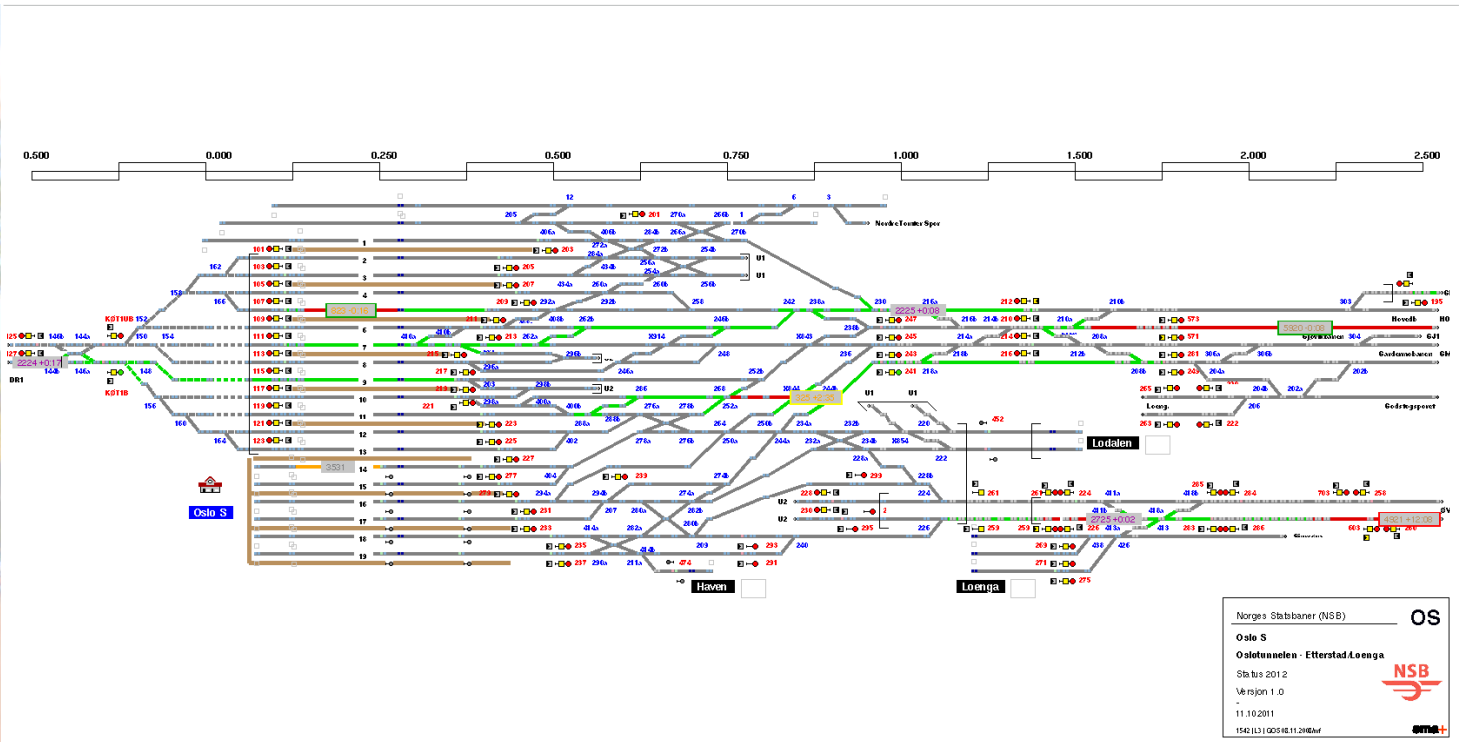

Use of Simulation to Evaluate Performance of Timetable Concepts

New Timetable for the Oslo-area

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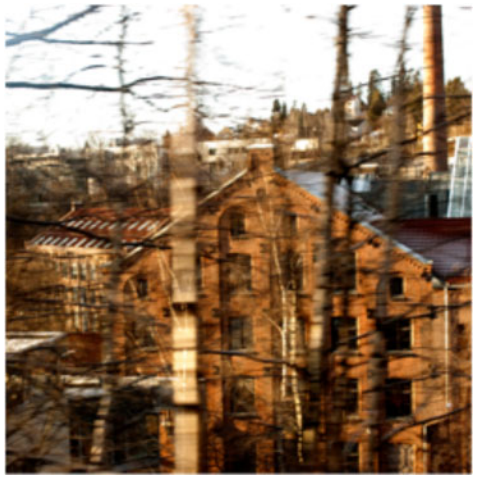
NSB Passenger Trains, Planning & Analysis

