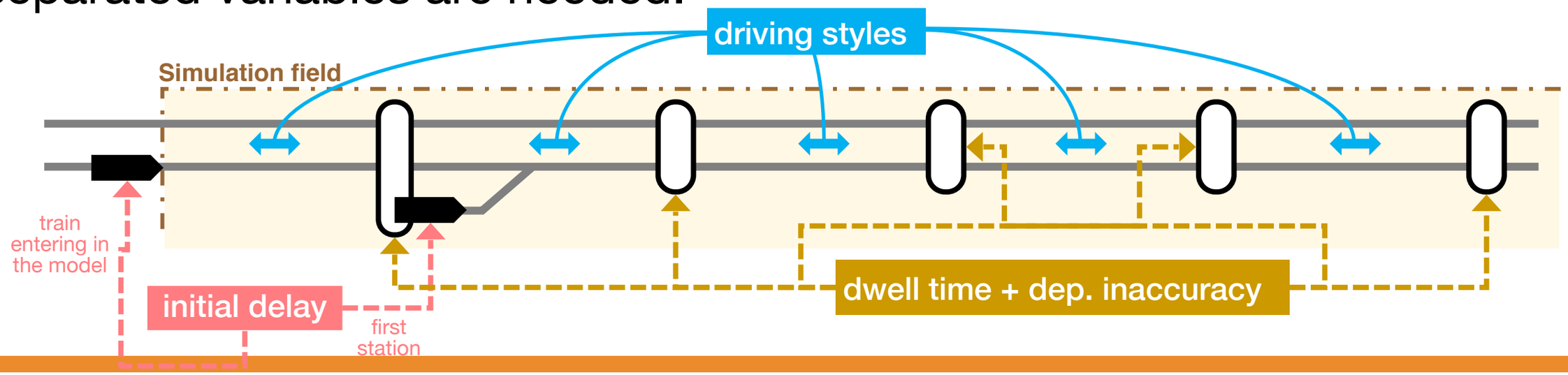
trenolab

Inputs: dwell times & delays

Delays to perform stochastic simulation can be inserted in trenissimo from real data through TRENOAnalysis and can be defined through a combination of three parameters:

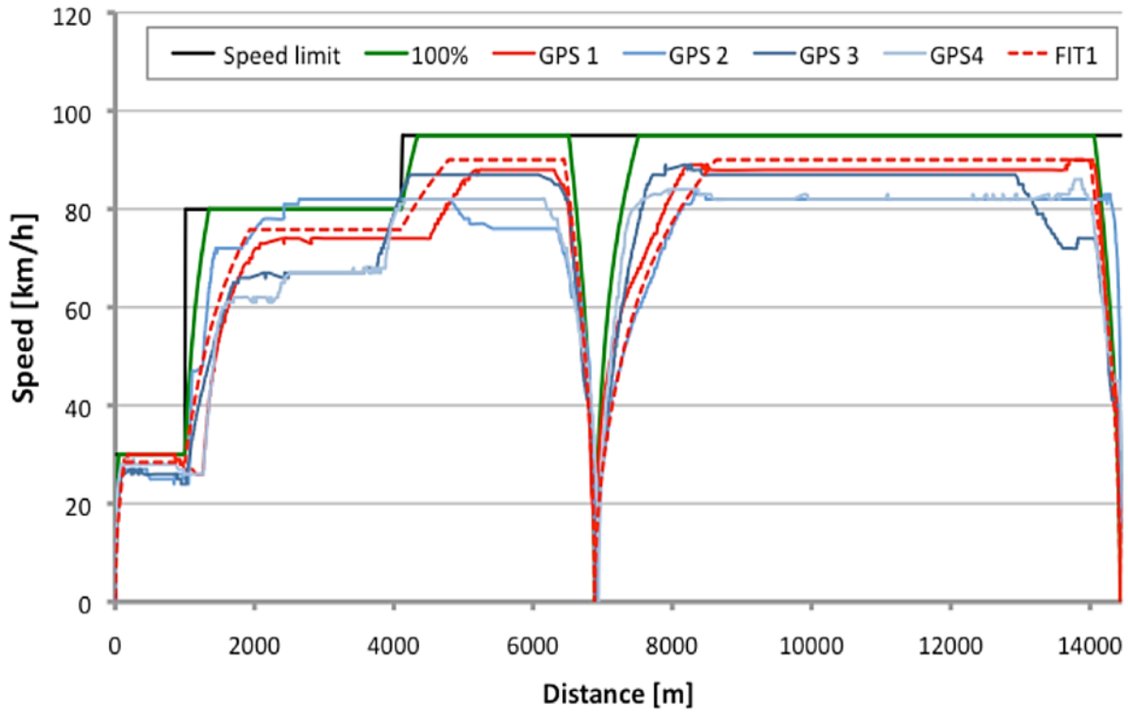
- *Initial Delays* (first station or entry times in the model)
- *Connection delay (departure of a new service after the trainset turns back within the model)*
- *Dwell Times*
- *Departure Inaccuracy*

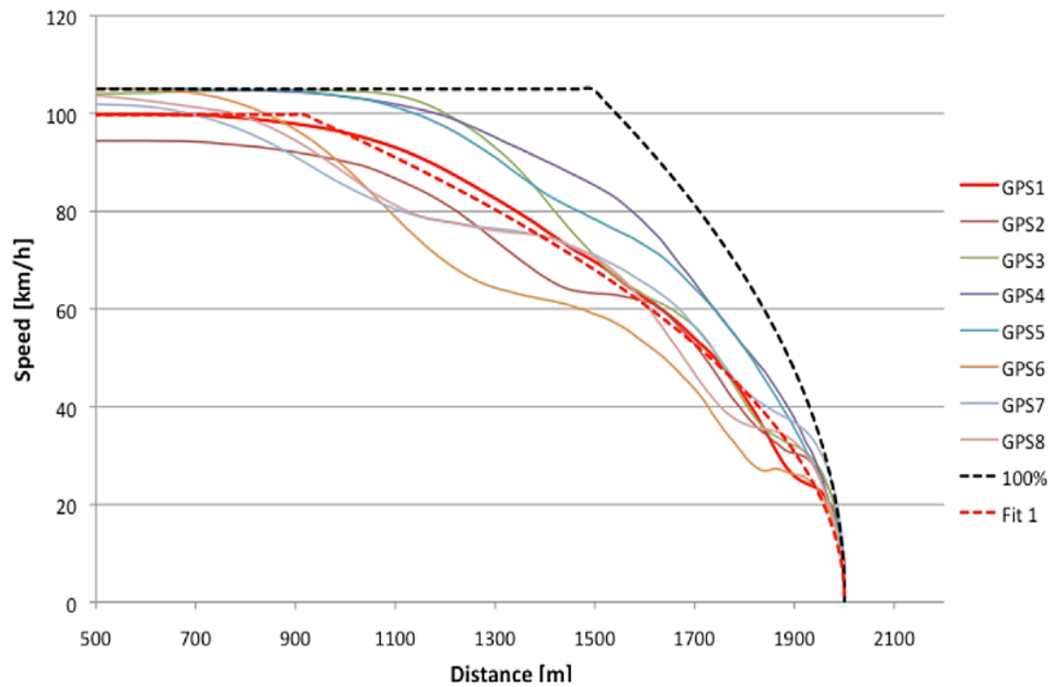
Dwell times and departure inaccuracy are both needed to model late departures at intermediate stations that are not just caused by the arrival + dwell time, but are the result of a delayed departure process. Thus, two separated variables are needed.



