# Improving public transport decision making, planning and operations by using Big Data

*Cases from Sweden and the Netherlands*

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Las Palmas 2015

# Challenges in PT industry

**Main challenges:**

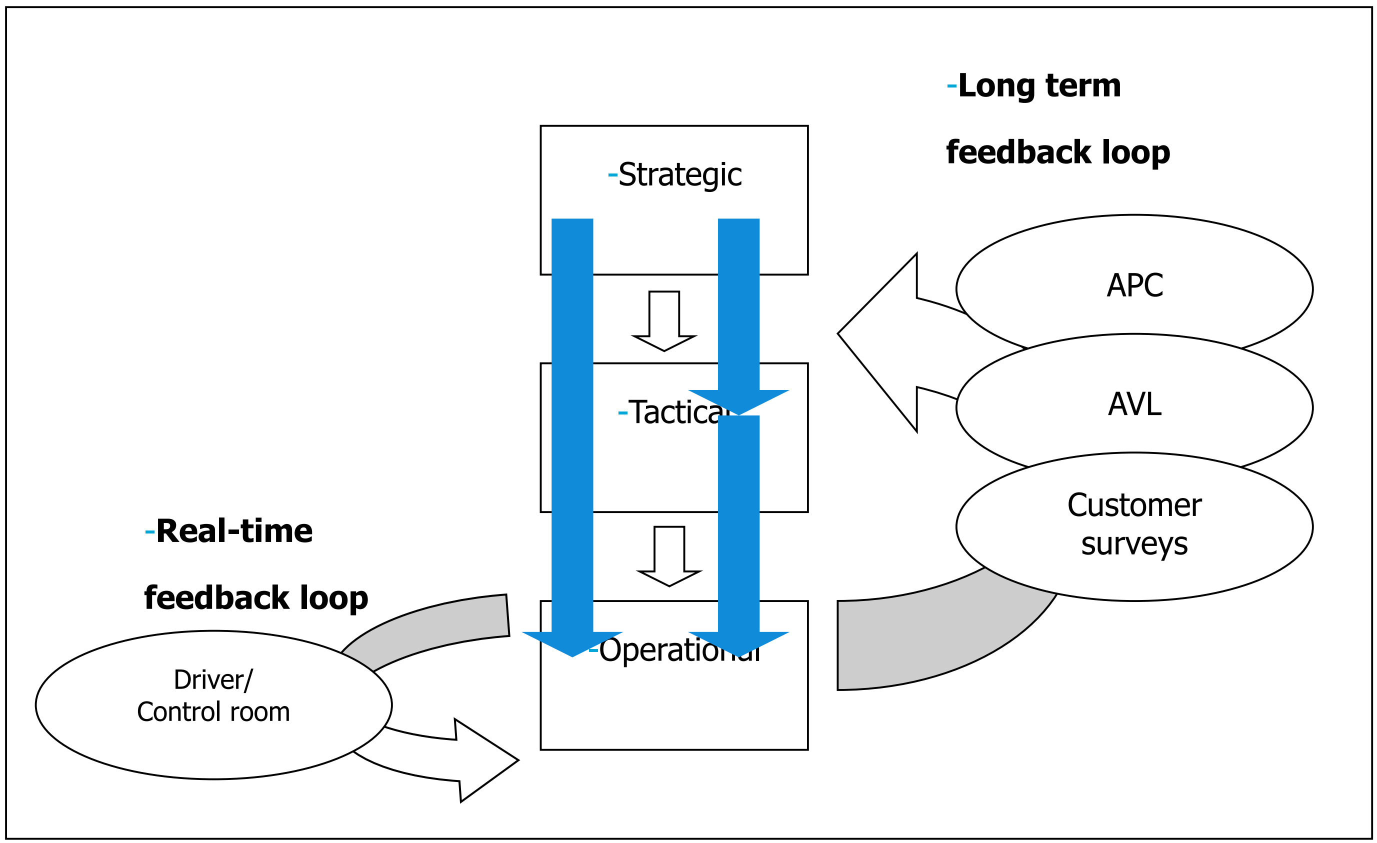
- **Increasing cost efficiency**
- **Increasing customer experience**
- **Motivating new strategic investments**

- Data and models enable achieving objectives

# Approach


- New methodologies
- Proven in practice

# Operations and feedback

# Applications

- Real-time information generation and dissemination
  - Real-time control strategies (e.g. holding, stop skipping)
  - Fleet management (e.g. short turning, deadheading)
  - Priority measures (e.g. traffic signal priority, dynamic lanes).
- Involve generating predictions on future system conditions
- Require instantaneous access to large amounts of online data and tools to assess and implement alternative measures in real-time
- Can be ultimately integrated into a decision support system

