KTH ROYAL INSTITUTE
OF TECHNOLOGY

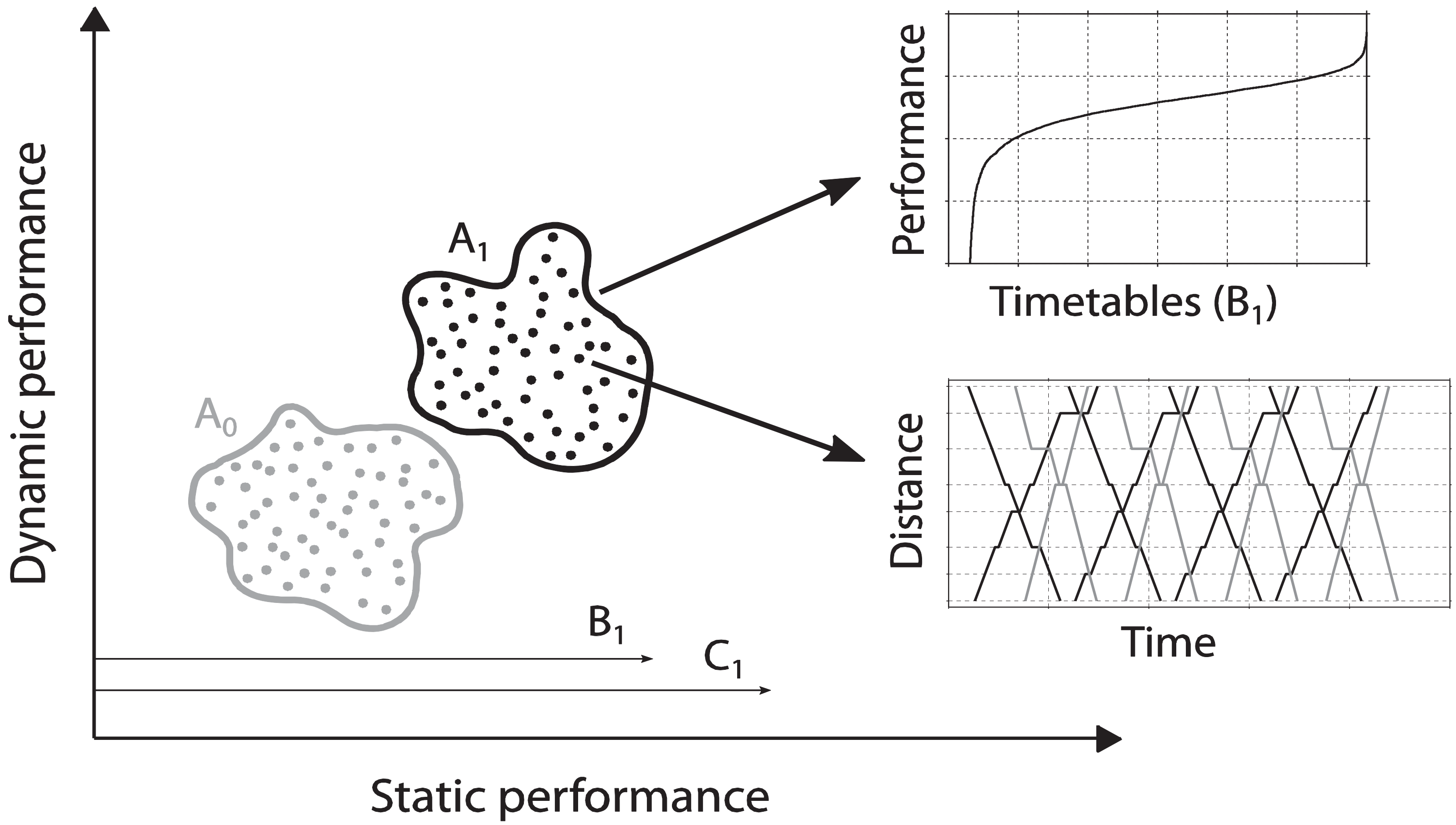
A simulation based framework for evaluating effects of infrastructure improvements on scheduled and operational delays