Inputs: driving styles

Since 2009 we have been analysing the behaviours of drivers (GPS tracking, log files of train event recorders) and we identified that drivers use the performances of trains in a remarkably different way during acceleration, cruising, coasting and in particular during the braking actions.





In trenissimo, these parameters are implemented as the “driving style” of each virtual driver.

Inputs: dispatcher

One of the key for a realistic simulation is to correctly model the dispatcher.

This is *an important innovation* in trenissimo, where a dispatcher, present in all stations/junctions, is modelled trough a set of algorithms, to manage situations such as (1) :

- **Single track crossing**:
  alternative tracks to allow crossing in real time; first train to deflecting platform or slowest track on crossing areas without station.
- **Single track deadlock avoidance**:
  additional rules to prevent deadlock (checks length of trains, …); No train in opposite direction of line section is allowed. Prevents 4th train on 2 sections.
- **Early departure avoidance**:
  stops all trains running earlier than a threshold.

Inputs: dispatcher

One of the key for a realistic simulation is to correctly model the dispatcher.

This is *an important innovation* in trenissimo, where a dispatcher, present in all stations/junctions, is modelled trough a set of algorithms, to manage situations such as (2) :

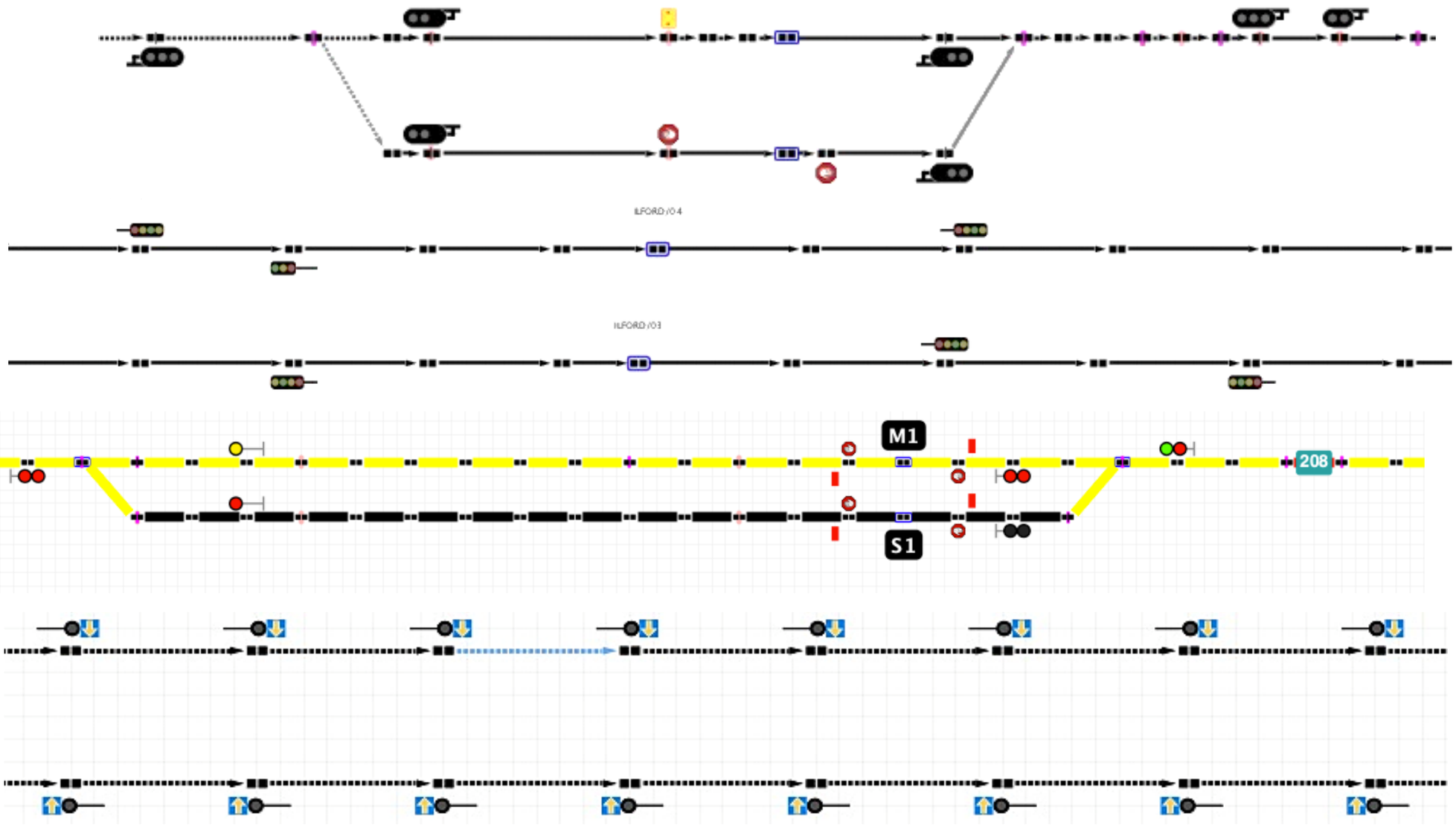
- ***Double track station alternate tracks***:
  chooses alternative platform when available
- **Junction**:
  avoid deadlocks on single track; keep planned order on double track (if delay diff < threshold)
- Terminal station:
  optimises entry and exit order of trains

Over ten dispatcher models are available *to accurately model* **various dispatching criteria running in reality**

trenolab

Signalling systems

In *trenissimo* different signalling systems are implemented and available, each with its realistic icons; new ones will be incrementally added.