Agenda



- Background: The new Oslo-area timetable
- Methodology and analysis
- Project challenges
- Results
- Conclusions

2012 timetable – design process

New timetable – new opportunities

Previous timetable

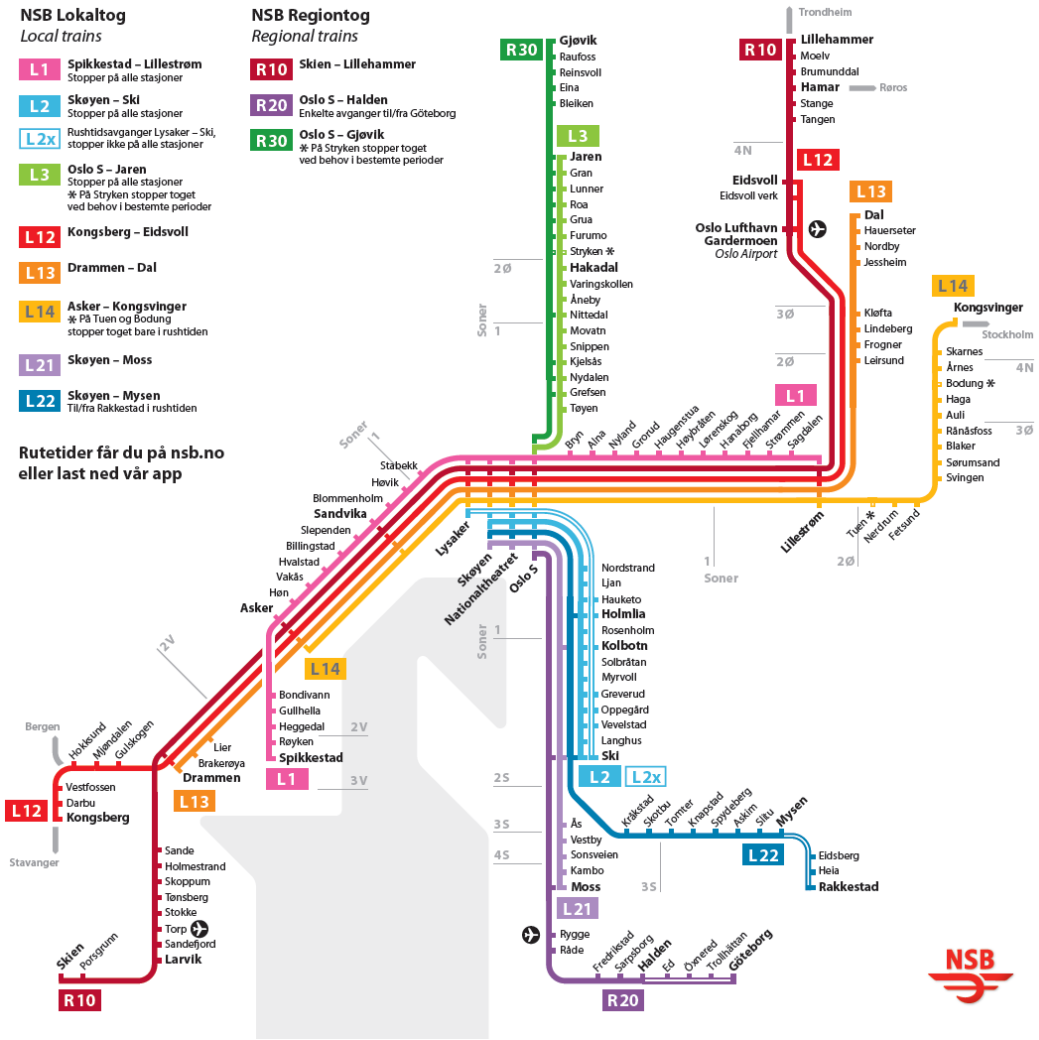
- Base structure of the timetable unchanged since 1999
- Known deficiencies in the current timetable
- Few possibilities for adjustments due to single-track lines and central area tunnel

2012 timetable

- Complete timetable recast
- ”Once-in-a-decade”-chance to rectify problems and to build in robustness

