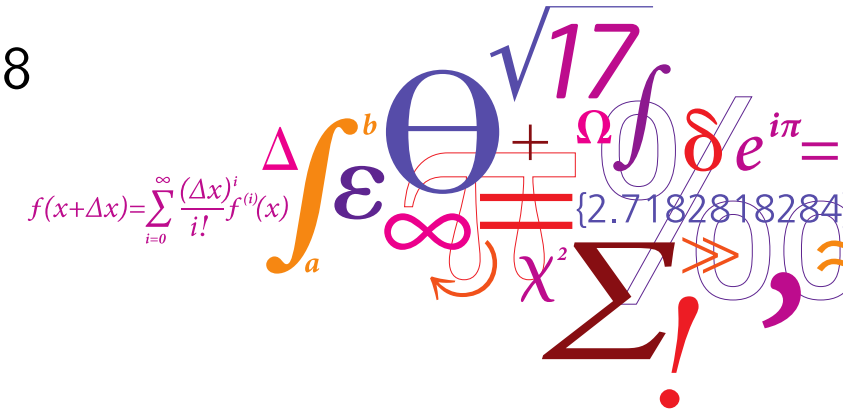
# Passenger focused disruption management

Evelien van der Hurk
DTU

28 March 2018




DTU Management Engineering
Department of Management Engineering

# Major Disruptions

# Classic Disruption Management

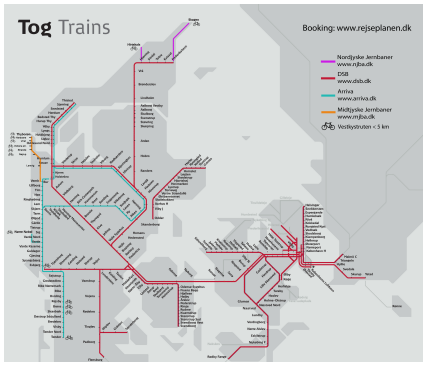



fig.: 1. Lineplan & Network Design

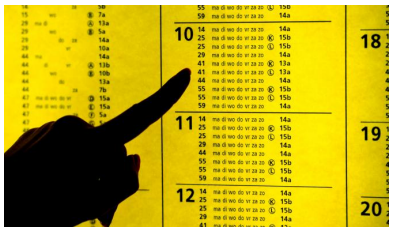
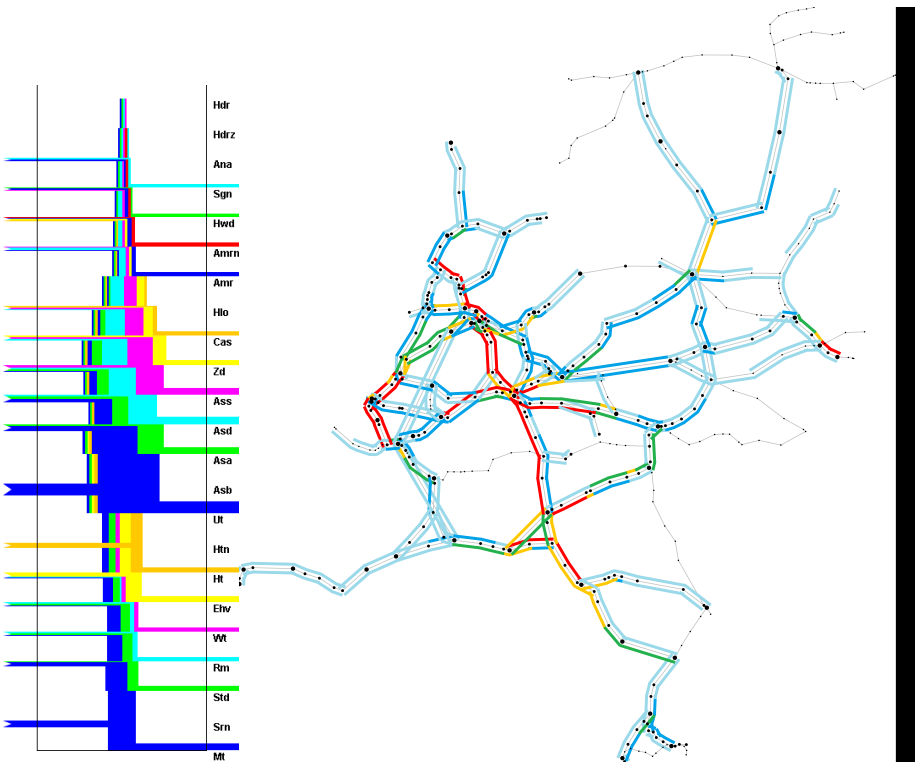


