IT08.Rail

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Userworkshop OpenTrack

The application of OpenTrack in education and research at Delft University of Technology

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Outline

The application of OpenTrack in education and research at Delft University of Technology

- Introduction
- MSc Course "Railway traffic management"
- MSc thesis projects
  - Capacity analysis
    - Single-run simulation
  - Dynamic traffic management
    - Multiple-run simulaton
- Conclusions

Education

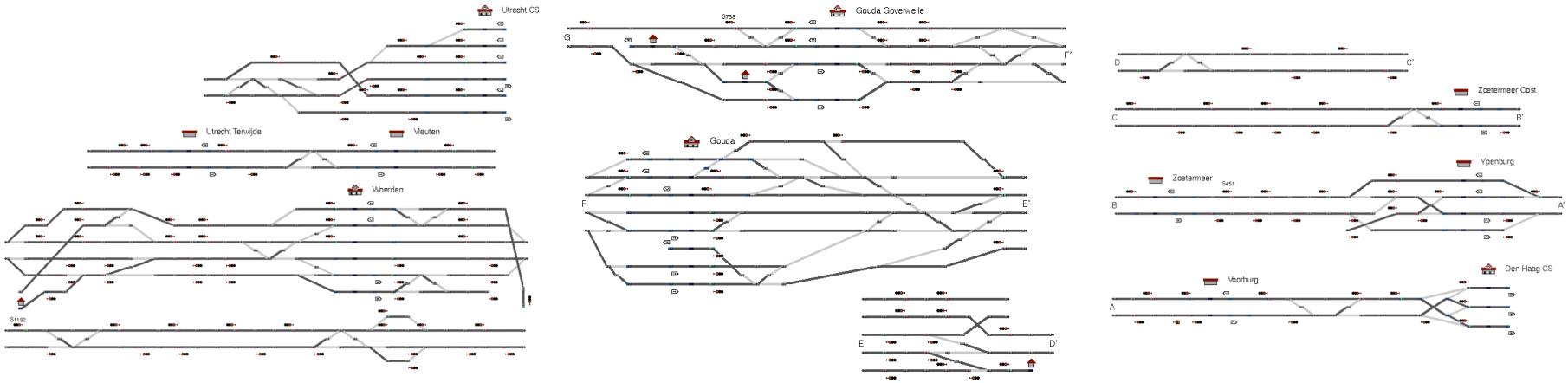
MSc Course Railway traffic management

- Theory
  - Railway timetables (design and analysis)
  - Railway traffic control (route setting, dispatching, rescheduling)
  - Safety and signalling systems, blocking time theory
- Practicum: OpenTrack exercises
  - Increase understanding of the theory of timetabling, capacity analysis and railway operations using simulation exercises
  - Given: infrastructure, engines & trains, itinaries, train line data

Education: given data

- Infrastructure The Hague – Gouda – Utrecht: 3 OpenTrack windows
- Train line data (direction The Hague – Utrecht only)
  - Three types, regular interval 30 min

Train	Type	Units	Stops	Start	Dwell times
1723	IC	2xICM3	Gvc-Vb-Ut	7:08	60
2025	IR	IRM4	Gvc-Ztm-Gd-Wd-Ut	7:16	60 (Wd 30)
9827	R	SGM3	Gvc-Vb-Ztm-Ztmo-Gd-Gdg	7:27	20

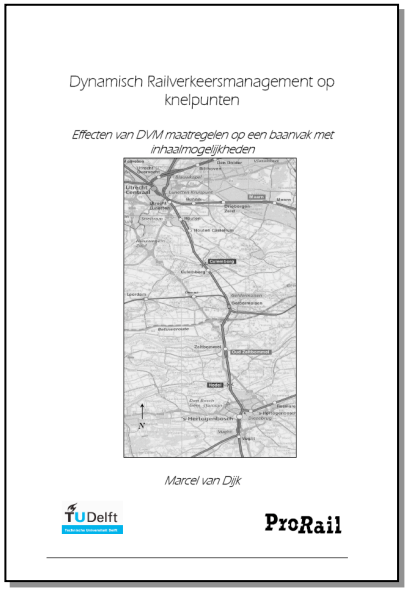


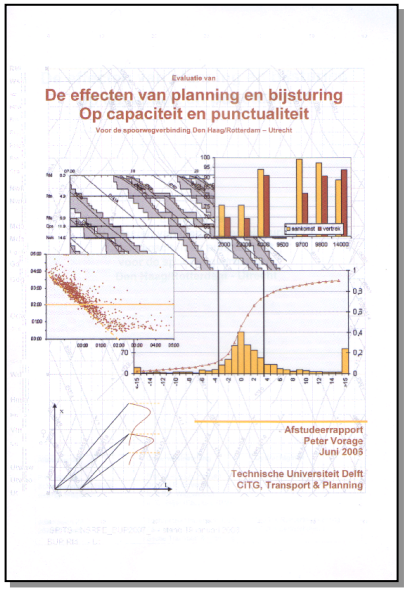
Education: OpenTrack exercises

- Exercise 1: Scheduling trains
  - Minimal running times, supplements, performance parameter
- Exercise 2: Simulating train runs, comparing schedule variants
  - Effect of track speed and stop pattern changes on running times
- Exercise 3: Capacity analysis
  - Minimum headway and capacity consumption (timetable compression)
- Exercise 4: Simulation of timetable disruptions
  - Signal failure (30 min), rolling stock breakdown (running at 40 km/h)

