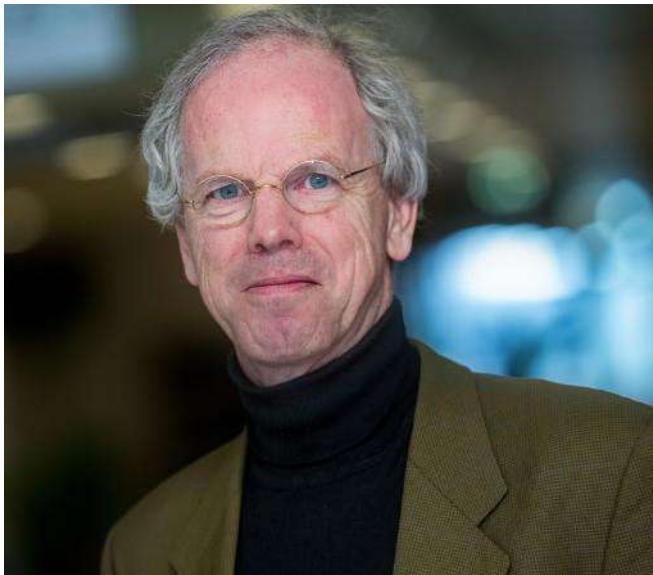


In Memoriam: Prof. dr. Leo Kroon (1958-2016)



PT Planning



Figure: 1.
Lineplan &
Network Design



Figure: 2.
Timetabling



Figure: 3.
Rolling Stock
Scheduling



Figure: 4. Crew
Scheduling

Major Disruptions



PT Planning & Disruption Management



Figure: 1.
Lineplan &
Network Design



Figure: 2.
Timetabling



Figure: 3.
Rolling Stock
Scheduling



Figure: 4. Crew
Scheduling

Reduce Delay

Increase capacity



- ▶ RS may take long to arrive
- ▶ Limited Flexibility

Balance passenger flows



- ▶ Detours better than capacity bottlenecks
- ▶ Advice for Uncertainty

Better Alternatives: Advice to Passengers



Advice

A specific route provided origin station, destination station, and departure time

Better Alternatives: Advice to Passengers

Concept:

- ▶ Alternative is a route
- ▶ Customized to origin, destination, and departure time of passenger

Context:

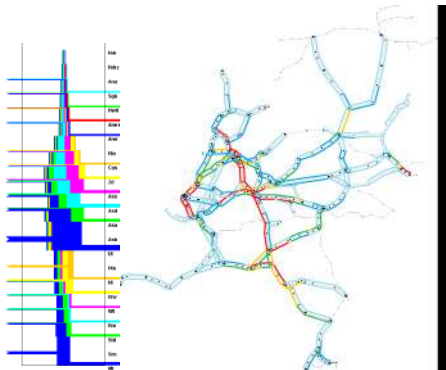
- ▶ Major Disruptions
- ▶ Uncertain Duration
- ▶ Capacity Shortages

Objective:

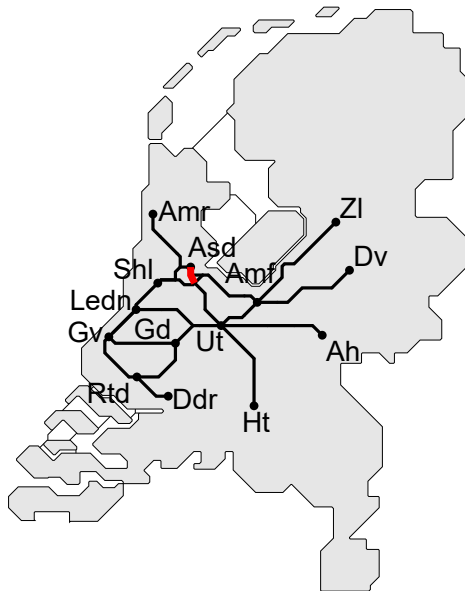
- ▶ Minimize Passenger Delay (Inconvenience)



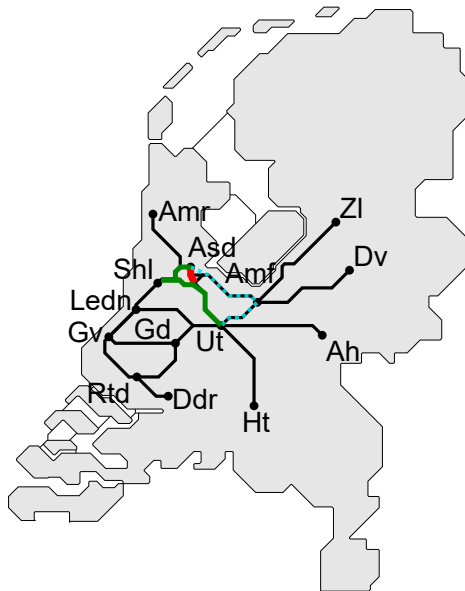
Passenger Route Choice and the OV-chipcard



