Danmarks Tekniske Universitet

Examination of operation quality for high-frequent railway operation

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Agenda

- Traditional assessment of punctuality
- Operation quality for high-frequent railway operation
  - Service frequency
  - Travel time
  - Combined approach
  - Passenger delay model
- Overview
- Conclusions

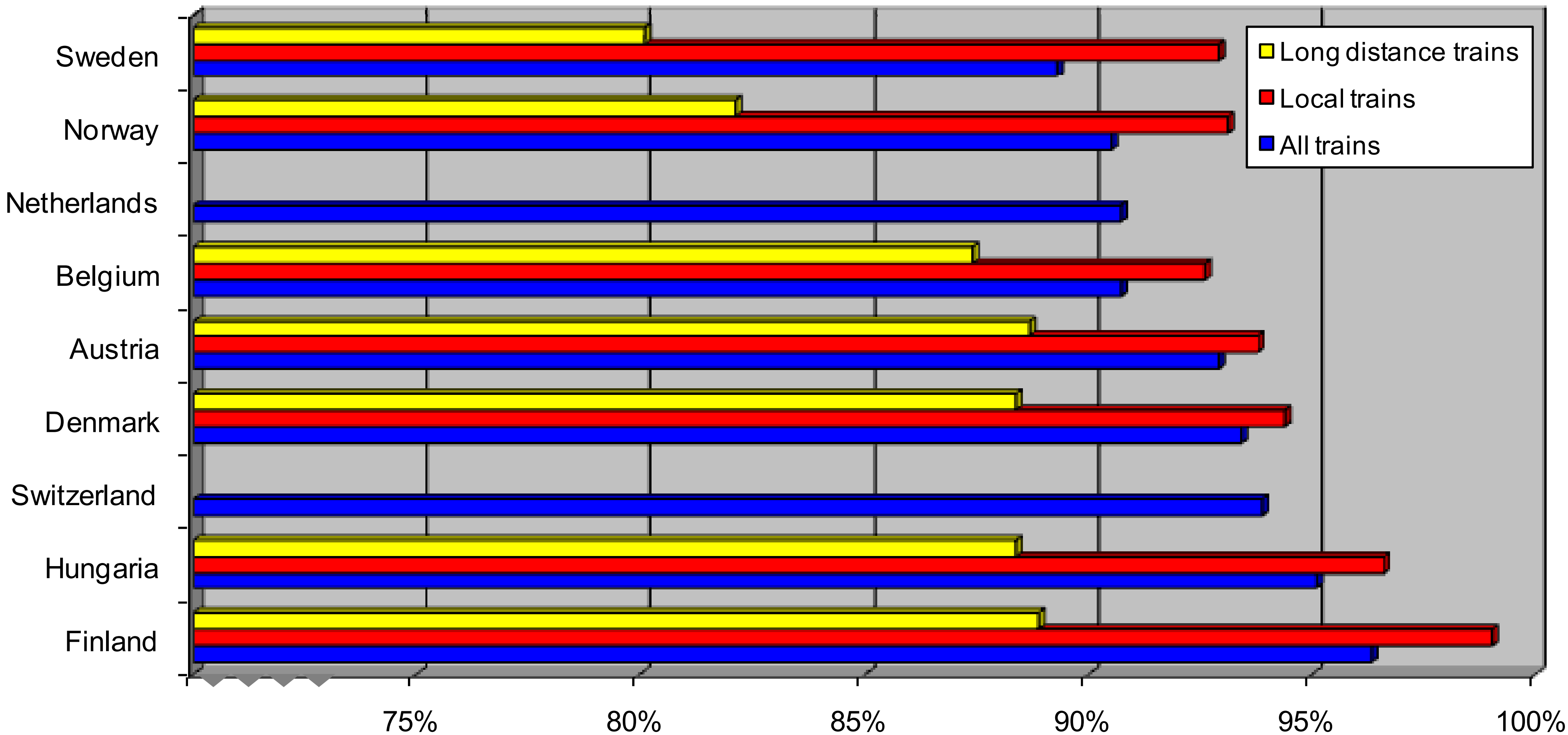
Traditional statement of punctuality

- When is a train delayed?
  - Danish S-train 2½ minutes
  - The Netherlands 3 minutes (departure)
  - Germany 5 minutes (line end station)
  - Danish Regional and Intercity trains 6 minutes
  - Danish freight trains 10 minutes
  - Great Britain 5 and 10 minutes respectively
  - AmTrack dependent on the lenght of the train route (not length of passengers' route)