# Applied examples

**Monitoring and predicting passenger numbers: Whatif**
**Improving service reliability**

**Quantifying benefits of enhanced service reliability in public transport**
*Van Oort, N. (2012)., Proceedings of the 12th International Conference on Advanced Systems for Public Transport (CASPT12), Santiago, Chile.*

**Optimizing planning and real time control**
*Van Oort, N. and R. van Nes (2009), Control of public transport operations to improve reliability: theory and practice, Transportation research record, No. 2112, pp. 70-76.*

Cats, O. (2014) Regularity-Driven Bus Operations: Principles, Implementation and Business Models, Transport Policy, vol. 36, pp. 223-230

**Optimizing synchronization multimodal transfers**
*Lee, A. N. van Oort, R. van Nes (2014), Service reliability in a network context: impacts of synchronizing schedules in long headway services, Transportation Research Record, No. 2417, pp. 18-26*

**Improved scheduling**
*Van Oort, N. et al. (2012). The impact of scheduling on service reliability: trip time determination and holding points in long-headway services. Public Transport, 4(1), 39-56.*

*Cats, O. et al. (2012) Holding Control Strategies: A Simulation-Based Evaluation and Guidelines for Implementation. Transportation Research Record, 2274, pp.100-108.*

# Case 1: The Hague, The Netherlands

# Smartcard data (1/2)

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

Issues

- Privacy
- Data accessibility via operators

Data

- 19 million smartcards; 42 million transactions every week
- Several applications of smartcard data:

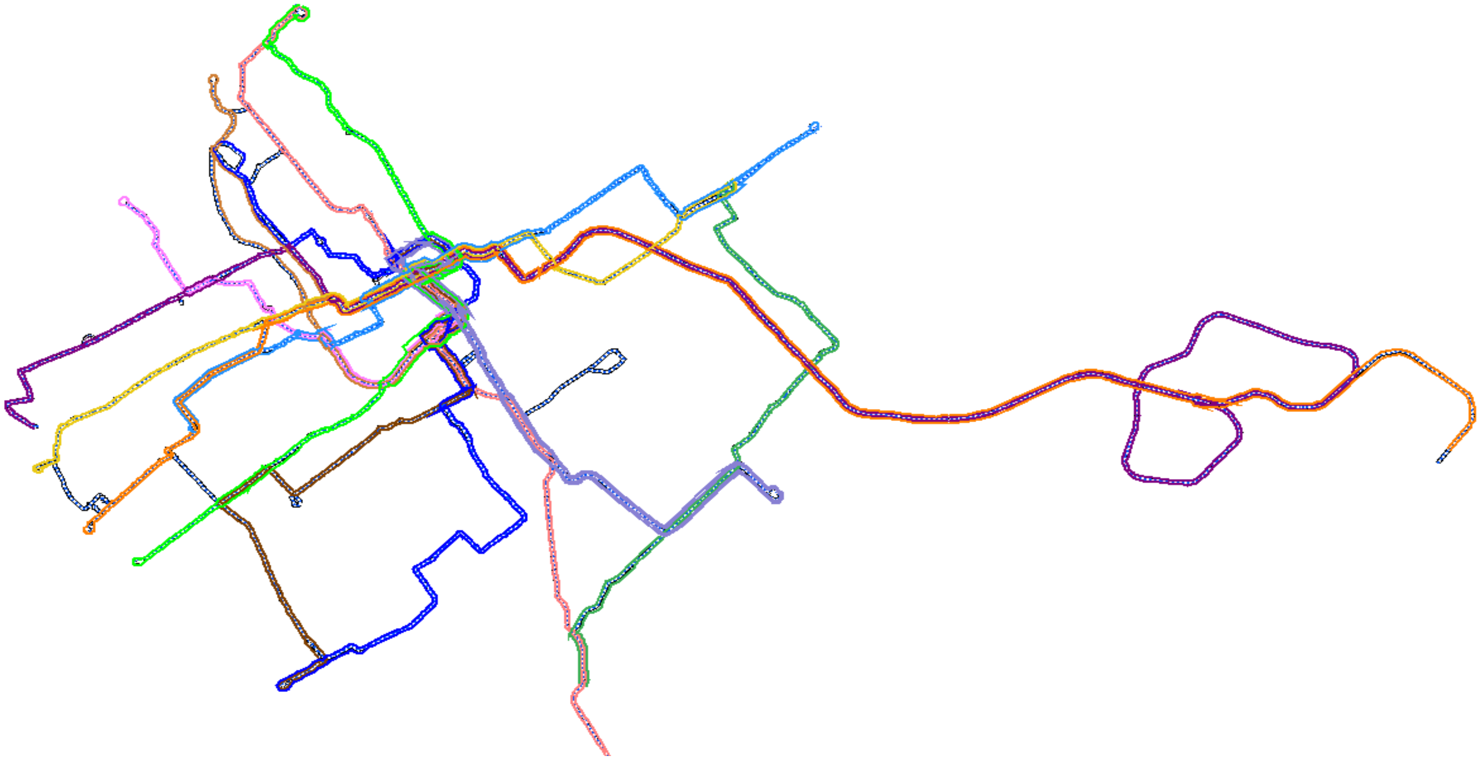
# Smartcard data (2/2)