Norway

UK

North America

ERTMS L2

Denmark

France

Switzerlan

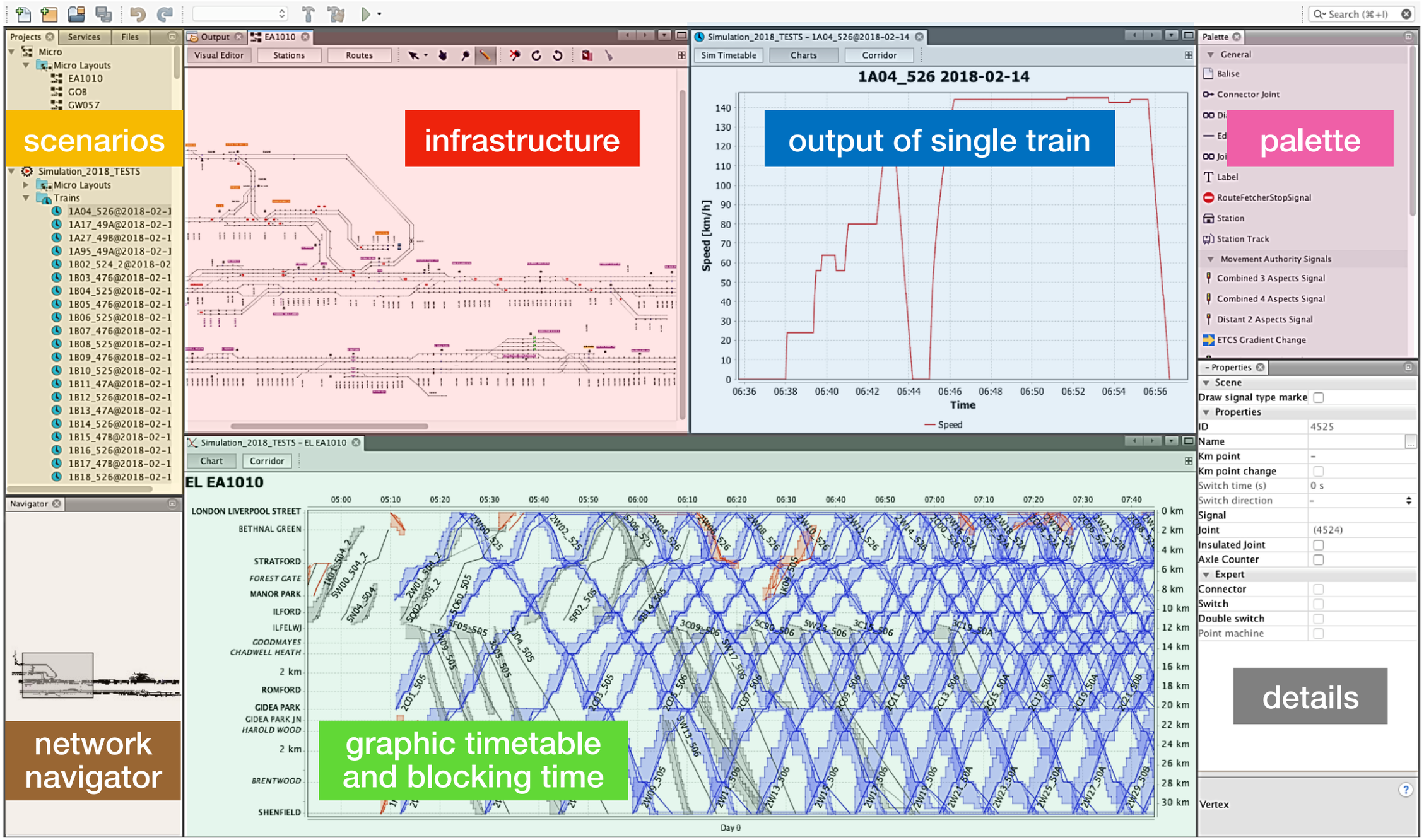
Italy

Serbia

trenolab

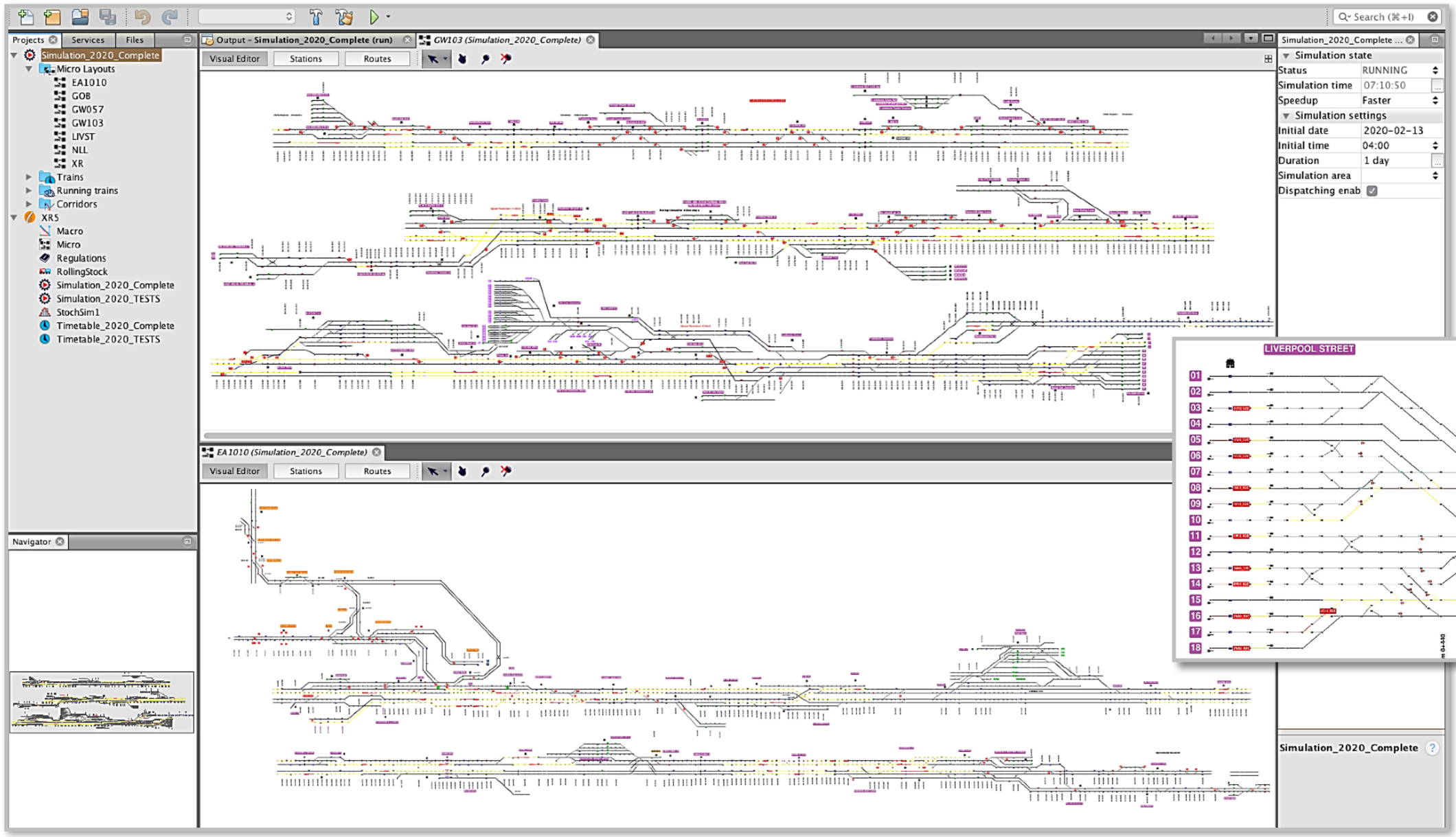
Workspace

The desktop(s) can be divided in any number of panels, to keep all relevant inputs, animations and outputs under perfect control.



Animation

The animation is run by the GPU, without slowing down the simulation. Additionally, the replay allows quickly re-running a part of it to identify the cause of a delay.