- When are the trains registered?
  - Arrival at station
  - Departure from station
  - Arrival at line end station

- Goal for punctuality
  - Denmark 90%
    - S-train 95%
  - The Netherlands 90%
  - AmTrack – Long distance 70%
  - AmTrack – Short distance 85%
  - AmTrack – Corridor trains 90%
  - AmTrack – Premium trains 94%
  - AmTrack – Contract based commuter trains 95%

Punctuality



Traditional assessment of punctuality

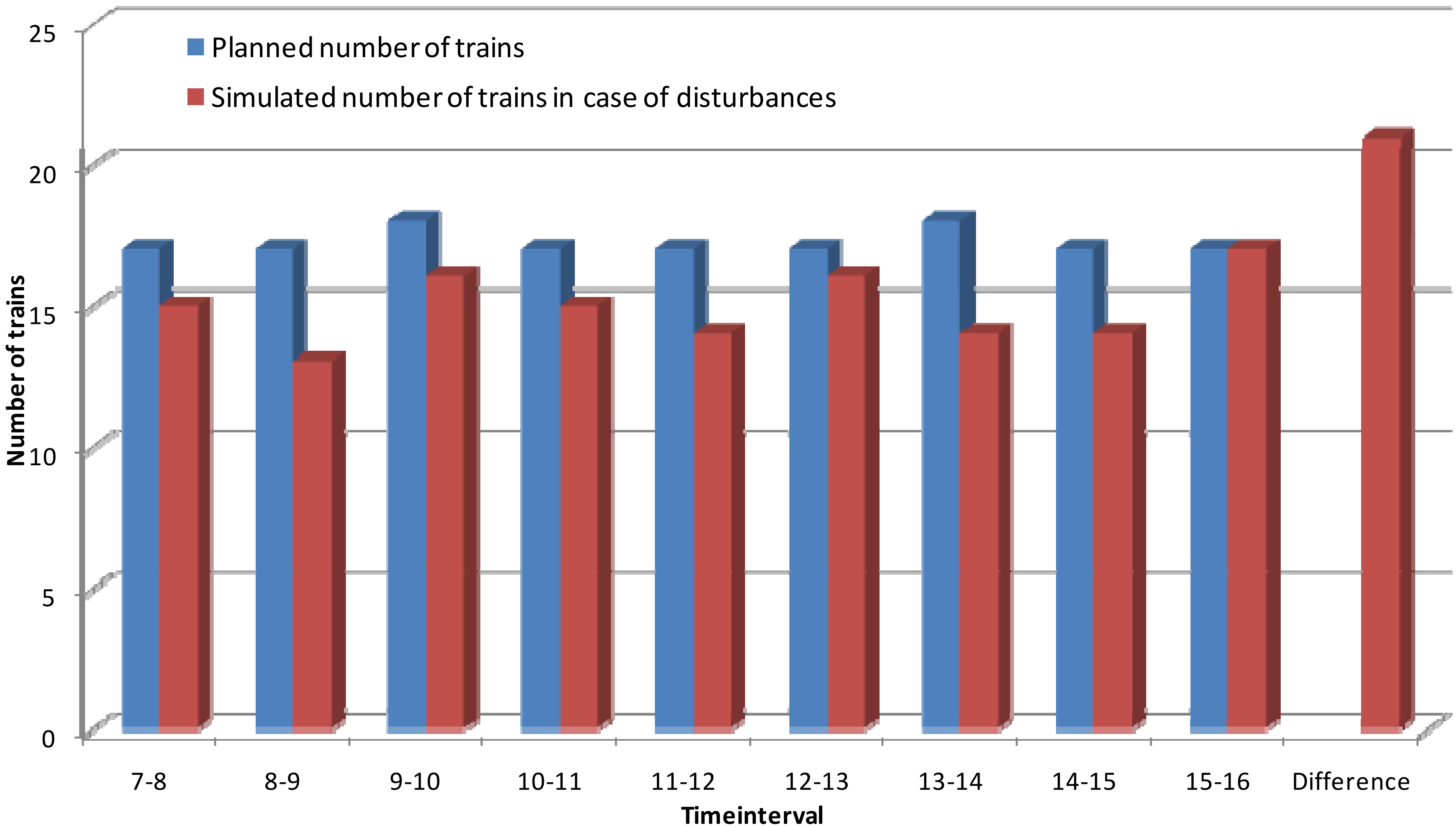
Advantages

- Low complexity
- Only planned and realized timetables are required

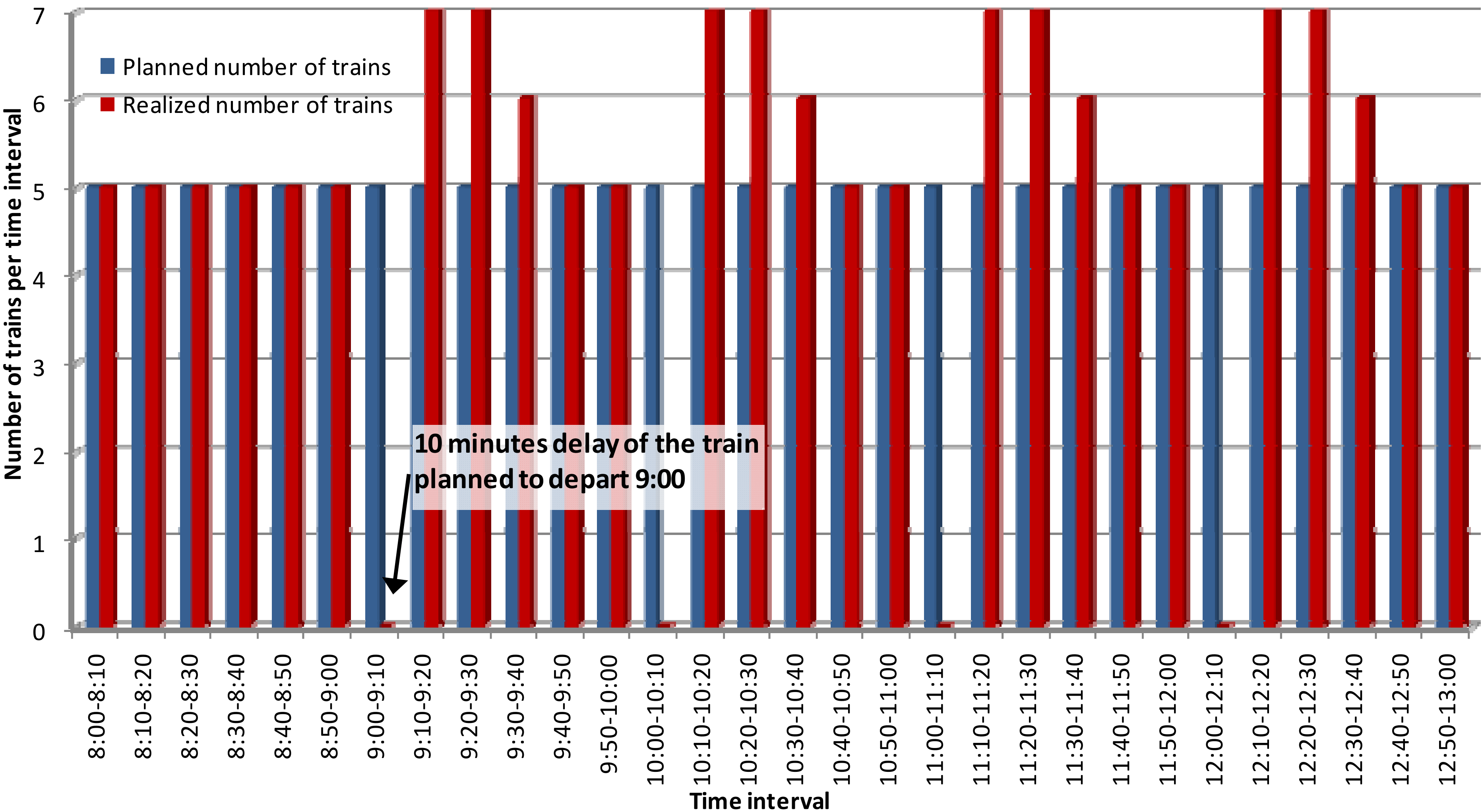
Disadvantages

- Not well-suited for high-frequent operation
- Travel time not taken into account