Our research focus:

**Connecting to transport model**
- Evaluating history
- Predicting the future
- Elasticity approach (quick and low cost)

# 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)

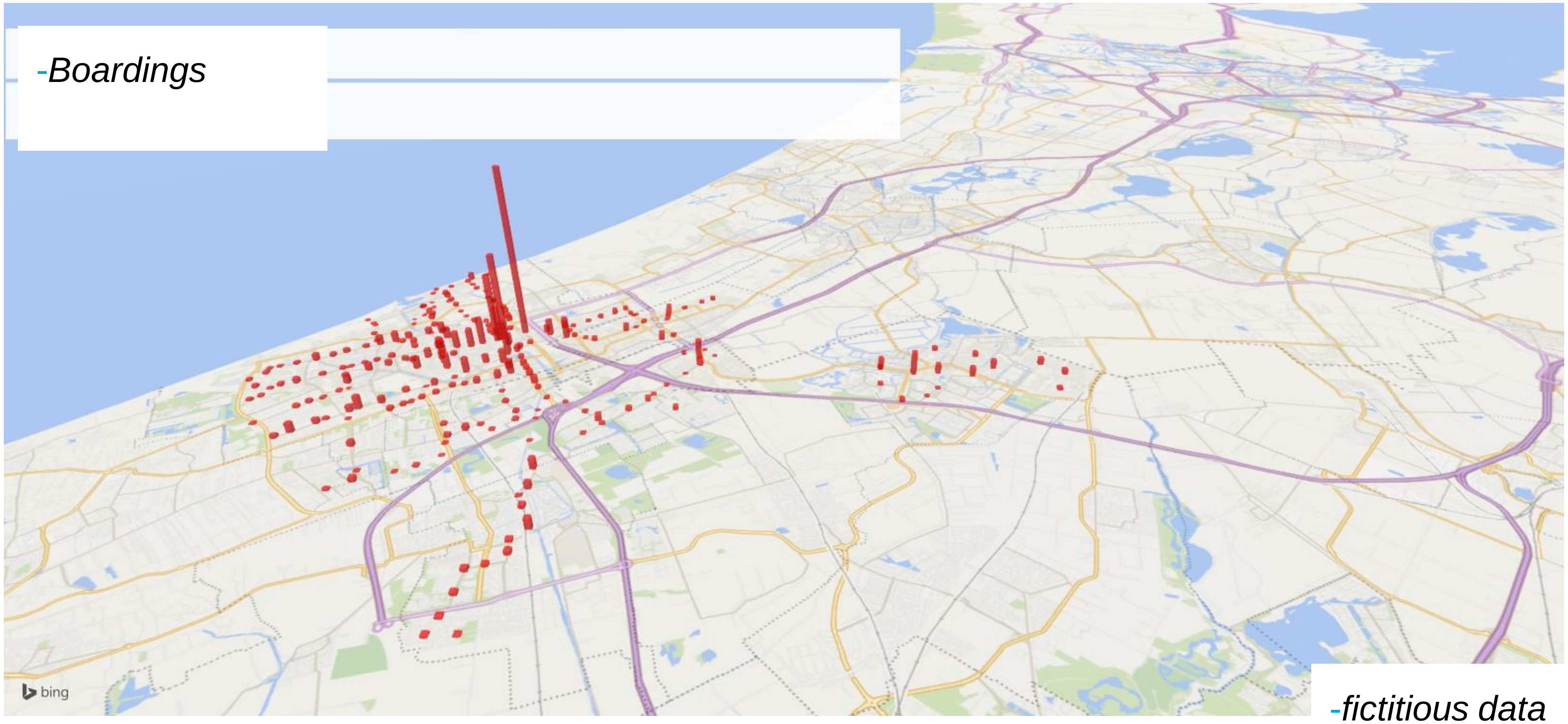