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

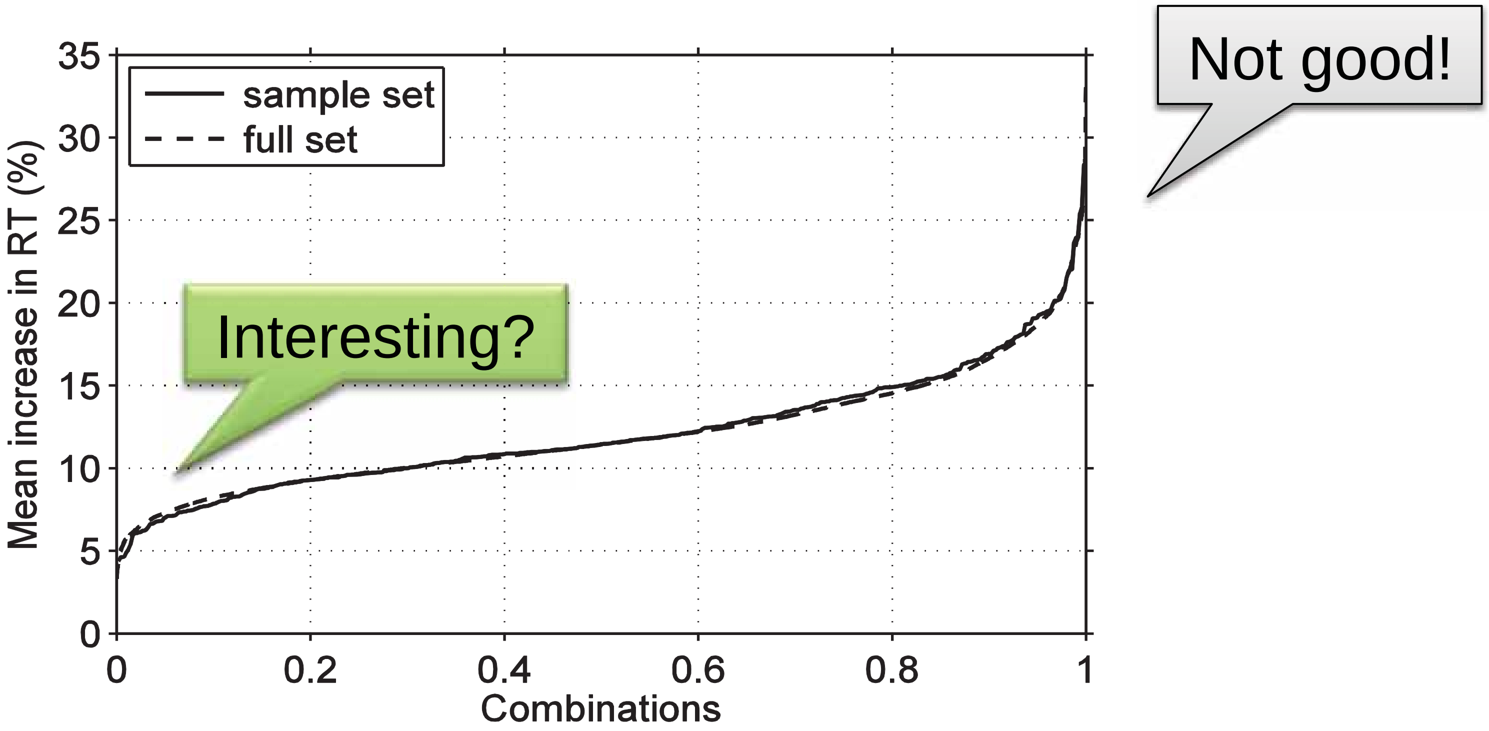
Timetable generation

- 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