fig.: 2. Timetabling

fig.: 3. Rolling Stock Scheduling

fig.: 4. Crew Scheduling

# Passenger Route Choice and the smart card



# Passenger Oriented Disruption Management

- From focus on resources
- and restoring original plan

- To focus on passenger service
- and flexible employing resources using travel data

# Passenger Oriented Public Transport Planning at DTU

Some examples within the IPTOP project:


fig.: 1. Lineplan & Network Design for planned closures, designing alternative shuttle plans

fig.: 2. Integrated Timetabling and Vehicle Scheduling for better transfers, with dynamic passenger route choice

fig.: 3. Estimating multi-modal OD matrices and passenger route choice from multiple data sources (with Rapidis)

# Today's Example: Advice to Passengers during Disruptions


## Advice

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

# Advice to Passengers during Disruptions

Concept:

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

Context:

- Major Disruptions
- Uncertain Duration
- Capacity Shortages

Objective:

- Minimize Passenger Delay (Inconvenience)


# Uncertain disruption duration

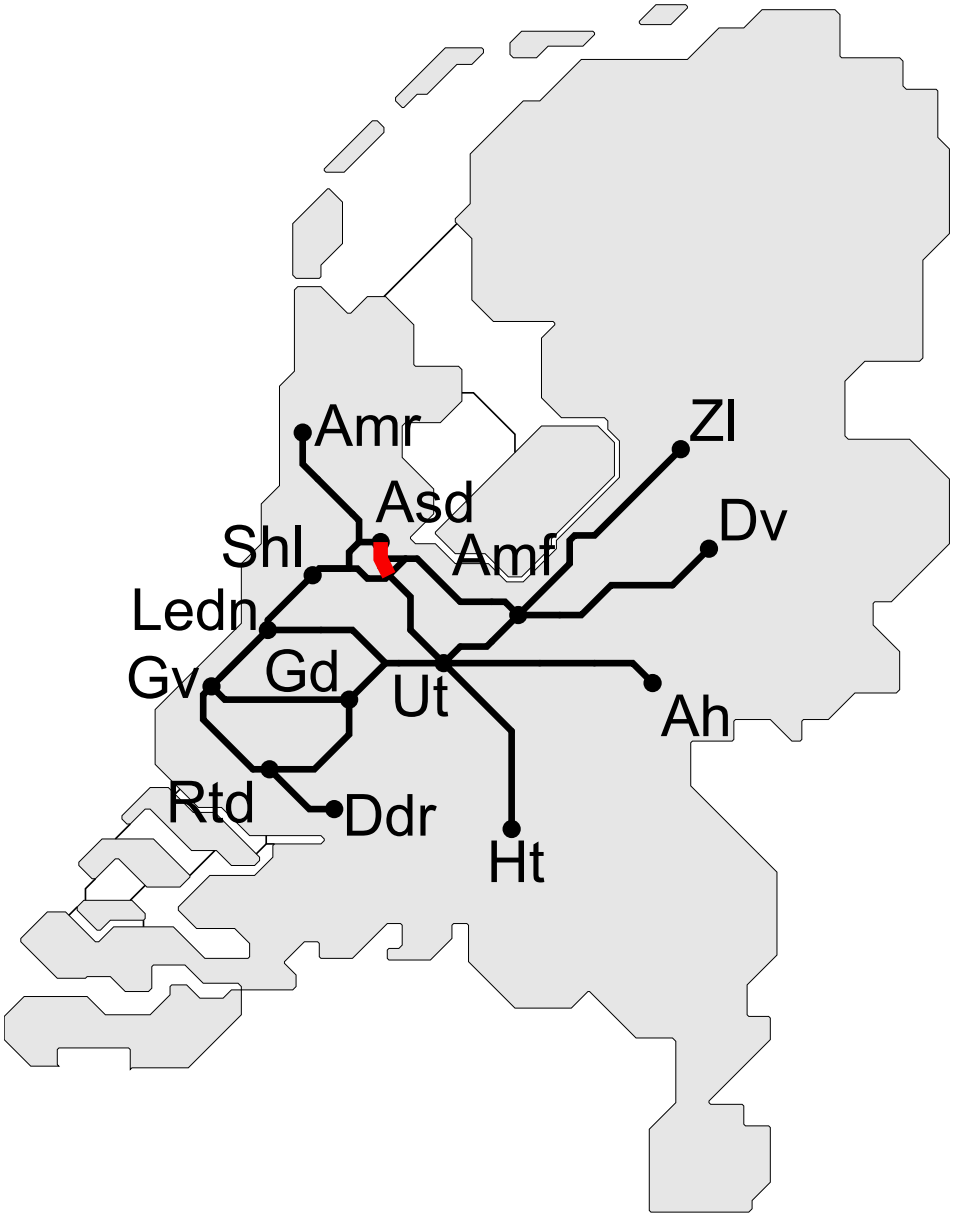
**Stage I** Start disruption: discrete set of scenarios (S,M,L) available
At time $t$ the true disruption length will be revealed