3) Processing and matching

Processing smart card data

- missing check outs
- short trips

# Connecting data to transport model (4/4)

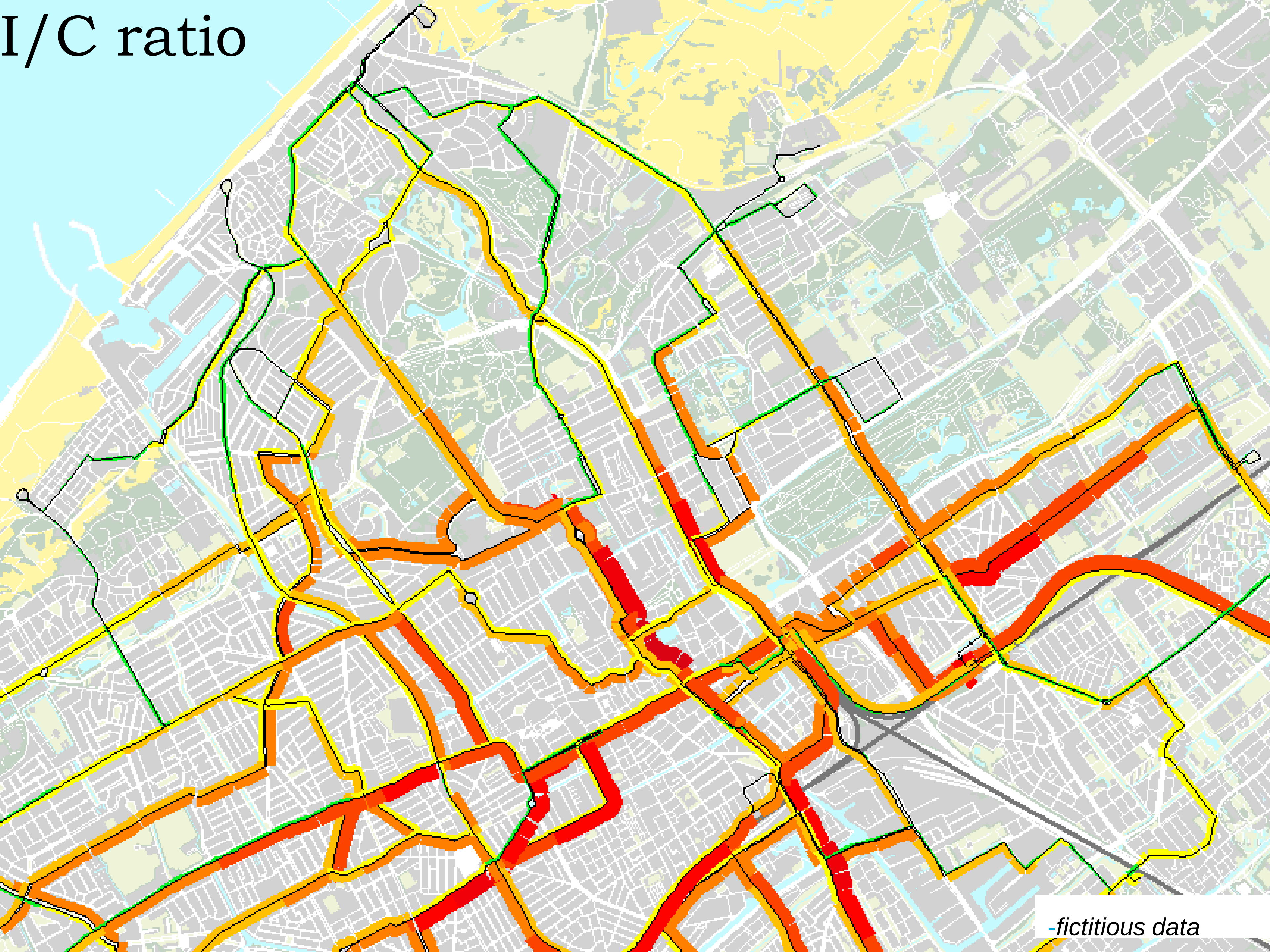
4) Route choice and visualization options of transport model




