Modal Choice- How to make the right decision?

A light rail perspective

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UITP INDIA
SEMINAR ON URBAN RAIL NETWORK – BUILDING SUSTAINABLE CITIES

December 2018

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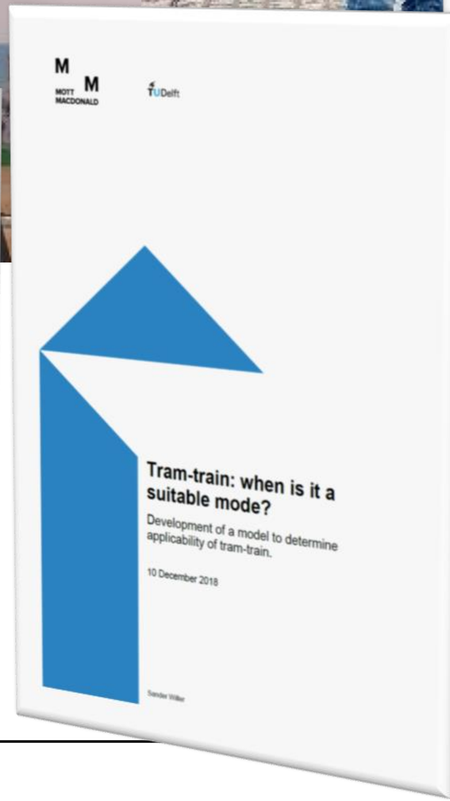
INCREASE REVENUE
Big data supports light rail in Utrecht
Written by Niels van Oort
Transport planners are starting to consider how "big data" retrieved from pas
computers and mobile phones could improve the design of urban rail networ


Light Rail Explained
Better public transport
& More than public transport
EMTA


MOTT MACDONALD
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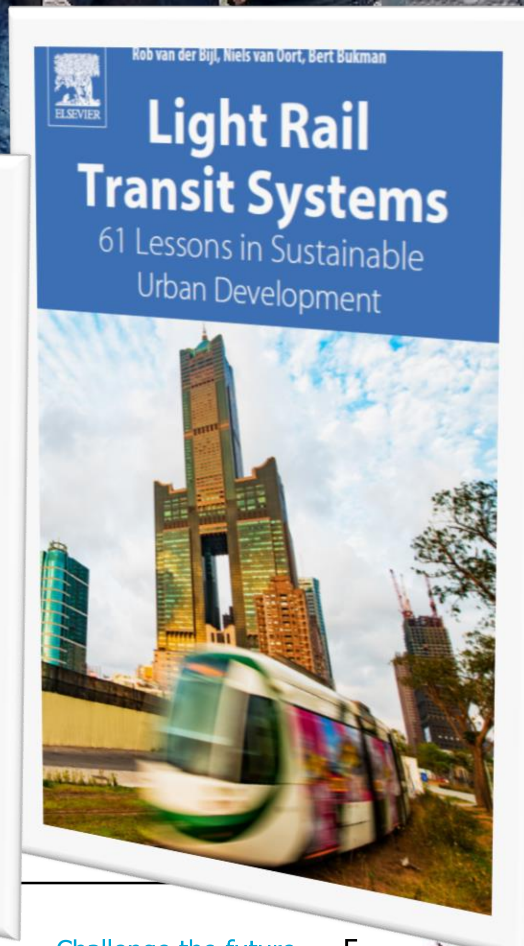
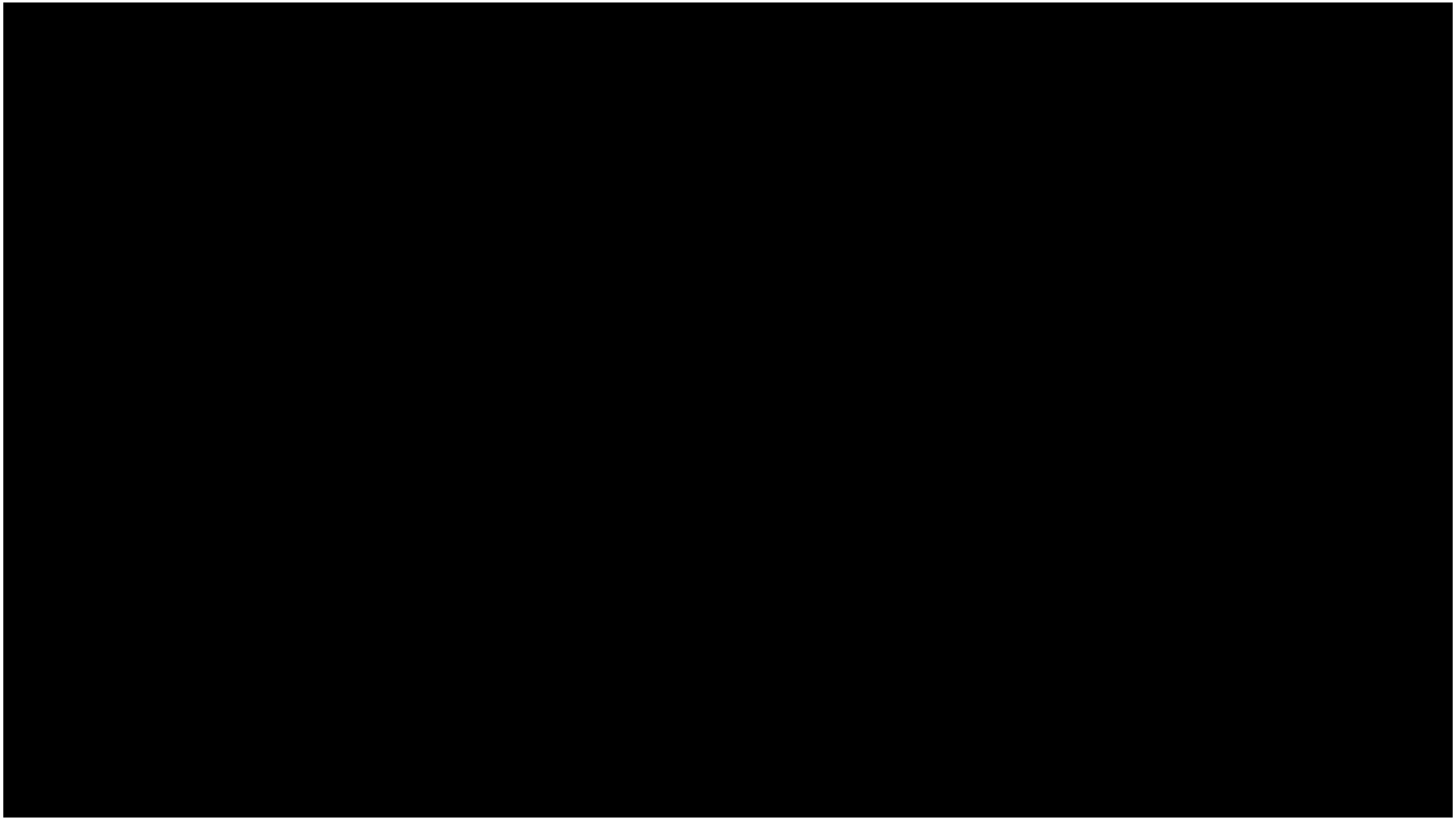
Tram-train: when is it a suitable mode?
Development of a model to determine applicability of tram-train.
10 December 2018


Rob van der Bijl, Niels van Oort, Bert Bukman
ELSEVIER
Light Rail Transit Systems
61 Lessons in Sustainable Urban Development

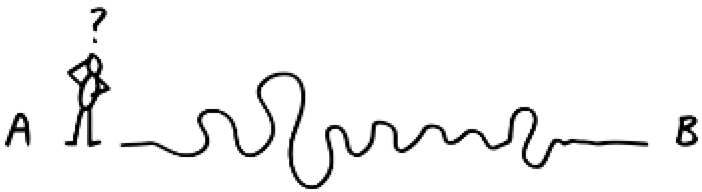

ELEKTRISCHE BUS
5599

Optimal mix of modes

- System choice: (Suburban) rail, metro, tram, bus, ferry,…
- All needed, depending on context
- Integrated network
- Much debate:
  - BRT: Bus Rapid Transit
  - LRT: Light Rail Transit
  - MRT: Mass/Metro Rapid Transit



Objectives



Lessons learned: 61 cases

- Light rail has been successfully implemented in many urban regions worldwide.

- Several light rail projects were not that successful or even failed.

- There is much debate on the (societal) cost-benefit ratio of these systems.

General findings:
succes

Project conception

- Focus on 'why' the project (short term and long term);

Politics

- The timeframe of contracts for the project must be consistent with political timeframes;

Communication

- Residents and citizens must be involved in the project;

General findings:
failure

Project conception

- Too few project variants or alternatives. Solutions for a good project are often found in the combination of different alternatives.