MSc projects

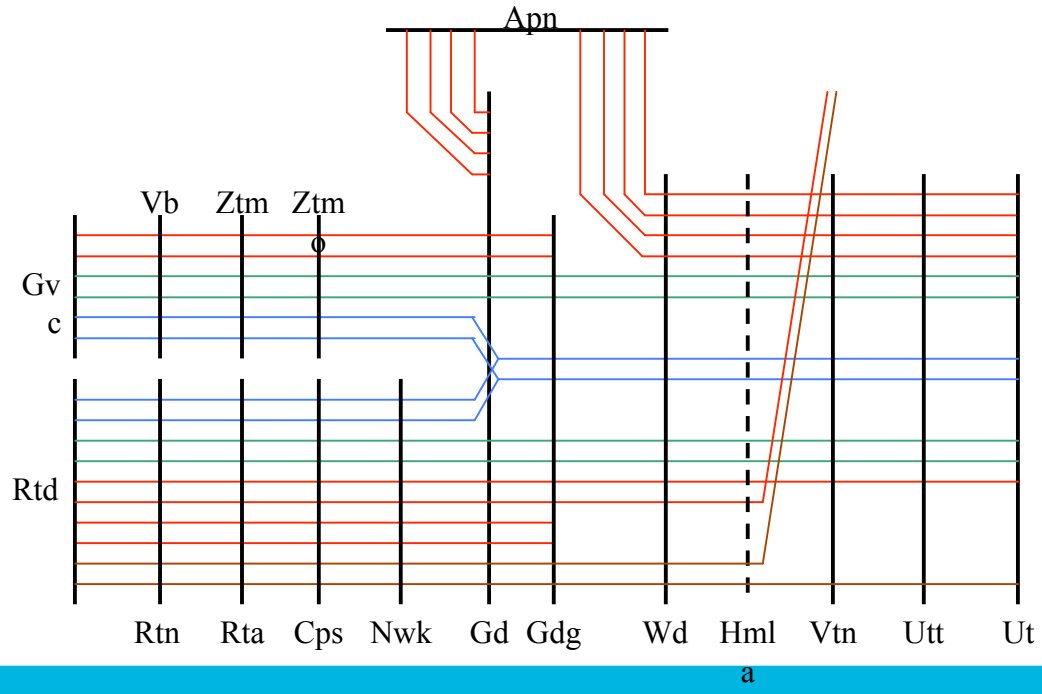
- P.W. Vorage: Capacity analysis (2006)
  - Rotterdam/The Hague – Gouda – Utrecht
  - Platform allocation Gouda
- M. van Dijk: Dynamic railway traffic management (2006)
  - Utrecht – 's Hertogenbosch
  - Dynamic overtaking, control strategy (FCFS, FOFS), planning strategy





Capacity analysis

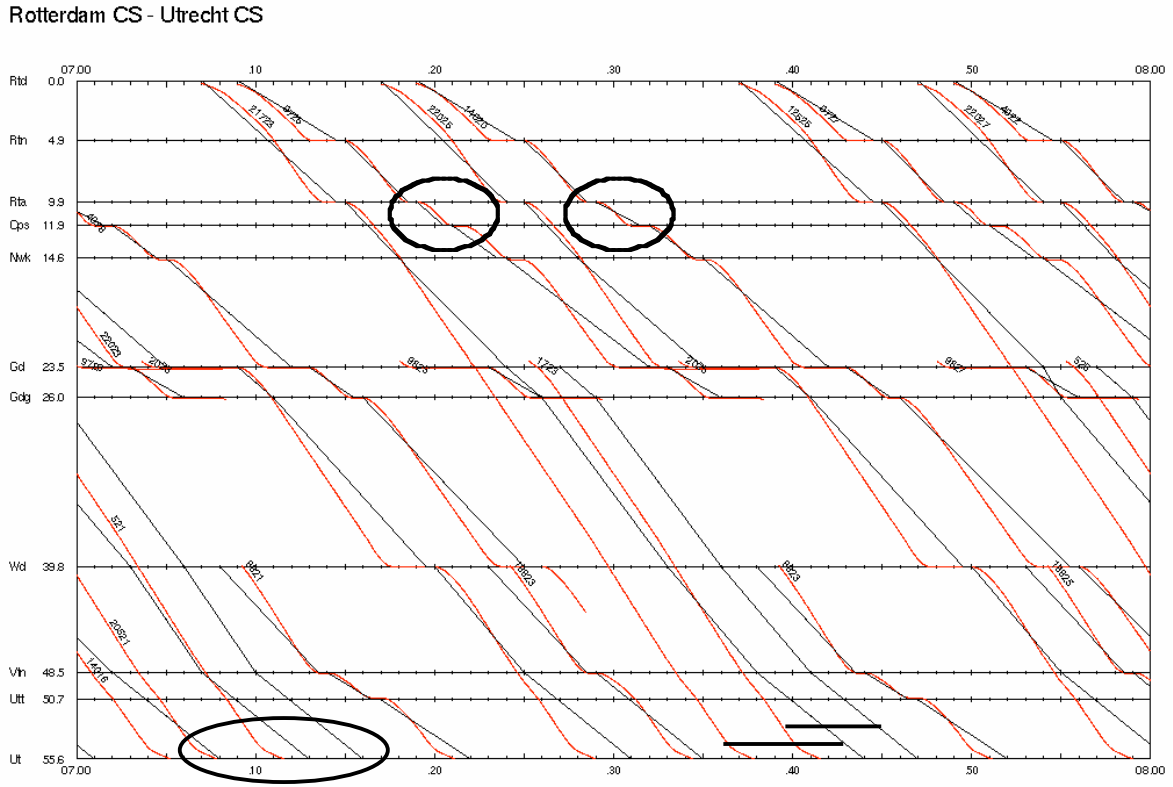
- MSc project P. Vorage (2006)
- In cooperation with ProRail (Traffic Control)
- Rotterdam/The Hague – Gouda – Utrecht
- Timetable 2005 and concept 2007