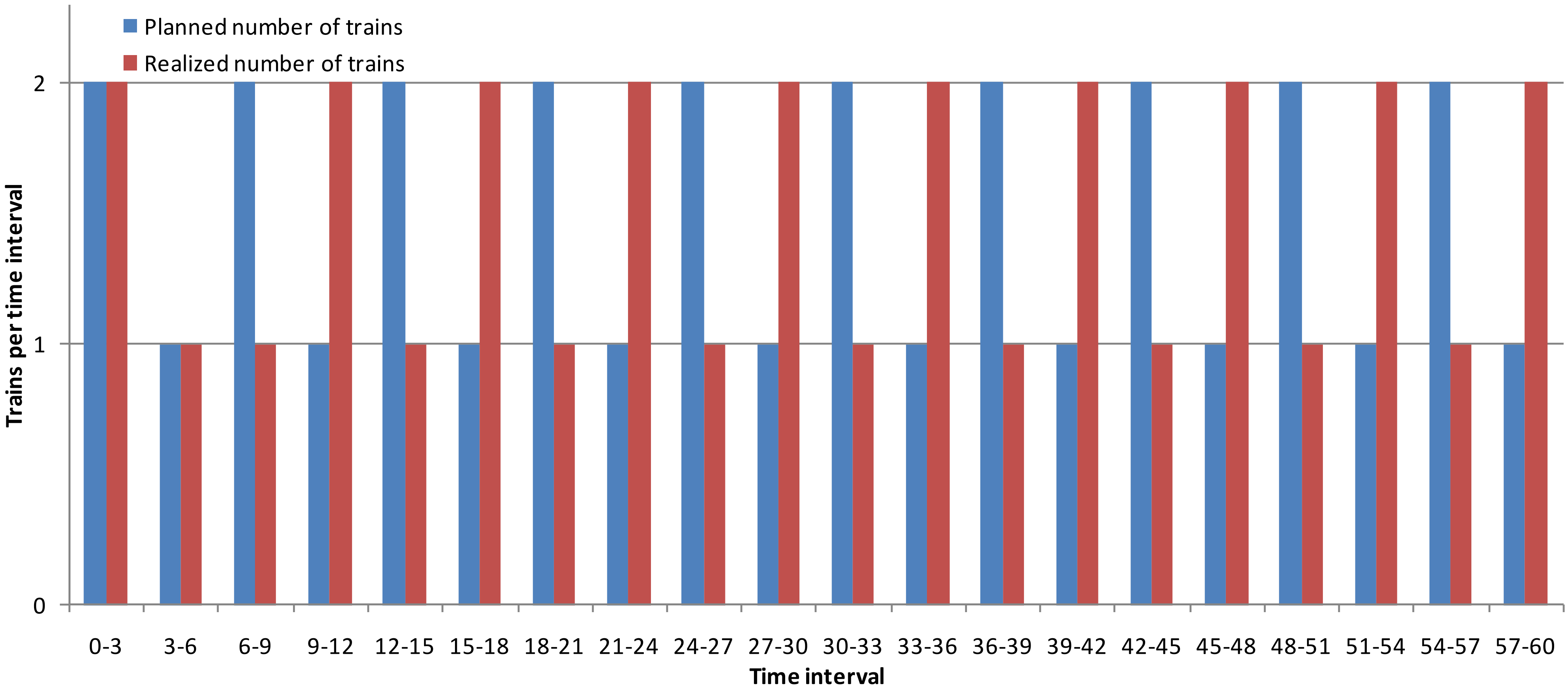
Service frequency



Long time intervals can hide flucturations



Too short intervals



Service frequency

Advantages

- Low complexity
- Reliability taken into account
- Requires the realized timetable only