Handling infrastructure scenarios

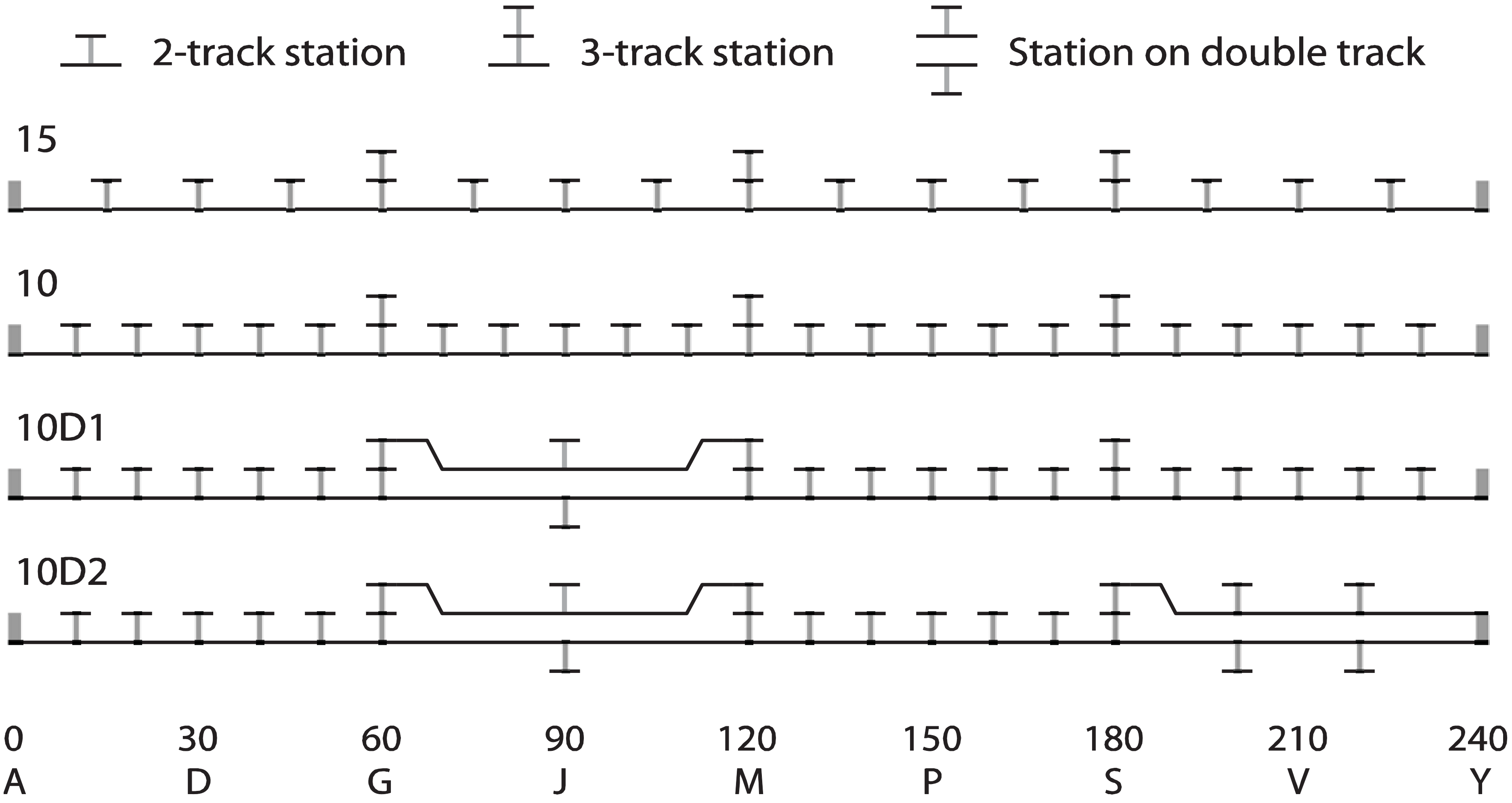
- Generation of multiple infrastructure variants?
  - Using RailSys interface takes time

