TOWARDS DATA-DRIVEN MODELS FOR THE MOBILITY SYSTEM

The mathematics of operations research - seminar Networks | Maaike Snelder

TNO innovation for life

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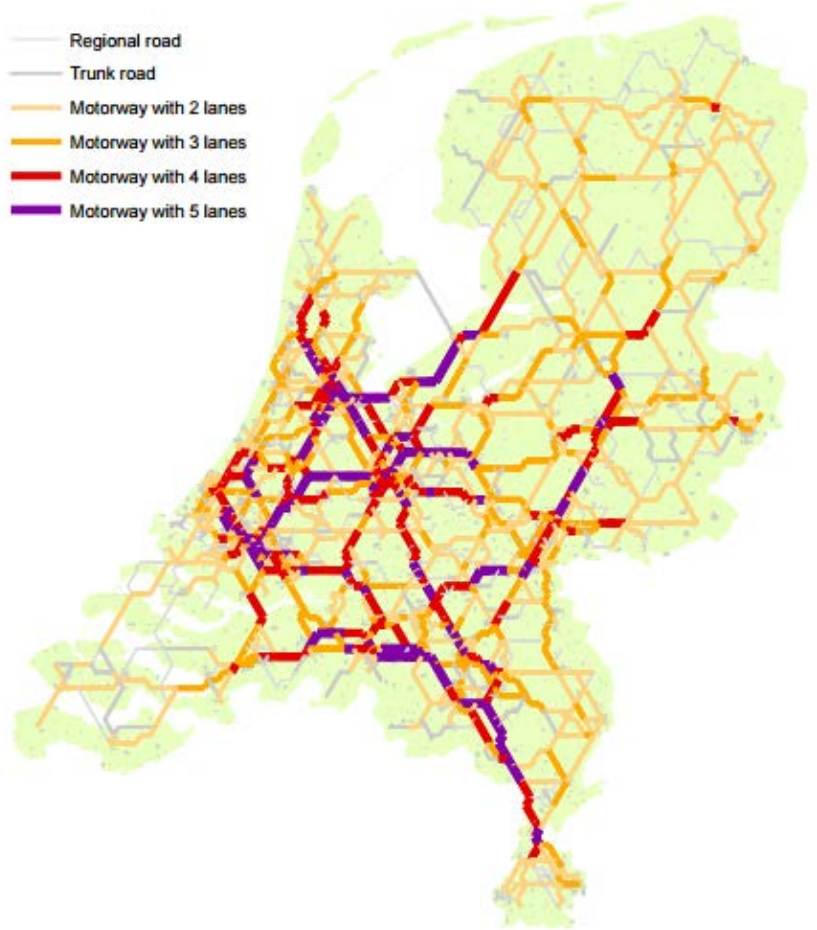
TU Delft

BACKGROUND

- Background: econometrics
- 2005-2010: PhD Robust Road network design
- 2004 - now: TNO senior researcher
- 2011 - now: assistant professor TU Delft

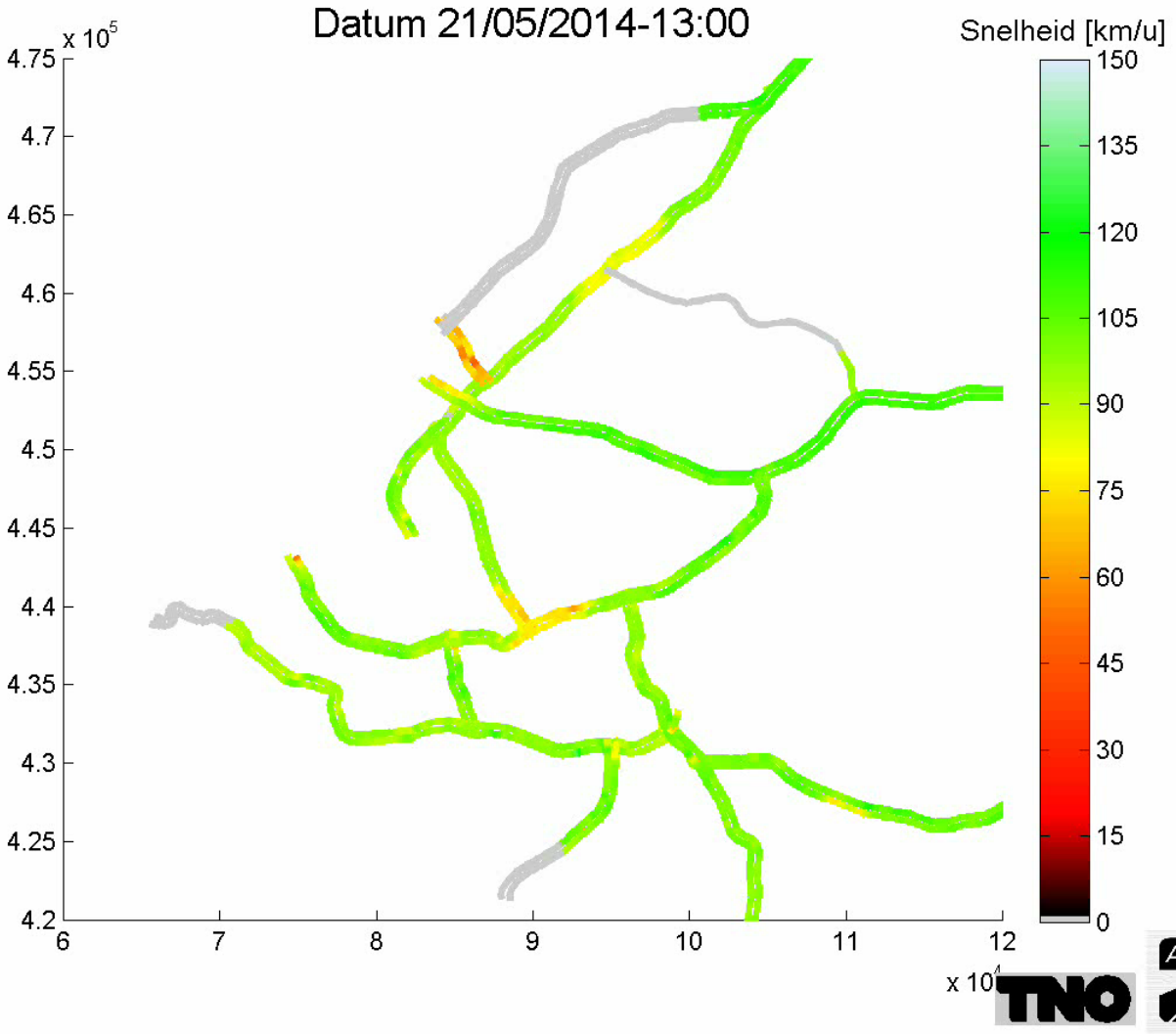


OUTLINE

1. Brief introduction- traffic an Transport models
2. New data sources
3. Example 1: In car route advice - Amsterdam Practical Trial
4. Example 2: Modelling boats on the canals of Amsterdam

TRAFFIC AND TRANSPORT MODELS

Used to support planning and evaluation studies on transport measures, such as new infrastructure, mobility policy, network management, ITS, traveller information systems, pricing measures, …



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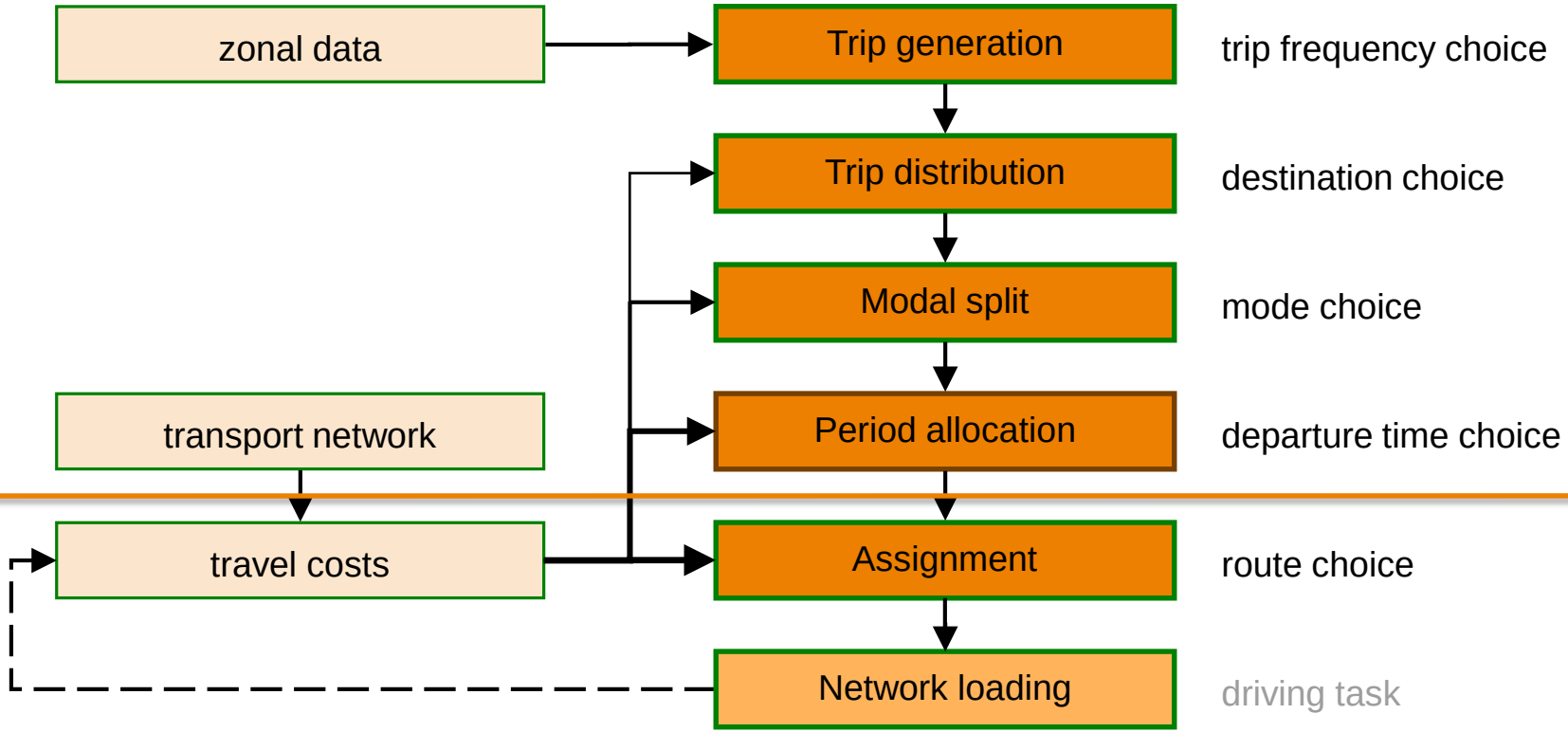
Traffic conditions on a transport network are a function of:

- Travellers' choices:
  - Trip
  - Destination
  - Mode
  - Departure time
  - Route choice
- Network characteristics
- Measures Traffic control centre
- Disturbances

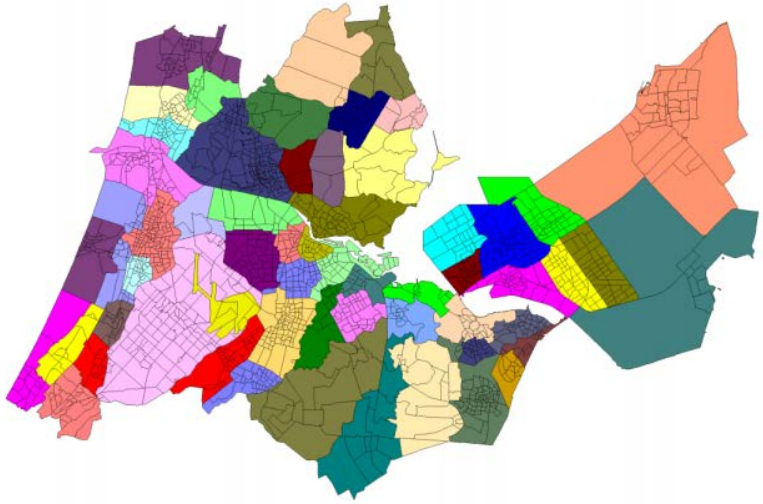
TNO ATOL

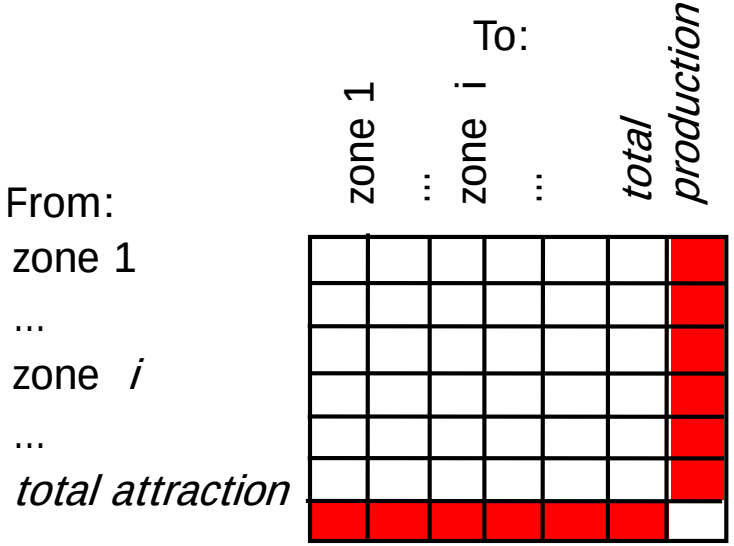
TRANSPORT MODELLING



Source:Pel, A.,CT5802 advanced tranportation modelling and network design

STEP 1 TRIP GENERATION

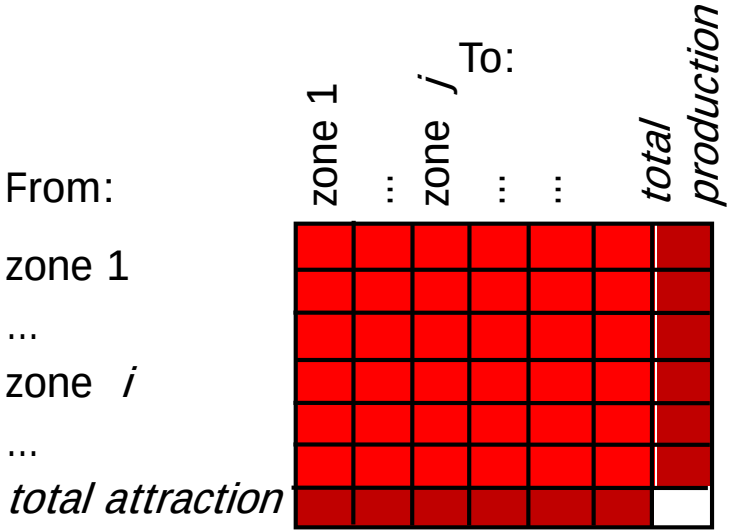




Models:

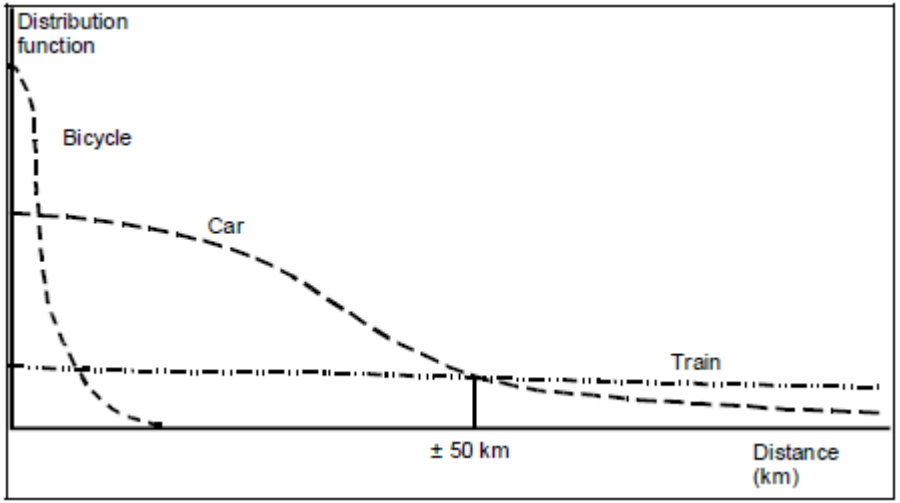
- Factors production: e.g., residential density, household structure, income
- Factor attraction: e.g., office and retail space, employment levels
- Production and attraction functions

STEP 2: TRIP DISTRIBUTION

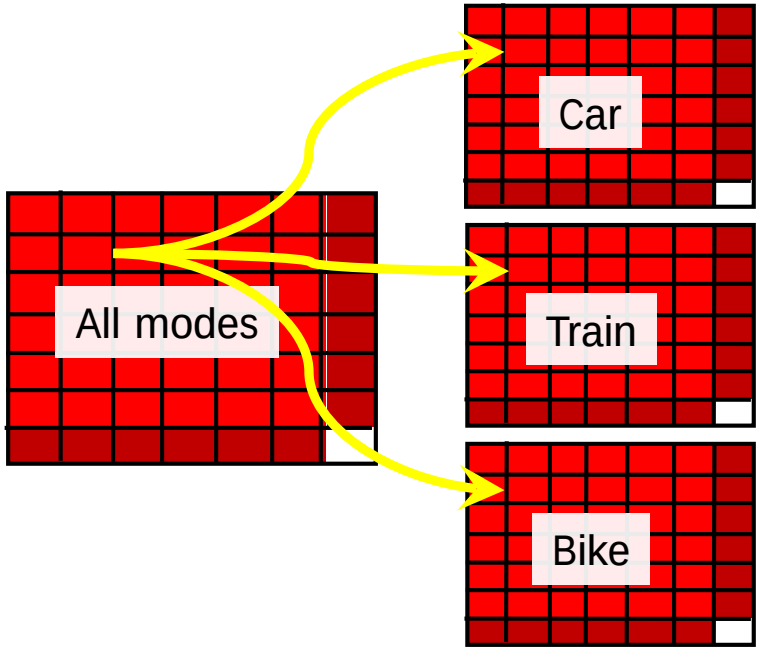


Models:

- Growth factor method with base matrix
- Gravity-based model with distribution function