Project organization

- Innovative public tendering (e.g. DBFMO and alike) comes with risks;

Politics

- Changing political climate;

Communication

- A technocratic attitude jeopardizes the project;

Justification of public transport

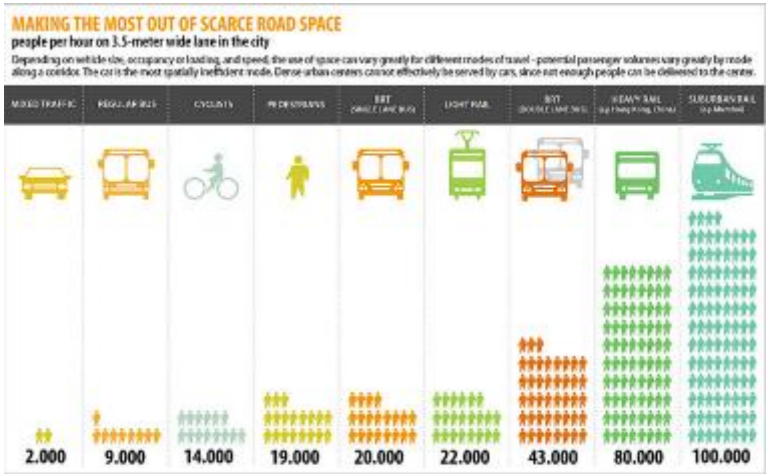
Framework of 5 E's

- Effective mobility
- Efficient city
- Environment
- Economy
- Equity

Van Oort et al. 2017

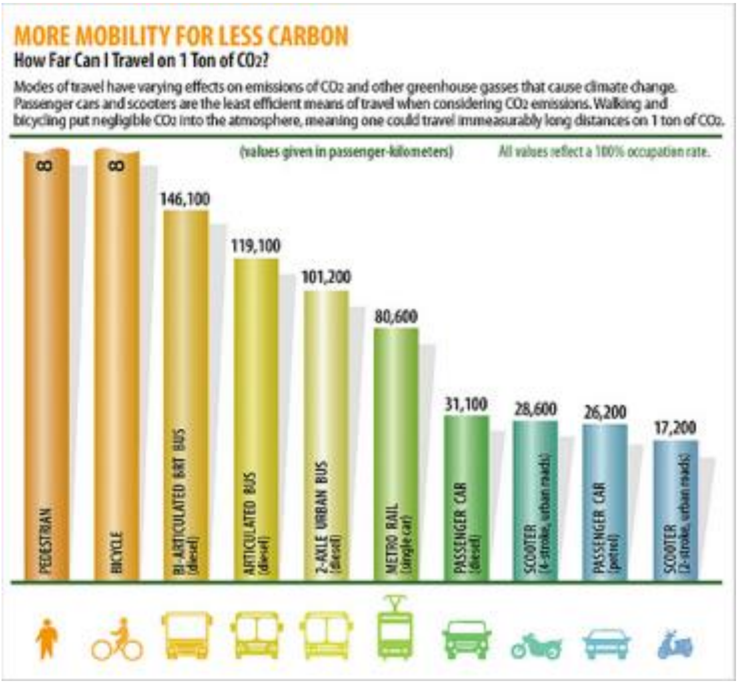
Efficient cities

- All kinds of (indirect) effects:
  - Urban planning & design
  - (Restructuring) the city
  - Quality of the city
  - Livability
  - Image & perception of the city



Environment

- More efficient regarding:
  - Energy consumption
  - (Direct) emissions
  - Land use
- Health



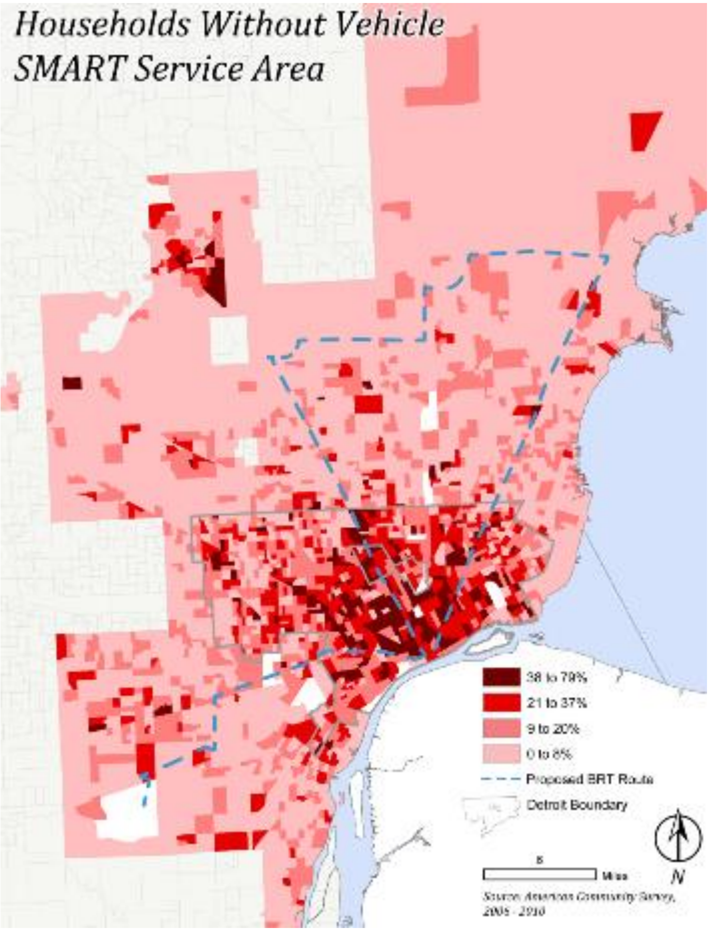
Economy

- Land value
- Real estate value
- Retail turnover & quality
- Employment
- Property development

	Increase due to high quality public transport accessibility	
Land value	+ 5%	+ 10%
House value	+ 2%	+ 5%

Equity

- Social access & connection:
  - Contra-segregation
  - Social mobility



Effective mobility

- Quality of service
  - Travel speed
  - Transfers
  - Service reliability
  - Robustness
  - Comfort
  - …

A

Light rail

19 minutes

B

Bus

15 minutes

C

Streetcar

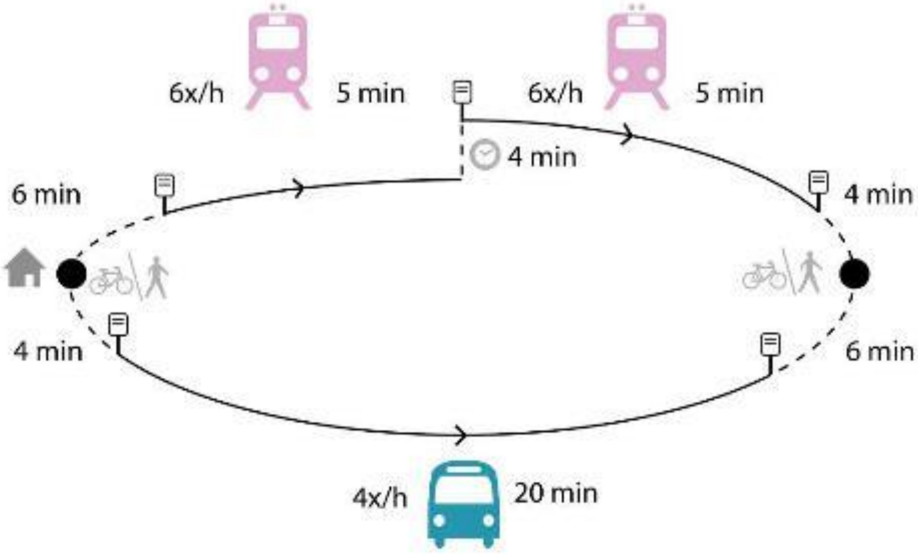
16 minutes

Rail bonus

- Research TU Delft (Bunschoten et al. 2013)
- Additional attractiveness of a rail system compared to a bus system with similar characteristics

Source	Result
Scherer (2011)	Slight pref. rail
Scherer (2009)	Slight pref. rail
Cain (2009)	Slight pref. rail
Bovy en Hoogendoorn-Lanser (2005)	Preference rail
Currie (2004)	Slight pref. rail
Ben Akiva (2002)	No difference
Welschen (2002)	0-10%
Kasch en Vogts (2002)	Preference rail
Megel (2001)	Slight pref. rail
Axhausen (2001)	Slight pref. rail
Berschin (1998)	+30%
Arnold en Lohrmann (1997)	+15%
Hüsler (1996)	+54%