- 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

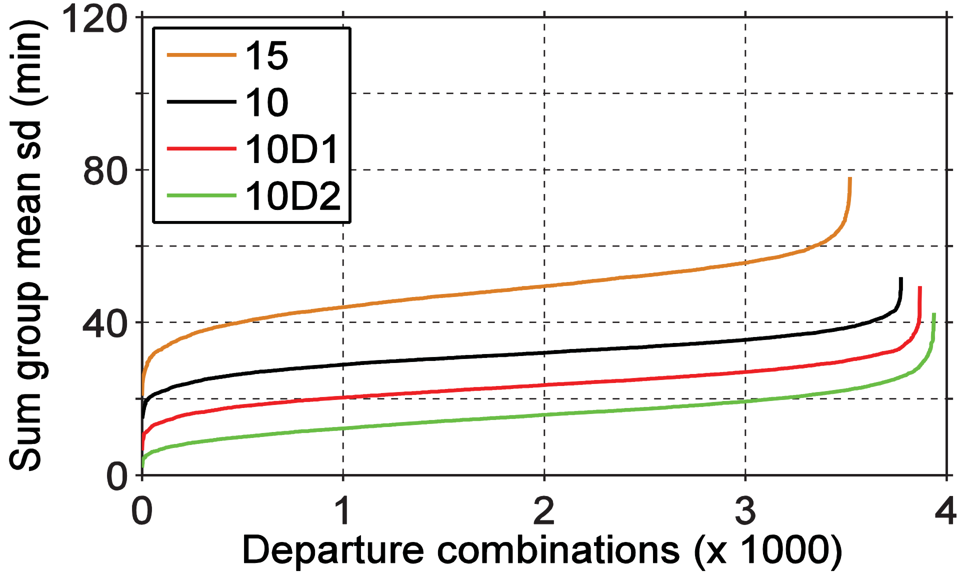
Infrastructure scenarios



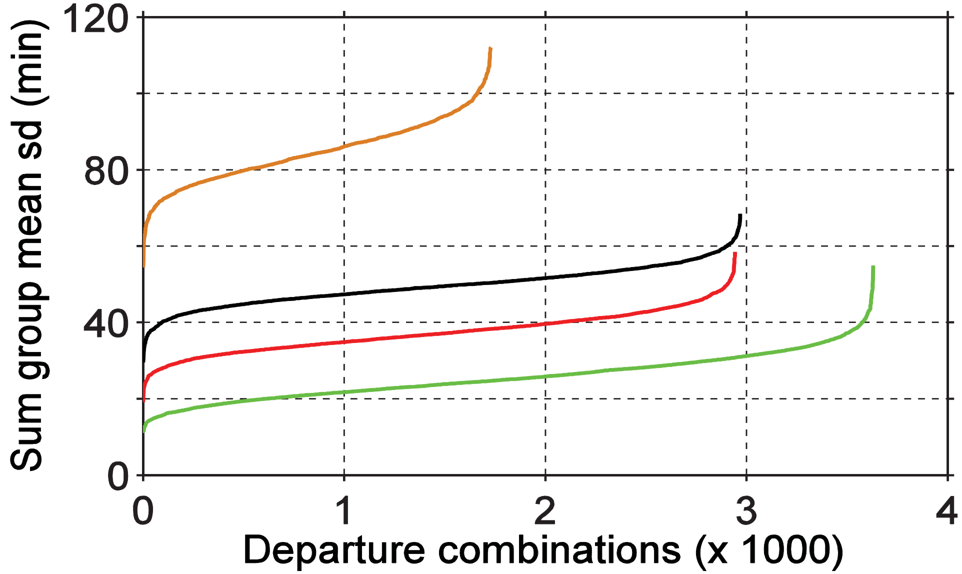
Result example – simulation of nominal timetables