-fictitious data

-fictitious data

# I/C ratio



# What if?

# 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**

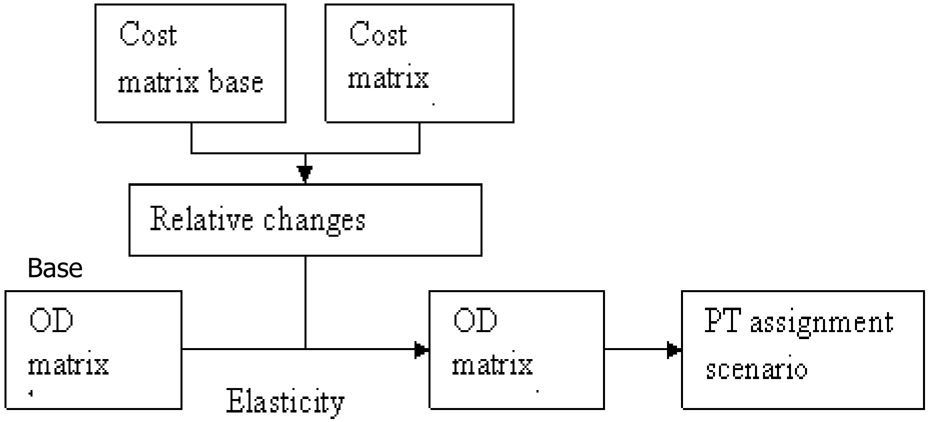
# What if: elasticity approach (1/2)

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

*With:*

| | |
|---|---|
| $C_{ij}$ | Generalized costs on OD pair *i,j* |
| $\alpha_1$, $\alpha_2$, $\alpha_3$, $\alpha_4$ | 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* |

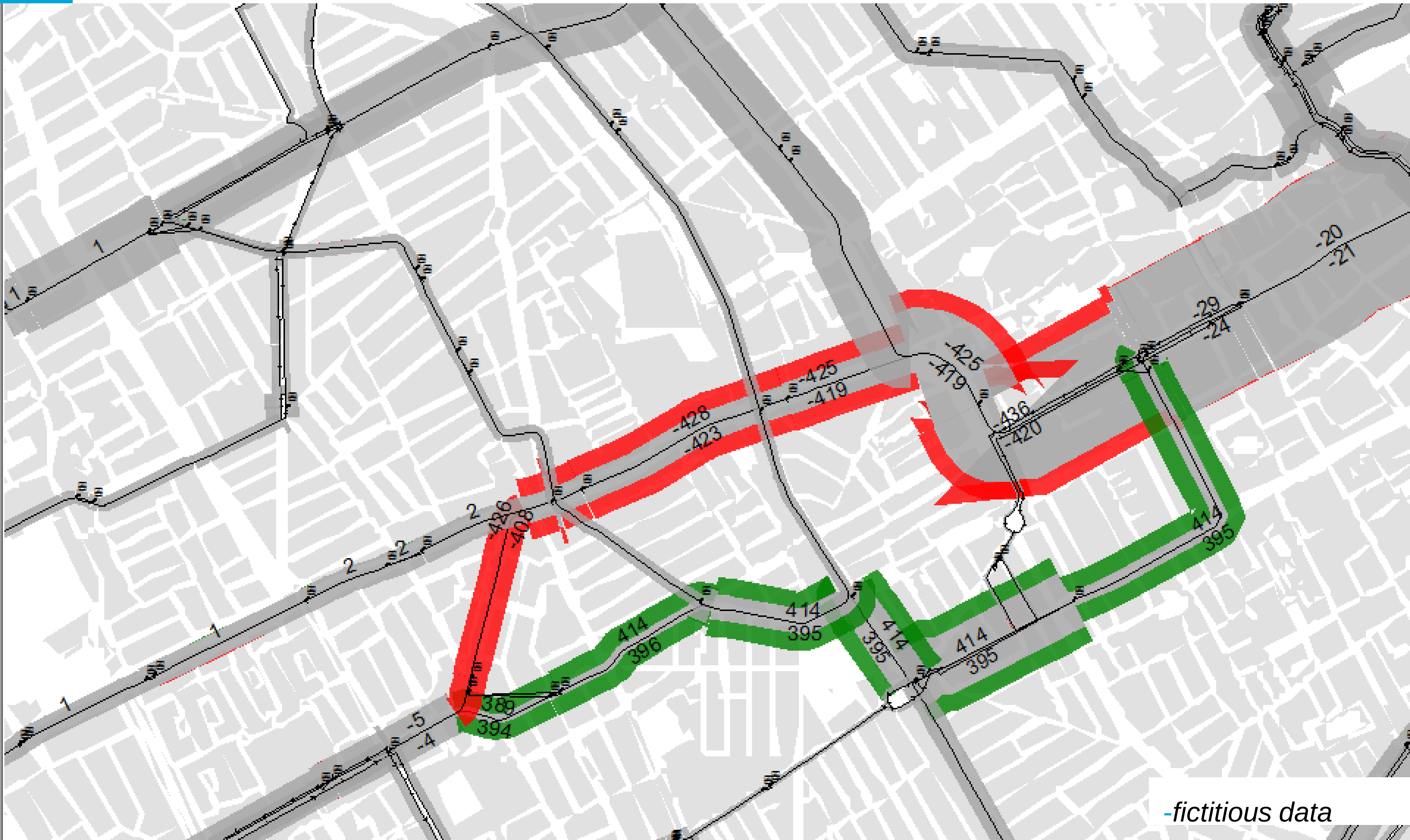
# What if: elasticity approach (2/2)