Rail Bonus: approx. 5-15%



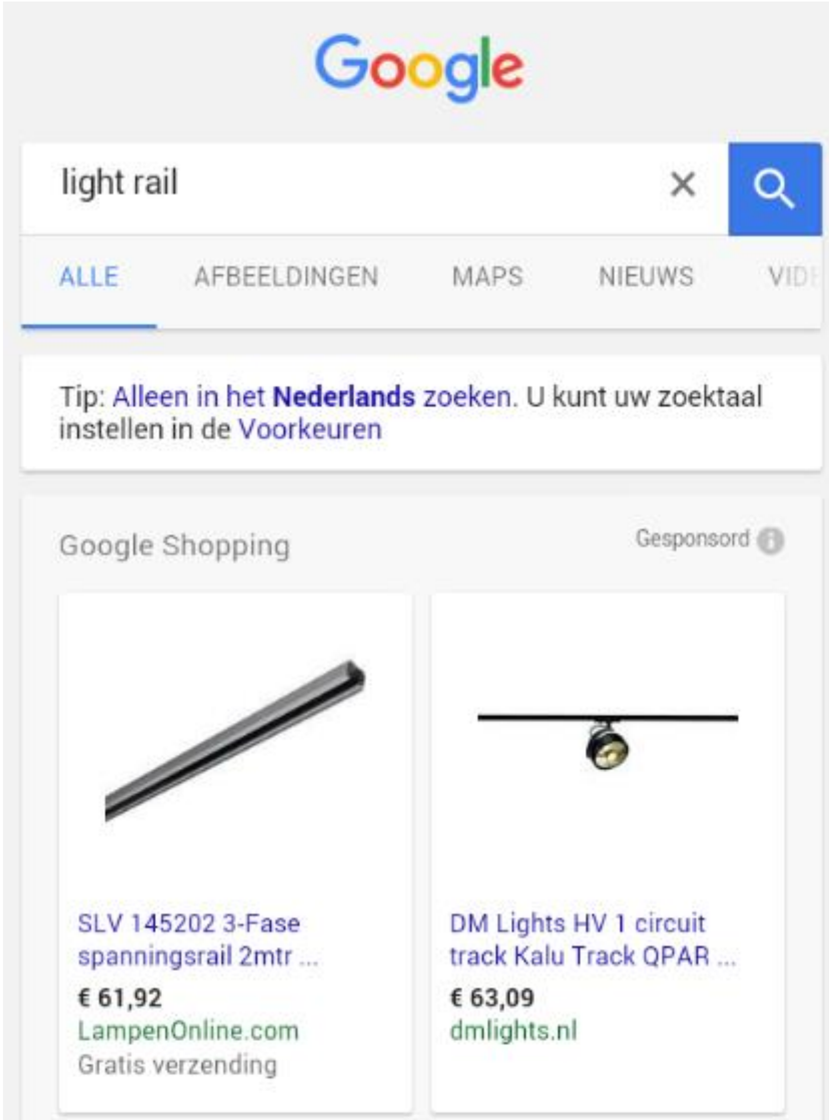
Light rail

A

B

C

D



Google
light rail
ALLE
AFBEELDINGEN
MAPS
NIEUWS
Tip: Alleen in het Nederlands zoeken. U kunt uw zoektaal instellen in de Voorkeuren
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Gesponsord
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€ 61,92
LampenOnline.com
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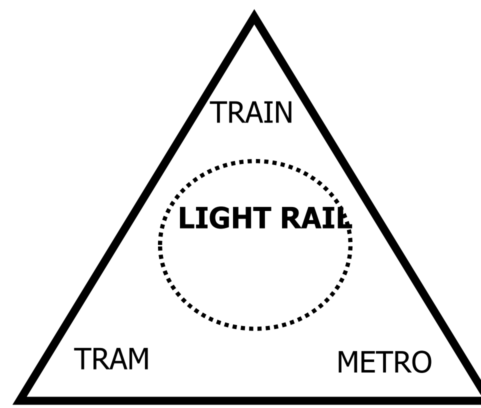
DM Lights HV 1 circuit track Kalu Track QPAR ...
€ 63,09
dmlights.nl

TRB 1978:

"Light rail transit is a metropolitan electric railway system characterized by its ability to operate single cars or short trains along exclusive rights-of-way at ground level, on aerial structures, in subways or, occasionally, in streets, and to board and discharge passengers at track or car-floor level."



“*Light rail is a rail-bound mode of public transport, which is used on the spatial scale of urban regions and cities. Contrary to train and metro, light rail is by definition able, up to a certain level, to integrate in the public space and mix with regular road traffic.”*

Van der Bijl et al. 2018

Service characteristics

	Light rail	Train	Tram	Metro
Covering areas	Medium	Large	Small/Medium	Small/Medium
Evironment	Integrated	Exclusive	Integrated	Exclusive/closed
Crossings	Several	Few	Many	None
Priority	Often	Always	Sometimes	NA
Stopping distance	0,4-2 km	2-100 km	0,2-0,8 km	0,4-2 km
Signaling	Often	Always	Sometimes	Always
Vehicle capacity	Medium	Hight	Low	Medium/high

Technical characteristics

	Light Rail	Regiotram	Tram	Train	Metro
Length	30–120 m	30–75 m	25–75 m	80–350 m	25–80 m
Width	265 cm	240/265 cm	220/265 cm	265/300 cm	220/300 cm
Impact strength	≤1500 kN	≤1500 kN	≤600 kN	≥1500 kN	≤1500 kN
Average speed	45 km/h	30 km/h	15 km/h	≥60 km/h	30 km/h
Maximum speed	≤100 km/h	≤100 km/h	≤70 km/h	≥80 km/h	≤80 km/h
Floor height	Low/high	Low/high	Low	High	High
Number of doors	Average	Average	Average/ more than average	Average/ less than average	Many
Number of seats/ standees	1/2	1/2	2/3	1/2 –4/none	3/4

Pros light rail

Compared to mass rapid transport/metro

CONS Light rail

Compared to mass rapid transport/metro

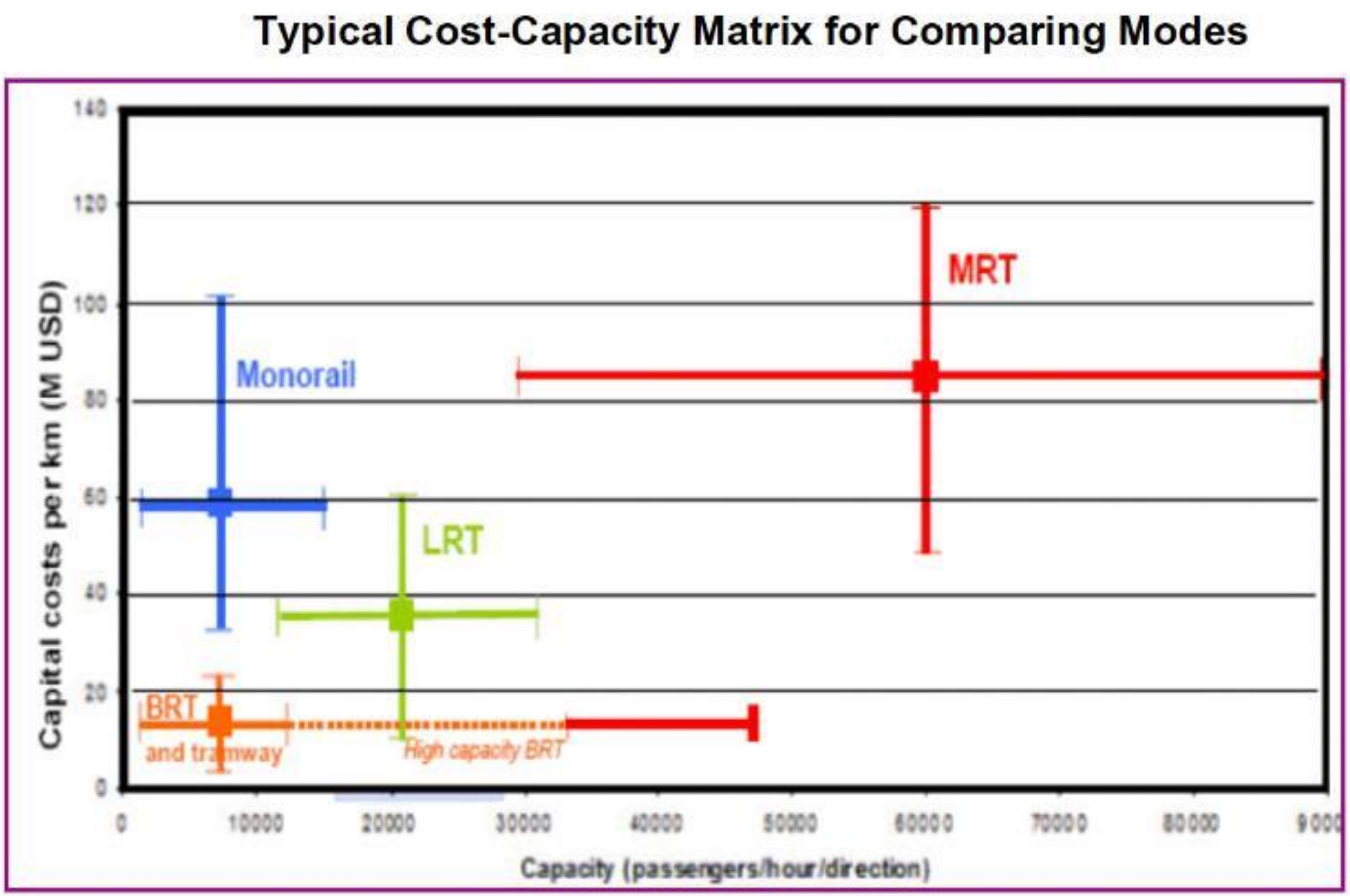
BRT vs. LRT vs. MRT

- Flexibility of planning
- Flexibility of operations
- Investment costs
- Simple implementation

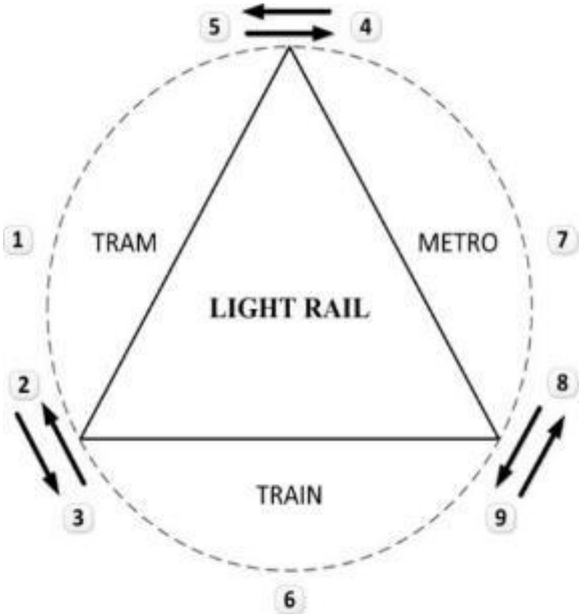
- Image and usage
- Hybrid
- No direct emissions
- Without compromises

- High capacity
- Fast
- Reliable
- Simple networks

Capacity and costs



Light rail system types



	Lightrail		Non- lightrail
1	(Regional) tram	6	Train
2	TramTrain	7	Metro
3	TrainTram	8	MetroTrain
4	TramMetro	9	TrainMetro
5	MetroTram		

A – Light Rail Operation
Tram/Regiotram (Type 1)

French-style second-generation trams, Dublin, Ireland.