R
IR
IC
Freight

Capacity analysis

- Minimal running times (100% performance) vs schedule (2005)
- Some unrealizable scheduled running times
- Varying running time supplements up to 25% (5:50, IC)



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Capacity analysis

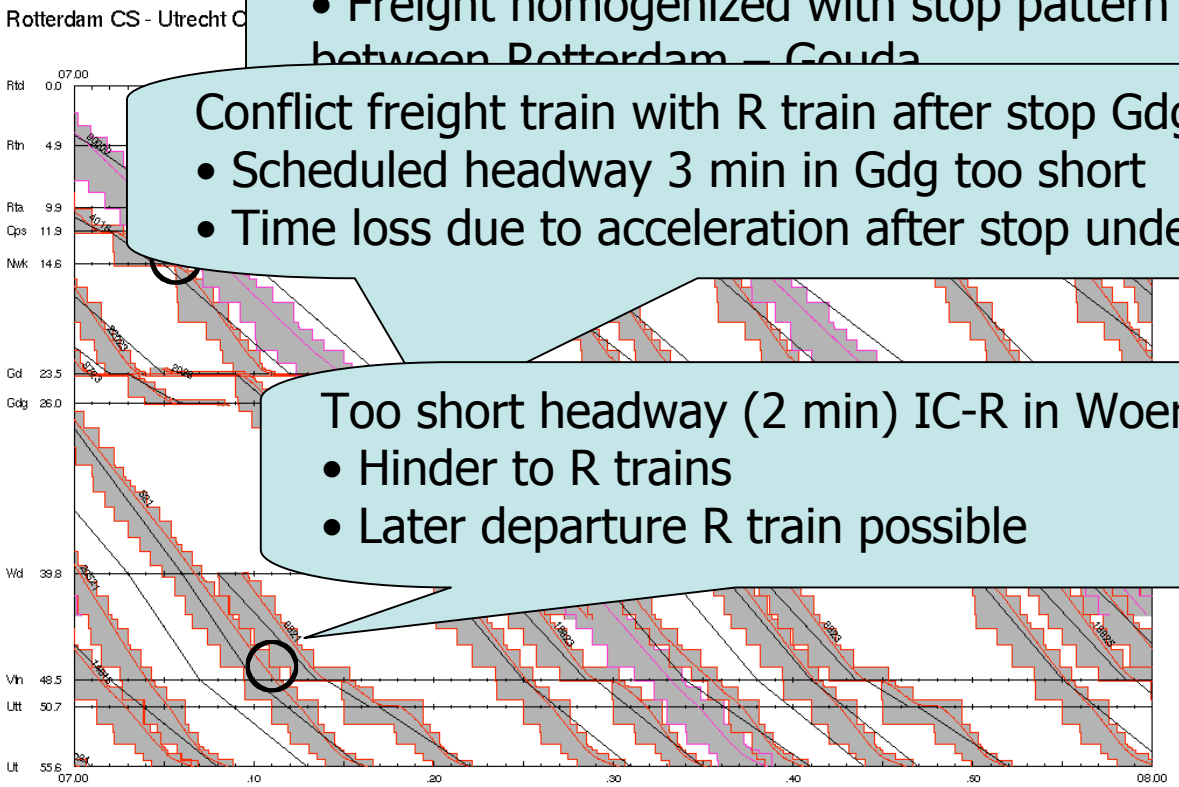
- Blocking time diagram (
- Short headways, smal
- ProRail issued c

Tight headway IC-R (2 min) in Rotterdam
• R accelerates quicker -> conflict in Rtn

Slow speed of freight train (61 km/h) due to R train
• Freight homogenized with stop pattern of R trains
between Rotterdam – Gouda

Conflict freight train with R train after stop Gdg
• Scheduled headway 3 min in Gdg too short
• Time loss due to acceleration after stop underestimated

Too short headway (2 min) IC-R in Woerden
• Hinder to R trains
• Later departure R train possible