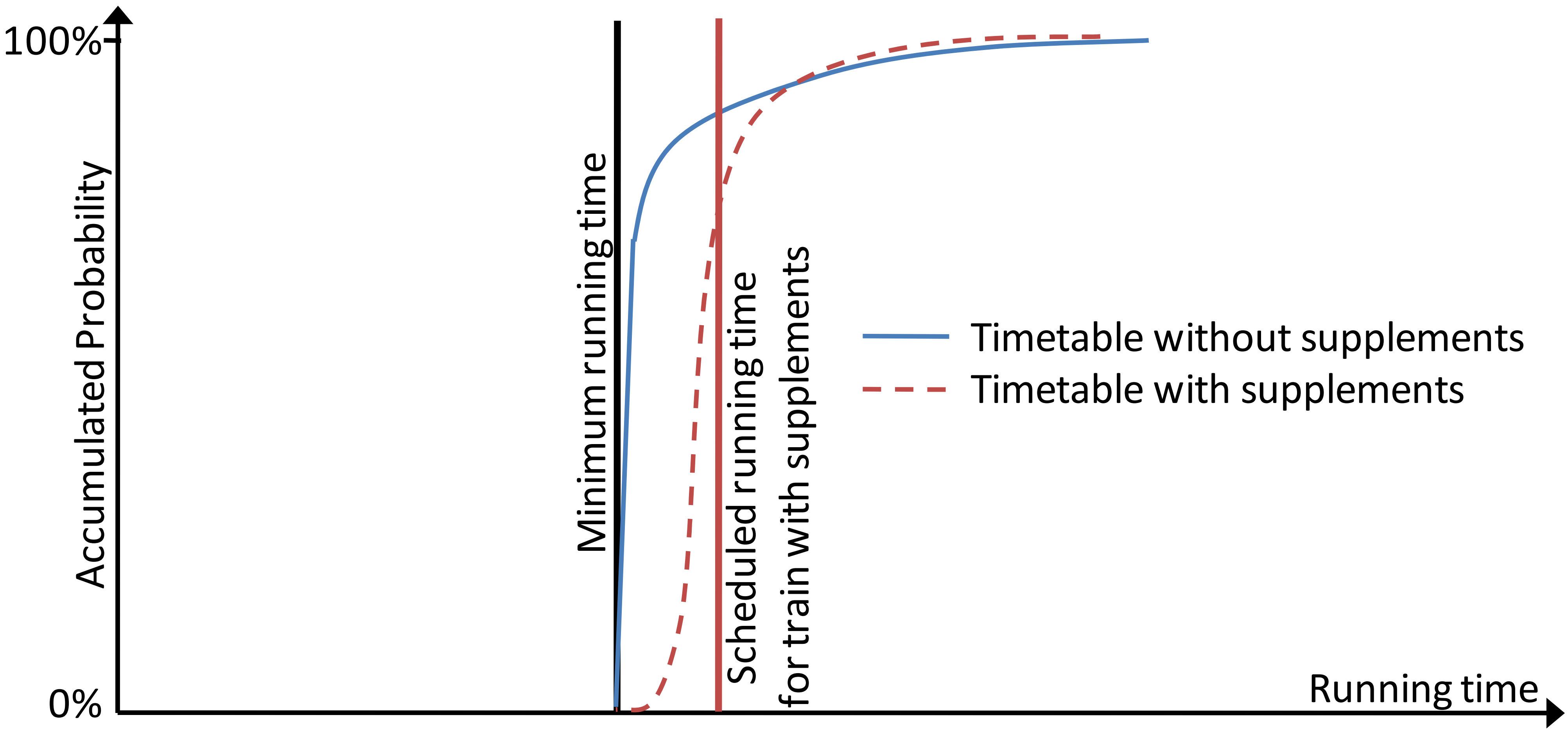
Disadvantages

- Works for high frequent operation only
- Travel time not taken into account
- The examined railway line only can be taken into account – not the entire network
- The time intervals are crucial

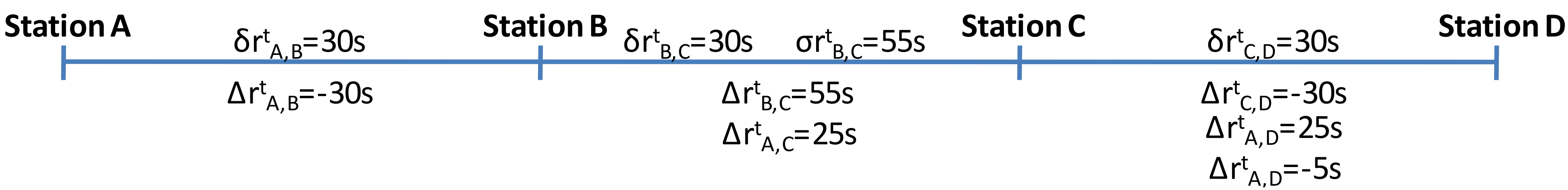
Travel time


Vanløse 9
Flintholm 8
Lindevang 7
Fasanvej 5
Frederiksberg 3
Forum 2
Nørreport
Kongens Nytorv 2
Christianshavn 3
Amagerbro 5
Lergravsparken 7
Øresund 9
Amager Strand 10
Femøren 12
Kastrup 14
Lufthavnen 15
5 Islands Brygge
7 DR Byen
UNIVERSITETET
9 Sundby
11 Bella Center
12 Ørestad
14 Vestamager
Zone 2
Zone 1
Zone 1
Zone 3
M
M1
M2