- Elasticities
- Literature (e.g. Balcombe)
- “Proven “ rules of thumb

- NOTE:
- Simple changes
- Short term
- Only LOS changes
- Accuracy

# Whatif results: Flows rerouting



# Whatif: increased speed

*-fictitious data*

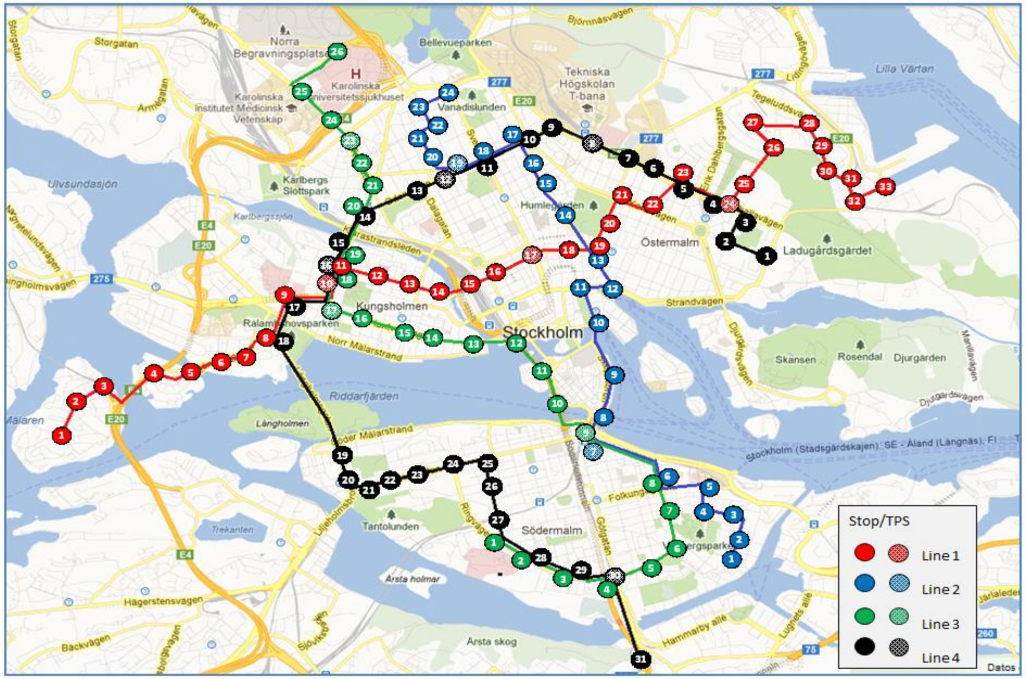
# Case 2: Stockholm, Sweden

# Stockholm trunk bus case study

- AVL for entire bus fleet used for:
  - Radio communication
  - Real-time monitoring
  - Fleet management strategies
  - Generation of real-time passenger information