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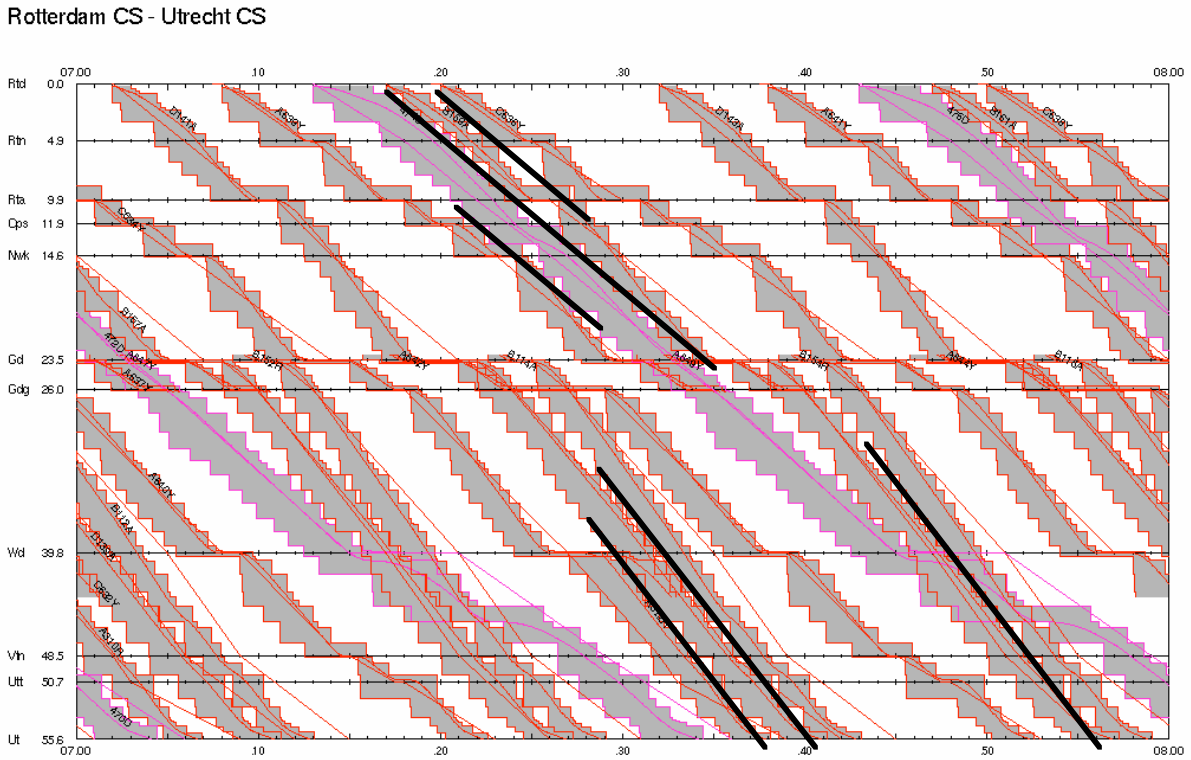
Capacity analysis

- Blocking time diagram (2007), on-time performance 85%
- Buffer time unevenly distributed
- Further homogenized traffic: IC's have excessive supplements



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Capacity analysis

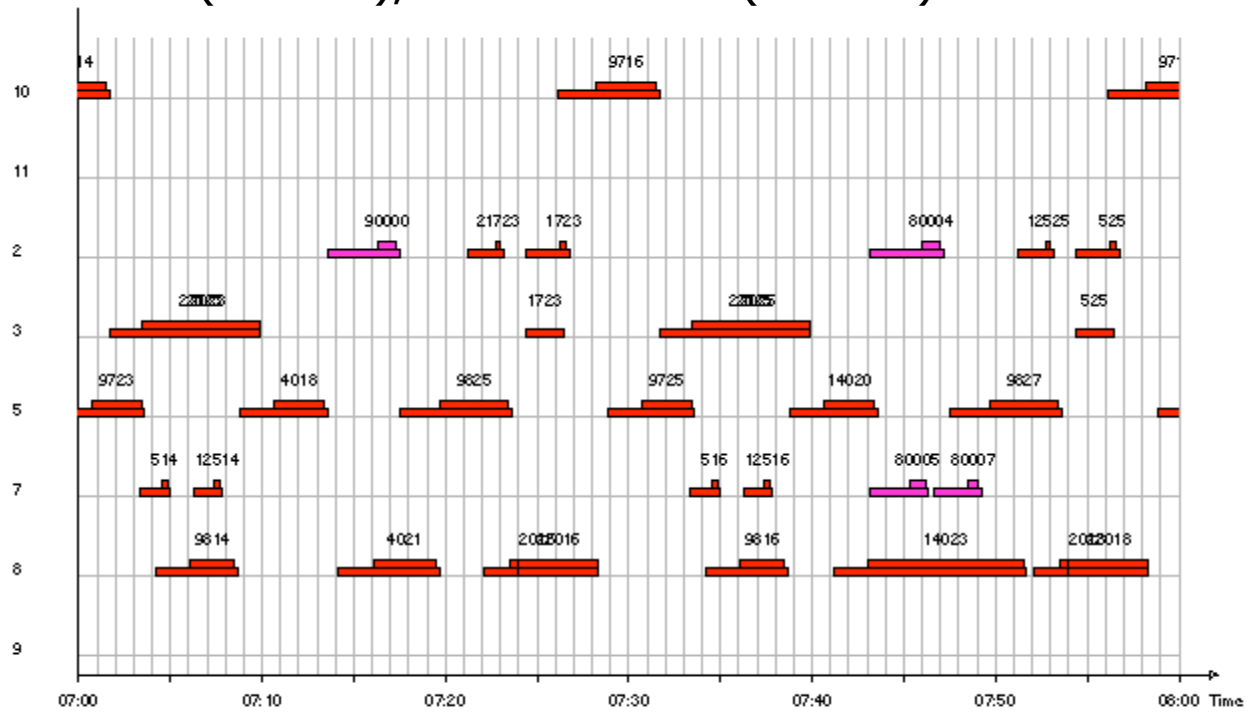
Comparison basic hour pattern 2005/2007

- Rotterdam-Gouda: equal train intensity but capacity decreased
  - Homogenization of traffic
- The Hague-Gouda: increased train intensity and capacity consumption
  - Changed traffic mix (2 IC, 2 IR, 2 R) to (4 IC, 4 R)
  - Increased running time differences due to removed stop from IC train (Voorburg) and added stop to R train (Ypenburg)
- Gouda-Utrecht: increased train intensity and capacity consumption

