Innovations in Public Transport modelling

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INDIAN METRO RAIL ORGANIZATIONS' SOCIETY

Introduction

Resume

- Strategic planner
urban public transport

- Consultant
transport modelling

- PhD Service reliability

- Hands on and academic experiences
data and modelling

https://www.tudelft.nl/en/ceg/research/stories-of-science/putting-public-transport-on-the-right-track

India experience

Challenges in PT industry

Main challenges:

- **Increasing cost efficiency (higher ridership, lower cost)**
- **Increasing customer experience, modal shift**
- **Motivating new strategic investments**

Data and models enable achieving objectives

Pragmatic solutions needed

Data sources

- Bluetooth, Wifi, Mobile phone data*
- Journey planners, traveler apps^
- Social media
- Signalling, vehicles
- Vehicle location (AVL)
- Passenger flows: smart cards

*De Regt K., Cats O., van Oort N. and van Lint H. (2017). Investigating Potential Transit Ridership by Fusing Smartcard Data and GSM Data. *Transportation Research Record: Journal of the Transportation Research Board*, No. 2652

^ Wang, Z., A.J. Pel, T. Verma, P. Krishnakumari, P. van Brakel, N. van Oort (2022). Effectiveness of trip planner data in predicting short-term bus ridership, Transportation Research Part C: Emerging Technologies, Volume 142.

Van Oort, N. and Cats, O. (2015). Improving public transport decision making, planning and operations by using big data: Cases from Sweden and the Netherlands. 18th IEEE international conference on intelligent transportation systems. Las Palmas, Spain.

Modelling

Ridership predictions

- To design and optimize planning and operations
- To justify investments

- Transport models: Generally focused on car traffic

Public Transport Modelling

Heavy and slow

Excellent operations

Public Transport Modelling

Heavy and slow **->** **Part 1: Data driven modelling**

Excellent operations

Public Transport Modelling

Heavy and slow	->	Part 1: Data driven modelling
Excellent operations	**- >**	**Part 2: Incorporating unreliability**

Public Transport Modelling

Heavy and slow -> Part 1: Data driven modelling

Excellent operations - > Part 2: Incorporating unreliability

More modelling research

Multimodality

Crowding impact

https://nielsvanoort.weblog.tudelft.nl/publications/

Part 1: Data driven predictions

Available tools PT industry

	4 step model	**Quick-Scan model (Spreadsheet)**
Modes	Car, public transport, bike	Public transport
Scale	National, regional, urban	Urban
Time horizon	10-20 years	< 5 years
Project type	Strategic, policies, infrastructure changes	Tactical, changing lines, frequencies
Usage	Modal split, cost-benefit analysis	Ridership effects

Pros/cons 4-step model

Pros	Cons
Extensive	Time consuming
Multimodal	Focused on road traffic
Multi-purpose	Non-intuitive
Suitable for long-term estimations	Rigid separation of modes
New scenarios can be modelled	A lot of input information is required
-	Feedback loops necessary, rarely leading to stability

van Oort et al., 2015; Ortuzar and Willumsen, 2011; Delanoy 2019

Pros/cons quick scan model

Pros	Cons
Very easy to use	Low level of detail
Fast	Inaccurate
-	Too much relying on assumptions
-	Unimodal

Upchurch and Kuby, 2014; van Oort et al., 2015; Delanoy 2019

In the middle: Elasticity model

	Multimodal model	Elasticity model	Quick-Scan model
Modes	Car, public transport, bike	Public transport	Public transport
Scale	National, regional, urban	Regional, Urban	Urban
Time horizon	10-20 years	< 10 years	< 5 years
Project type	Strategic, policies, infrastructure changes	Tactical, changing lines, frequencies, stops	Tactical, changing lines, frequencies
Usage	Modal split, cost-benefit analysis	Network effect	Ridership effects

PT modelling

Traditional (4-step) model
Multimodal (~PT)
Network
Complex
Long calculation time
Visualisation
Much data
Detailed results

Simple calculation
PT only
Line
Transparent
Short calculation time
Only numbers
Little data
Assessments

Short term predictions

Elasticity method based on smartcard data

Smartcard data

The Netherlands

- OV Chipkaart
- Nationwide (since 2012)
- All modes: train, metro, tram, bus
- Tap in and tap out
- Bus and tram: devices are in the vehicle

Data

- 19 million smartcards
- 42 million transactions every week

- Several applications of smartcard data

(Pelletier et. al (2011). Transportation Research Part C

Van Oort, N., T. Brands, E. de Romph (2015), Short-Term Prediction of Ridership on Public Transport with Smart Card Data, Transportation Research Record, No. 2535, pp. 105-111.