Tram-train (Type 2)

A pioneer tram-train is the famous Karlsruhe system, Germany.

Train-tram (Type 3)

Train shares tracks and terminus of the local city tram, Zwickau, Germany.

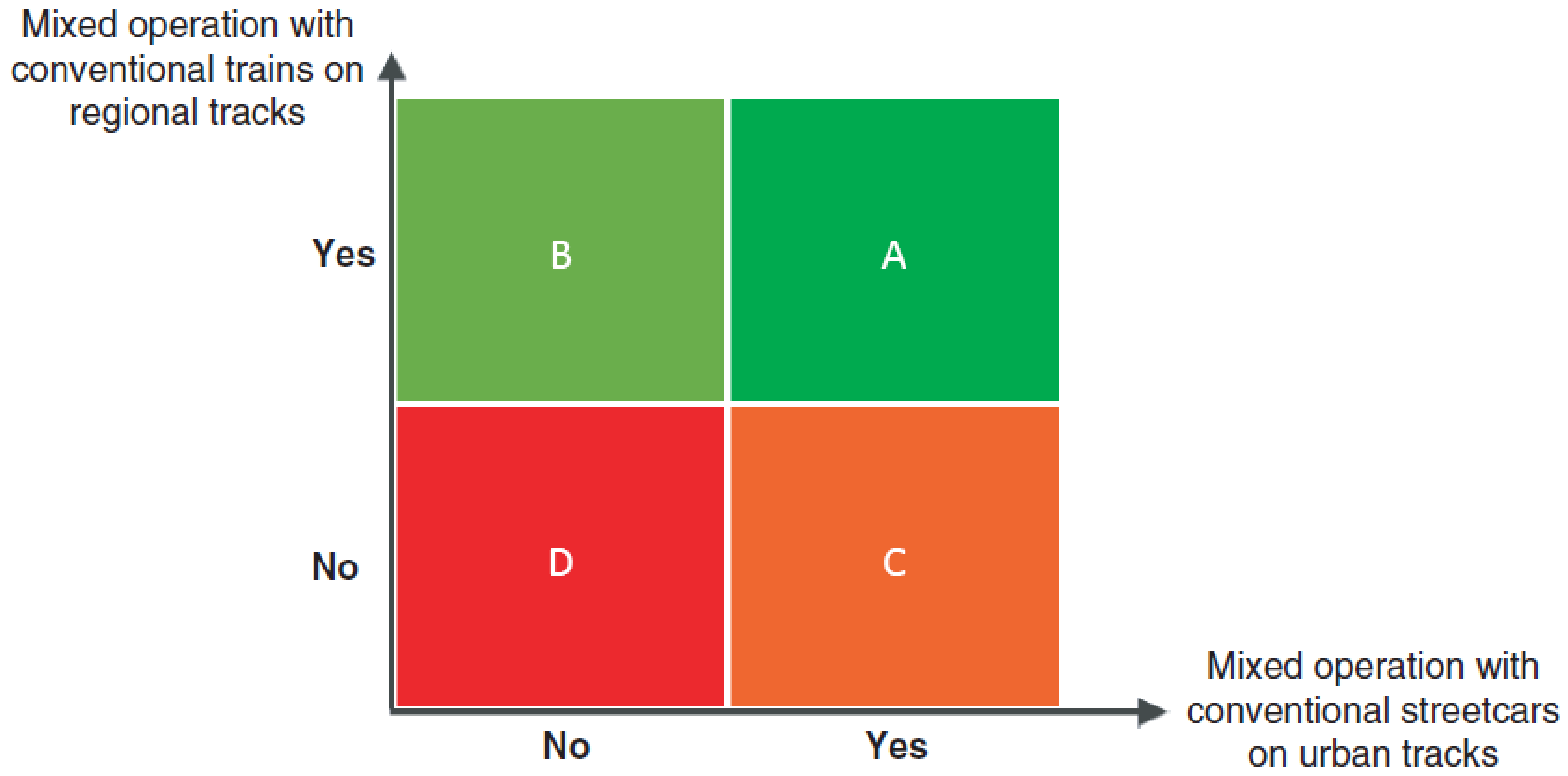
Metro-tram (Type 4)

Metro-tram LRV of line 51 in Amstelveen, Amsterdam region, Netherlands.

Tram-metro (Type 5)

LRV using metro-style infrastructure and stations, Düsseldorf, Germany.

Tram- train types



Willer, S. (2018)

Tram-Train examples

Germany	France	Netherlands	United Kingdom	Spain
Karlsruhe (network)	Mulhouse (line)	Hoekse Lijn (line)	Sheffield (line)	Cádiz (line)
Kassel (network)	Nantes (network)	RijnGouweLijn (line)*	Cardiff (line)	
Chemnitz (network)	Paris (line)	RandstadRail (network)		
Nordhausen (line)		Groningen (network)*		

Note: * System was proposed but not implemented.

Parameter	Mean	Median	Minimum	Maximum
Line length	32.6 km	30.6 km	7.9 km	64 km
Number of stops	24.8	22.5	5	54
Stop spacing	1.7 km	1.3 km	0.7 km	6.4 km
Average speed	36.6 km/h	35 km/h	23 km/h	58 km/h
Trip time	54.5 minutes	51.5 minutes	18 minutes	98 minutes
Frequency	3.1 tph	2 tph	1 tph	12 tph

Willer, S. (2018)

City	Class	City population	Population served by system
Karlsruhe	A & C	300,000	1,000,000*
Kassel	A	195,000	350,000
Chemnitz	A & C	246,000	330,000
Nordhausen	A	44,000	6,000
Mulhouse	A	112,000	150,000
Sheffield	A	550,000	650,000
Nantes	B & D	290,000	450,000
Cádiz	B	120,000	300,000
Cardiff	B	360,000	-**
RandstadRail	C	530,000 & 650,000***	1,400,000
Paris T4	D	280,000	-****
Groningen	A	200,000	270,000
RijnGouweLijn	B	72,000 & 121,000*****	315,000

* Only the analysed lines, within the KVV tariff area. ** The tram-train line is a small extension to a train line, and as such less focussed at connecting the region with a destination further away from a railway station. *** The Hague and Rotterdam. **** The tram-train line in Paris is feeding line. The city population reflects the served population, as the full city population is not relevant to this specific line and would distort data analysis. ***** Gouda and Leiden.

Willer, S. (2018)

Light rail = hybrid

Light rail infrastructure

- Traditional street-based;
- Shared-space;
- Traffic lane;
- Separate tramway;
- Metro style tramway;
- Railway for tram-train.

Street-based (Almaty, Kazachstan)

Shared space (Reims, France)

PT Lane (Edinburgh, Scotland)

Separated tramway (Berlin, Germany)

Metro track (Rotterdam, Netherlands)

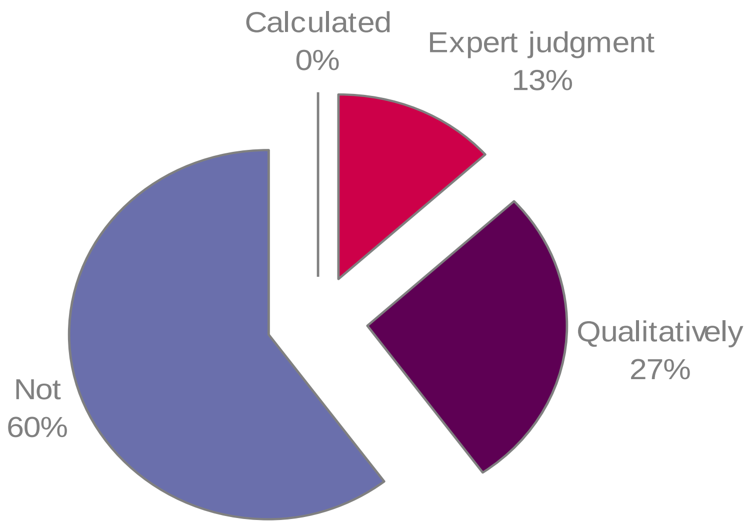
Train track (Gouda, Netherlands)