Time supplements vs. no supplements



Travel time delays



σr^{t}: delay
δr^{t}: time supplement
Δr^{t}: time difference from published timetable

Travel time

Advantages

- Low complexity
- Requires the realized timetable only
- Travel time is taken into account

Disadvantages

- Works best for high frequent operation
- Frequency not taken into account
- The examined railway line only can be taken into account – not the entire network

Combined approach

The service frequency and travel time approaches can be combined
- Combined approach

Advantages

- Low complexity
- Reliability taken into account
- Travel time is taken into account
- Requires the realized timetable only

Disadvantages

- Works best for high frequent operation
- The examined railway line only can be taken into account – not the entire network
- The time intervals are crucial

Passenger delay models

- 0th generation
  - Train delay multiplied with the amount of passengers
- 1st generation
  - Route choice model
  - Full knowledge
- 1½ generation
  - Route choice model
  - Full knowledge is achieved when the passengers arrive at the station
- 2nd generation
  - Passengers know the delay distributions and take this into account when considering their route according to 1st generation models
- 3rd generation
  - Passengers plan their route according to the planned timetable
  - Passengers reconsider their route at that point in time and space where a certain threshold of delay is achieved
  - When passengers reconsider their route full knowledge is assumed

	Train delays (0th generation)	Cross section delays (0th generation)	Counting train delays (0th generation)	Optimal route choice model (1st generation)	1½ generation model	Passenger delay model (2nd generation)	Passenger delay model (3rd generation)
Considerations of passenger delays	No	Partly	Partly	Partly	Partly	Yes	Yes
Complexity of the method	Very simple	Low	Low	Medium	Medium	High	High
Needs of information on passenger demand	No	Average alighting passengers	Counted passengers	OD matrix	OD matrix	OD matrix	OD matrix
Passengers may predict delays in the future (full information is assumed)	No	No	No	Yes	Yes	Partly	Can be incorporated
Passengers may arrive before time if a better con-nection emerges	No	No	No	Yes	Yes	Yes	Yes
Accuracy	Very low	Quite low	Fairly low	Low	Medium	Medium	High
Bias	Mostly under-estimates delays	Will quite often under-estimate delays	Will fairly often under-estimate delays	Large under-estimation of delays	Under-estimates delays	No sys-tematic bias	No system-atic bias

3rd generation passenger delay models

Calculation of optimal route and the time usage by use of a route choice model on the **planned** timetable

↓

Storage of the passengers "planned" routes

↓

Calculation of time usage by route choice model on realised timetable. The passengers follow – as far as possible – their **"planned" route**