Summed group mean values of deviations to nominal run time

Passenger trains 120 / 120 / 240
Four infrastructure variants

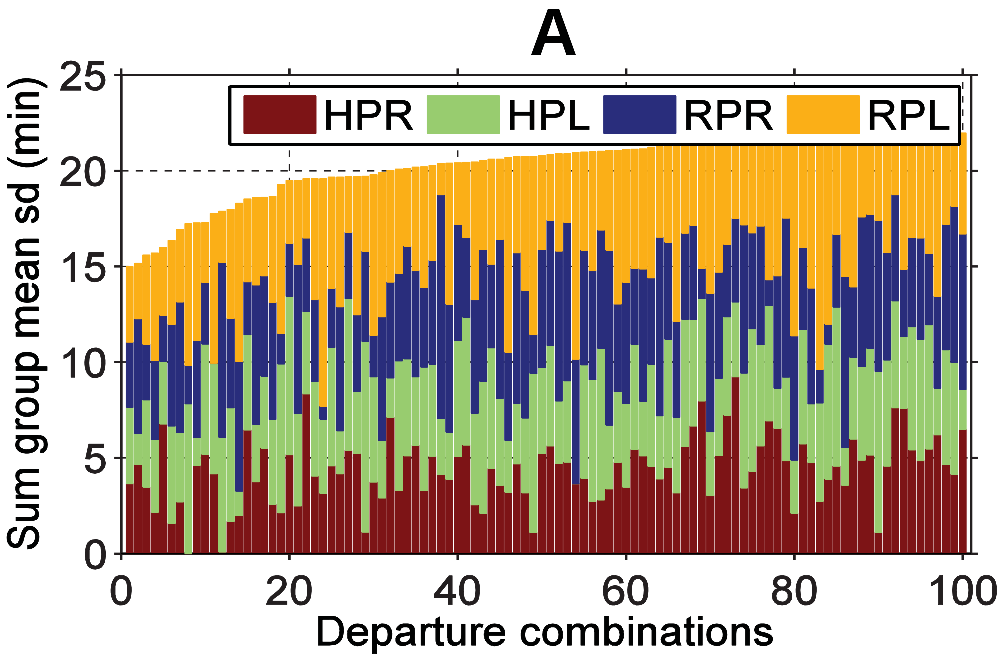


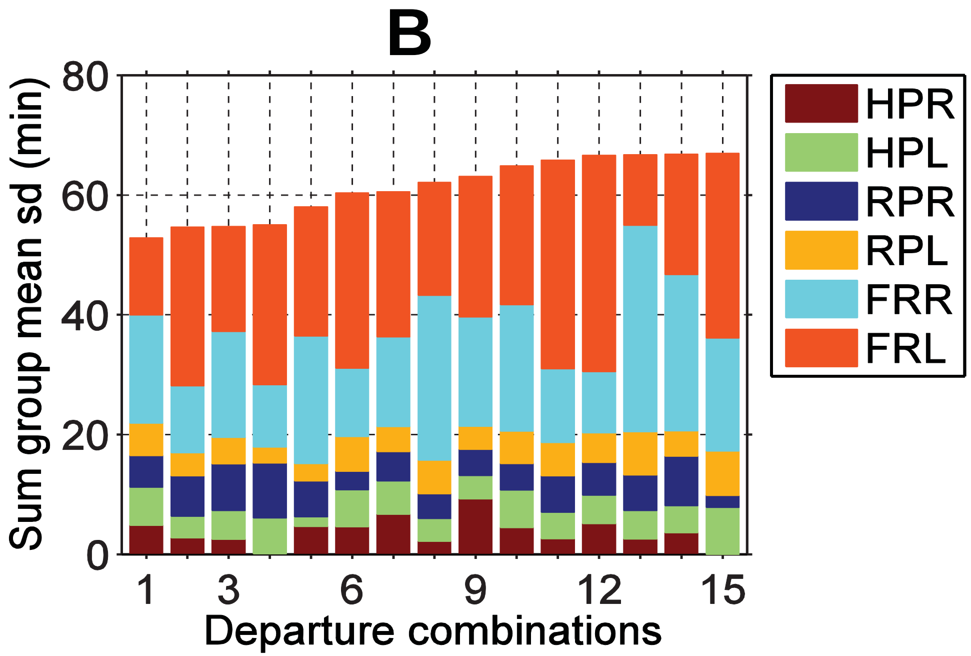
Passenger trains 120 / 60 / 240
Four infrastructure variants