Combining models and smartcard data

Connecting to transport model
- Evaluating history
- Predicting the future

- Whatif scenario's
  - Stops: removing or adding
  - Faster and higher frequencies
  - Route changes

- Quick insights into
  - Expected cost coverage
  - Expected occupancy

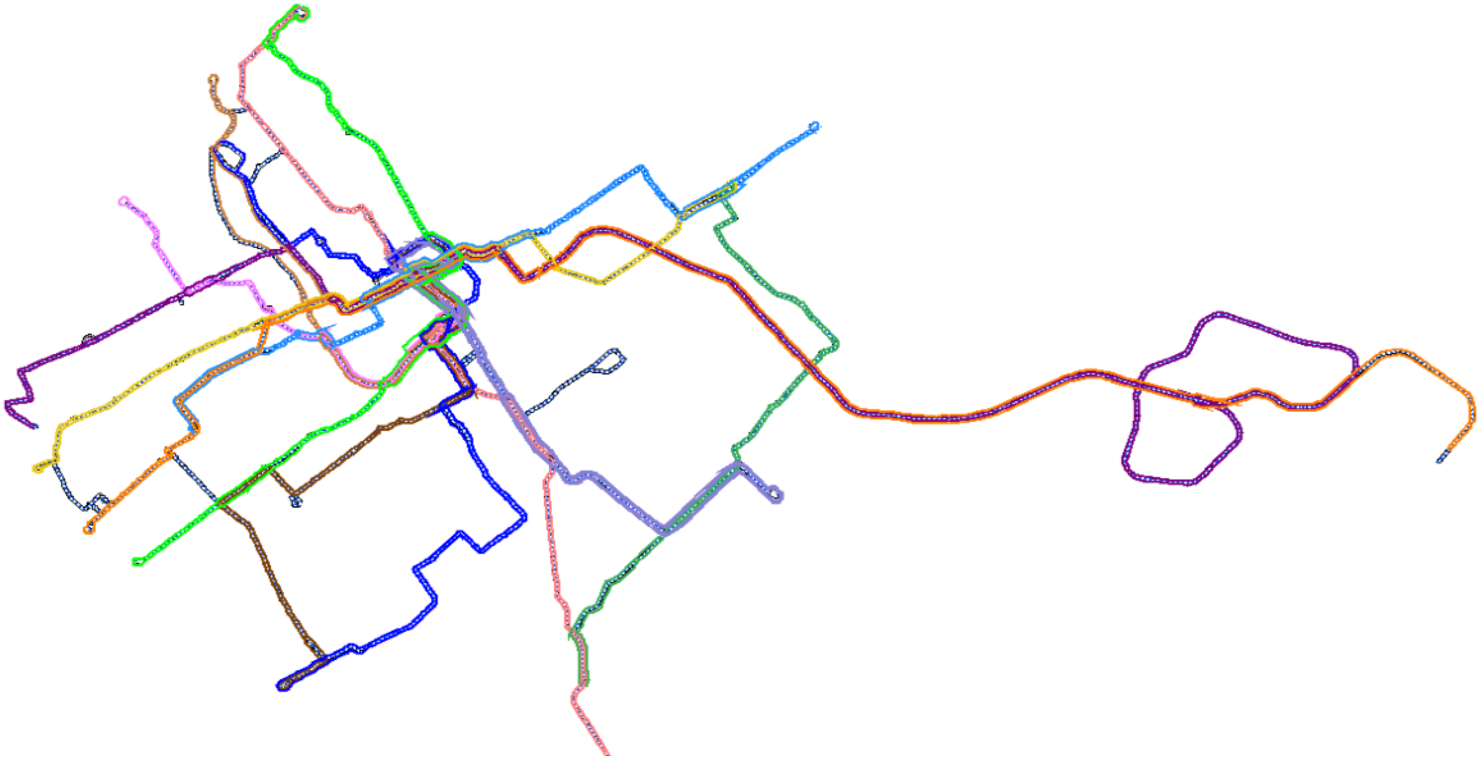
OmniTRANS
Transport Planning Software

New generation of transport models: data driven

Van Oort, N., T. Brands, E. de Romph (2015), Short-Term Prediction of Ridership on Public Transport with Smart Card Data, Transportation Research Record, No. 2535, pp. 105-111.