**Stage II** Time $t$: true disruption length revealed
update rolling stock schedule and passenger information

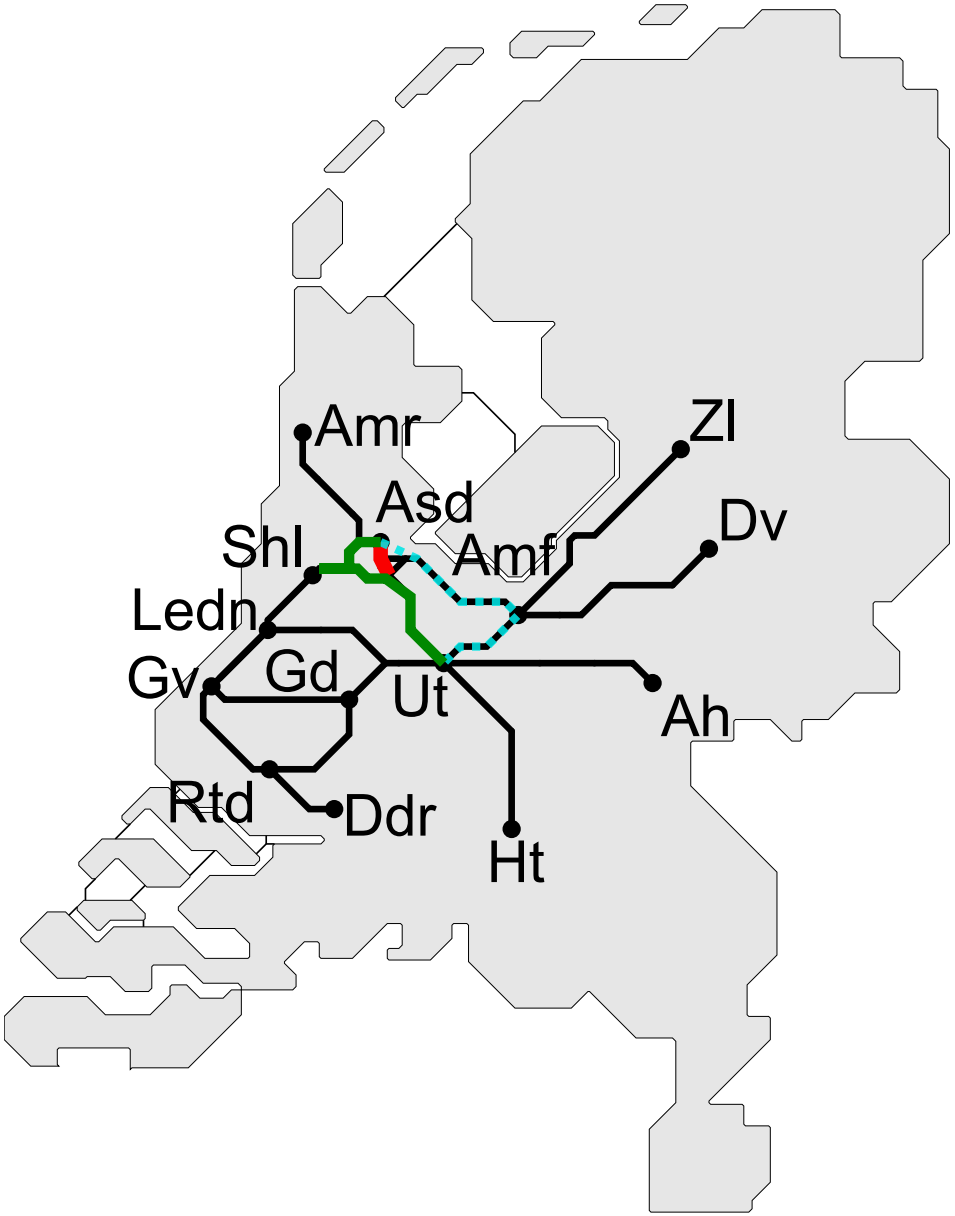
## Objective

- Minimize expected passenger inconvenience in Stage 1

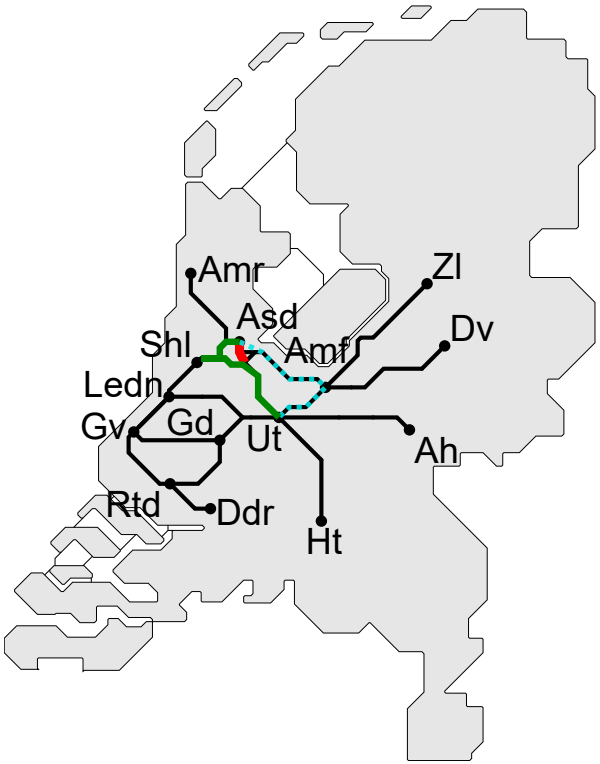
# Disruption Amsterdam - Utrecht



# 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 | | | |
|---|---|---|---|
| Asd | Amf | Amf | 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 No | Yes | Cap Diff | From Shl | To Ut | Nr. Passengers No | Yes | Cap Diff |
|---|---|---|---|---|---|---|---|---|---|
| 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.