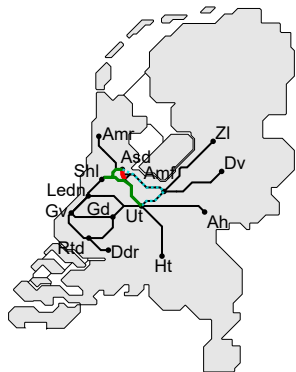
Disruption Amsterdam - Utrecht



Disruption Amsterdam - Utrecht



Disruption Amsterdam - Utrecht



Shortest Alternative

From Asd	To Shl	From Shl	To Ut
15:59	16:12	16:14	16:47
16:11	16:27		
16:29	16:42	16:44	17:17
16:41	16:57		
16:59	17:12	17:14	17:47

Second Alternative

From Asd	To Amf	From Amf	To Ut
16:27	17:04	17:11	17:28
		17:24	17:39
16:57	17:34	17:41	17:58
		17:54	18:09

Disruption Amsterdam - Utrecht: Advice to avoid bottleneck

Passenger flows without advice (No) and with advice (Yes) to travel through Amf and avoid bottleneck at Shl.

From Asd	To Shl	Nr. Passengers		Cap Diff	From Shl	To Ut	Nr. Passengers		Cap Diff
		No	Yes				No	Yes	
15:59	16:12	406			16:14	16:47	670		
16:11	16:27	1140							
16:29	16:42	1490			16:44	17:17	1694		
16:41	16:57	1011							
16:59	17:12	1144			17:14	17:47	1419		
Asd	Amf	No	Yes	Diff	Amf	Ut	No	Yes	Diff
16:27	17:04	580			17:11	17:28	299		
					17:24	17:39	334		
16:57	17:34	722			17:41	17:58	228		
					17:54	18:09	355		

at capacity, more passengers, less passengers

Disruption Amsterdam - Utrecht: Advice to avoid bottleneck

Passenger flows without advice (No) and with advice (Yes) to travel through Amf and avoid bottleneck at Shl.

From	To	Nr. Passengers		Cap	From	To	Nr. Passengers		Cap
Asd	Shl	No	Yes	Diff	Shl	Ut	No	Yes	Diff
15:59	16:12	406		0	16:14	16:47	670		-572
16:11	16:27	1140		0					
16:29	16:42	1490		0	16:44	17:17	1694		0
16:41	16:57	1011		0					
16:59	17:12	1144		+572	17:14	17:47	1419		+242
Asd	Amf	No	Yes	Diff	Amf	Ut	No	Yes	Diff
16:27	17:04	580		0	17:11	17:28	299		0
					17:24	17:39	334		0
16:57	17:34	722		0	17:41	17:58	228		0
					17:54	18:09	355		0

at capacity, more passengers, less passengers

Disruption Amsterdam - Utrecht: Advice to avoid bottleneck

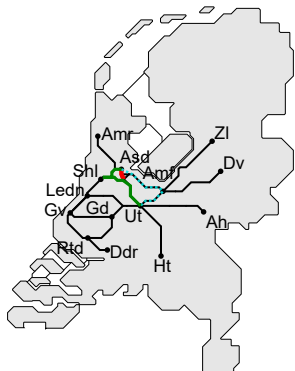
Passenger flows without advice (No) and with advice (Yes) to travel through Amf and avoid bottleneck at Shl.

From	To	Nr. Passengers		Cap	From	To	Nr. Passengers		Cap
Asd	Shl	No	Yes	Diff	Shl	Ut	No	Yes	Diff
15:59	16:12	406	406	0	16:14	16:47	670	670	-572
16:11	16:27	1140	969	0					
16:29	16:42	1490	1336	0	16:44	17:17	1694	1690	0
16:41	16:57	1011	1011	0					
16:59	17:12	1144	1208	+572	17:14	17:47	1419	1774	+242
Asd	Amf	No	Yes	Diff	Amf	Ut	No	Yes	Diff
16:27	17:04	580	905	0	17:11	17:28	299	623	0
					17:24	17:39	334	334	0
16:57	17:34	722	837	0	17:41	17:58	228	343	0
					17:54	18:09	355	355	0

at capacity, more passengers, less passengers

Disruption Amsterdam - Utrecht

Uncertain disruption duration

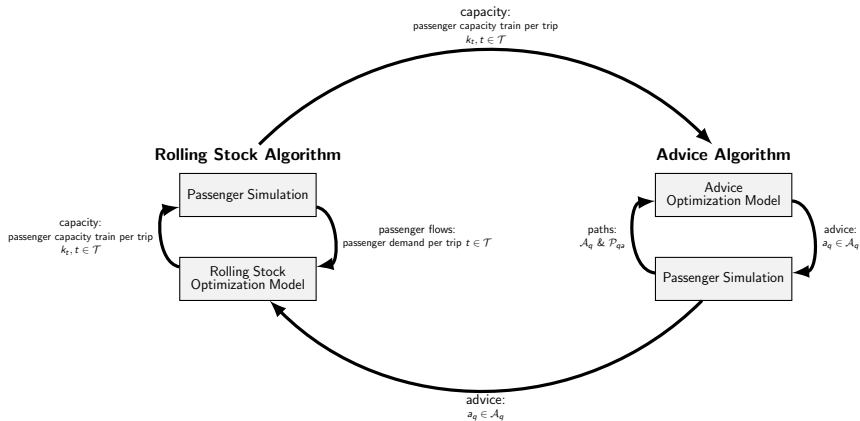


Uncertain Disruption Length:

- ▶ Passengers: detour or wait?
- ▶ Experiments: No advice has bottlenecks both with correct and wrong estimation of duration!