Connecting data to transport model (1/4)

1) Importing PT networks (GTFS) (Open data)



Connecting data to transport model (2/4)

2) Importing smartcard data (Closed data)

Chip ID	Check in stop	Check out stop	Check in time	Check out time	Line number	(vehicle number)	(ticket type)
1	35	488	10:27	10:52	9	..	Regular single
2	23	86	8:01	8:09	1	..	Student
2	86	90	8:17	8:55	3	..	Student
3	73	94	7:20	7:53	4	..	Annual ticket
3	94	73	16:55	17:27	4	..	Annual ticket

Connecting data to transport model (3/4)

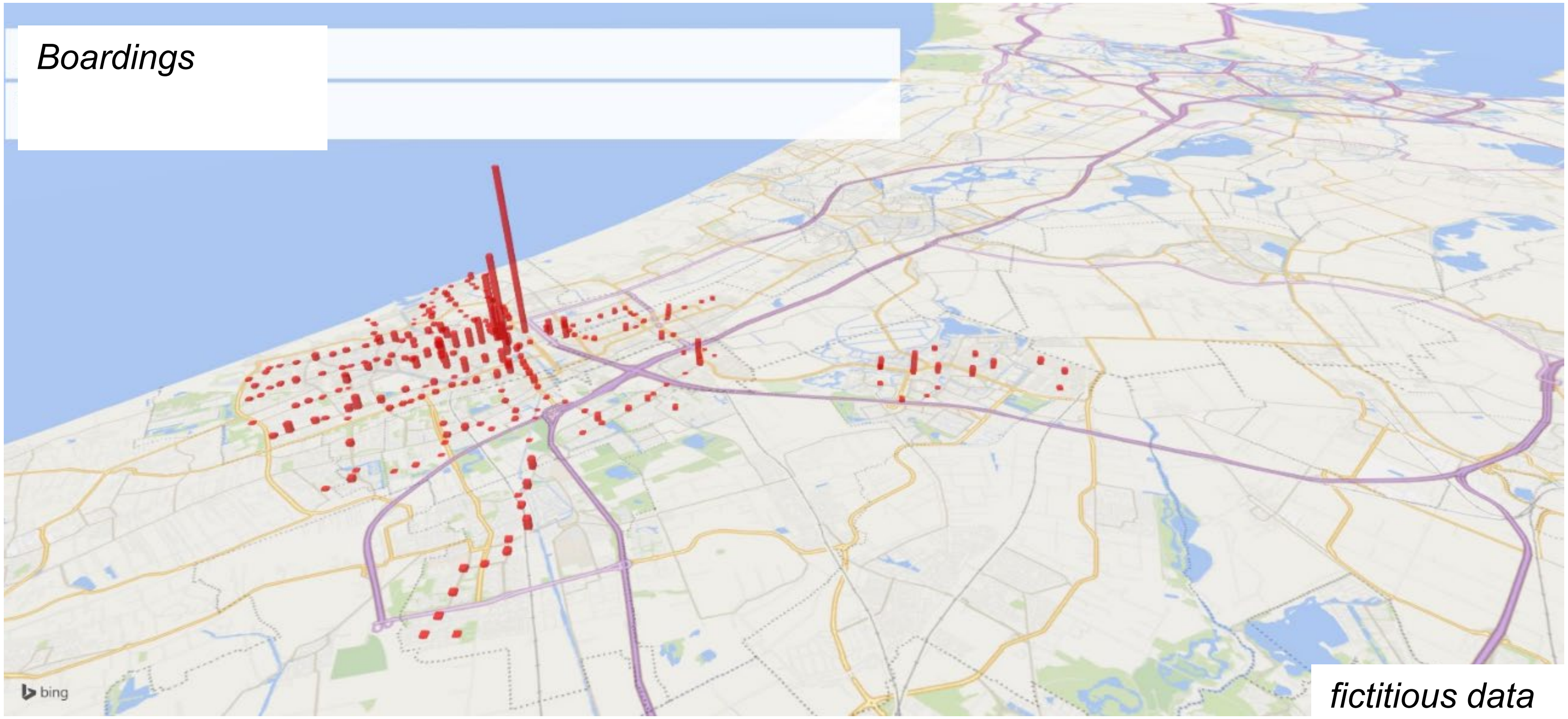
3) Processing and matching

Processing smart card data

- missing check outs
- short trips

Connecting data to transport model (4/4)

4) Route choice and visualization options of transport model



What if?