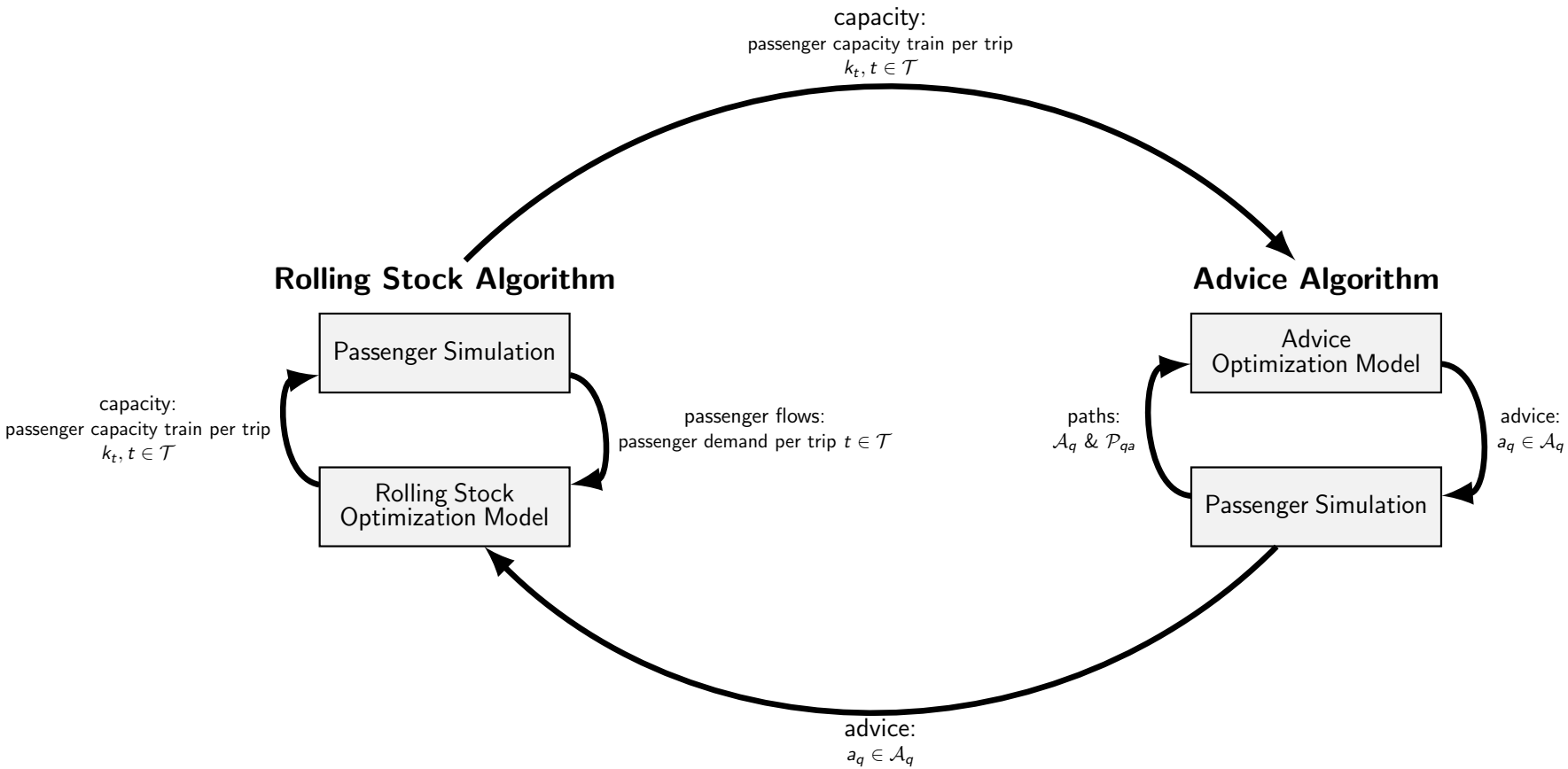
| From Asd | To Shl | Nr. Passengers No | Nr. Passengers Yes | Cap Diff | From Shl | To Ut | Nr. Passengers No | Nr. Passengers Yes | Cap Diff |
|---|---|---|---|---|---|---|---|---|---|
| 15:59 | 16:12 | 406 | 406 | 0 | 16:14 | 16:47 | 670 | 670 | -572 |
| 16:11 | 16:27 | 1140 | **969** | 0 | | | | | |
| 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**