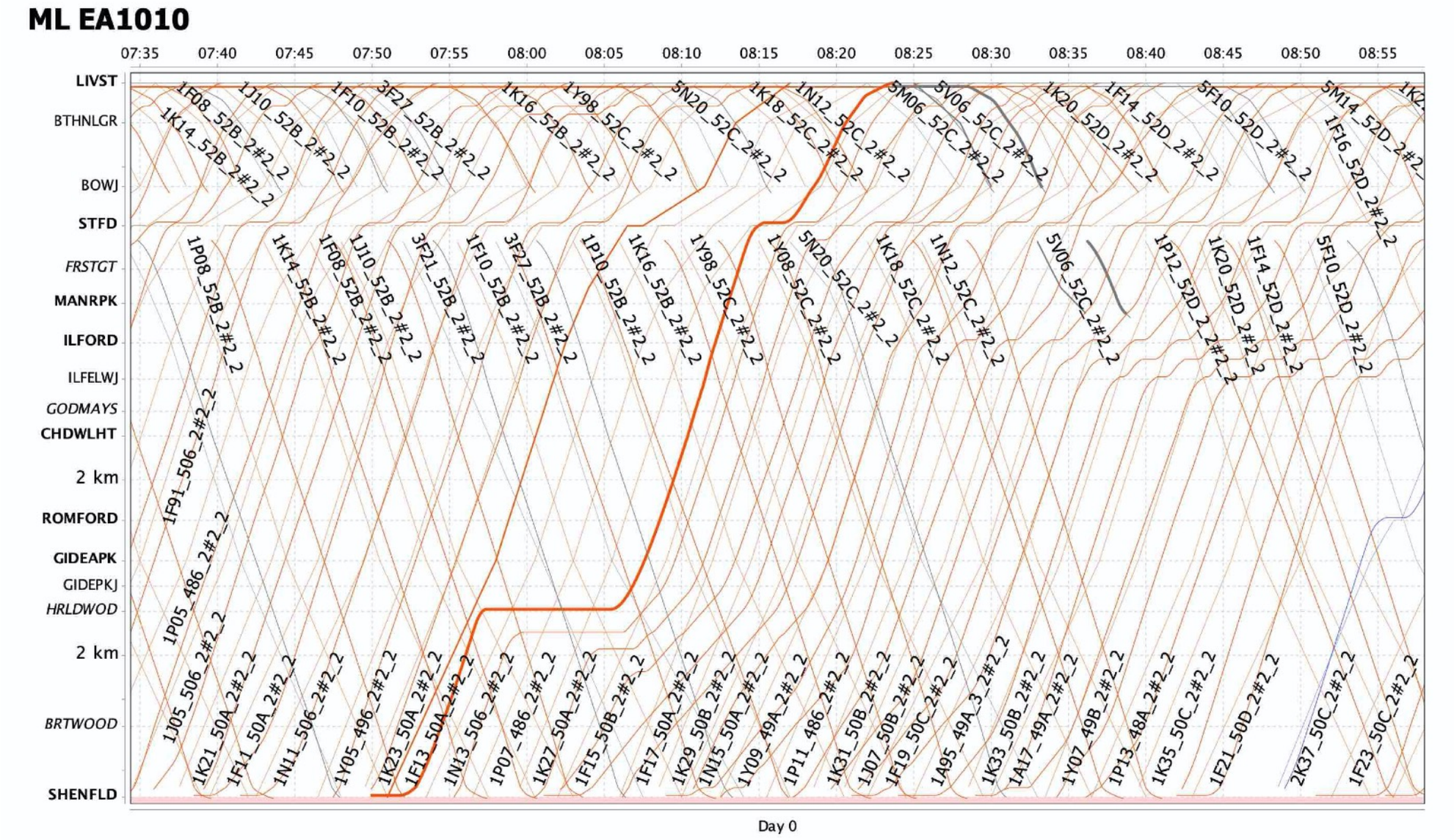
Types of simulation

Type	Includes	How to run	Requires…
Single train	One train	Single click from RTC in TRENOplus	run trenissimo
Deterministic Simulation	+ All trains	Export timetable from TRENOplus and run trenissimo	run trenissimo
Stochastic Simulation	+ Stoch. Factors, + N Runs	in trenissimo OR as script OR on server/cloud	run trenissimo OR run script OR app on server
“ScriptSim” for power users	+ All combinations of any input variable.		