STEP 3: MODAL SPLIT

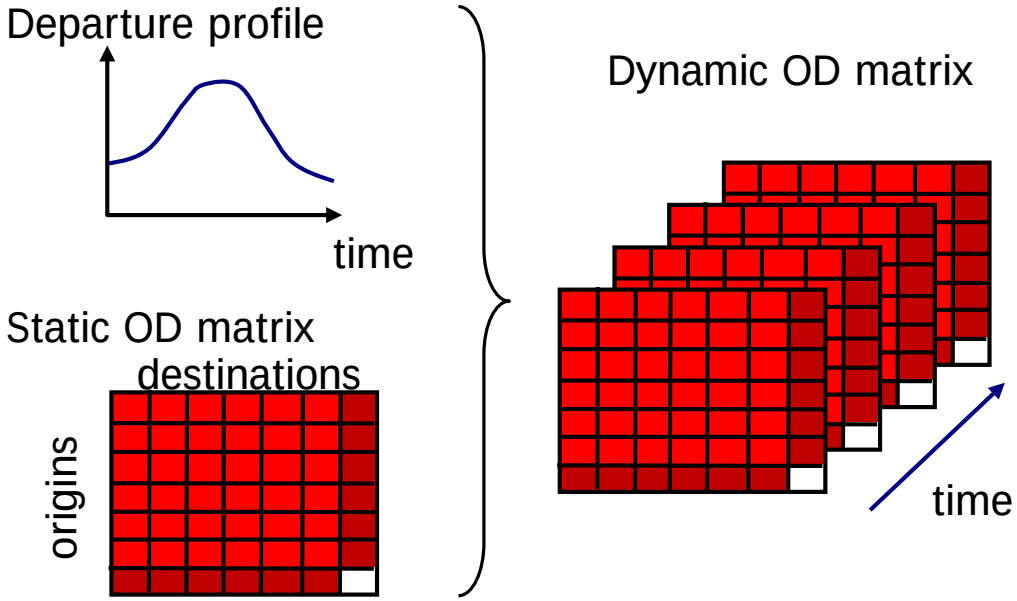


Models:

- Logit model (mixed logit, nested logit,..)

$$\beta_{ijv} = \frac{\exp[bV_{ij}^{v}]}{\sum_{w}(\exp[bV_{ij}^{w}])}$$

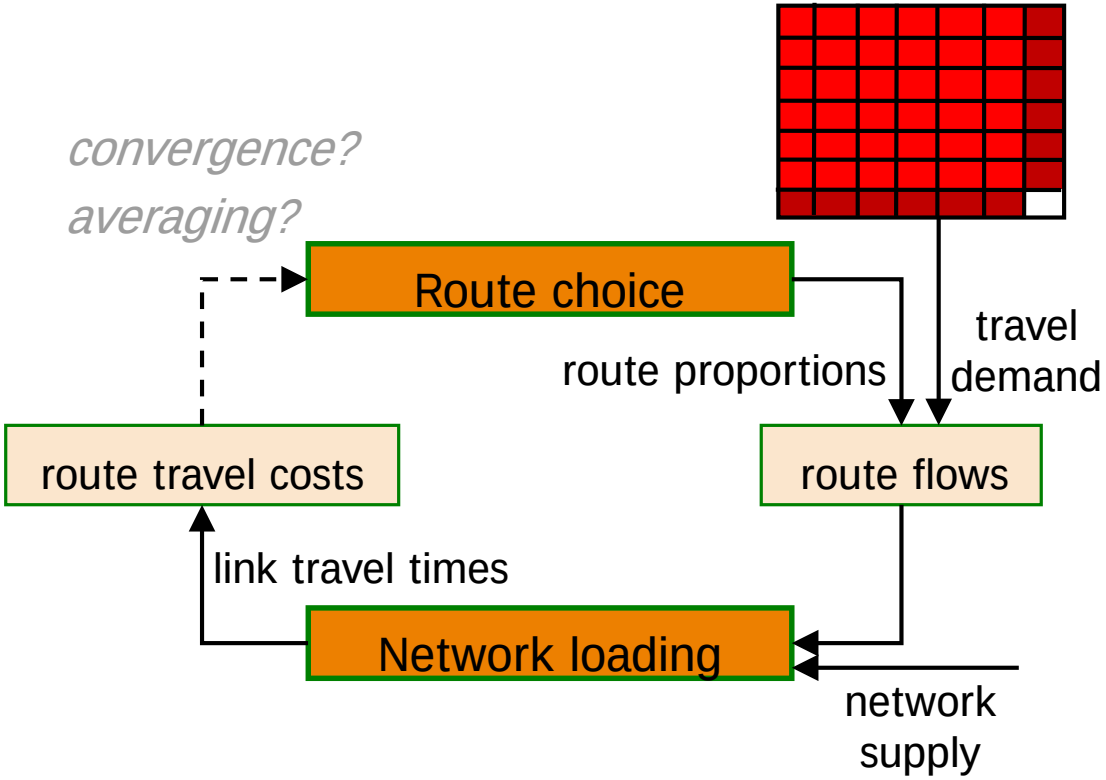
STEP 4: PERIOD ALLOCATION



Models:

- Utility theory with penalty on earliness or lateness relative to preferred departure or arrival

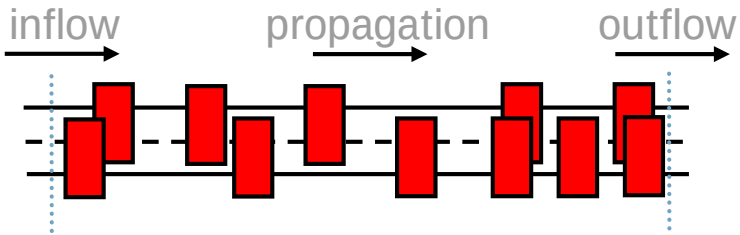
STEP 5: TRAFFIC ASSIGNMENT



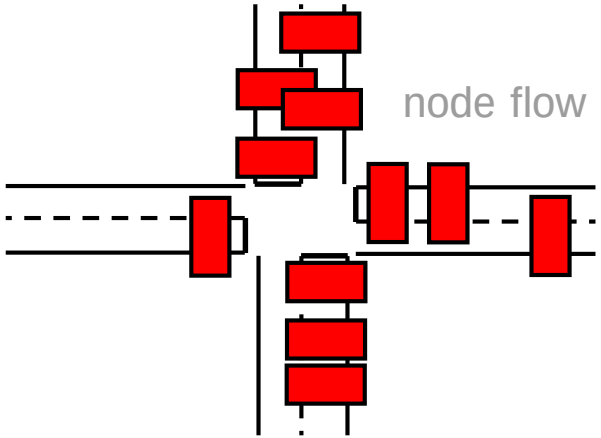
Models:

- Probit model, Logit model (MNL, PS-logit, C-logit), assuming SUN, DUE, SO, ...

NETWORK LOADING



Link model



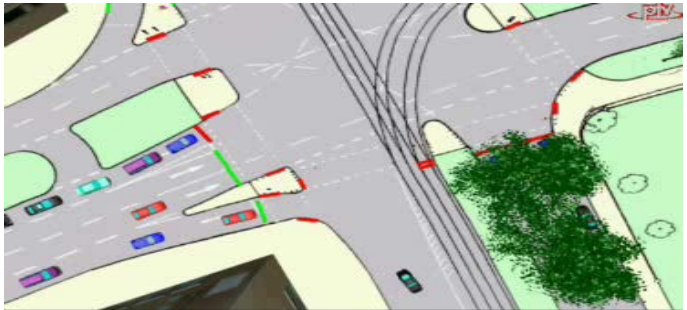
Node model

Can be mathematically expressed as a set of constraints:

Flow conservation, flow propagation, first-in-first-out, maximum on in- and outflow, maximum on density