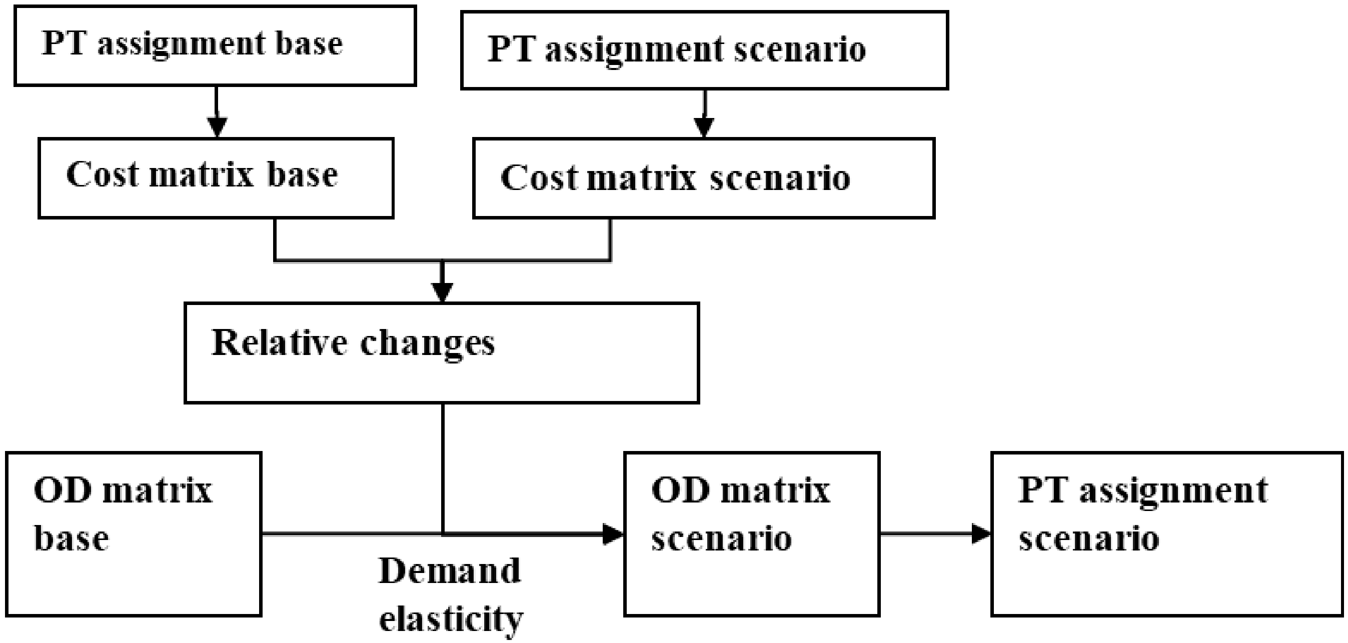
What if: elasticity approach (1/2)

$$C_{ij} = \alpha_1 T_{ij} + \alpha_2 WT_{ij} + \alpha_3 NT_{ij} + \alpha_4 F_{ij} \qquad (1)$$

With:

C_{ij}	Generalized costs on OD pair *i,j*
α_1, α_2, α_3, α_4	Weight coefficients in generalized costs calculation
T_{ij}	In-vehicle travel time on OD pair *i,j*
WT_{ij}	Waiting time on OD pair *i,j*
NT_{ij}	Number of transfers on OD pair *i,j*
F_{ij}	Fare to be paid by the traveler on OD pair *i,j*

What if: elasticity approach (2/2)



NOTE:

Simple changes

Short term

Only LOS changes

Accuracy

Elasticities

Literature (e.g. Balcombe)

“Proven “ rules of thumb

Whatif scenarios

Adjusting

Speed

Fares

Routes

Frequency

Illustrating impacts on (indicators):

- Cost coverage
- Occupancy
- Ridership
- Revenues

Part 2: Service reliability

Service reliability in demand models

- Traditionally, demand models do not incorporate service reliability of public transport

- New developments
  - Insights in mechanisms vehicle and passenger
  - Data availability

- New research theme

Van Oort (2011) Service reliability and urban public transport design

Why?