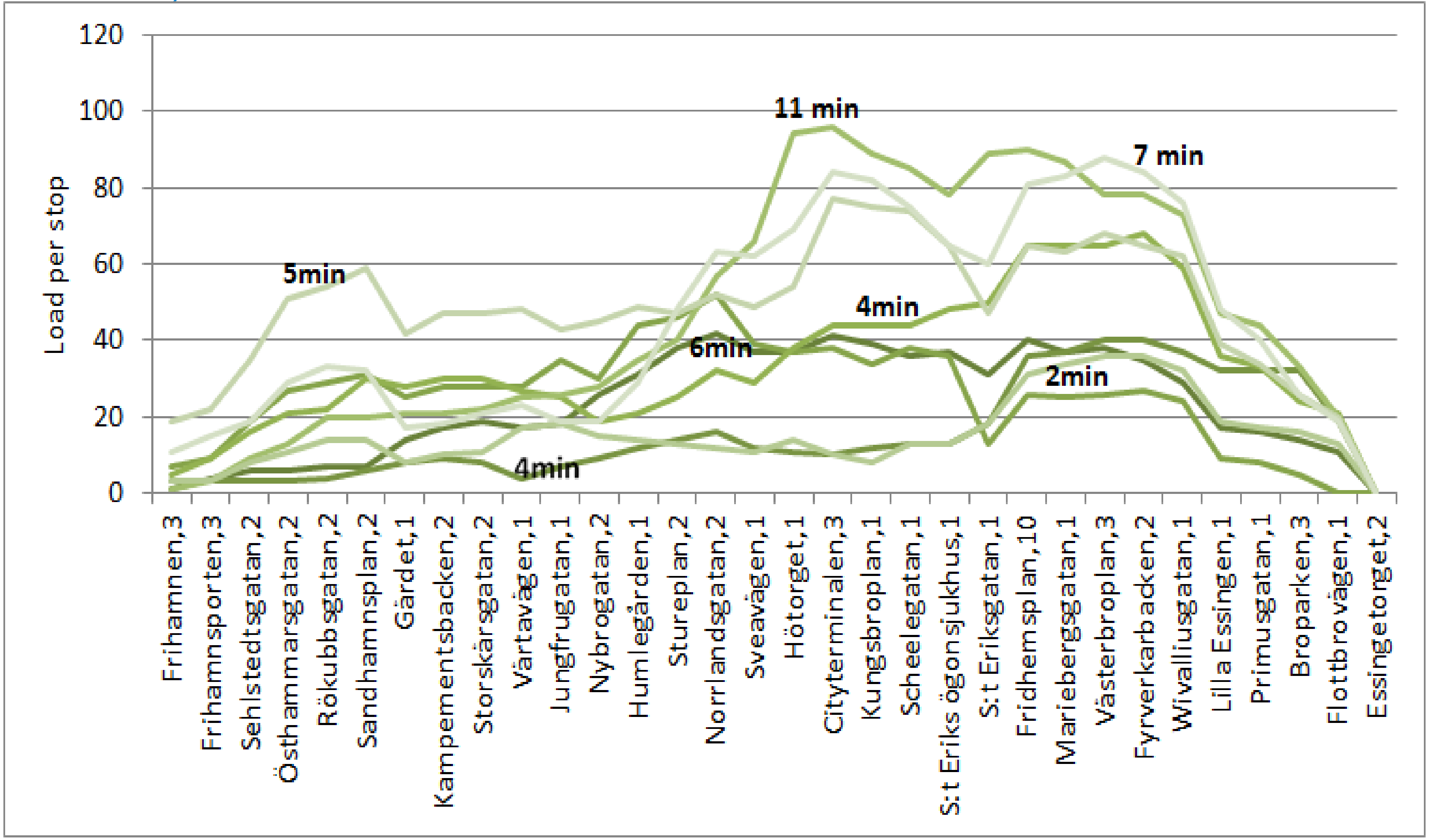
- Ongoing work to make APC (10-15% buses) and AFC (90% users, check-in only) available in real-time

- 5-7 min headway
- Partially dedicated ROW
- 58% of all bus pass-km in Stockholm inner-city



# Primary problem: service unreliability

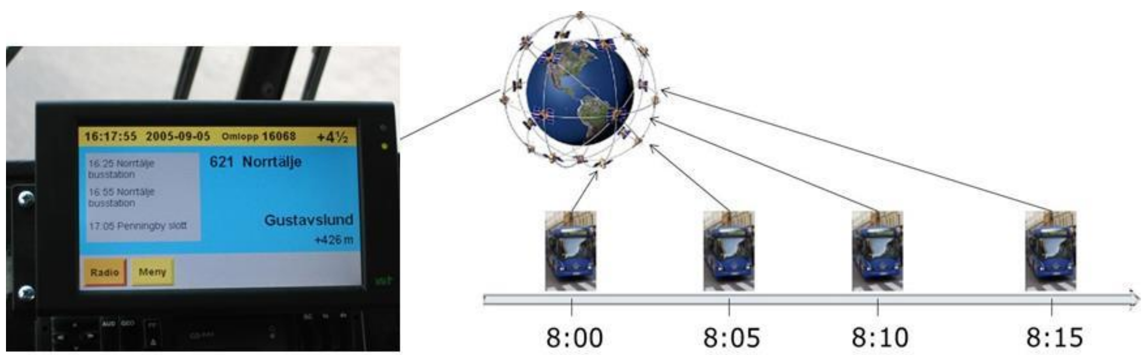
## Line 1, 16:00-17:00



# Study objective and approach

- **Developing and evaluating operational and control strategies to mitigate the bus bunching phenomenon**

1. Analyzing reliability at the stop, line and network level
2. Investigate the underlying determinants of service reliability
3. Design and test – first in a simulation envorionment then in the field -