Method

Solution Approach



Advice

Advice is recommended path:

- ▶ Only passengers affected by the disruption receive advice
- ▶ Advice paths are constructed to be *attractive*
- ▶ Solutions are evaluated under assumption not all passengers follow advice

More details: van der Hurk, E, L.G Kroon, G. Maróti. *Passenger Advice and Rolling Stock Rescheduling under Uncertainty for Disruption Management*, Transportation Science. (to appear.)

Results

Experimental Design

- ▶ 5 Disruption locations (cases)
- ▶ Compare
 - ▶ *No advice* Kroon, Maróti & Nielsen, TS, 2014.
 - ▶ *With advice* (this research)

Name	Disruption
D1	Rotterdam (Rtd) – The Hague (Gvx)
D2	Gouda (Gd) – Utrecht (Ut)
D3	Utrecht (Ut) and Amersfoort (Amf)
D4	The Hague (Gvx) – Leiden (Ledn)
D5	Amsterdam (Asd) – Utrecht (Ut)



Passenger Guidance and Rolling Stock Rescheduling

Table: Lower is better. Gap (%) from lower bound

Case	No Advice (r)	Advice (r)		
		$\phi = 1$	$\phi = \text{logit}$	$\phi = 0$
D1	8.33	8.17	8.18	8.35
D2	35.6	16.51	26.39	31.22
D3	6.55	5.31	5.67	6.89
D4	8.86	5.98	6.20	6.68
D5	92.5	10.10	19.21	23.66

Improvement due to:

- ▶ Reduction in worst-case delays
- ▶ Reduction in number of affected passengers

Disruption locations: Small and Large Improvement

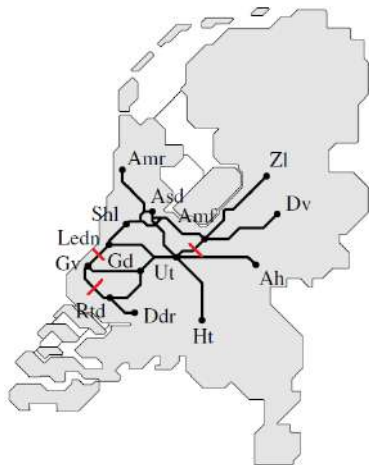


Figure: Small improvement

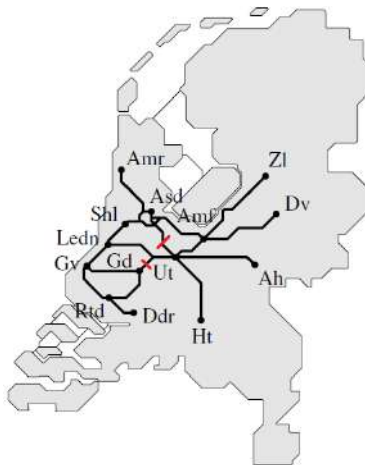


Figure: Large Improvement

Computation Time (in minutes)

Case	Full		Rolling Stock Algorithm It.		Advice Algorithm It.		Passenger Simulation	
	Mean	Max	Mean	Max	Mean	Max	Mean	Max
D1	4.33	4.45	1.03	1.11	0.49	0.69	0.03	0.03
D2	10.55	11.59	2.01	2.08	2.11	2.33	0.11	0.18
D3	4.96	5.15	1.09	1.11	0.71	0.79	0.03	0.03
D4	5.05	5.22	1.11	1.24	0.75	0.76	0.03	0.03
D5	7.58	8.45	1.65	1.77	1.65	1.93	0.05	0.17

Conclusions and Discussion

Conclusions

Providing personalized travel advice...

- ▶ Reduces passenger inconvenience
 - ▶ average delay
 - ▶ worst case delay
 - ▶ number of affected passengers
- ▶ By:
 - ▶ warning for capacity shortages
 - ▶ integrating rolling stock rescheduling and advice
 - ▶ (warning for uncertain disruption duration)
- ▶ Solutions also good when not all passengers follow the advice
- ▶ Solutions can be found reasonably fast



<http://www.robustrails.man.dtu.dk>

<http://www.iptop.transport.dtu.dk>

<http://www.computr.eu>, evdh@dtu.dk

OR Spectrum, Public Transport, Transportation Science,
Transportation Research Part A-E