A simulation based framework for evaluating effects of infrastructure improvements on scheduled and operational delays

Hans Sipilä
Introduction

• Railway investment appraisal
  • Cost-benefit analysis
• Timetable assumptions for future traffic
  • Mix of trains
  • Frequency
• Evaluating multiple timetables
  • Find a representative set of timetables
  • Improve analysis and reduce the influence of assumptions
  • Increase reliability in comparisons
• Simulations with stochastic delays
Multiple timetables – performance
Timetable generation

• Nominal timetables (unscheduled)
  • Combinatorial variation of train initiation (entry) times in network – input to simulation
  • Train runs defined by
    – First choice paths through stations
    – Nominal run times including pre-scheduled stops

• Simulation in RailSys (microsimulation software)
  • Conflict manages the unscheduled operation
    – Meets, overtakings, dispatching (priorities)
  • Results in operational timetables of varying quality
Timetable generation

• Number of combinations depends on
  • Number of train groups
  • Number of initiation locations
  • Group cycle times (frequency)

• Reduce to a manageable number of combinations
  • Initiation headway restrictions between trains
    – Spreading departures
  • Decrease time resolution, e.g. [0 1 2 3 4 5 6 7 ...] becomes
    – [0 2 4 6 ...] or [0 3 6 ...]

• Sampling
Evaluation of simulated nominal timetables

- Scheduled delay (deviation from nominal run times)
- Regularity
- Limits for acceptable timetables

Not good!

Interesting?
Handling infrastructure scenarios

• Generation of multiple infrastructure variants?
  • Using RailSys interface takes time

• Model developed to speed up this process
  • Make a library of different station layouts
    – Defined on spreadsheets (e.g. Excel)
  • Linking of stations
    – Line properties
  • Scripts transform information to node-link structures
  • Recursion for route properties
  • Ready-to-go infrastructure file
Case study

- Single-track line (240 km)
  - Inter-station distance
  - Double-track expansion
- Three train groups (categories)
  - Passenger service HP, 1 scheduled stop
  - Passenger service RP, 3 scheduled stops
  - Freight service FR
- Two traffic frequencies
  - 120 / 120 / 240 min and 120 / 60 / 240 min
- 4000 sampled combinations
Infrastructure scenarios

- 2-track station
- 3-track station
- Station on double track

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10

10D1

10D2

0  30  60  90  120  150  180  210  240
A  D  G  J  M  P  S  V  Y
Result example – simulation of nominal timetables

Summed group mean values of deviations to nominal run time

Passenger trains 120 / 120 / 240
Four infrastructure variants

Passenger trains 120 / 60 / 240
Four infrastructure variants

Graphs showing the summed group mean values of deviations to nominal run time for different departure combinations.
Choosing timetables for simulations with stochastic delays – Example case 10

- **A** – Pick the 100 ”best” timetables from the viewpoint of passenger trains, lowest summed mean values
- **B** – From this set, pick 15 timetables giving lowest summed mean including freight trains
- Passenger trains HPx och RPx, freight trains FRx
Operational simulations

- Introduce stochastic (and systematic) delays
- Delay types
  - Entry – initiation of trains
  - Dwell
  - Run time variations
- Dynamic performance of timetables
  - Vary delay levels (distributions)
  - Limits on on-time performance and mean delays
- Relate to scheduled delays
Operational simulations – Result example for Case 10PD

Mean values of scheduled and operational delays in one direction
- lower entry delays
- higher entry delays

Passenger trains 120 / 60 / 240

Freight trains 120 / 60 / 240
Operational simulations – Result example

Summed group mean values of exit delays

- lower entry delays
- higher entry delays

Passenger trains 120 / 120 / 240
Three infrastructure variants

Passenger trains 120 / 60 / 240
Three infrastructure variants

Graphs showing the sum of mean delays over time for different infrastructure variants.
Conclusions – pros and cons

- Possibility to evaluate multiple timetables
  - Static and dynamic performance
- Less influence from timetable assumptions
- Infrastructure variants created quickly
- Timetable, infrastructure and delays treated as variables
- Input to cost-benefit analysis

- Microsimulation takes time
- Synchronous simulation – deadlocks on single-track lines
- How much better are some of the “not found” timetables?
Thank you!