Enhanced forecasting

- Improved synthetic matrices
- Improved, more realistic assignment
- Less correction by calibration required

Additional application of model

- Insights in passenger effects of change in level of service reliability
- Base for cost benefit analysis

Both evalution and prediction

Network impacts

Service reliability

- Match of operations and planning
- Unreliability is caused by variability of operations and/or suboptimal planning

- Unreliability affects passengers:
- Travel time (mainly waiting time)
- Distribution of travel time and arrival time
- Comfort

- Passengers consider service reliability as one of the main quality aspects, but perceive it as insufficient

Van Oort (2011) Service reliability and urban public transport design

Measuring service reliability

New focus

Passenger on time?

Passenger oriented metrics

- Average additional travel time per passenger
- St. deviation of travel time
- Enabling quantifying unreliability effects in time and money

Van Oort (2011) Service reliability and urban public transport design

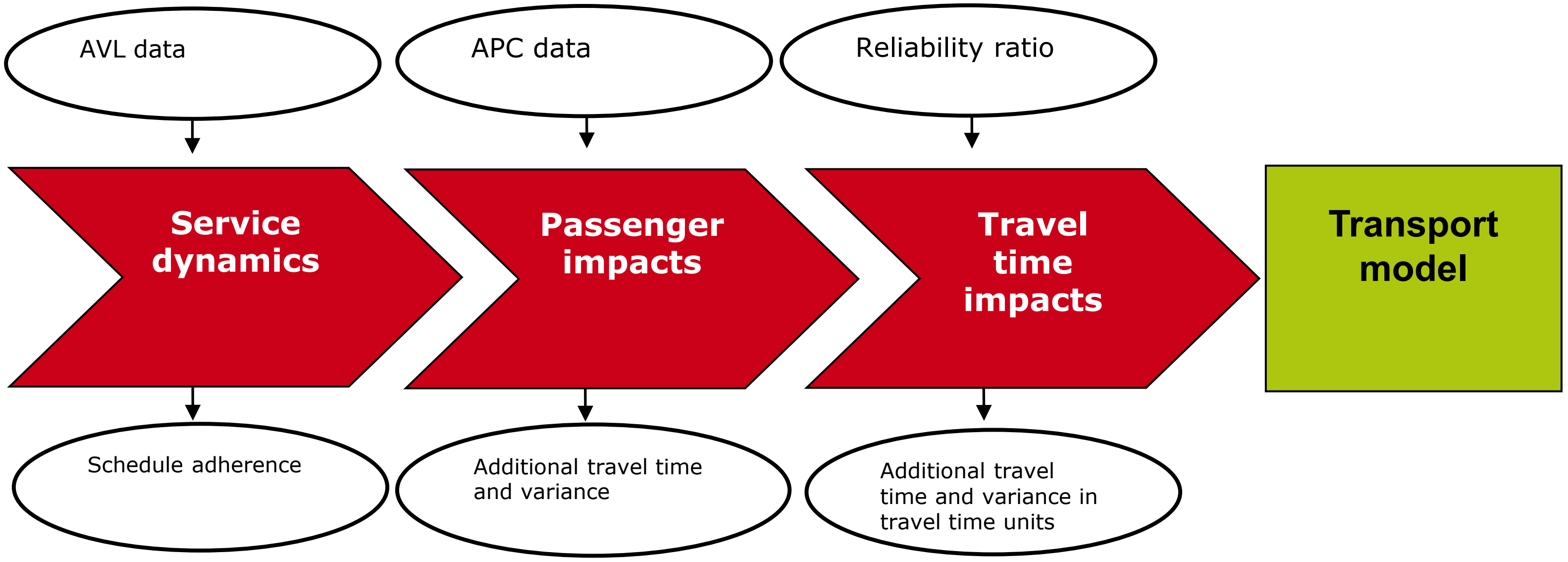
State of the art

- Developed a scientific framework
- Applied in VRU model in Utrecht

- Using AVL and smartcard data
- Using algoritms of PhD Van Oort calculating passenger impacts
- Applying mean variance approach using value of reliability