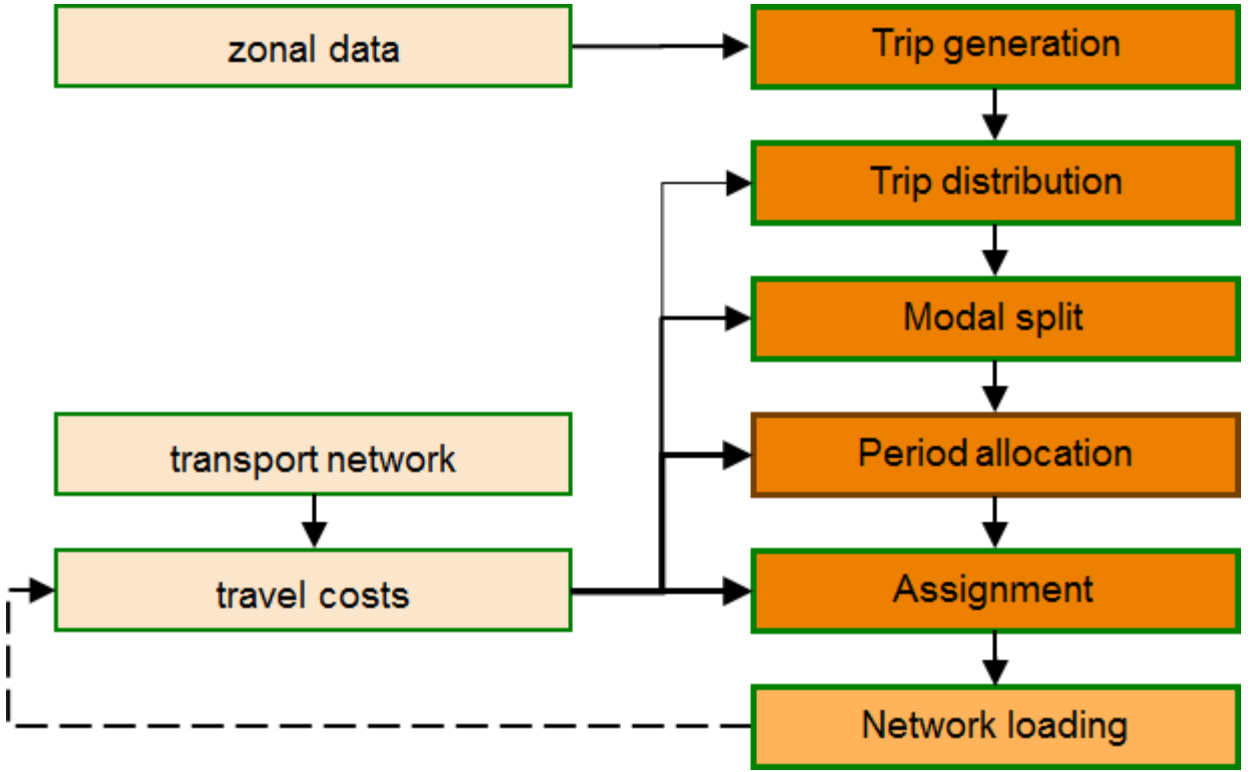
LEVEL OF ANALYSIS – CLASSIFICATION OF MODELS

Traffic representation		Traffic propagation: vehicle interaction	Traffic propagation: flow-density rel.
	individual vehicles	microscopic models	mesoscopic models
	aggregated flow	(n/a)	macroscopic models



ESTIMATION, CALIBRATION, VALIDATION

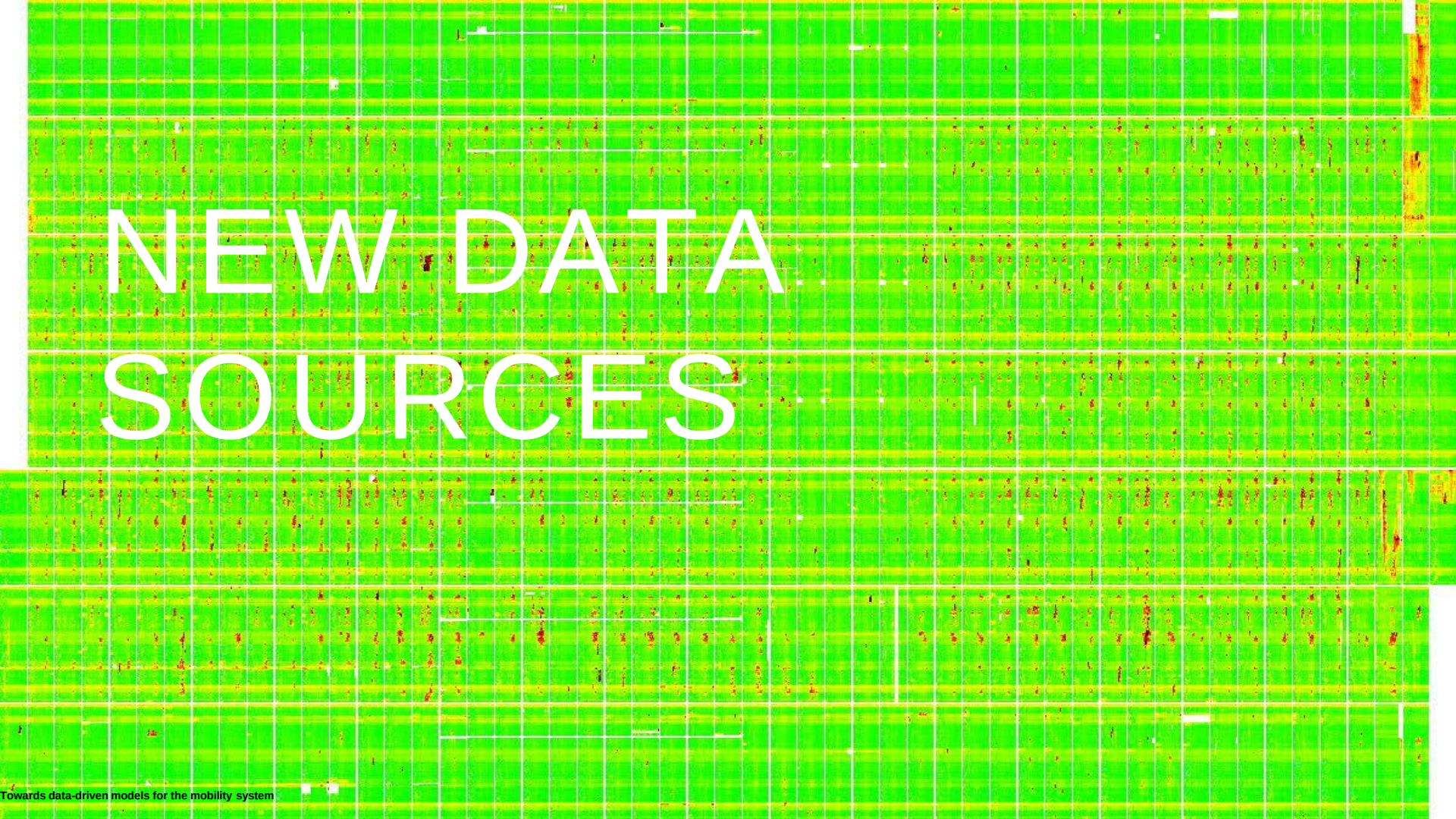
- Data sources
  - OViN. Large scale questionnaire. Trips, mode, travel time, distance etc.
  - Traffic volumes



NEW DEVELOPMENTS

- Modelling new measures, like automated vehicles

- Type of models
  - Probabilistic and stochastic models
  - **Marginal models**
  - **Data-driven modelling: Use of new data sources in models**


NEW DATA
SOURCES

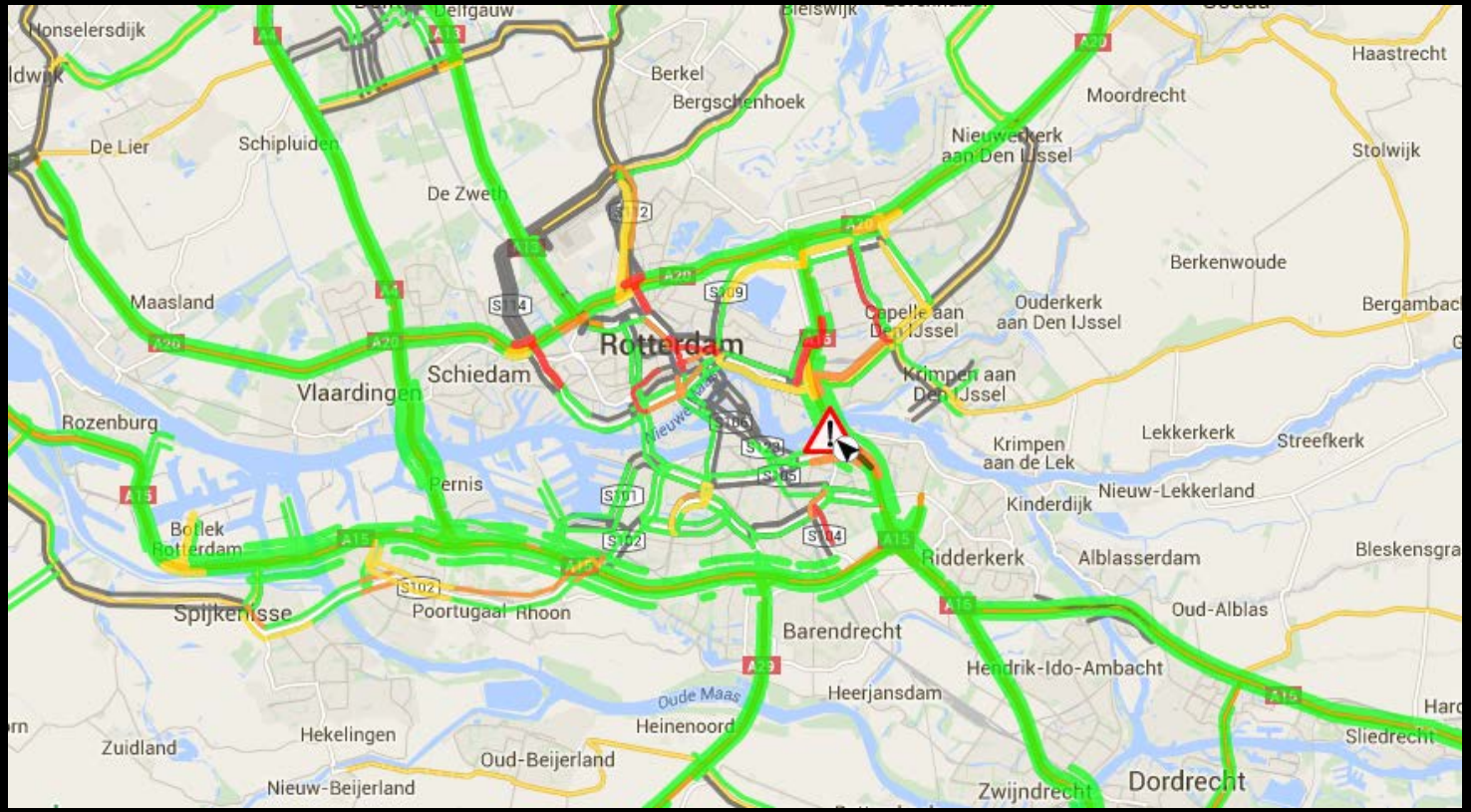
25.000 sensors measuring:

- Averaged speed (km/h)
- Flow (veh/min)
- VMS

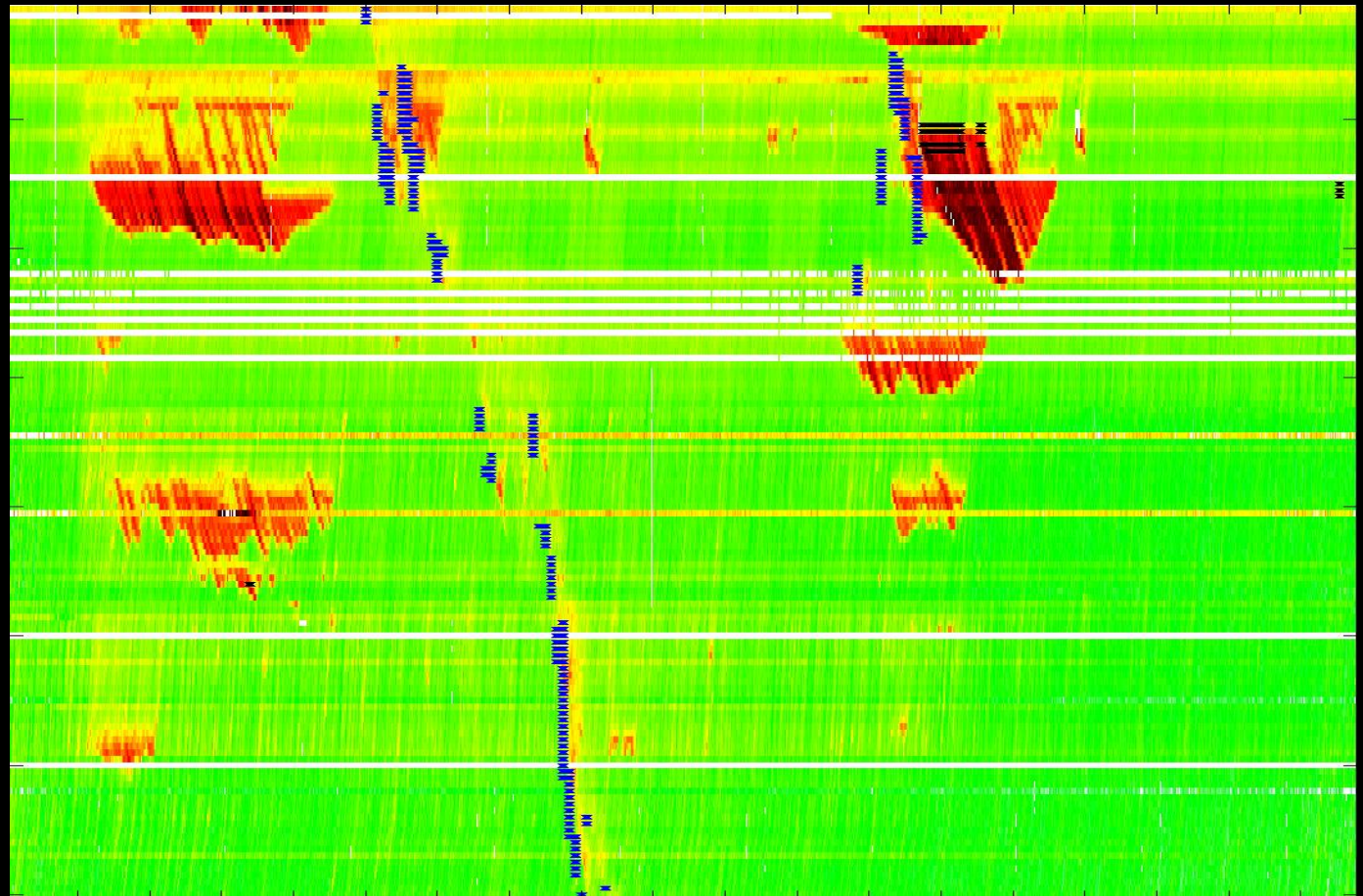
Real time:

- Read
- Enriched/processed
- Translated into traffic information

A few thousands of travel time trajectories
Real time read, processed and translated to traffic information

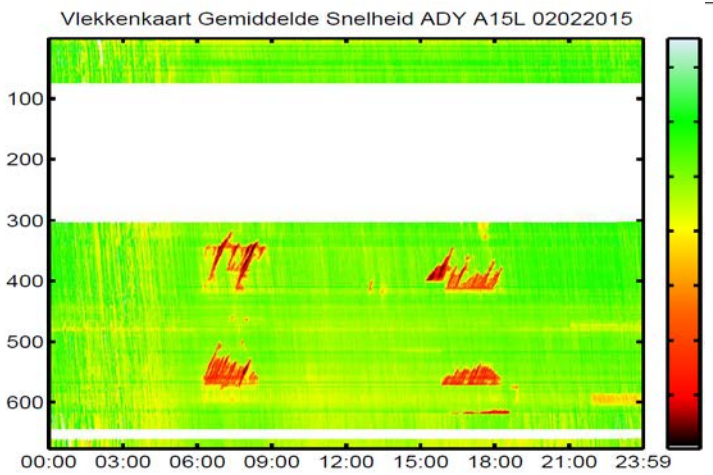


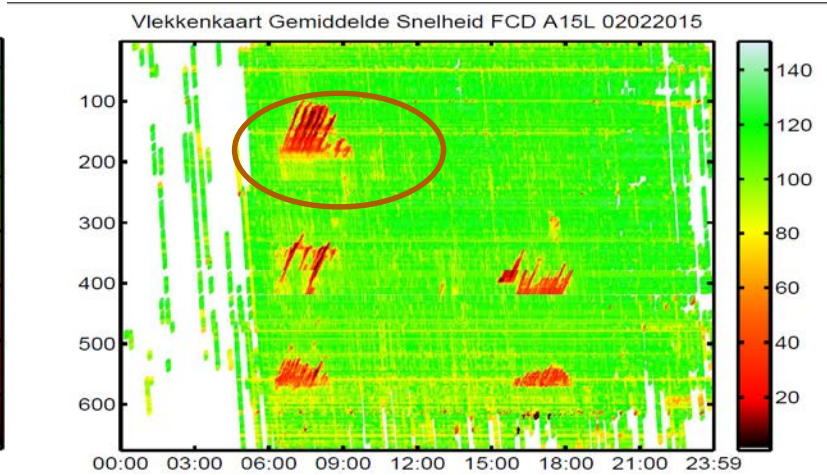
Data fusion: Merging traffic data with KNMI radar data

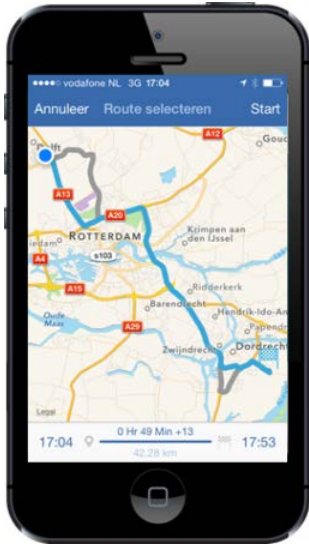


FCD VS INDUCTION LOOP DATA (ADY)