# From Research to a Field Test

**Modeling -** Transit operations simulation model, BusMezzo

**Validation -** Tel-Aviv and Stockholm case studies

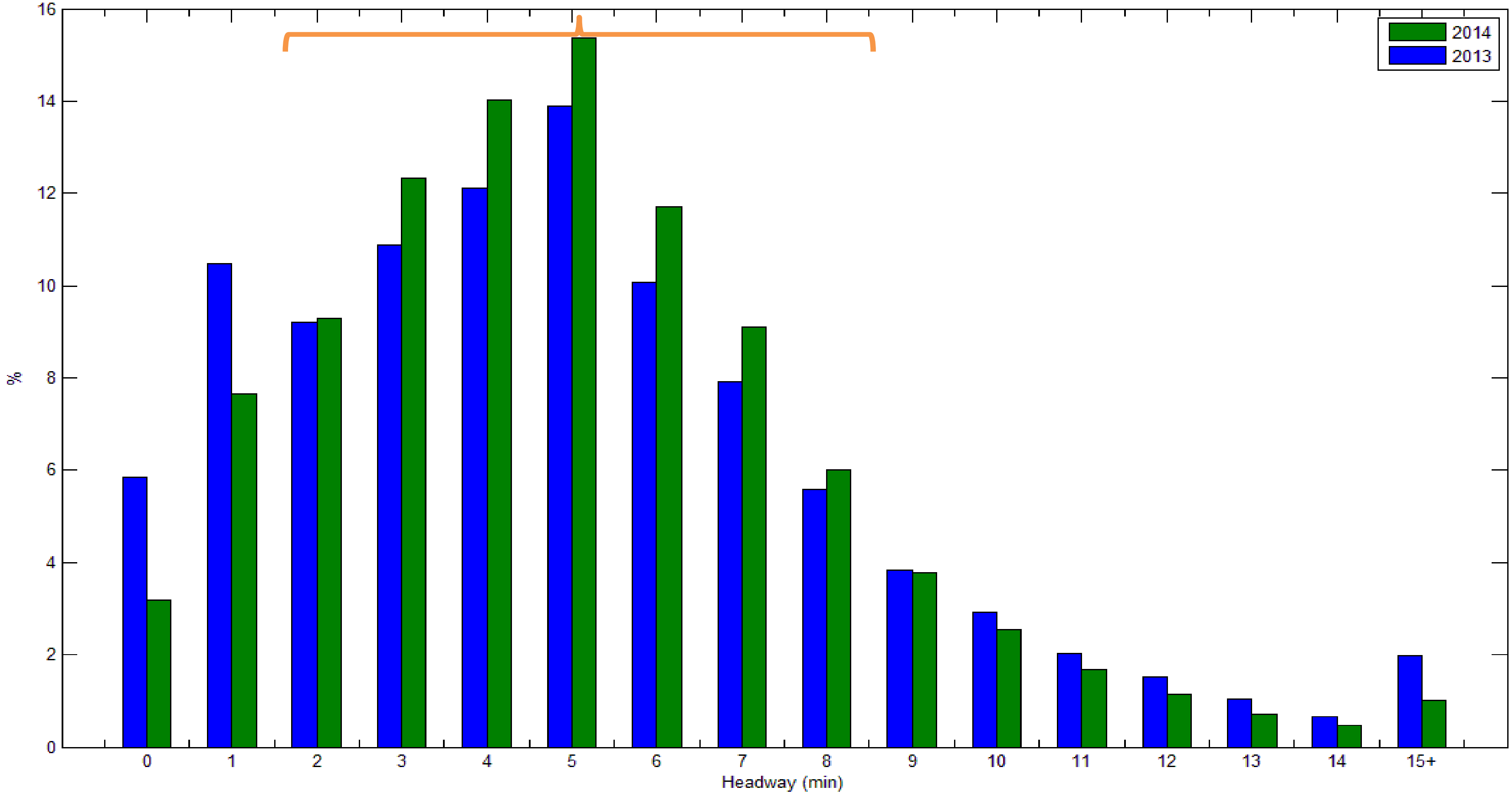
**Evaluation and Optimization** - Real-time holding strategies for Stockholm case study

**Series of experiments –** Field trials with lines 1,3 and 4 in Stockholm

**Implementation –** Full-scale operations and business model

# More regular services

- Line 4, 7:00-19:00



# Main outcomes from field experiments

- Excessive waiting time -25%
- In-vehicle time -10%
- Total travel time (1172->1056 sec) -10%
- Annual savings of **4,5 million Euro** for weekdays 7am-7pm (underestimation of congestion effects)

# Summary

- Major challenges in public transport
- Data supports optimization
- Evaluating and controlling -> predicting and optimizing

- Connecting data to transport models enables short term predictions
- Combining strenths of two approaches (complex <-> simple)

- Developing and evaluating operational and control strategies to mitigate the bus bunching phenomenon

Next steps

- Updating elasticities (using smartcard data)
- Additional factors in cost function (reliability, crowding, etc)
- Data fusion

# Questions / Contact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**Publications:**

http://nielsvanoort.weblog.tudelft.nl/

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