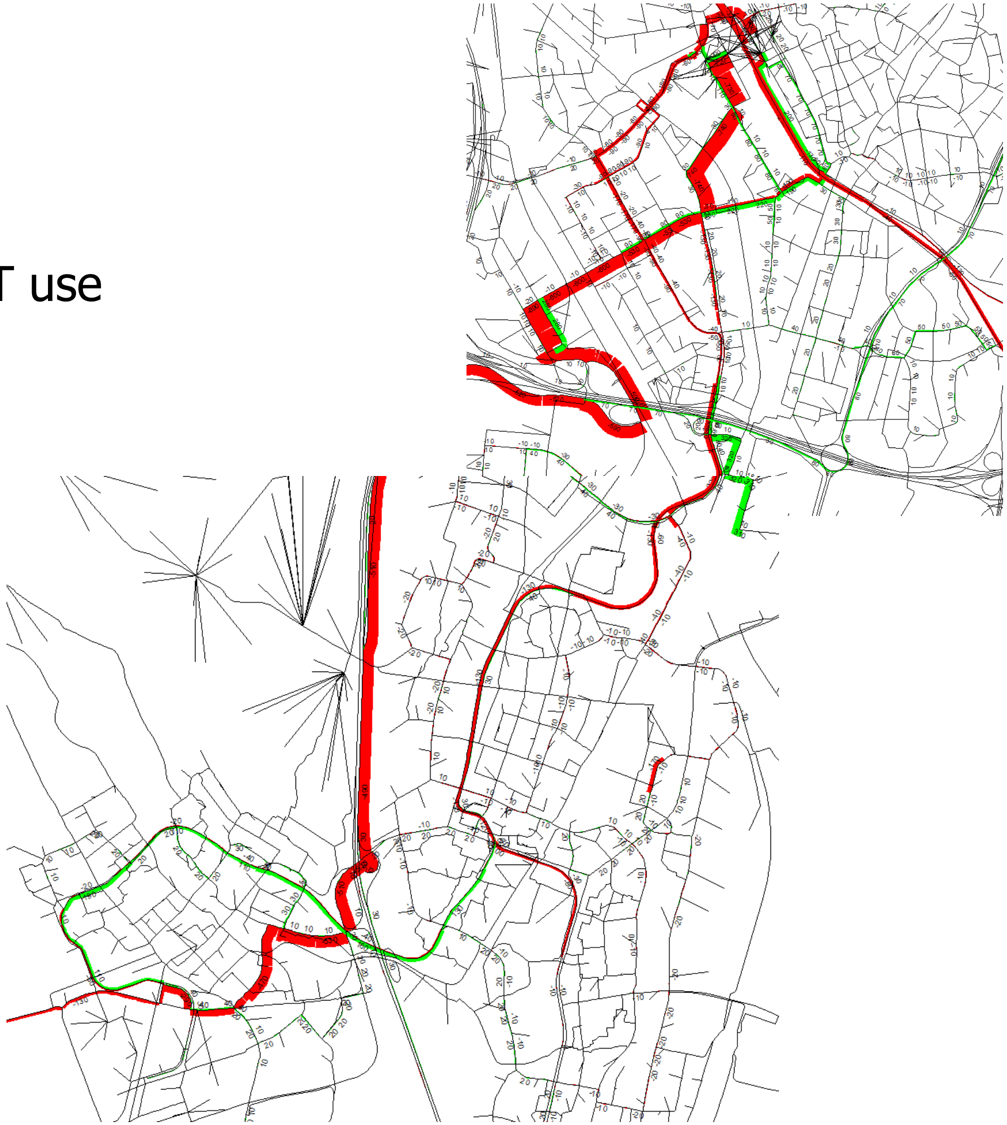
Van Oort et. al (2014) Incorporating unreliability of transit in transport demand models: theoretical and practical approach

Three step approach



Results

- Enhanced skim matrices
- Reduction of overestimation of PT use
- Enhanced route choice within PT



Wrap up

Heavy and slow -> Part 1: Data driven modelling

Excellent operations - > Part 2: Incorporating unreliability

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Questions / Contact /References

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