BLIND SPOTS





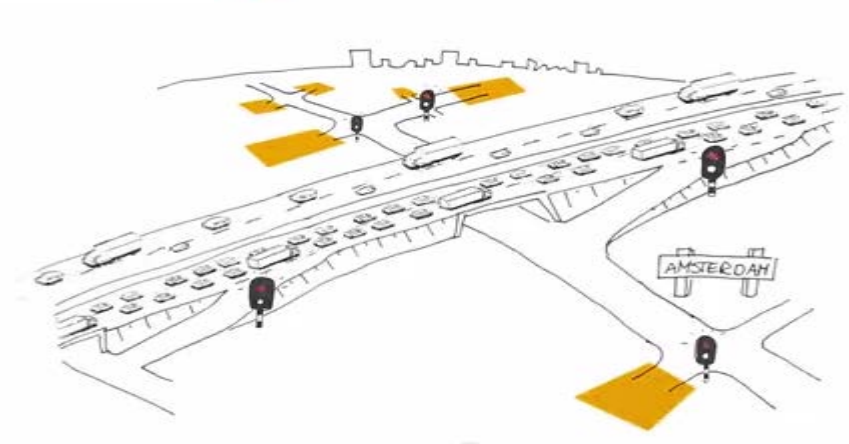


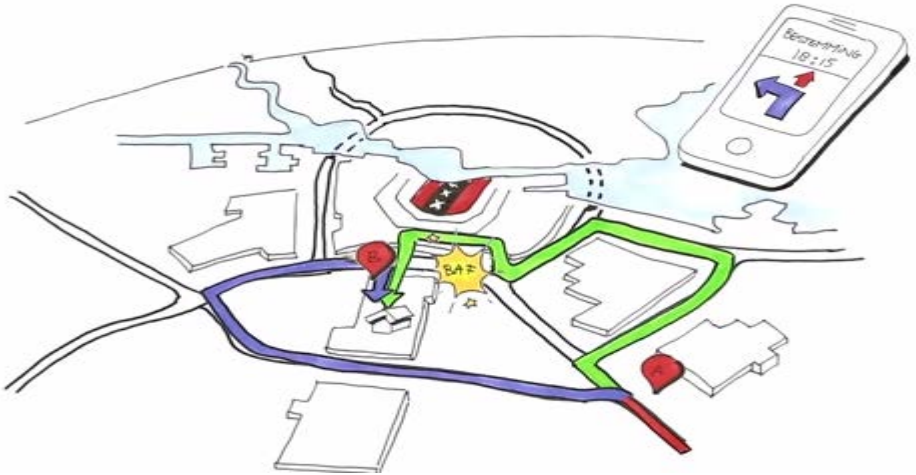
Speed, flow, routes, OD-matrices

AMSTERDAM PRACTICAL TRIAL

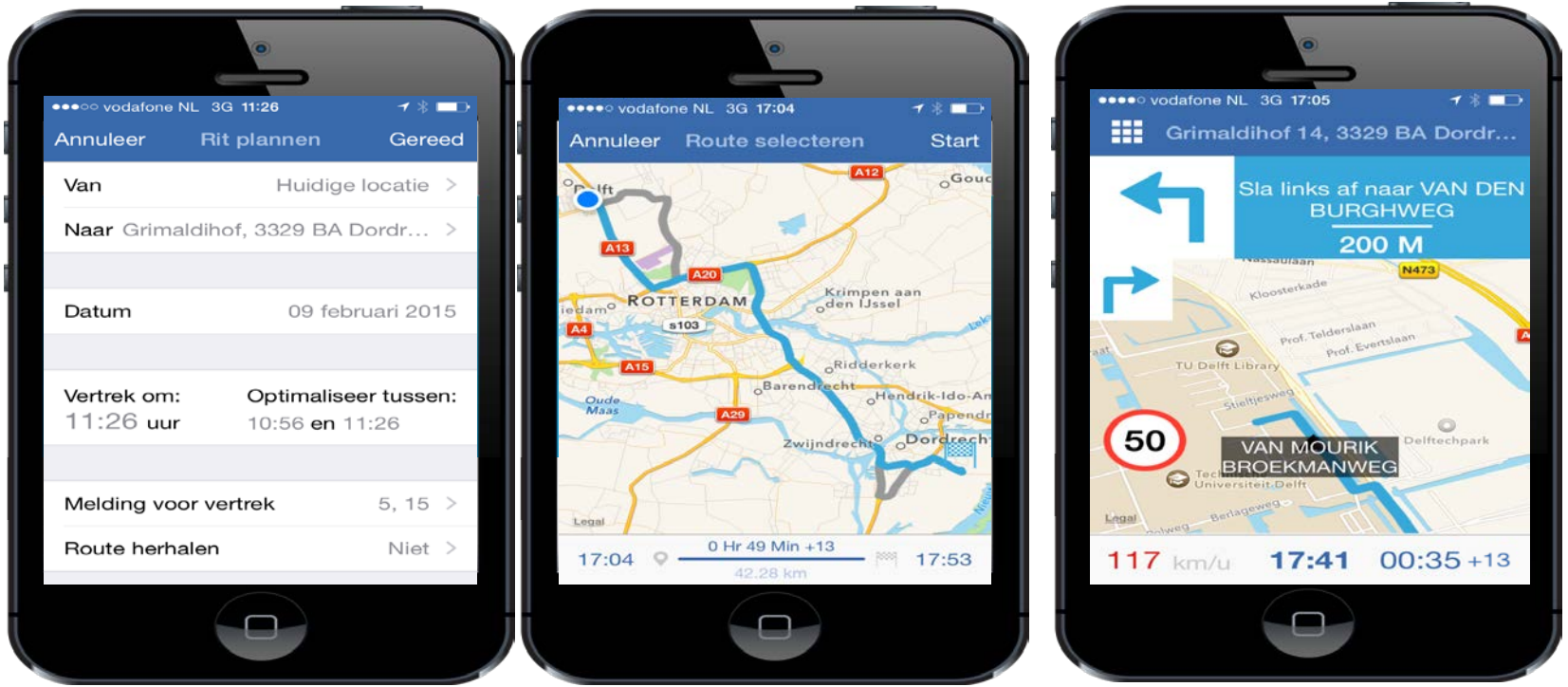
REAL-TIME TRAVEL TIME PREDICTION FRAMEWORK FOR DEPARTURE TIME AND ROUTE ADVICE

AMSTERDAM PRACTICAL TRIAL





APP FOR REGULAR CONDITIONS AND EVENTS



SMART ROUTING

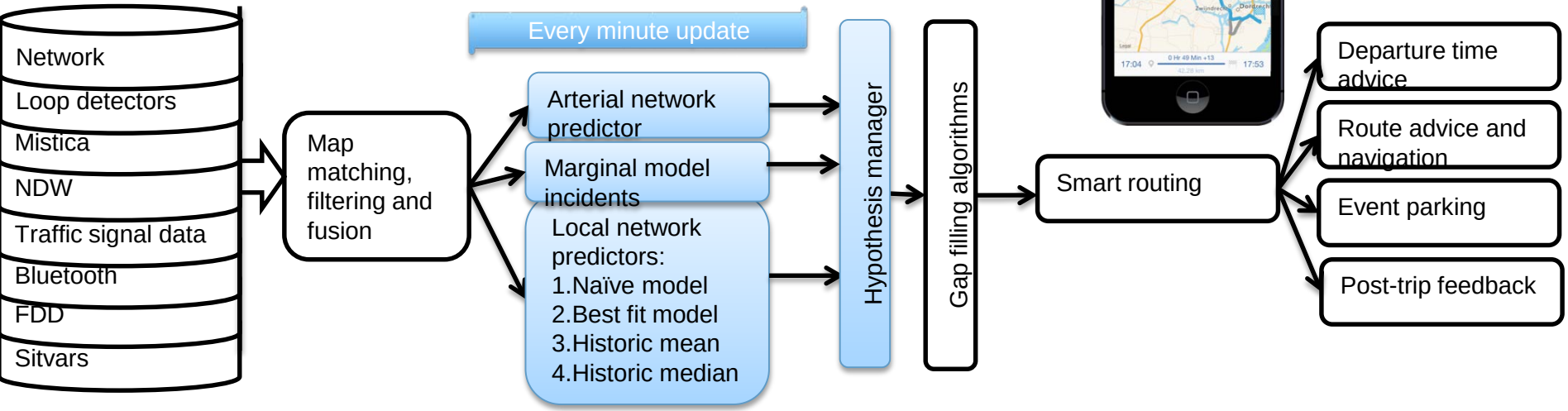
- Actual and predicted travel times
- Previous advises
- Personal preferences

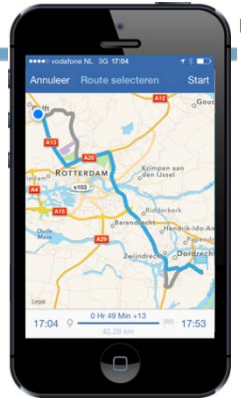
NETWORK

- All motorways
- More detailed road network around Amsterdam and Rai and Arena
- Other roads: free-flow assumed

16 thousand links
68 thousand nodes

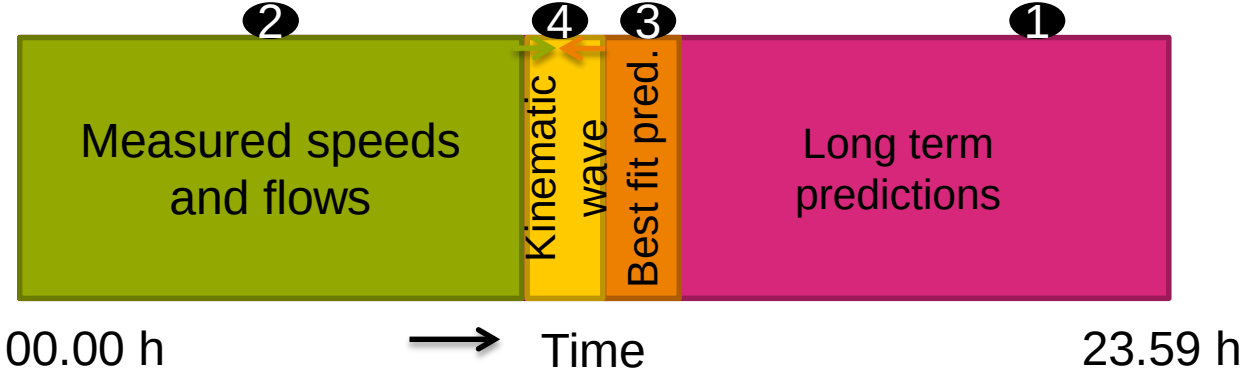
FRAMEWORK





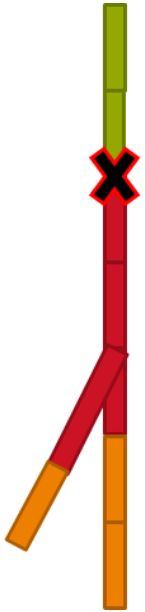
- Different and more complex prediction models can be added to the framework