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

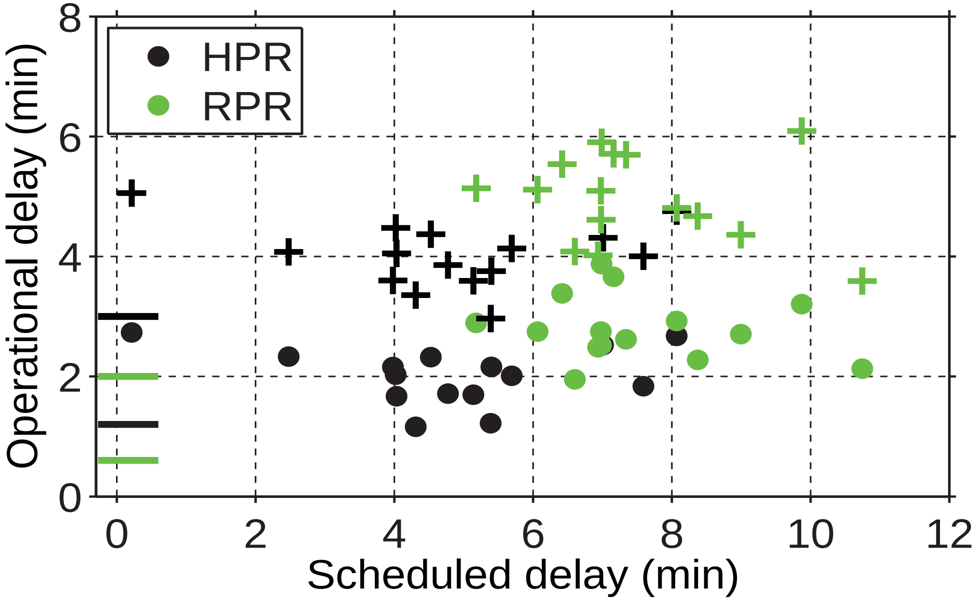
- Introduce stochastic (and systematic) delays
- Delay types
  - Entry – initiation of trains
  - Dwell
  - Run time variations
- Dynamic performance of timetables
  - Vary delay levels (distributions)
  - Limits on on-time performance and mean delays
- Relate to scheduled delays

Operational simulations – Result example for Case 10PD

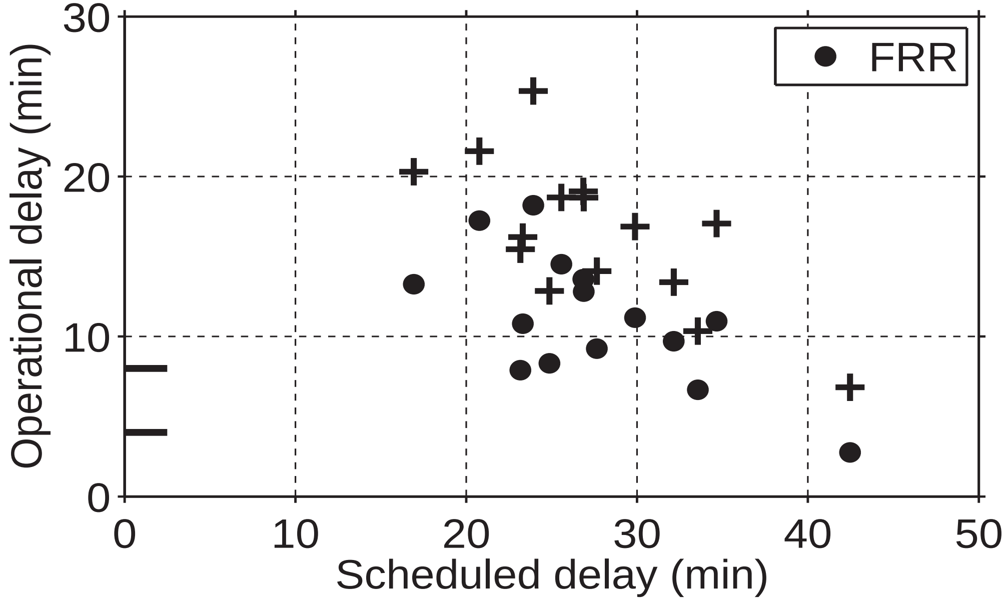
Mean values of scheduled and operational delays in one direction