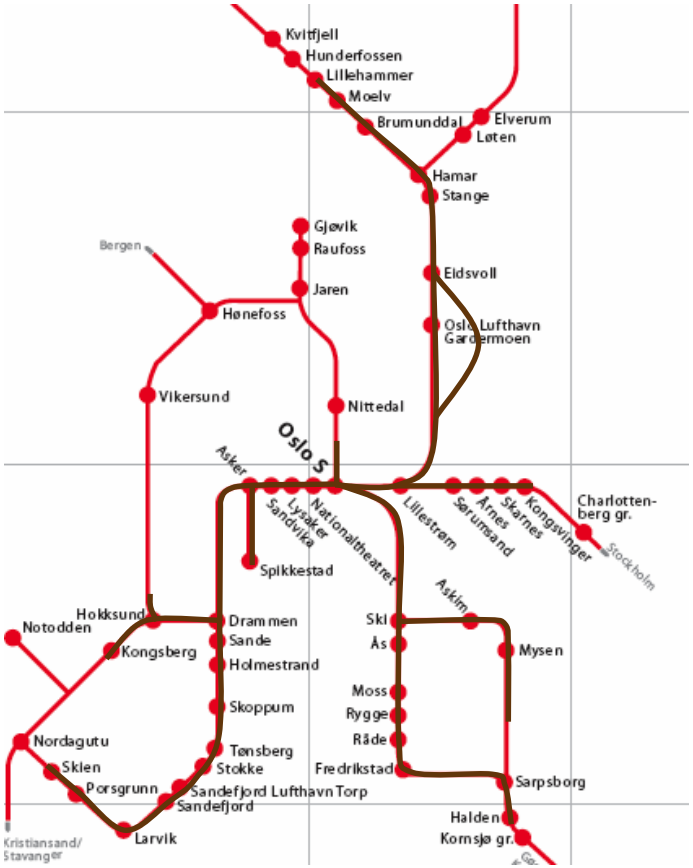
Main characeristics

- Simplicity
- Evenly spaced trains
- Increased train frequencies



New Timetable Simulation Project

- Joint project between NSB and Jernbaneverket, the infrastructure owner
- Project period August-December 2011
- Largest-scale rail operations modelling project in Norway so far:
  - 850 route-km
  - 150 stations
  - 600 trains (local, long-distance, freight)
- Used OpenTrack-modelling tool
- Compared three different timetables:
  - Previous timetable
  - 1st phase of the new timetable (from Dec 2012)
  - Full implementation (from Dec 2014)



"To which degree is the new timetable concept free of conflicts and sufficiently robust to absorb delays in normal operations?"

Analysis

Timetable conflict analysis

- Single, undisturbed simulation
- Graphical analysis

Comparison of timetable concepts and robustness analysis

- Multiple simulation with delays
- Comparison between the three timetables
- Evaluation criterion: ”Average arrival delay per stop”
    - Good base for comparison
    - Passenger-related
- Analyses for the entire Oslo-region and for sub-areas
- Development of delays over time (moving average)

Modelling Variation in Station Dwell Times

- More realistic planned dwell times are an important feature in the new timetable
- Use of observed dwell time distributions in the simulation
- OpenTrack could only model dwell time delays of planned departure time
- Alternative modelling methodology used a large constant and a small variable dwell time component
- Effect of extended dwell times is not fully represented in simulation results
- OpenTrack-functionality has since been extended to include dwell time variation

Dispatching

- Simulation with delays and perturbations requires dispatching decisions
- Unusual conditions in Norway:
  - High proportion of single-track lines
  - Local and regional trains have higher priority than freight and long-distance trains
- Typical problems:
  - Route reservation
  - Overtaking
  - Deadlocks
- Modelling solutions:
  - Connections
  - Artificial stops
  - Through-signalling (”reserve with previous”)
  - Zero-speed signal aspect for long freight trains
- Simplifications result in a higher number of successful runs acceptable for analysis