# 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

# Advice Optimization

Solution: advised route for all passenger groups (ODt)
Decision variables

$y_{qa}$ advice $a$ provided to passenger group $q$ in all scenarios

$x_{qp}$ passenger group $q$ assigned to realized path $p$

## Advice Optimization

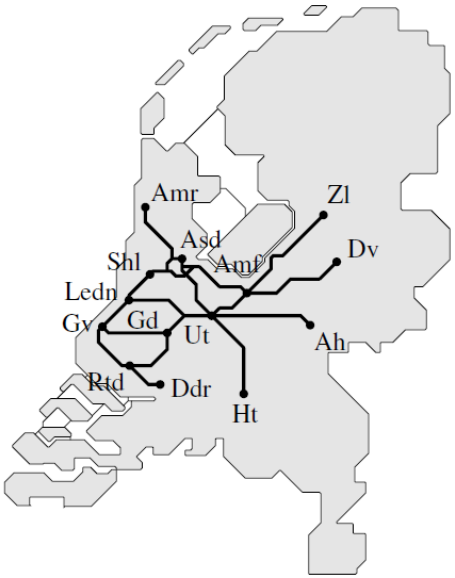
| | |
|---|---|
| Objective | Minimize expected passenger inconvenience over all disruption scenarios |
| Constraints | - Select one advice per passenger group<br>- Assign all passengers to realized paths, belonging to the selected advice<br>- Assign passengers such that the demand per trip does not exceed the capacity |

# 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 ($r$) | | | |
|---|---|---|---|---|---|
| | | $\phi = 1$ | $\phi =$logit | $\phi = 0$ | max improvement |
| D1 | 8.33 | 8.17 | 8.18 | 8.35 | **-0.16** |
| D2 | 35.6 | 16.51 | 26.39 | 31.22 | **-19.1** |
| D3 | 6.55 | 5.31 | 5.67 | 6.89 | **-1.24** |
| D4 | 8.86 | 5.98 | 6.20 | 6.68 | **-2.88** |
| D5 | 92.5 | 10.10 | 19.21 | 23.66 | **-82.4** |

Improvement due to:

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

# Disruption locations: Small and Large Improvement

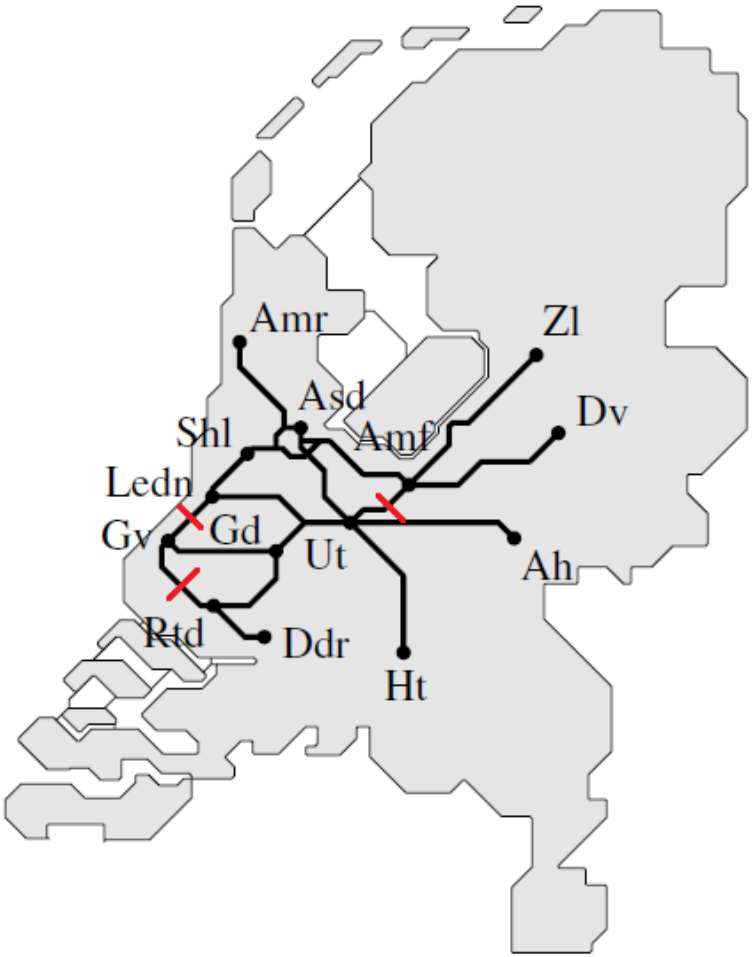



fig.: Small improvement

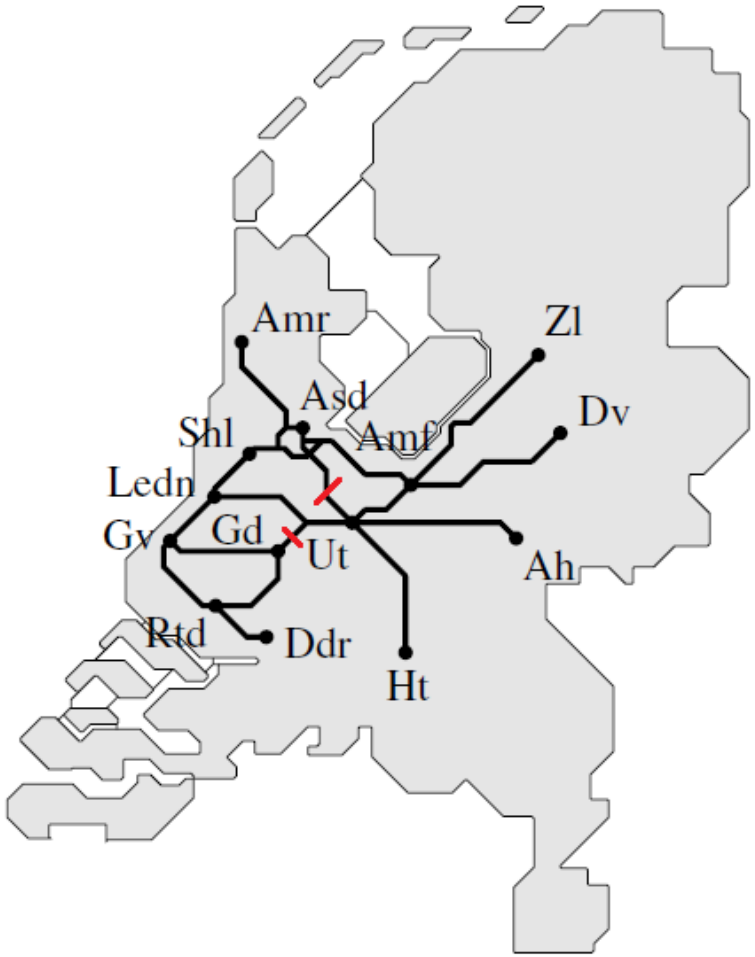



fig.: Large Improvement

# 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

## Passenger Oriented Disruption Management

Travel data opens op new opportunities for better passenger service

Example personalized travel advice:

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


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.)

`http://www.robustrails.man.dtu.dk`

`http://www.iptop.transport.dtu.dk`

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