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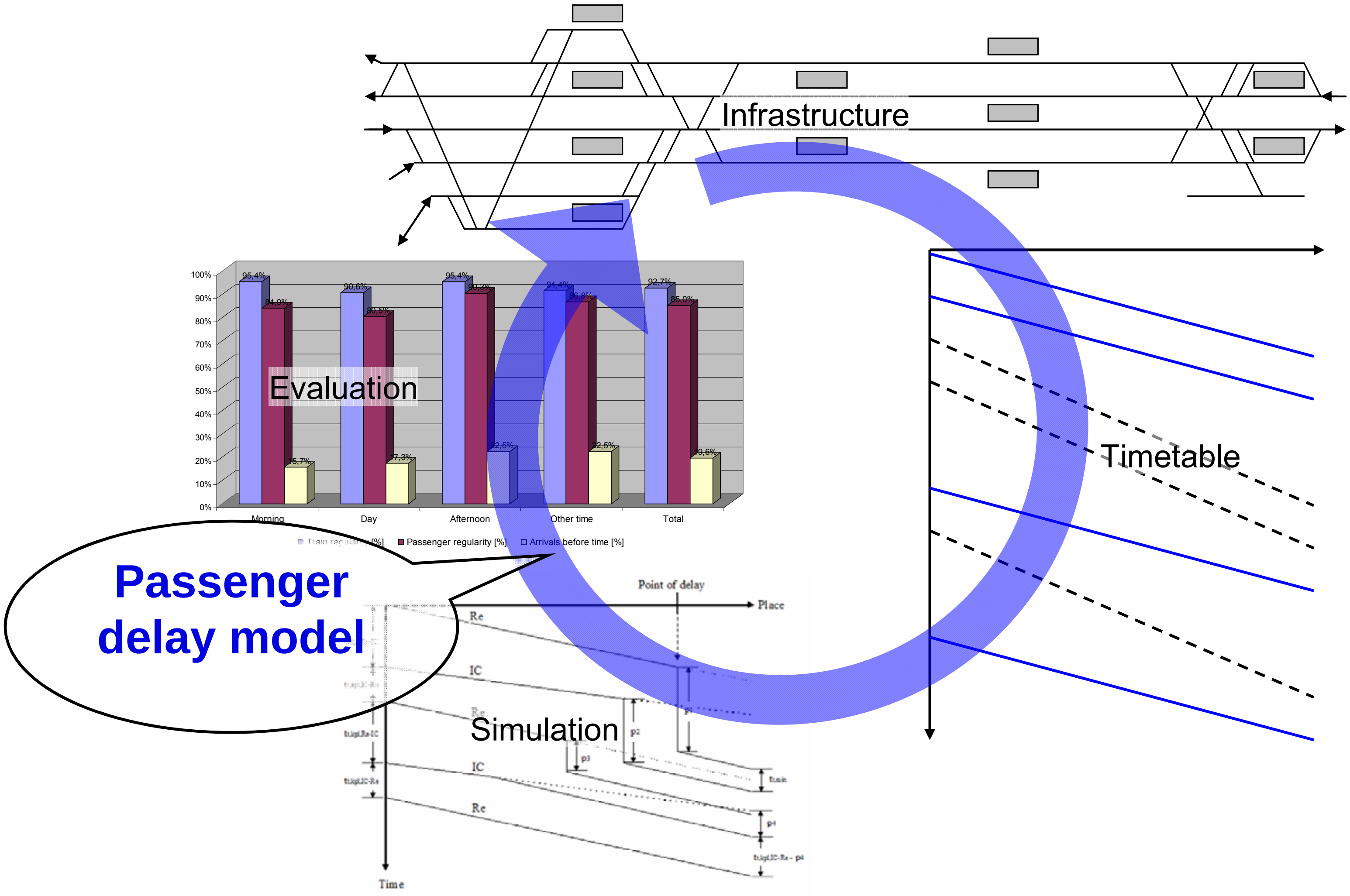
Difference in time