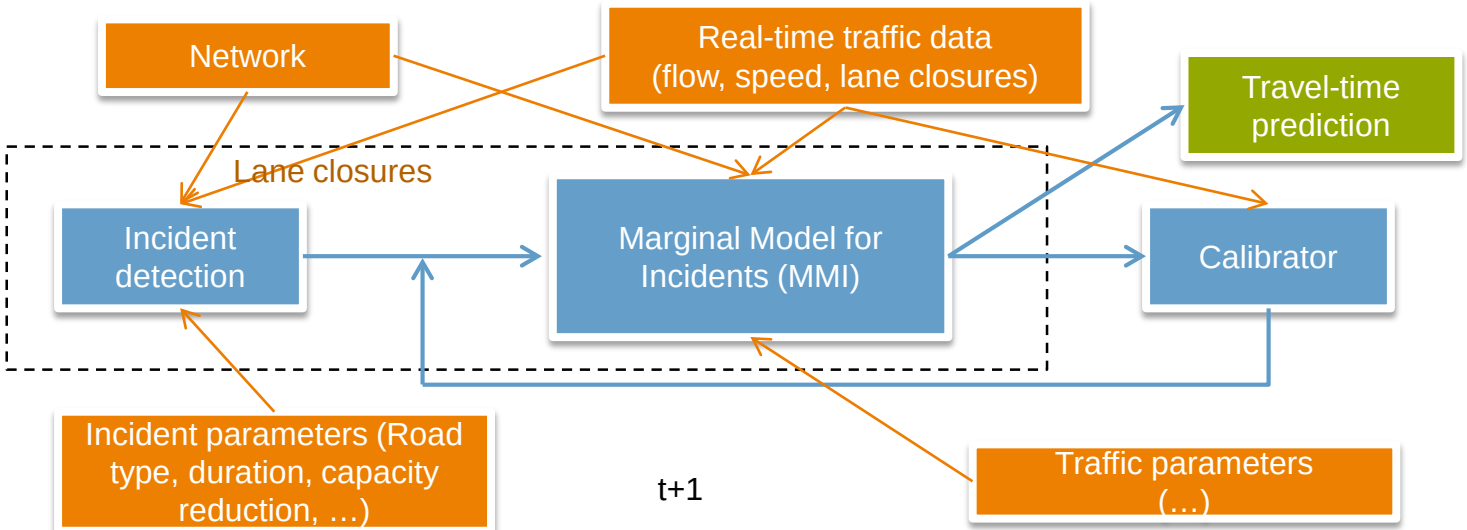
ARTERIAL NETWORK PREDICTOR



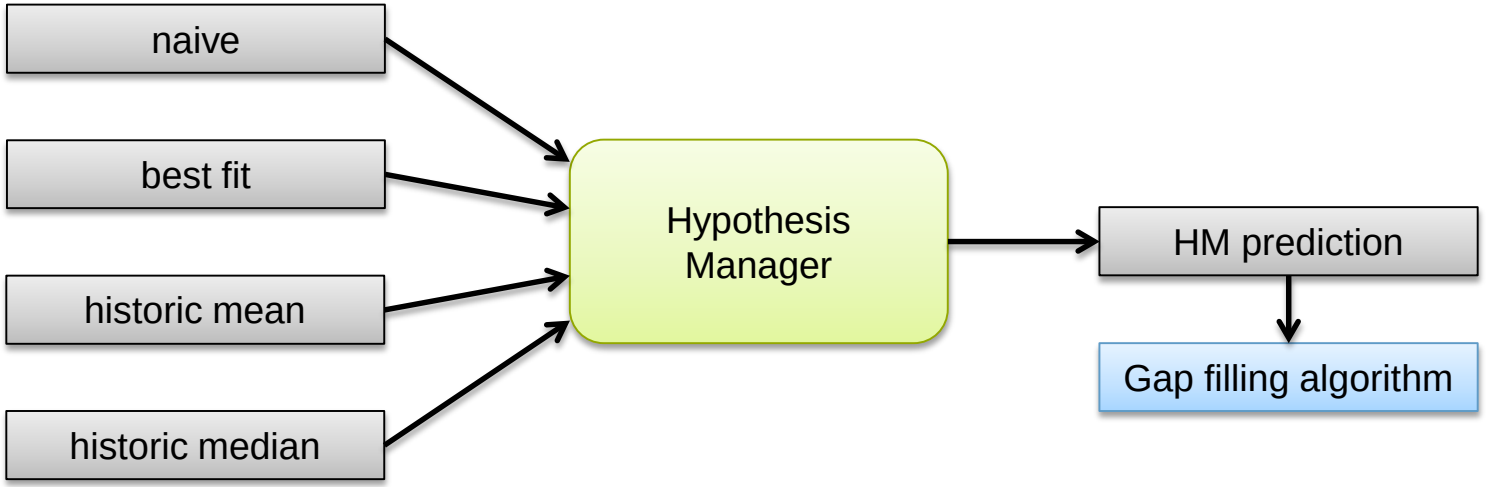
INCIDENT MODULE - A HYBRID MARGINAL MODEL

All input and updating is data-driven / predictions are traffic flow theory driven