2 light rail cases

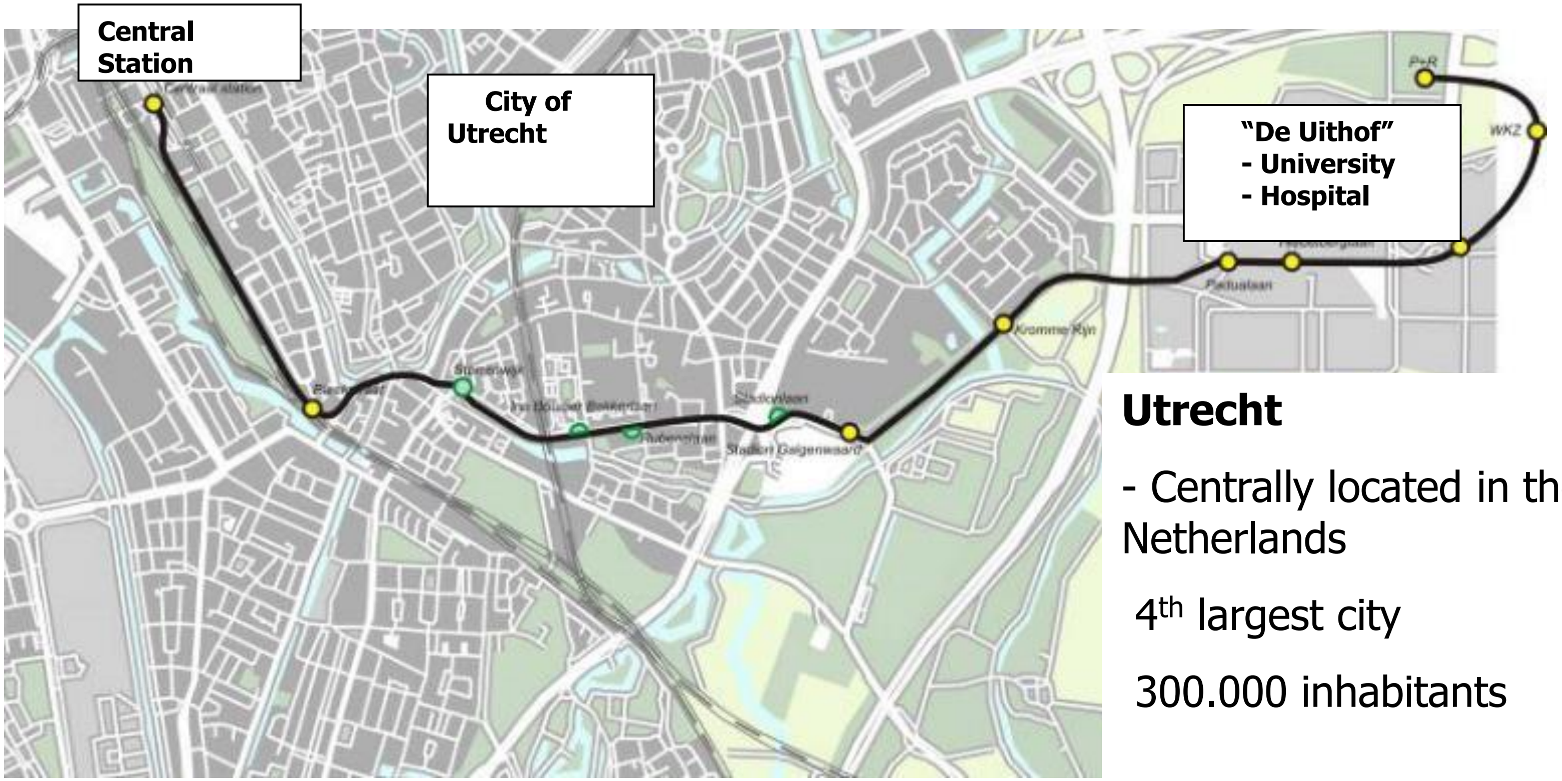
Case 1: Utrecht Uithoflijn

Decision making in public transport

- Most PT projects aim at enhanced reliability
- Service reliability is often missing in CBA and transport models
- We developed:
  - Methodology to incorporate passenger impacts of service reliability:
    - Transport models (reliable forecasts)
    - Cost benefit analyses
- Applied in Utrecht



Case: Uithoflijn (line 12)



Utrecht

- Centrally located in the Netherlands

4th largest city

300.000 inhabitants

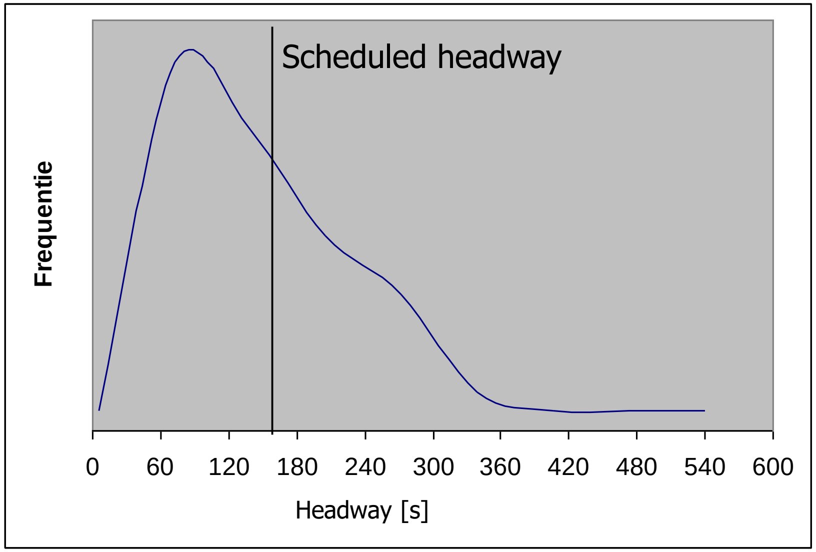
Problem analysis

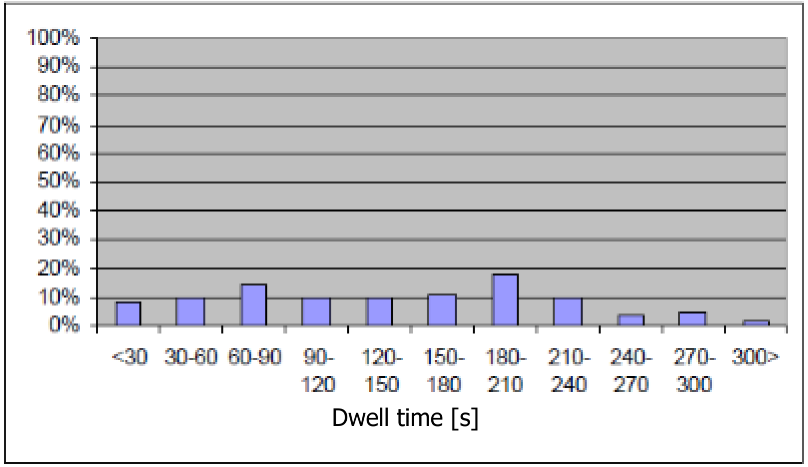
- Busiest bus line in the Netherlands: 27.000 passengers per day
- Frequency of 23x/hour/direction using double-articulated buses: 30x/hour/direction necessary
- Poor reliability and lack of capacity

- Mobility is still growing
  - +25% planned property in the Uithof: +8.000 students, +10.000 employees
  - Total: 53.000 students, 30.000 employees and 3.500 visitors (hospital)
  - No additional parking space
  - Demand forecast: 46.000 passenger per day