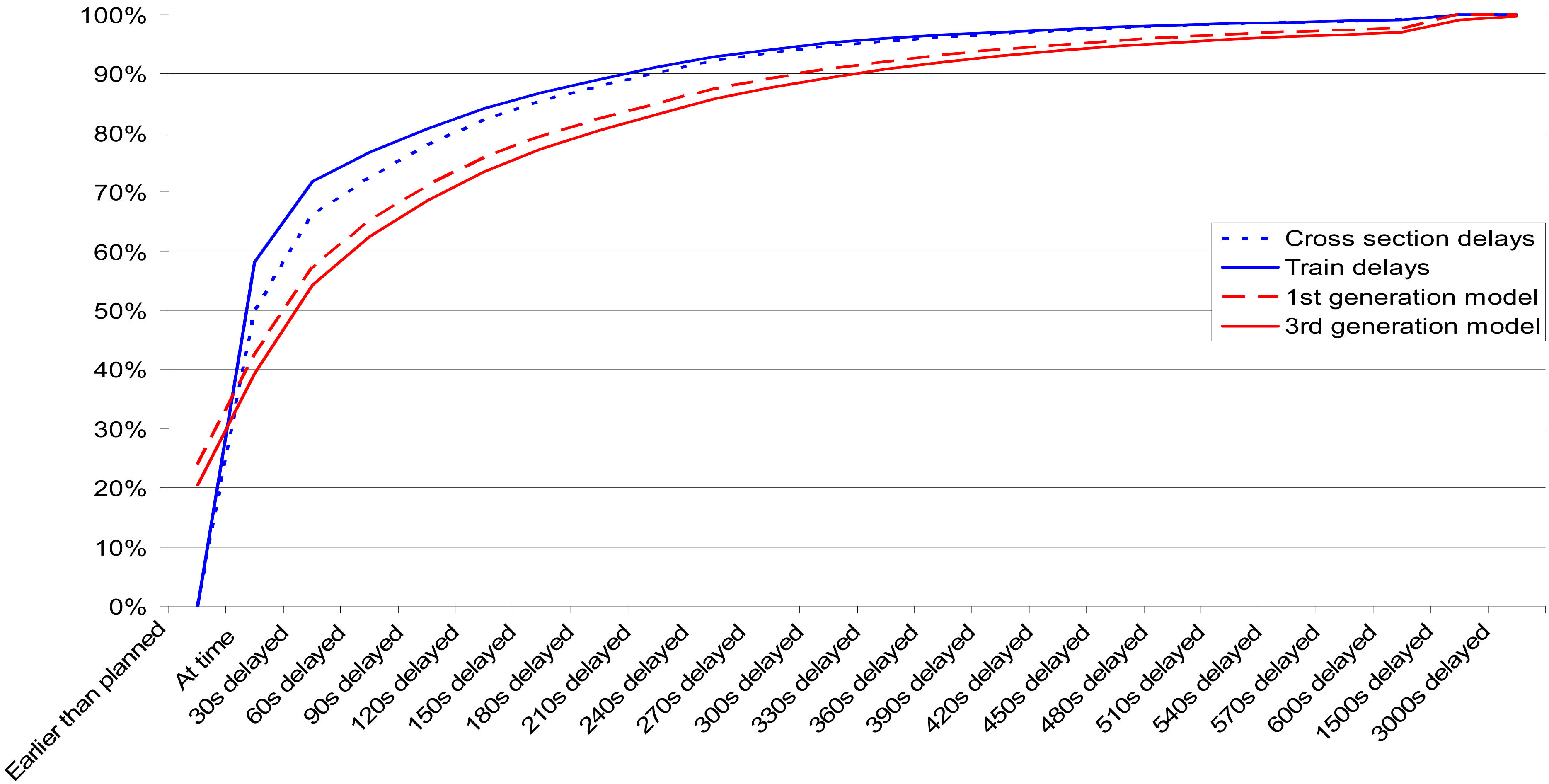
⇓

Passenger delay

Coupling of the passenger delay model with railway operation simulation tools



Simulated passenger delays



Passenger delay approach

Advantages

- Takes the passengers' experience into account
  - 3rd generation models are at present the most advanced models in daily use
- Can be used for evaluation of both high and low frequent operation
- Can include both a single railway line or the entire network
  - Includes transfers
- Additional information about inconveniences for passengers
  - e.g. unscheduled transfers

Disadvantages

- Data intensive
  - Planned timetable
  - Realized timetable
  - Origin-Destination matrix divided into time intervals
- High degree of complexity
- Requires calibration of the model

Overview

	Service frequency	*Travel time*	*Combined approach*	*Passenger delay*
Frequency	Yes	No	Yes	Implicitly/Yes
Reliability	Yes	No	Yes	Yes
In vehicle time	No	Yes	Yes	Yes
Total travel time	No	No	Rough estimate	Yes
Capacity restrictions	No	No	No	Can be incorporated
Complexity	Low	Low	Low	Medium to high
Required data	Realized timetable	Realized timetable	Realized timetable	Planned and realized timetables & OD-matrix
Include transfers	No	No	No	Yes
Entire network	No	No	No	Yes
Low frequency	Partly	Partly	Partly	Yes
Changed route choice	No	No	No	Yes
Load factor of trains	No	No	No	Yes
Future operation	No	No	No	Yes
Precision	Low	Low	Below medium	High

Conclusions

- "Traditional" assessments of punctuality is not the best method for high-frequent railway operation

- Simple approaches to assess operation quality for high-frequent operation
  - Service frequency
  - Running time
  - Travel time

- Operation quality does not necessarily reflect passengers' experience

- 3rd generation passenger delay models reflects passengers' experience the best
  - Can be used for all frequencies
  - Can examine the entire network as well as a particular railway line
  - Can be combined with railway operation simulation software to guesstimate future delays
  - Data intensive

Thank you for your attention

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