Running the Simulations: Use of Scripts

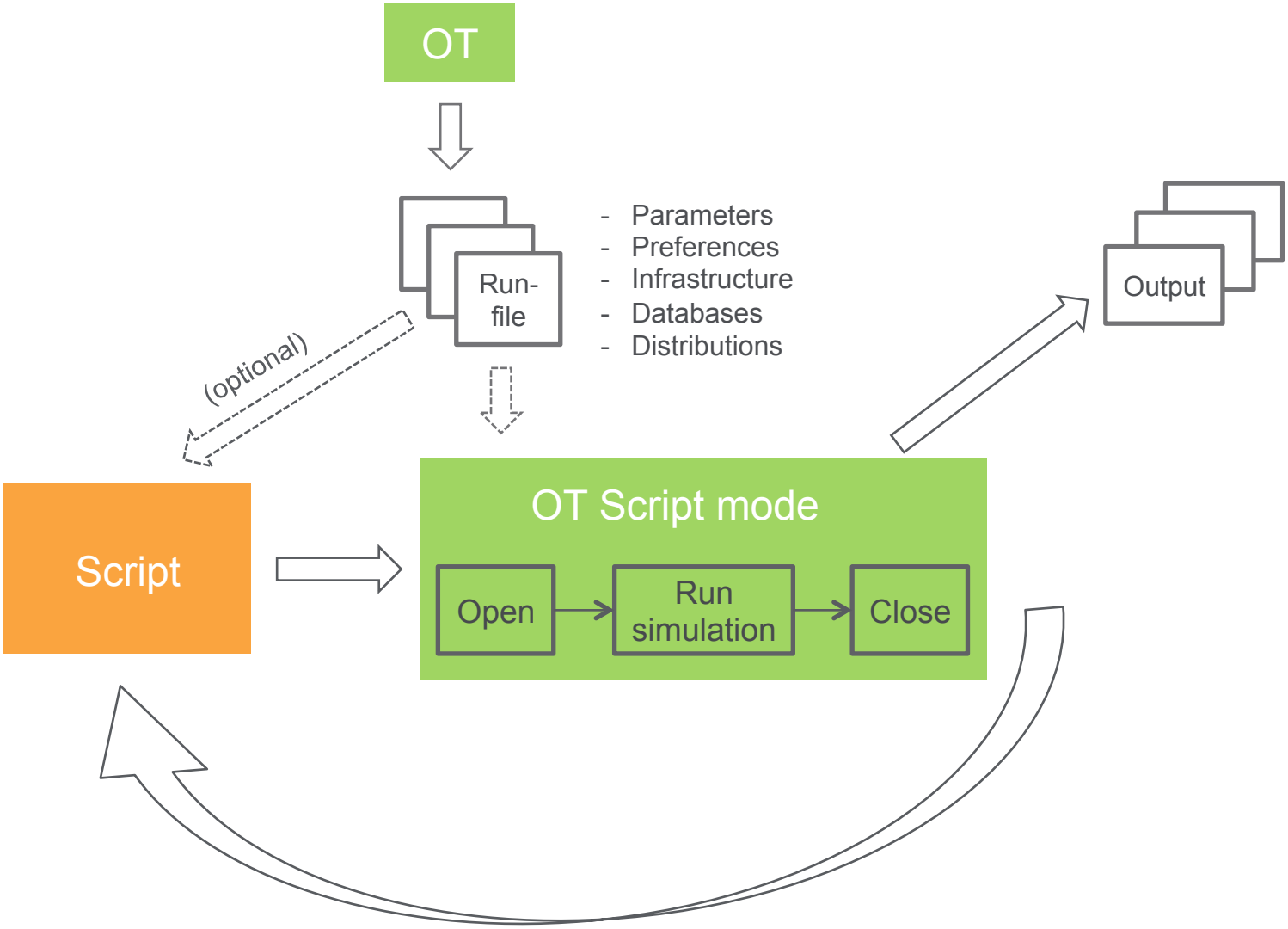
- To obtain statistical reliable results, we needed to run a large amount of simulations
  - 5 different delay levels; 50 simulations per delay level per timetable

  (in total ca. 700 single simulation runs, 8700 hours of train traffic, 770 000 trains)

- One simulation run needed 30- 40 min to finish
  - Possible to start multiple simulation runs, but with the size of our model OpenTrack could not handle more than 3-4 simulation runs without crashing