Solution
Introduction of a light rail line: 16-20x/hour

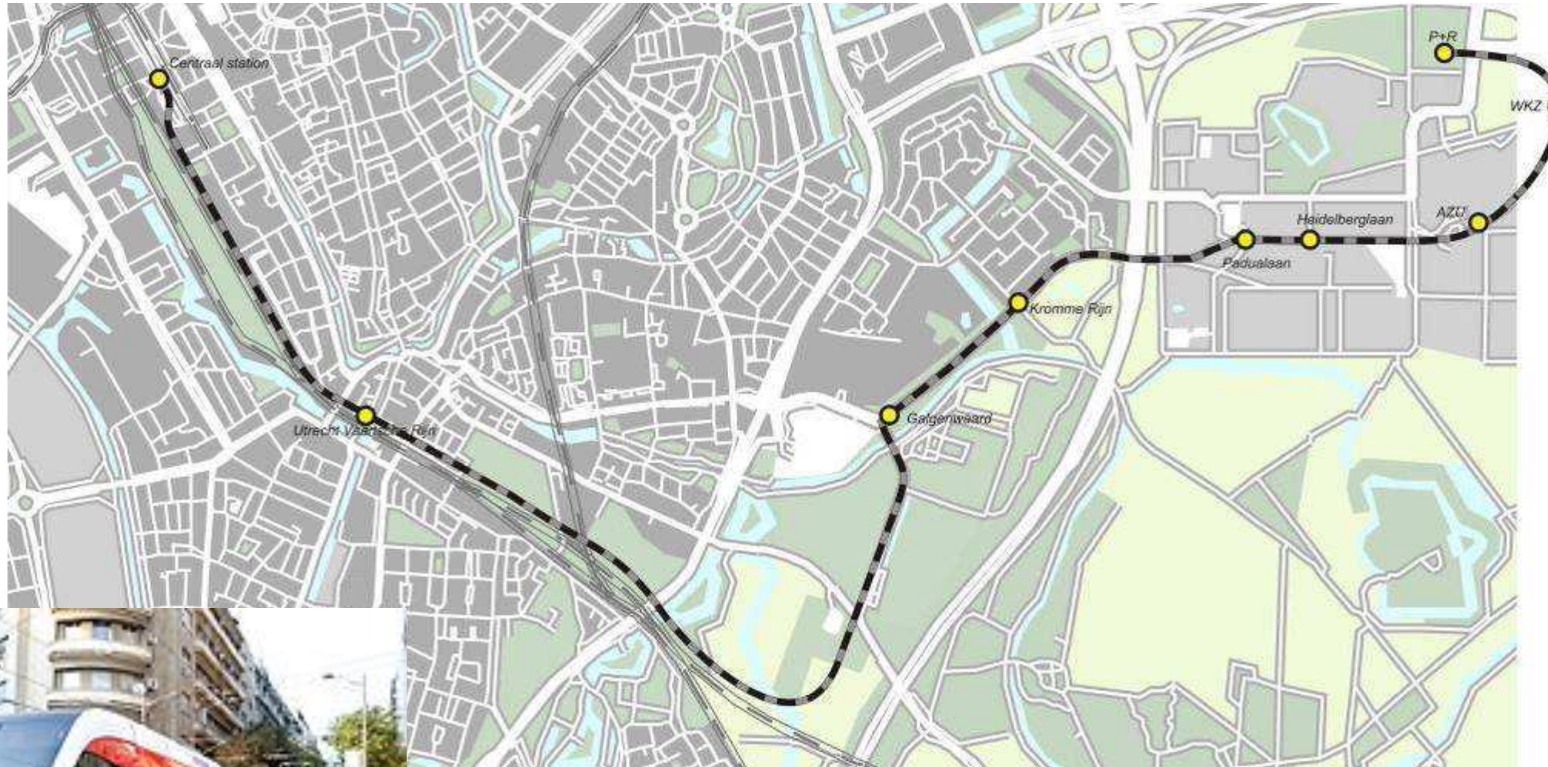
Poor reliability





Avg. =2,5 min; σ= 1,3 min

New tram line

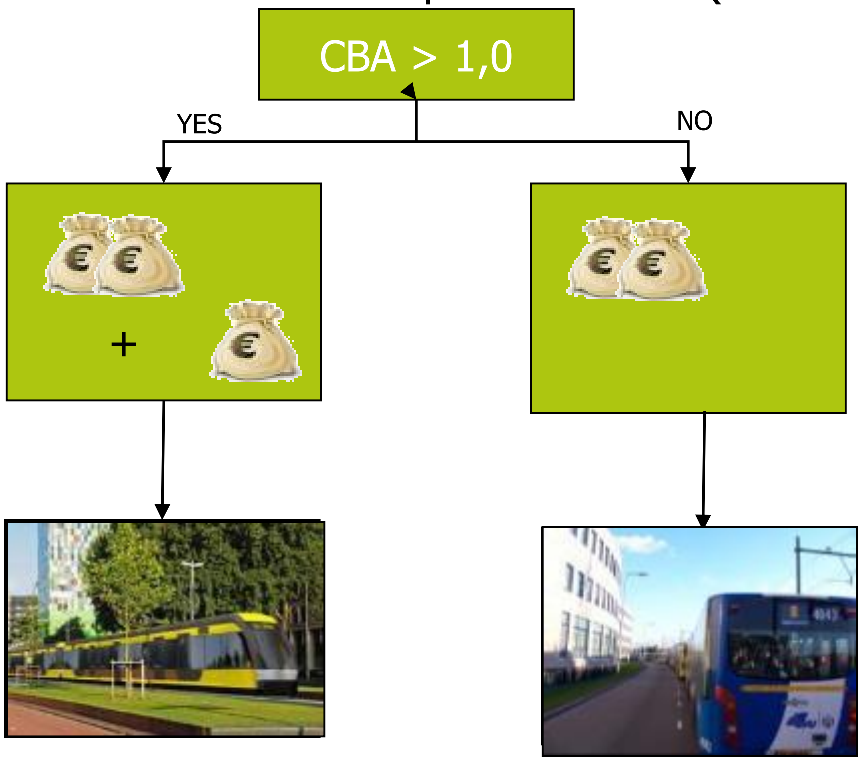


7,5 km
Operations are planned to start in 2018

12 connected CAF vehicles (2x37,5 m)

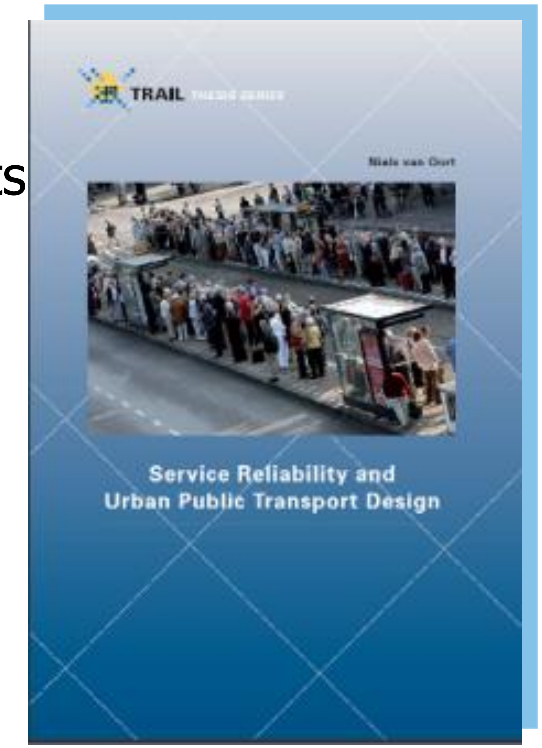
Ministry requires CBA

- Regional parties agreed with plans and finances
- €110 million of Minister of Transport available (about 1/3 of total costs)



Our approach

- **Calculations of:**
  - Future demand, including tram bonus impacts
  - Costs (infrastructure and operations)
  - Benefits
    - Travel time gains
    - **Reliability gains**



Van Oort, 2011

Results CBA

	Value compared to reference case (millions in 2011)
Investment costs	-€222
Operating costs	€66
Total costs	*€288*
Additional ticket revenues	€40
Increased travel time	€67
Service reliability effects	
- Less waiting time	€123
- Reduction in distribution	€78
- Increased probability of finding a seat in the vehicle	€4
External effects (emissions, safety, etc.)	€8
Total benefits	*€336*
Benefits-costs	**+€48**
Benefit cost ratio	**1.2**

Additional waiting time due to unreliability

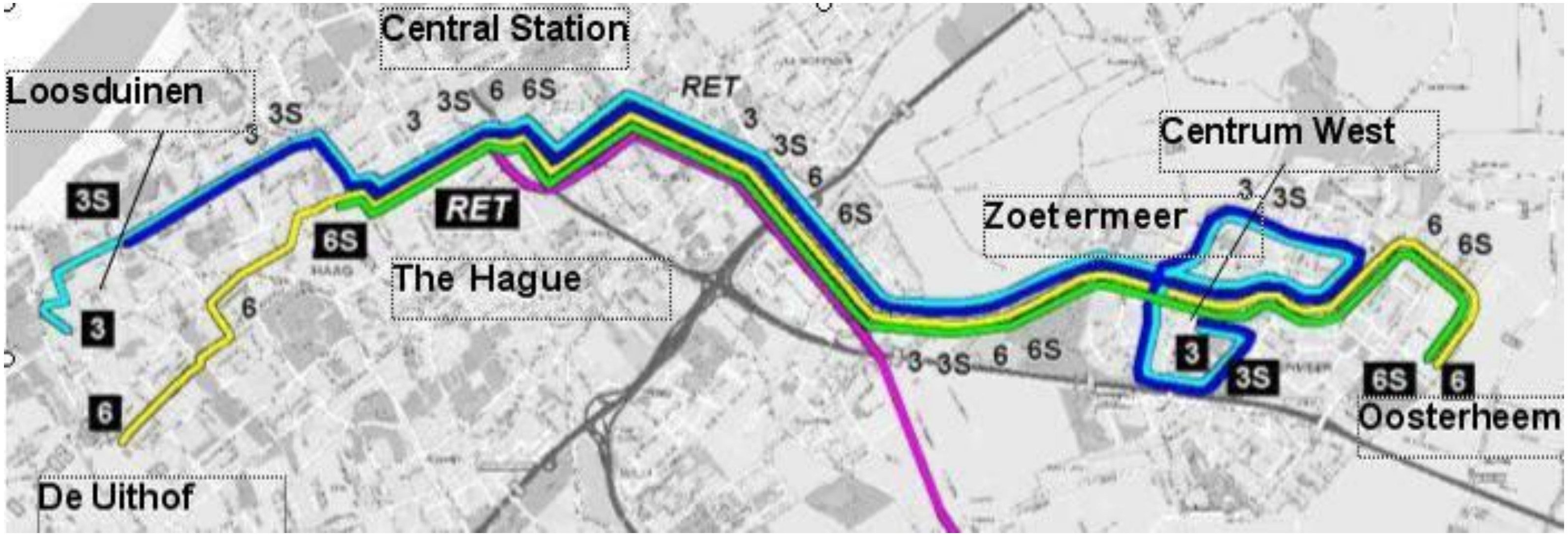
Distribution of travel time due to unreliability

Service reliability effects are over >60% of all benefits!

This method was approved by the Dutch Ministry and the Minister provided the €110 million

Case II : controlling RandstadRail

RandstadRail



90.000 travelers per day

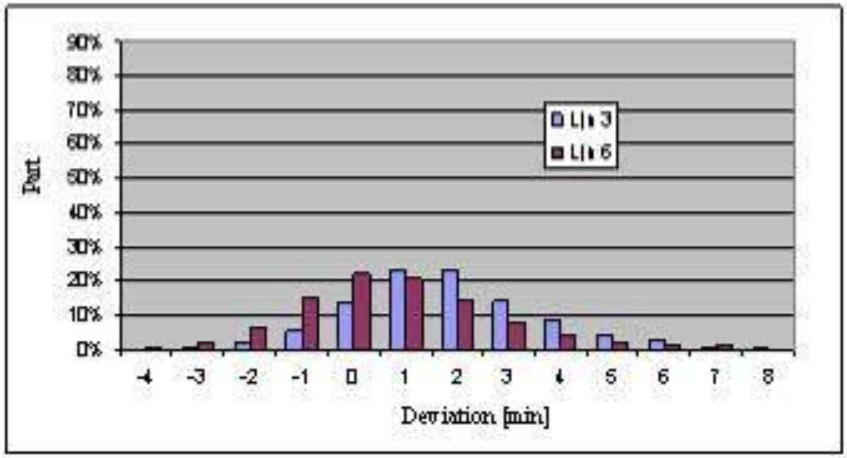
Two lines; 33 and 27 km | 41 and 31 stops

5 min headway per line per direction

50 Low floor vehicles

Why controlling?