	2005			2007		
Line	Tr/h	Buffer (min)	Capacity consumption	Tr/h	Buffer (min)	Capacity consumption
Rtd-Gd	10	10	85%	10	14	75%
Gvc-Gd	6	28	45%	8	12	80%
Gd-Ut	12	16	75%	14	12	80%

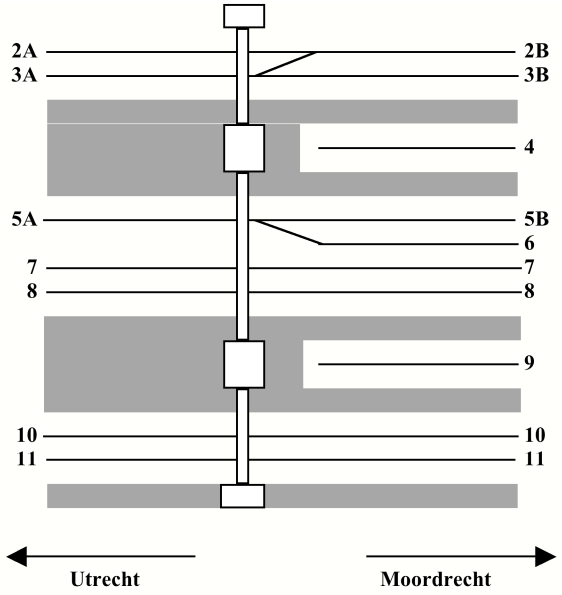
Platform capacity consumption Gouda

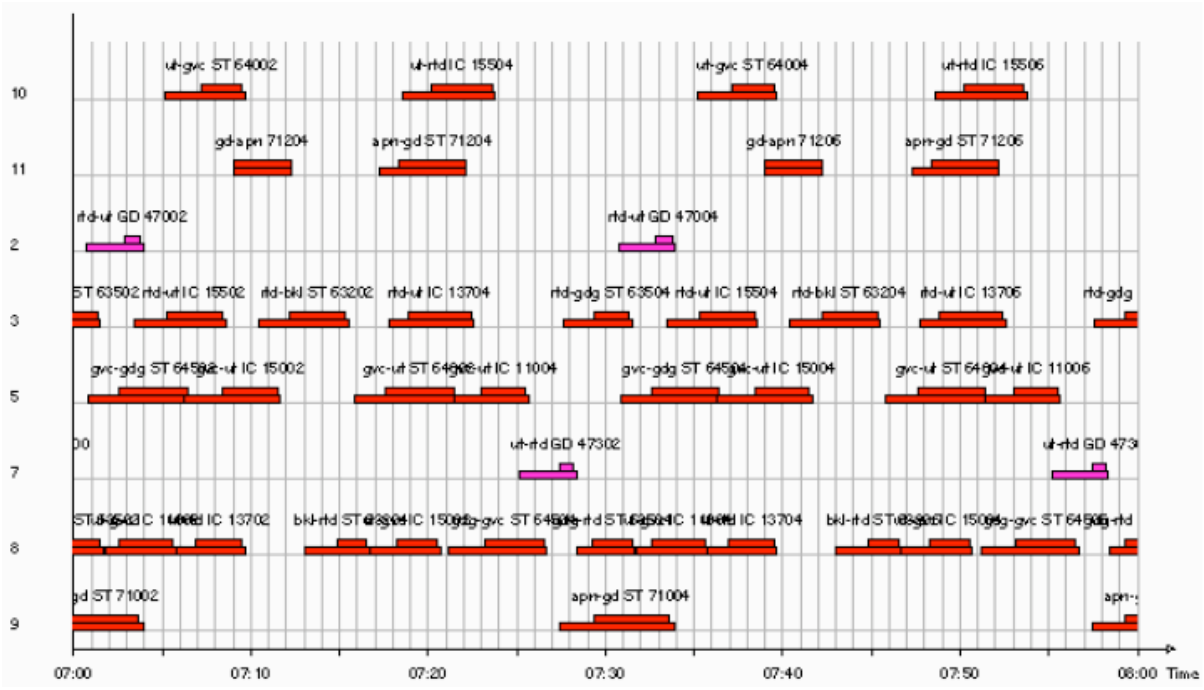
- Timetable 2005
- Platform track occupation (upper) and blocking time (lower)
- Capacity consumption up to 60%
  - Platform track 8: 60% (6 trains), track 10: 20% (2 trains)



Platform capacity consumption Gouda

- Timetable 2007 (concept)
- Blocking time conflicts at platform tracks
- Uneven capacity consumption on tracks 8 (12 trains) and 10 (4 trains)