trenolab

Incident simulations

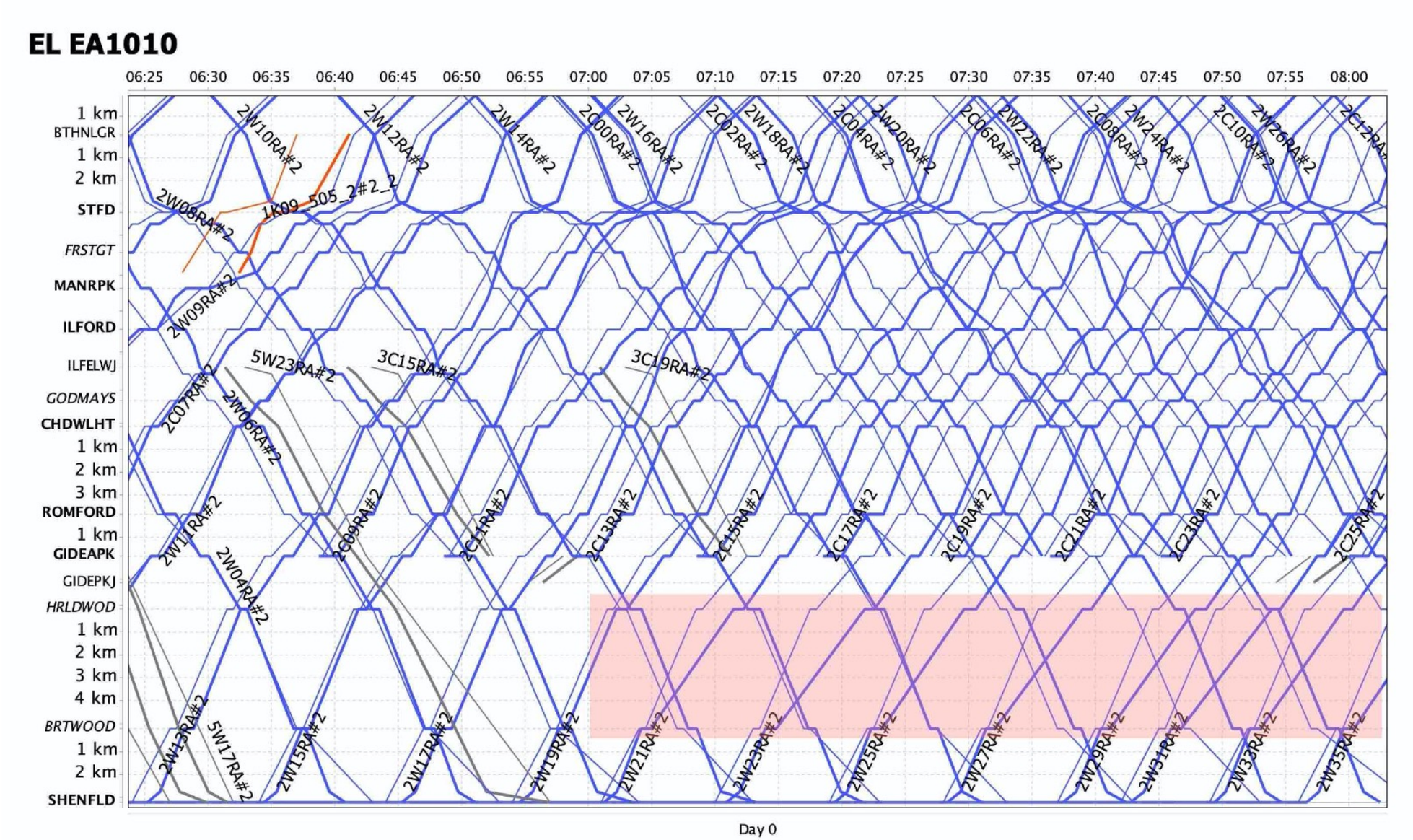
A wide set of incidents can be simulated to prepare the what-if contingency plans



In this simulation a train alarm triggered an emergency stop lasting 8’ between Harold Wood and Gidea Park with the subsequent trains gradually recovering the line delay.

Incident simulations

A wide set of incidents can be simulated to prepare the what-if contingency plans



In this simulation the ATO failure at 7.00 a.m. starting at Brentwood for the next 5 km requires to lower the train speed to 36 km/h

“scriptsim” for power users

3 variables:

- **Train Length: ShortTrain, Train, LongTrain**
- **Dwell Time: Ref, Ref+5, Ref+10**
- **Input delays: Current, Low, High**

trenissimo runs the combination of all variables for the user-defined number of days, producing a complete set of outputs for each:

1	ShortTrain	Ref	Current
2	ShortTrain	Ref	Low
3	ShortTrain	Ref	High
4	ShortTrain	Ref+5	Current
5	ShortTrain	Ref+5	Low
6	ShortTrain	Ref+5	High
…	…	…	…

trenolab

Outputs

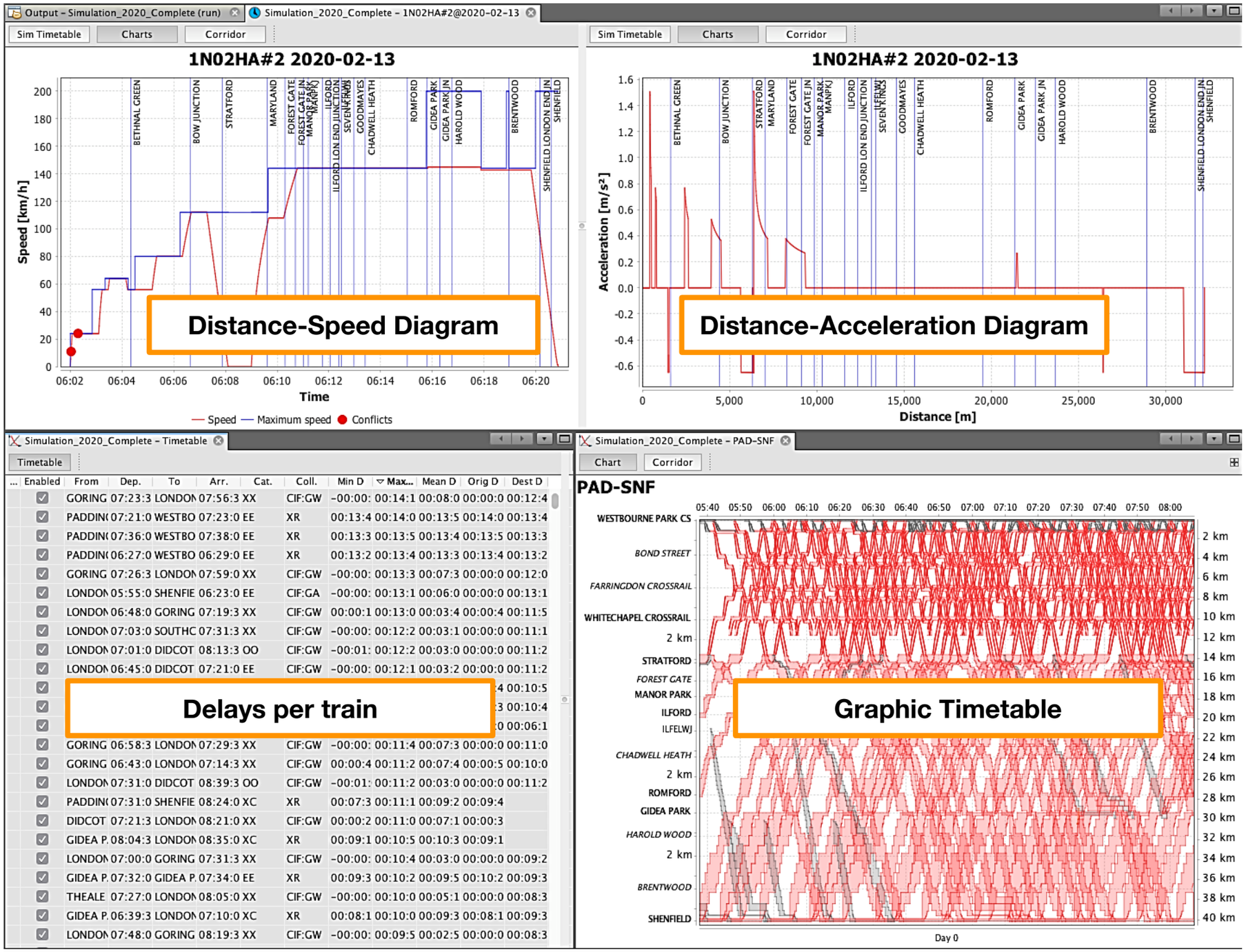
trenissimo produces all standard outputs of the microscopic simulation, including:

- **replay** of the animation, which allows viewing again the animation of the simulation on the entire simulation area.
- **graphic timetables** showing the results of the deterministic and stochastic simulation, with the possibility to highlight conflicts and visualise the blocking times.
- **delay statistics** to identify quickly the most delayed trains.
- **train diagrams** like speed profile, acceleration, tractive effort, etc.
- **occupation diagrams** showing the occupation of any block section or track.
- **signal aspect diagrams** showing the time intervals in which any signal was showing each of its aspects.

All diagrams can be exported as images, and the corresponding data exported to Excel or LibreOffice for further analysis. And thanks the broad set of diagrams of TRENOAnalysis, it is possible to view and compare multiple simulation and scenarios very efficiently.

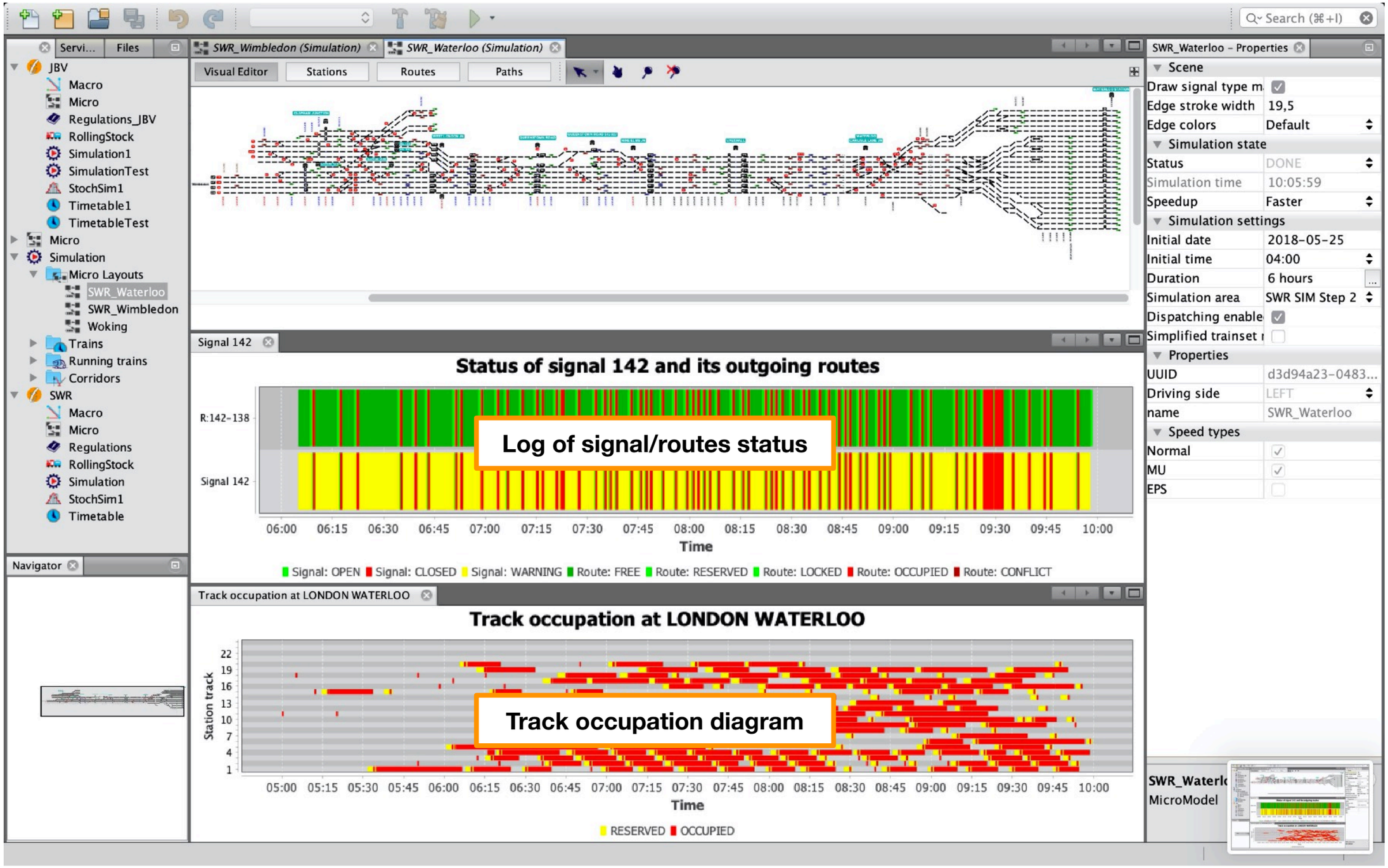
Outputs

Selected examples of standard outputs



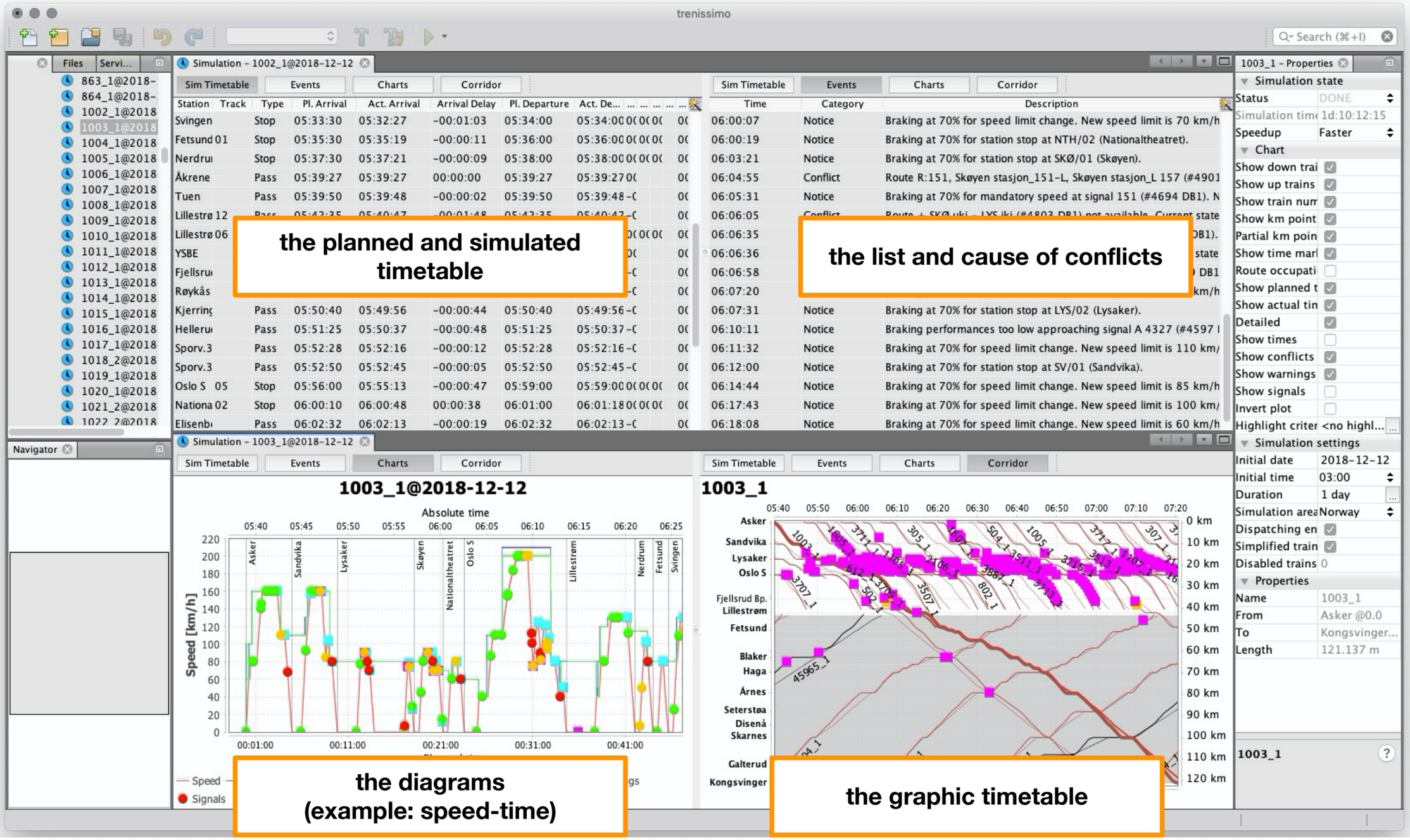
Outputs

Selected examples of standard outputs



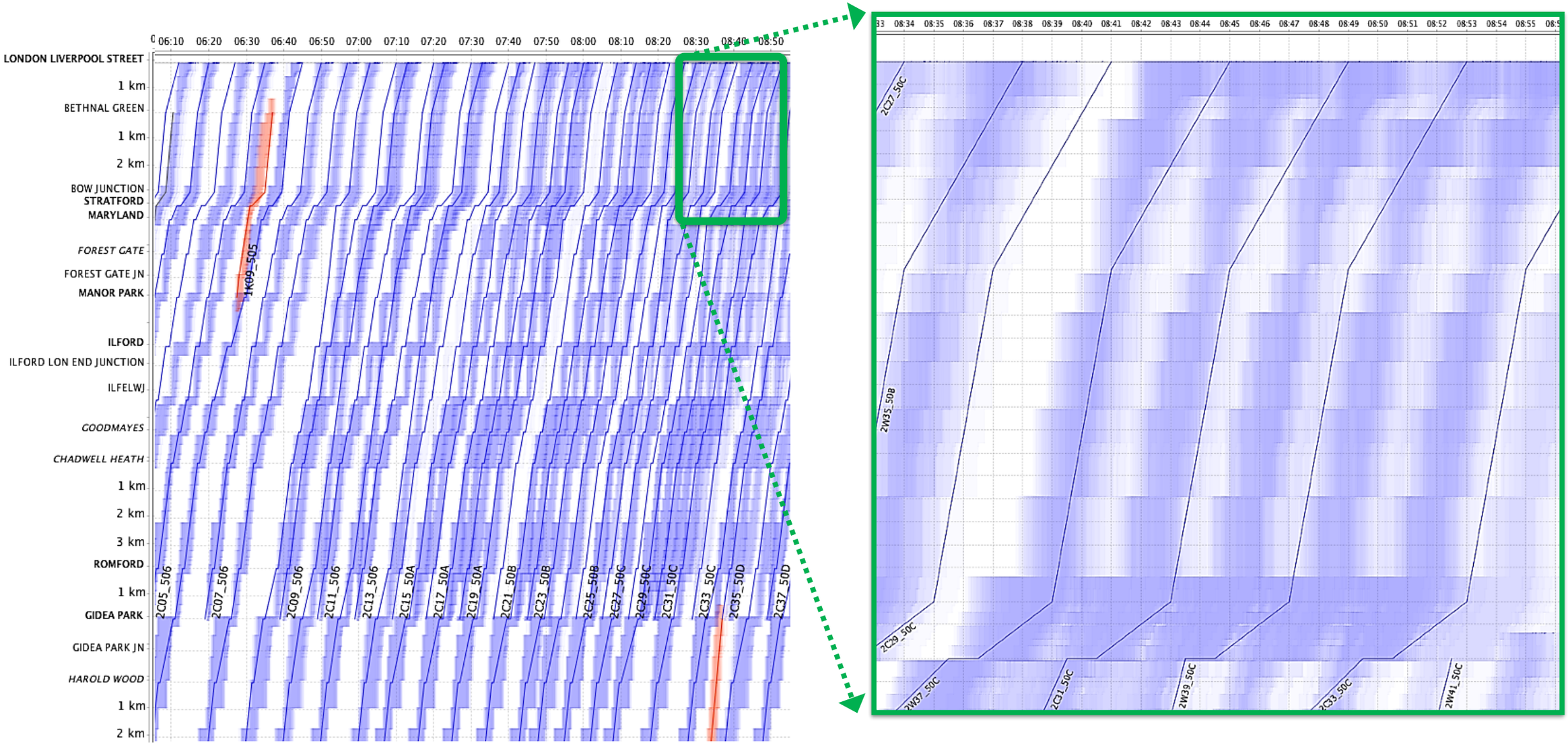
Outputs

A key feature is the possibility to navigate across all outputs: for example, double clicking on a train on the list or on the graphic timetable you access:



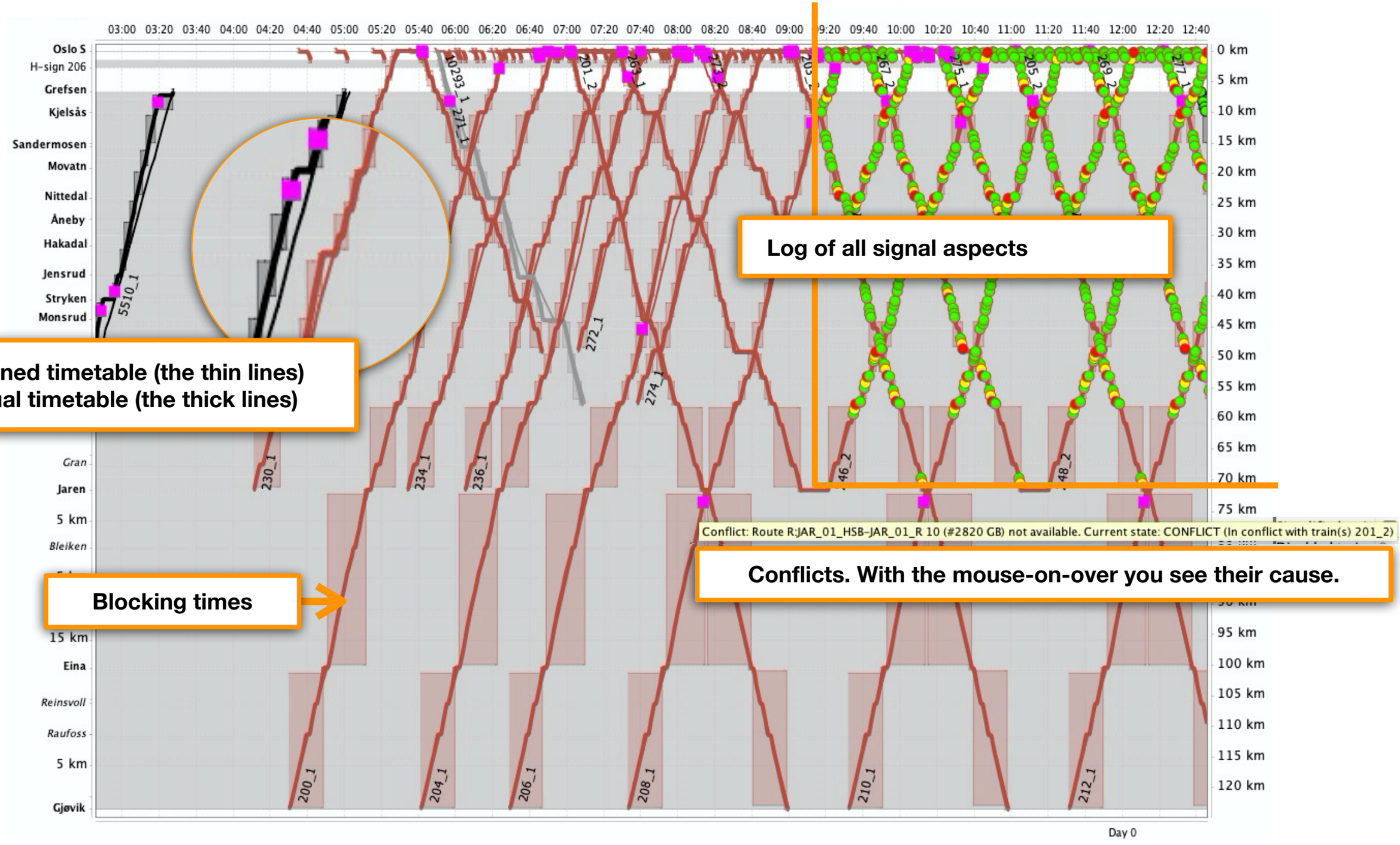
Stochastic blocking times

Completely new is the visualisation of the stochastic blocking times, that show the probability of occupation of the block sections along a corridor. They were first introduced by our founders in an award-winning scientific paper in 2011.



Special outputs

A key feature is the possibility to navigate across all outputs: for example, double clicking on a train on the list or on the graphic timetable you access:



Selected use cases

- Efficient and very fast stochastic simulation of complex nodes and large railways networks.
- Very detailed and realistic stochastic modelling of metro and dense suburban's networks, taking in account the influence of the passenger flows.
- Evaluation of performances, punctuality of the services and the robustness of timetables.
- Effective impact of investments (new rolling stock, signalling, equipments, infrastructures, …) on Capacity&Delays
- Sensitivity analysis
- Impact of possessions (due to maintenance works, etc.) and incidents and simulation of operations alternatives/solutions
- Impact of seasonal effects (leaves, snow…)

trenolab

Two years with *trenissimo*

In its first two years, *trenissimo* has been successfully used in a variety of contexts including:

UK	Crossrail	Simulation of the current and long-term configurations
UK	South Western	2020 timetable robustness estimation
UK	South Western	Evaluation of the impact of a swinging overlap at sig. W908
UK	South Western	Estimation of Class 701 Running Times and Planning Rules
UK	Great Western	2020 timetable robustness estimation
UK	West Midlands	2021 timetable robustness estimation (London - Birmingham)
UK	West Midlands	2021 timetable robustness estimation (Birmingham area)
UK	Castlefield corridor	Simulation of current timetable and infra performance studies
UK	ECML	Performance modelling of timetable for capacity studies
Switzerland	Gotthard-Milan	Simulating multiple scenarios for 2035 timetable
Serbia	Belgrade	Simulation on public metro performance
US	Metrolink	Network-wide simulations for planning short-term operational
Norway	Entire network	Network-wide simulation with 2019 and 2033 infrastructure
France	Lyon region	Network-wide simulation
France	Paris Est	Timetable review of summer 2021 with restricted operations
France	Tram line 4	Timetable and Robustness review of the Tram 4 line in Paris
Canada	Eglinton Light Rail	Simulation of the mixed tram and metro operations
Canada	Trillium line, Ottawa	Simulation of line performance

Perspectives and vision

- ➔ trenissimo is the beginning a new era for the dynamic simulation of heavy and metro railway networks.
- ➔ the unparalleled simulation speed and ease of use will dramatically change the planning processes.
- ➔ trenissimo is designed to receive real time inputs, which will allow using it to support the dispatching decisions.

For more information don’t hesitate to contact us:

g.medeossi@trenolab.com