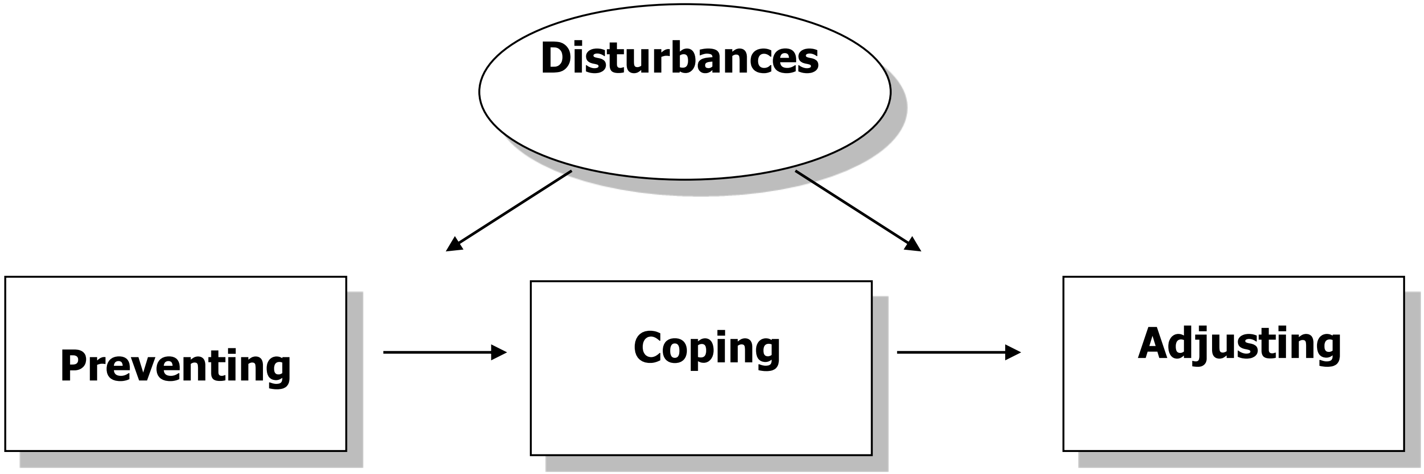
- High level of quality and reliability
- In urban area
  - Poor punctuality
  - Poor regularity
- High number of vehicles per hour per direction (>24)
- Signalling applied: limited capacity
- Shared tracks with tram and metro
- Operational targets of transit authority



Without controlling?

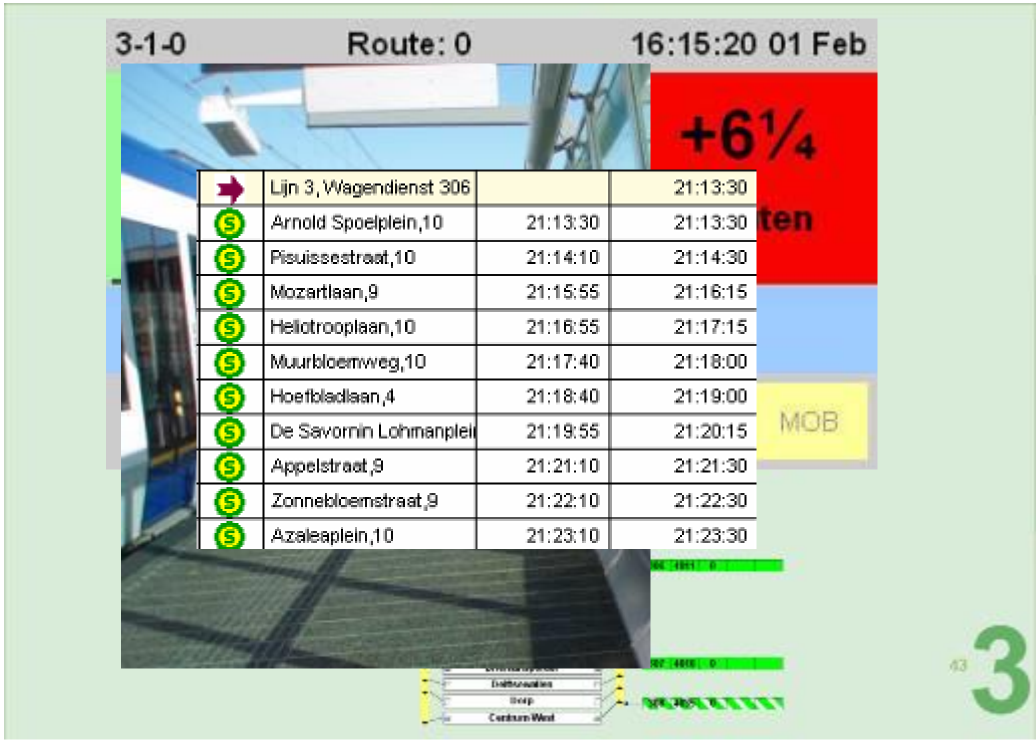
- Bunching -> Increase in average waiting time
- Overcrowding -> Probability of having a seat decreases
- Uncertainty -> Less satisfied travellers

How to deal with deviations?



Main elements

Preventing unplanned stopping
Punctuality
Dwelling
Timetable
Dispatching room

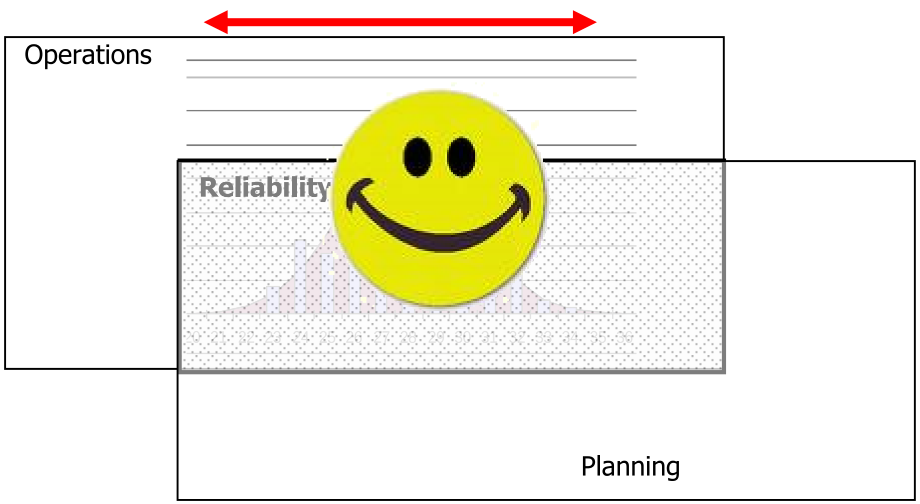


Actual effects

- Continuous monitoring operational quality
  - To optimize timetable
  - To find and remove bottlenecks