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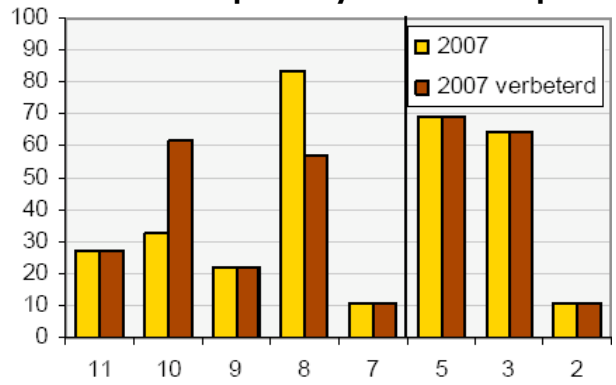
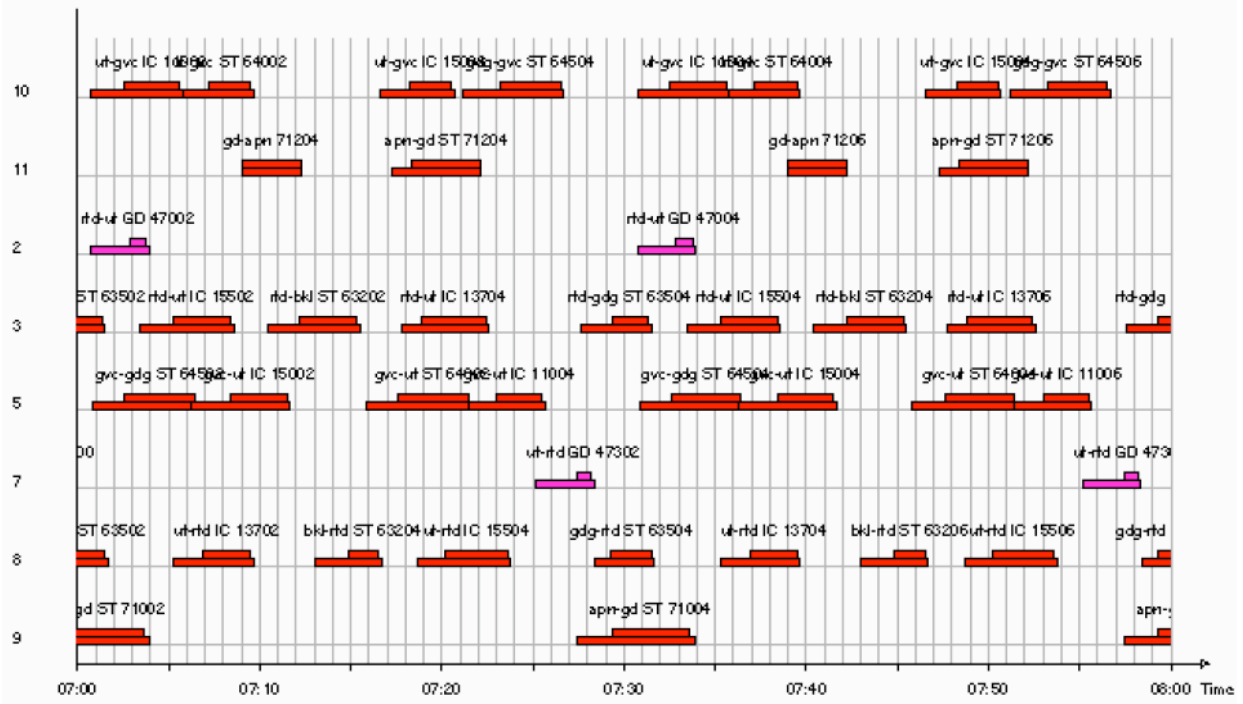
Platform capacity consumption Gouda

- Timetable 2007 (improved)
- Proposed adjusted allocation of platform 8 and 10
  - Platform 8: all 8 trains to Rotterdam
  - Platform 10: all 8 trains to The Hague

Platform capacity consumption





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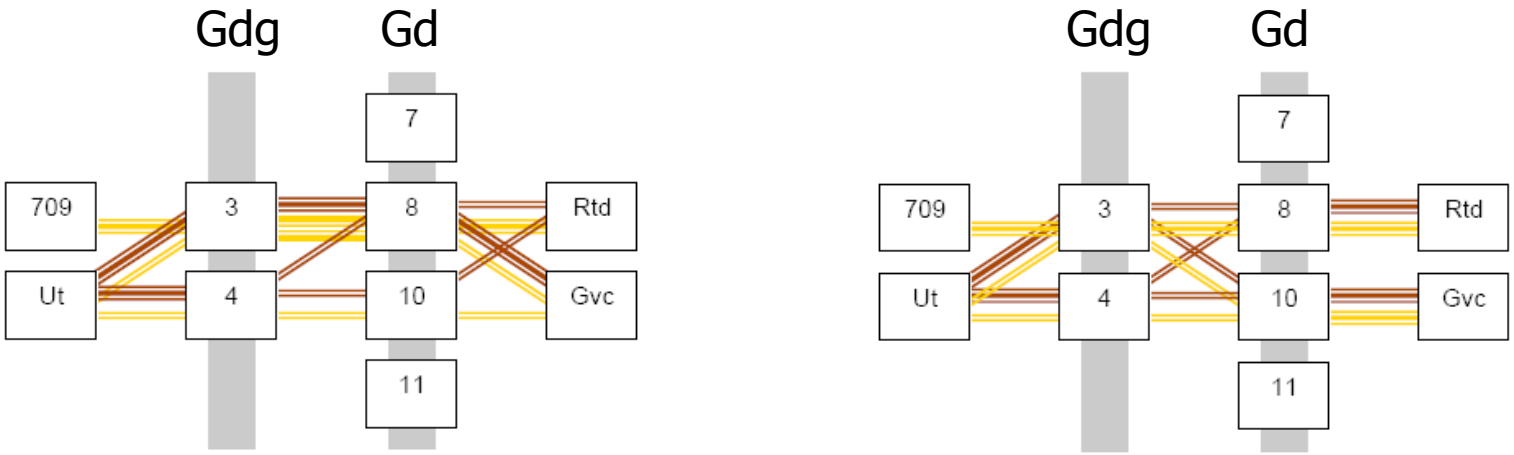
Platform capacity consumption Gouda