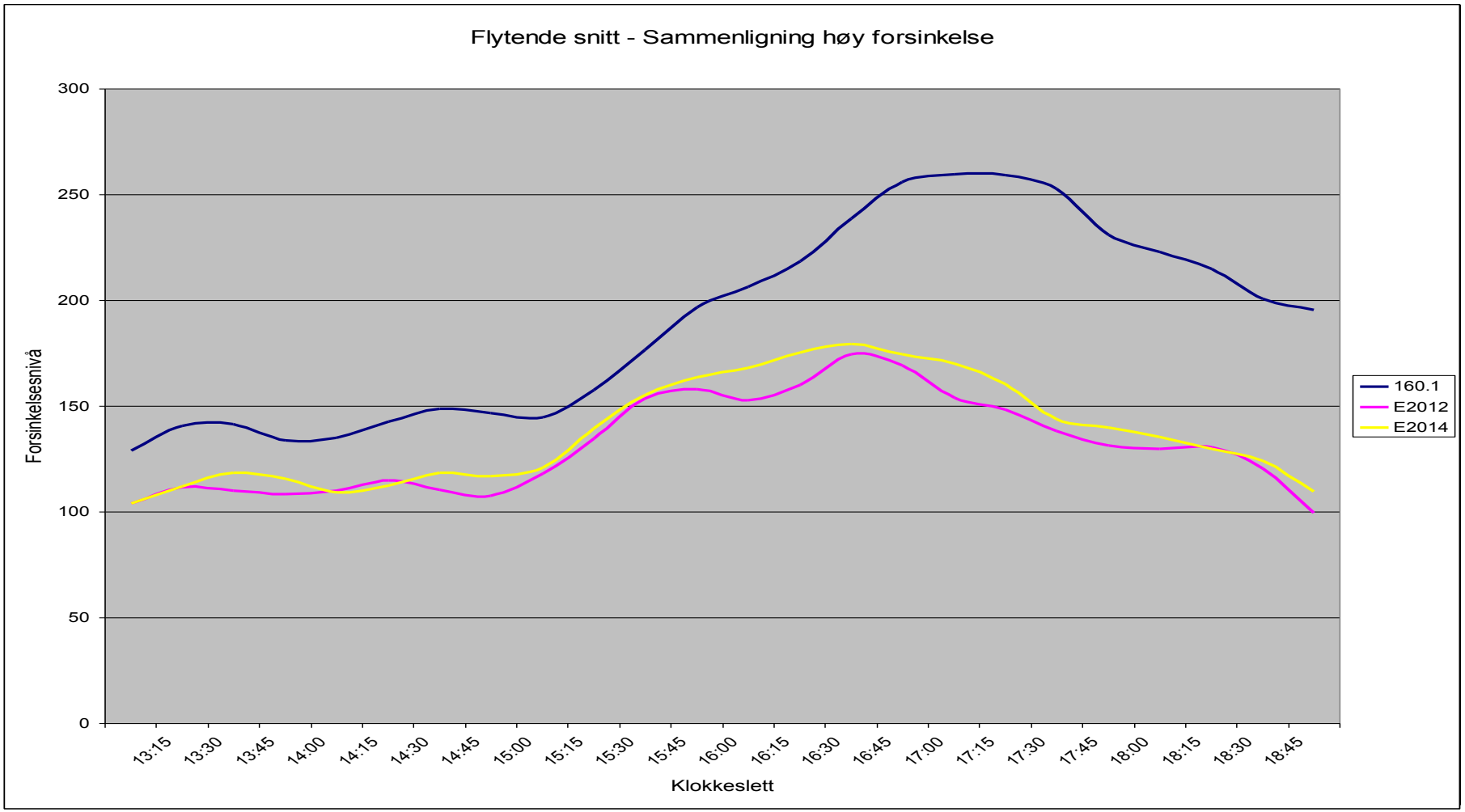
- To be able to complete the project we worked together with OpenTrack Ltd. to find a way to automate the simulations. A script functionality for OpenTrack was developed

Running the Simulations: Use of Scripts



Simulation Results (Example)

Delay scenario «High»



Conclusions from the Simulations – Experiences in Operation

- Conclusions from the simulations
  - The new Oslo-area timetable are operationally feasible
  - Overall lower delays than previous timetable
  - Improved robustness

- Experiences so far
  - The transition to the new timetable went well
  - More realistic station dwell times gives better punctuality (especially for inner-suburban trains)
  - Other problems have caused delays – too early to evaluate the overall effects of the new timetable

Conclusions

- Simulation can produce quantitative measures to assess punctuality and robustness of different timetable concepts
- Running large models is difficult, but:
- Large models are necessary to assess network effects of changes in larger areas
- Results are very sensitive to the use of different dispatching solutions or unresolved dispatching problems
- Good cooperation with OpenTrack Ltd. contributed to successful completion of the project, especially with respect to script-functionality