Improvements

- Variation of driving time
- Punctuality
- Customers satisfaction

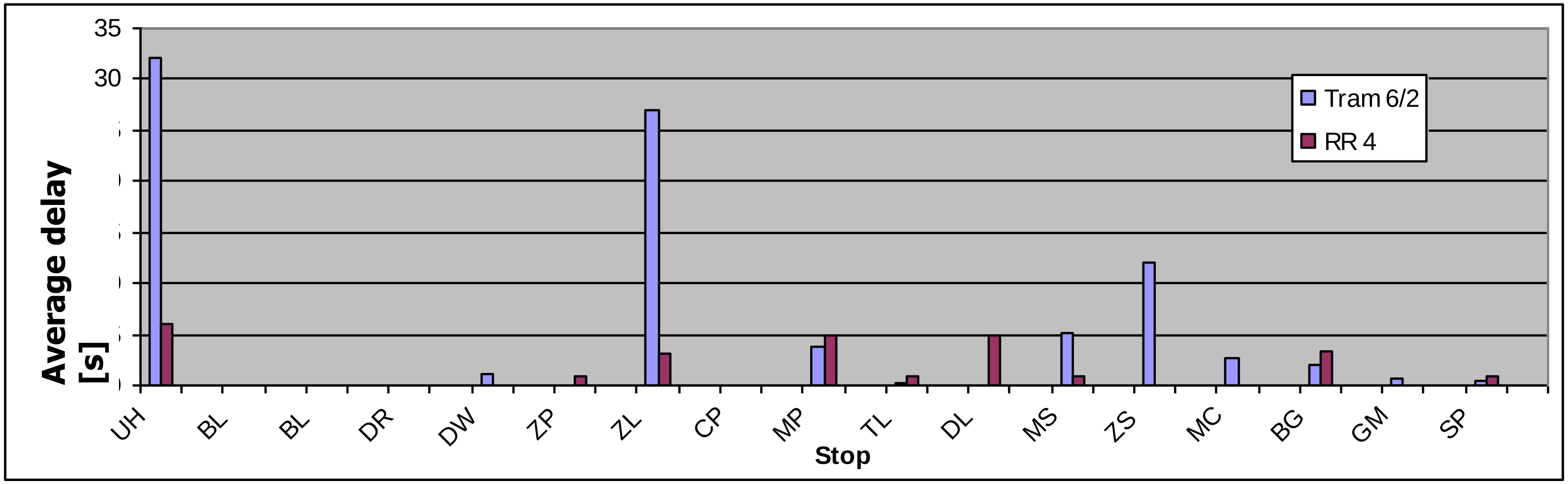


Variation of driving times

Unplanned stopping

Average delay 90 s → 20 s

Standard deviation - 50%

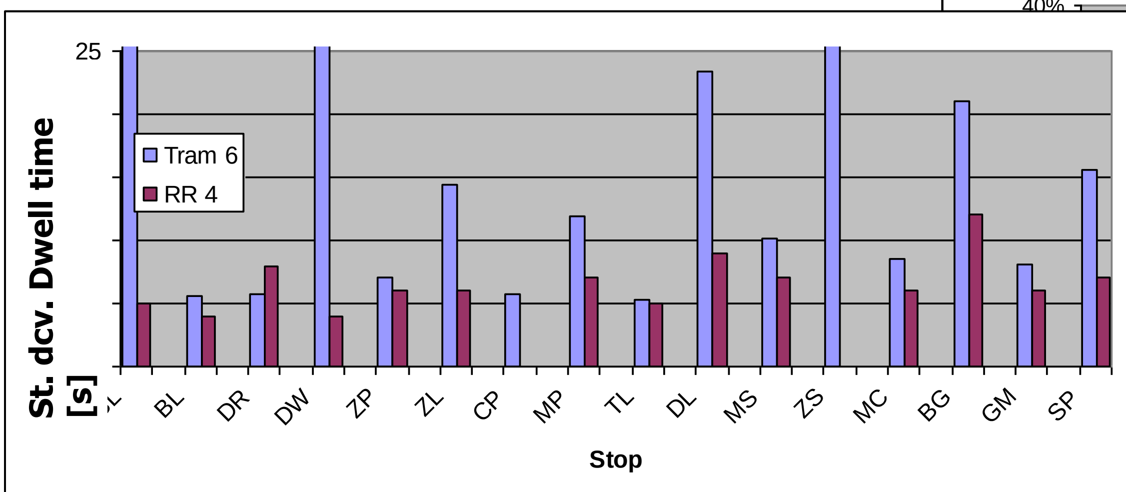


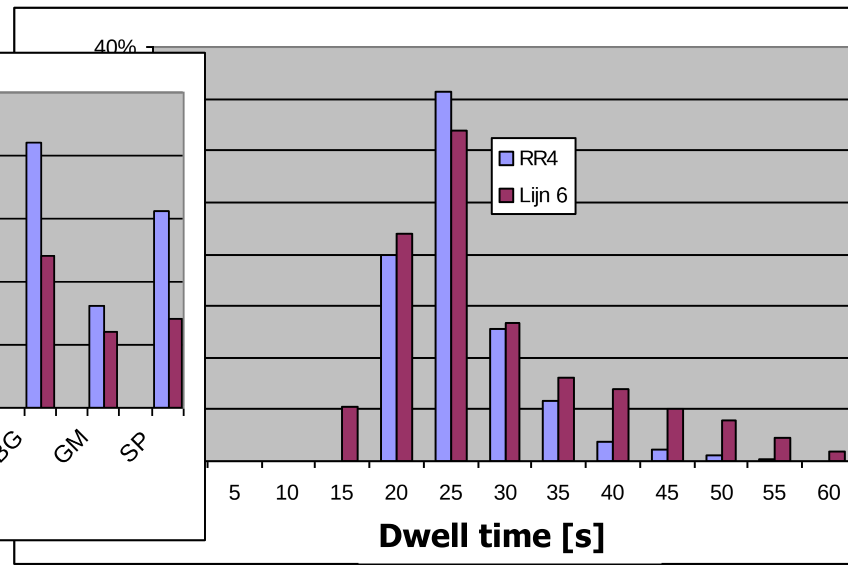
Variation of driving times (2)

Dwelling

Average dwell time 28 s → 24 s

Standard deviation - 70%



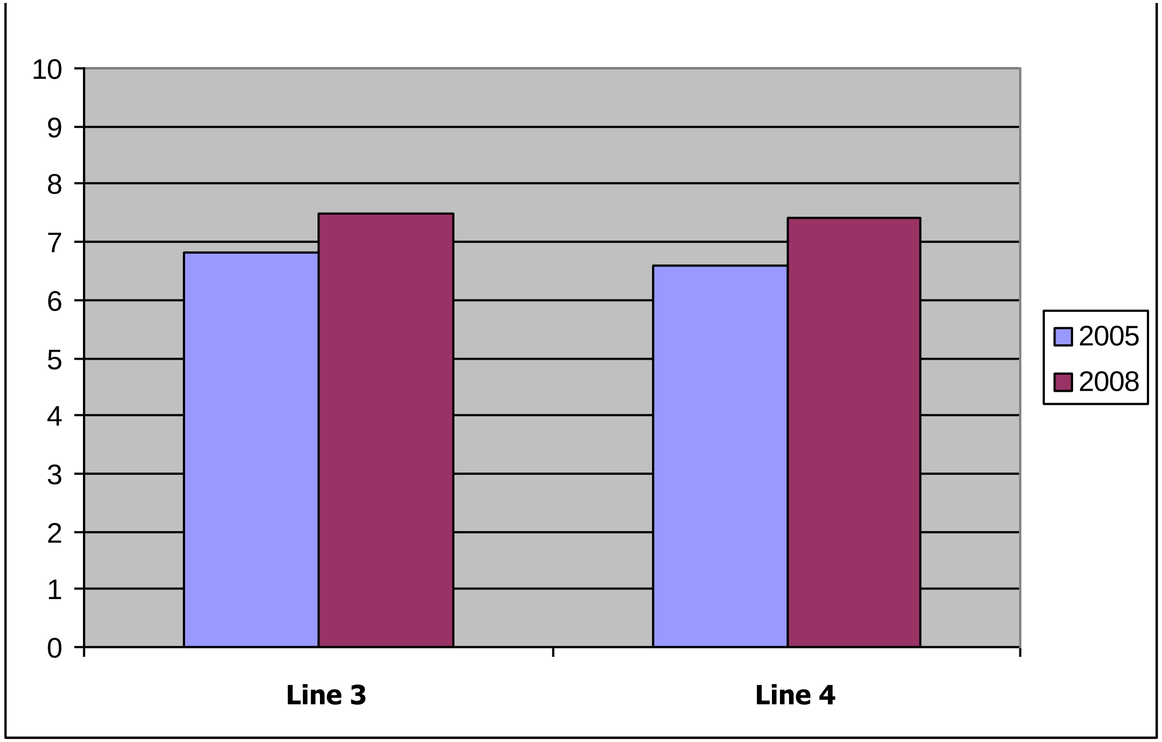


Punctuality

Departure punctuality: 70%→ 93% <-1,+1>
Driving ahead of schedule: 50%→7% <←,0>

15% less waiting time for passengers

Customers satisfaction



Summary

- Light rail is a valuable addition to the PT planning tool box
- Light rail is flexible and hybrid
- Lessons from light rail projects: justification and broader scope than transport
- Framework of 5 E's
    - Efficiency
    - Effectiveness
    - Economy
    - Environment
    - Equity

Cases

- Light rail enables increase in service realibility
- Little attention to service reliability in cost-benefit analyses
- Service reliability benefits made the difference in Utrecht

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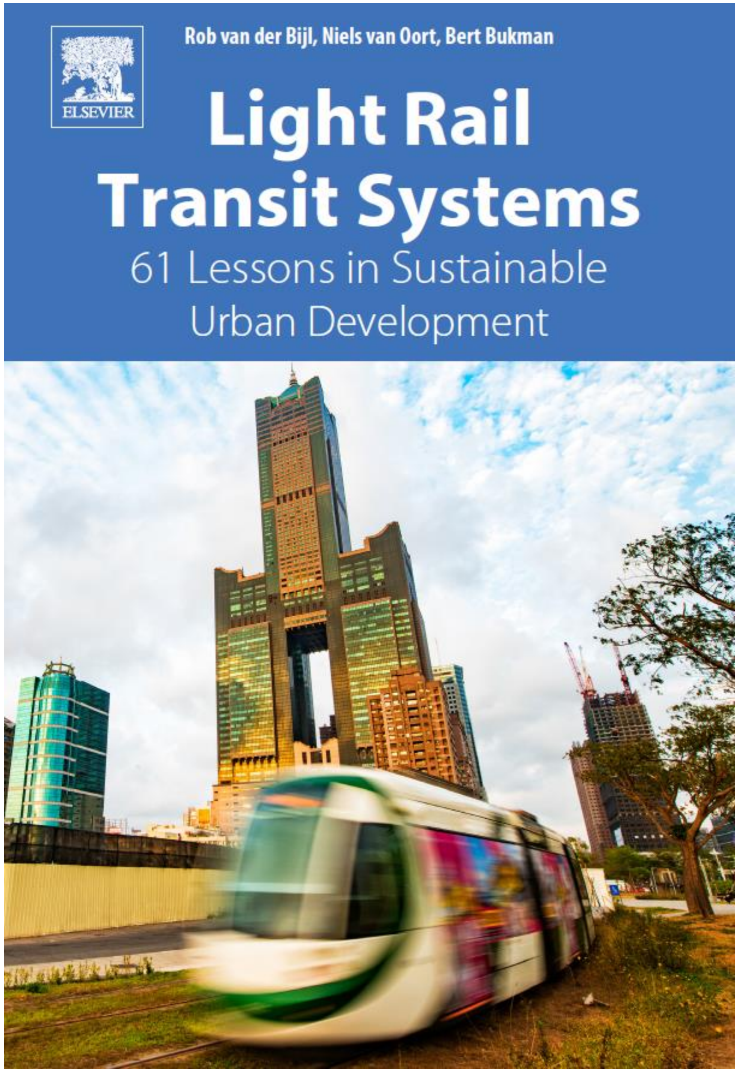

Van der Bijl, Van Oort, Bukman 2018

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