- Proposed adjusted routing and crossings Gouda Goverwelle (Gdg) and Gouda (Gd)



- Actual adjusted platform allocation (2007):
  - Platform 8: 10 trains (6 to Rotterdam, 4 to The Hague)
  - Platform 10: 6 trains (2 to Rotterdam, 4 to The Hague)

Dynamic railway traffic management

- MSc project M. van Dijk (2006)
- In cooperation with ProRail (Railway Development)
- Utrecht – 's Hertogenbosch
- Timetable 2004 and future heavy traffic corridor model (6 IC + 6 R)

- Comparison of combinations of strategies
  - Infrastructure: number of overtaking locations
  - Planning: conventional versus recovery time savings
  - Control: order at overtaking locations (FCFS, FOFS)
- Multiple simulation required
  - Validation of initial delay and running time distributions

Validation

Reference situation

- Timetable 2004

Realization data (from train describer records)

- Departure delays input station (Utrecht)
- Running times Utrecht – s' Hertogenbosch (including stops)
- Arrival delays output station 's Hertogenbosch (sum of the above)

Validation procedure

- Fit departure delay distribution input station (initial delays)
- Tune unhindered running times w.r.t. realization data
- Tune running of all trains

Validation

Tuning parameters (per train category)

- Initial delay
  - Delay probability
  - Mean delay (exponential distribution)
  - Maximum delay
- Running time
  - Delayed performance parameter (technical minimum running time)
  - On-time performance parameter (mean running time)
  - Scheduled arrival, departure and through times (delay measurements)
- Dwell time
  - Delay probability
  - Mean delay (exponential distribution) (per stop)
  - Maximum delay

Validation regional trains

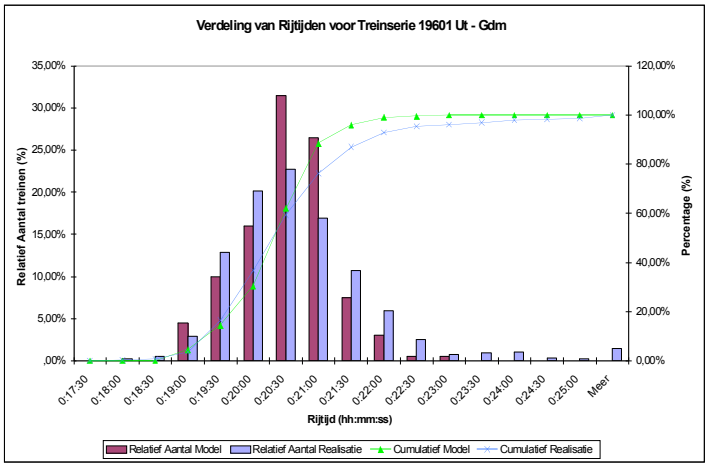
Running time (R 19600)

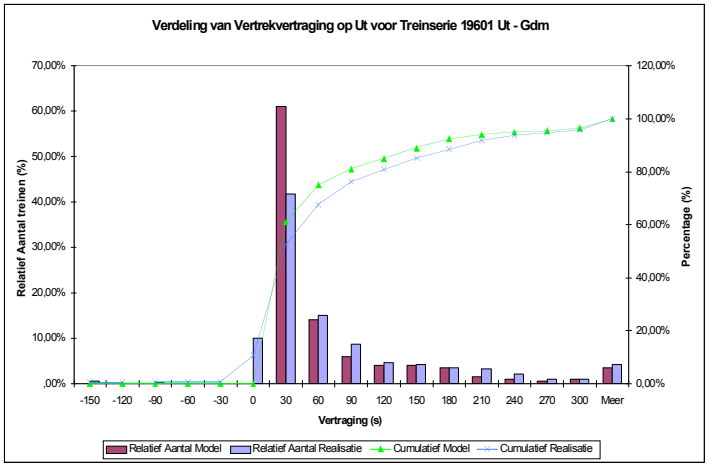
- Delayed performance parameter
  - Technical minimum running time
- On-time performance parameter
  - Mean running time
- Dwell times
  - Minimum dwell time
  - Delay probability
  - Mean delay (exponential distribution)