- ● lower entry delays
- ✚ higher entry delays

Passenger trains 120 / 60 / 240



Freight trains 120 / 60 / 240



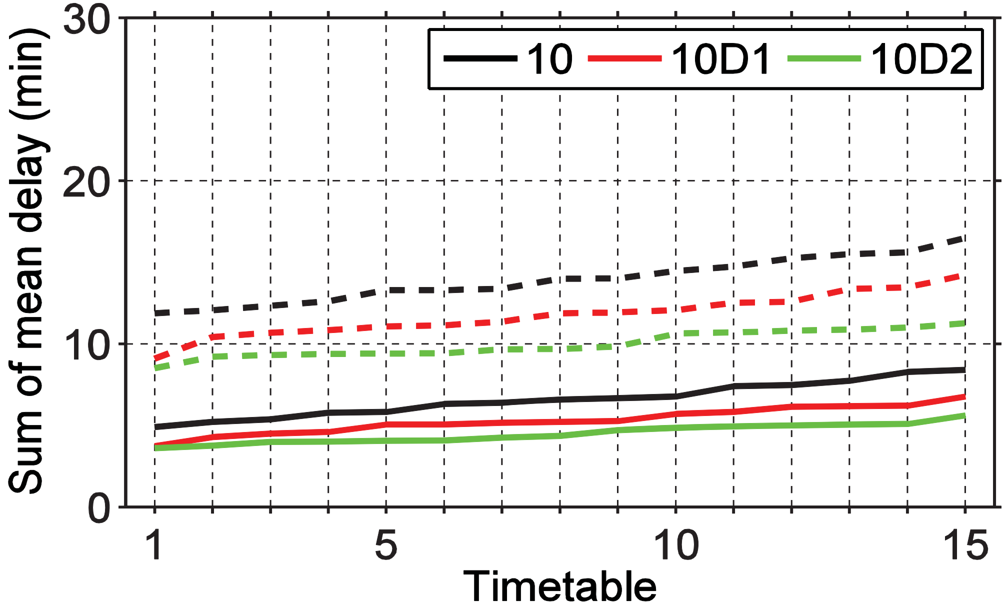
Operational simulations – Result example

Summed group mean values of exit delays

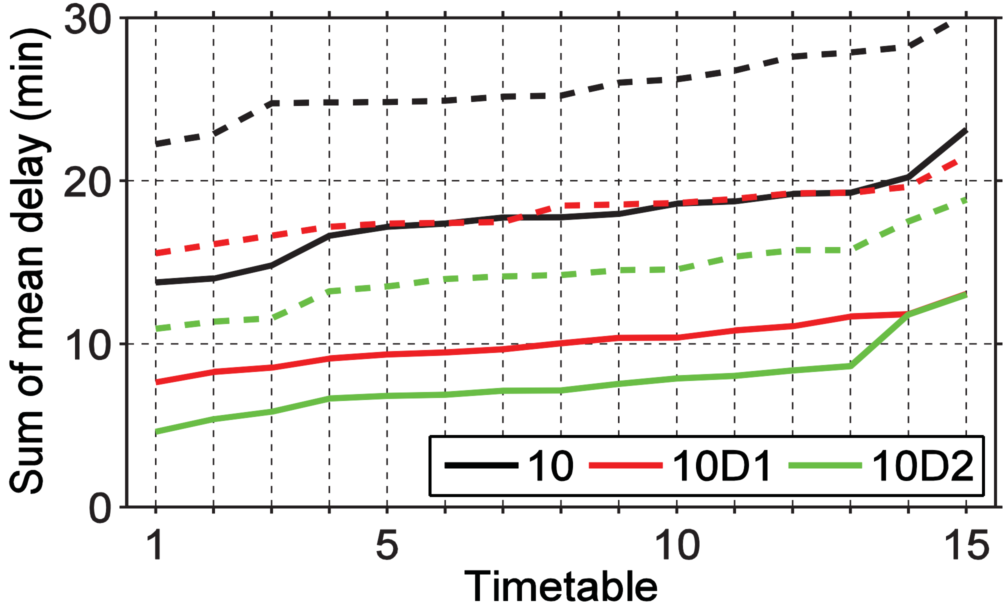
——— lower entry delays

- - - - - higher entry delays

Passenger trains 120 / 120 / 240
Three infrastructure variants



Passenger trains 120 / 60 / 240
Three infrastructure variants



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!