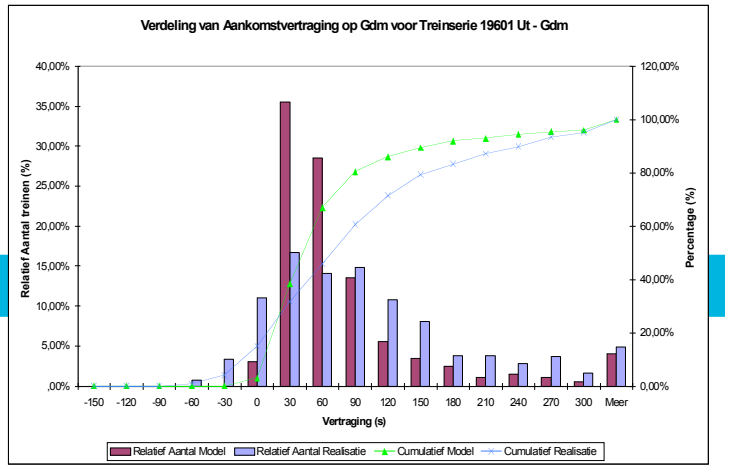
Initial delay

- Straight-forward parameter estimates

- Good fits between model and realizations







Validation IC trains

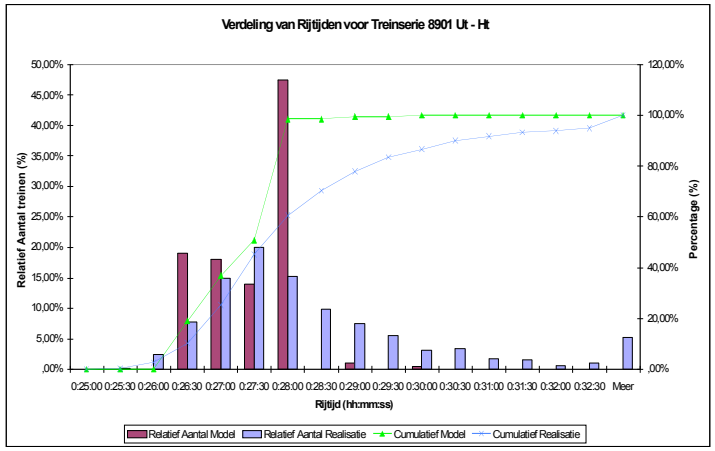
Running time (IC 8/900)

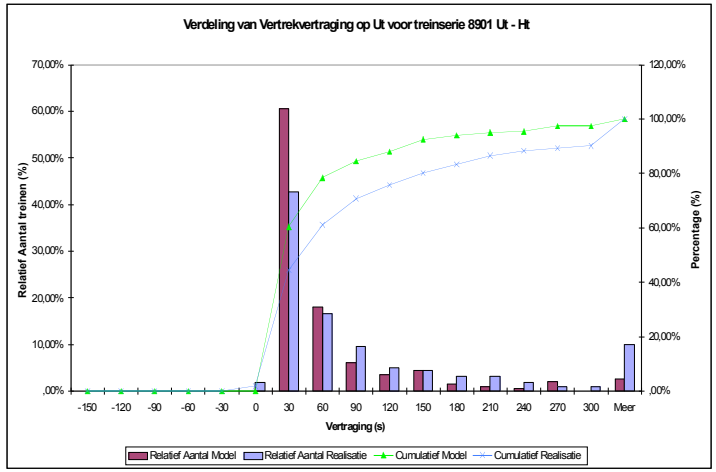
- Delayed performance parameter
  - Technical minimum running time
- On-time performance parameter
  - Mean running time
- No intermediate dwell times!
- Scheduled through times
  - Move between delayed/on-time running

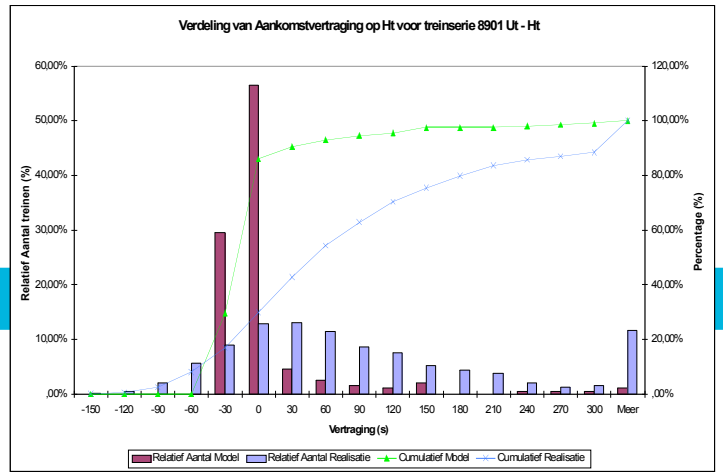
- Difficult to smooth the two modes corresponding to delayed/on-time running

New feature (not yet in study)

- Performance distributions
  to model stochastic driver behaviour







Validation (all trains)

- Reference timetable 2004
- Varying values
- Delayed performance parameter 97%
- Mean dwell delay 20 s (for min dwell time 40 s)

	Intercity		Regional				
Train line	3500	8/900	6000	16000	19600	7101	7102
On-time perf. (%)	87	83	88	80	83	90	90
Delayed perf. (%)	97	97	97	97	97	97	97
Mean initial delay (s)	80	95	94	49	71	19	164
Max initial delay (s)	1600	1800	1500	1200	900	1500	1300
Prob. initial delay (%)	60	60	65.5	46	49	31	97
Min dwell time (s)	-	-	40	40	40	60	40
Mean dwell delay (s)	-	-	20	20	20	0	20

Comparing strategies

Traffic

- Timetable 2004 (4 IC + 4 R)
- Heavy traffic corridor (6 IC + 6 R)

Planning

- Conventional feasible timetable
- Saving recovery times (regional trains depart as early as possible)

Control (order at overtaking locations)

- First Come First Served (FCFS)
- First Out First Served (FOFS)
  - The train that will first reach the next overtaking location goes first

Infrastructure

- Number of overtaking locations
  - Houten, Geldermalsen, Zaltbommel at about ¼, ½ and ¾ distance
  - In reference timetable 2004 Geldermalsen is overtaking station

Comparing strategies (results)

Performance criteria

- Running times
- Capacity consumption
- Number of route conflicts (restricted signals, safety)

Timetable 2004

- Saving of recovery times + FOFS
- Overtaking in Geldermalsen sufficient

Heavy traffic (6 IC + 6 R)

- Saving of recovery times + FCFS + 2 overtaking locations (Ht, Gdm)

Conclusions

- New MSc project (start 1 February 2008)
  - Validation of OpenTrack
  - In cooperation with Movares railway consultancy

- Future intentions
  - Together with ProRail and Dutch railway consultancies
  - Automatic import from Dutch infrastructure database
  - Validated railway simulation tool