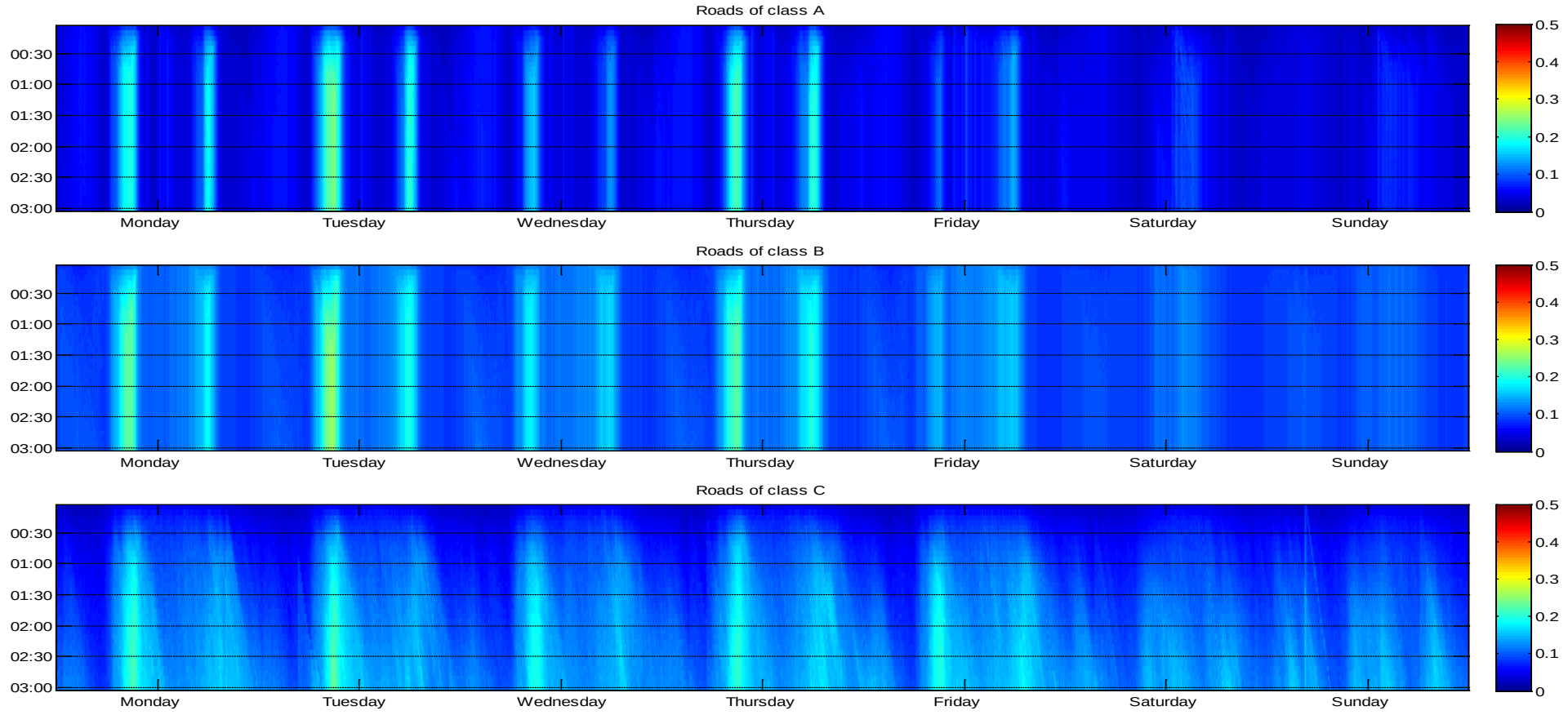
HYPOTHESIS MANAGER



$$E = \frac{\sum_{l=1}^{N} |P_l - R_l|}{\sum_{l=1}^{N} R_l}$$

P_l: predicted traveltime link l
R_l: realised traveltime link l

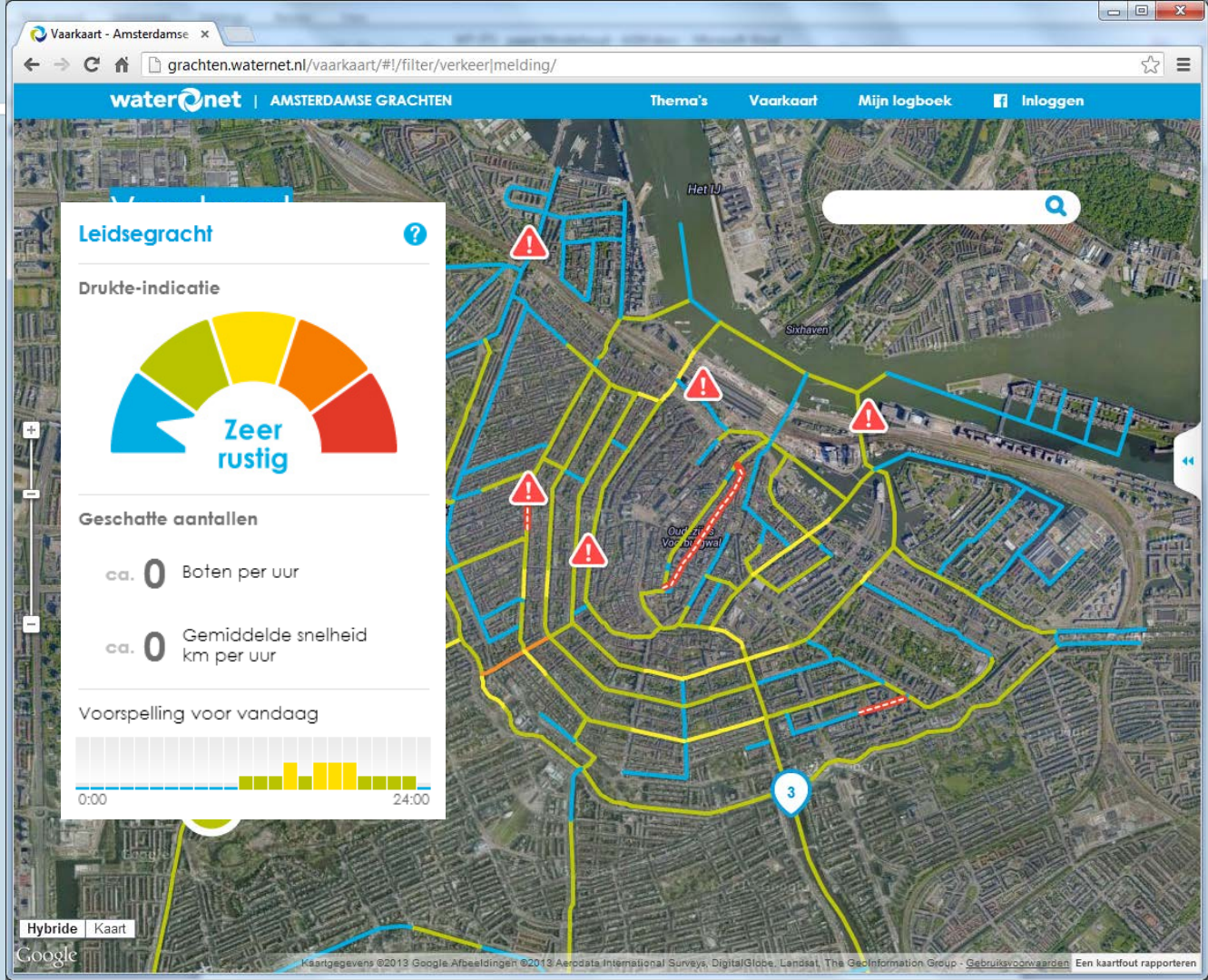
QUALITY INDICATION PREDICTION MODELS



CONCLUSION AMSTERDAM PRACTICAL TRIAL:

- Framework for travel time prediction introduced
- New incident module introduced
- Avarage accuracy of predictions 80%-100%
- Quality is monitored in detail (for all predictors and all links every day) → improvements can be made where needed the most
- Works in combination with smart routing algorithm

CANALS OF AMSTER-DAM



PROBLEM STATEMENT

- More crowded
- More noice
- Number and types of boats unknown

- Waternet
  - Inform toerists and resident
  - Strategic measure
  - Enforcement (speeds and noice)

3 BOAT TYPE - 27 SCENARIOS

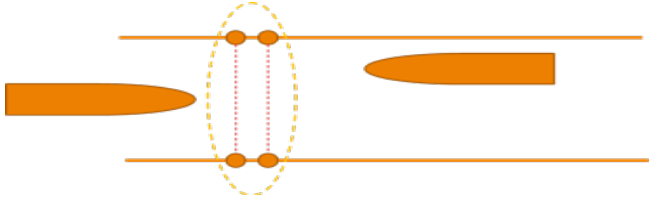
Boat types

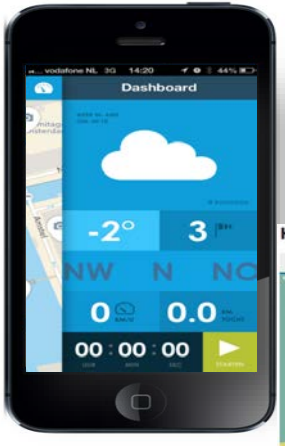
1. < 4 meter
2. 4 – 14 meter
3. > 14 meter

Scenarios – day codes

1. Day type:
    1. Weak day
    2. Weekend day
    3. Event
2. Weather
    1. Bad < 5
    2. Normal 5 -7
    3. Beautiful >7
3. Season
    1. Nov - March
    2. Apr – June & Sept- Okt
    3. July - Aug

DATA COLLECTION

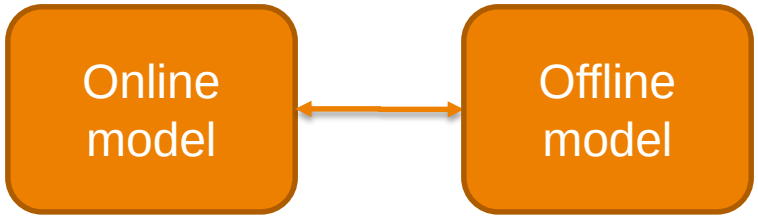




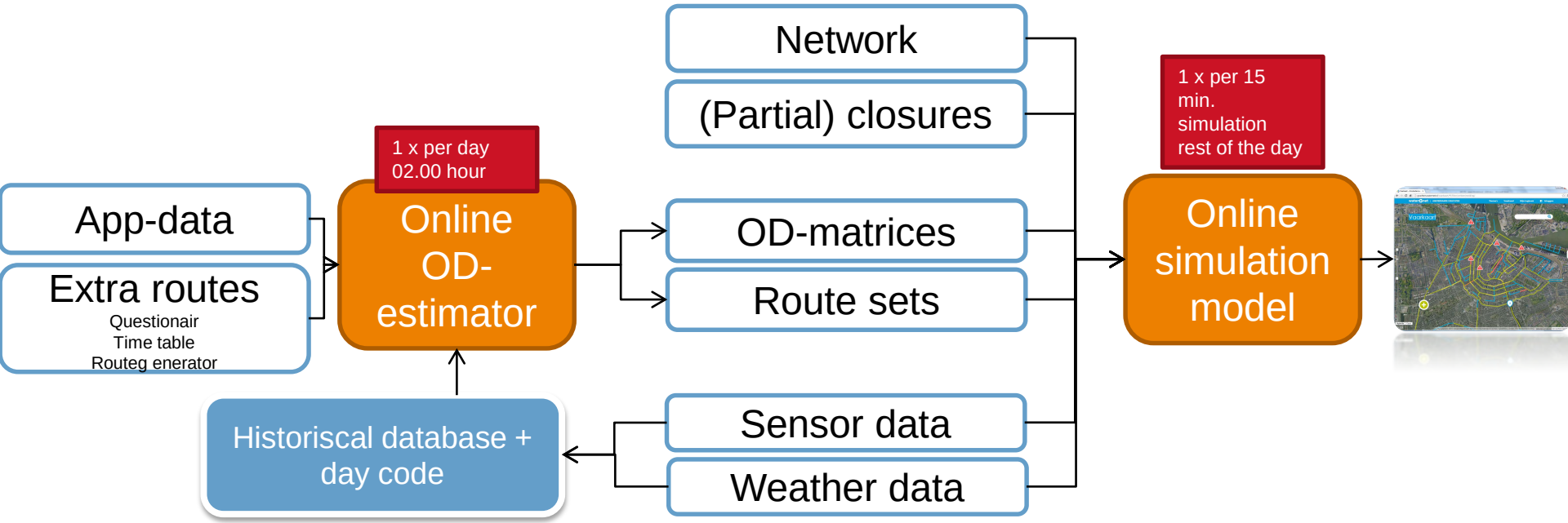
Questionair
arachnea
marktonderzoek

MODEL

- 2 versions



ONLINE MODEL



OFFLINE MODEL

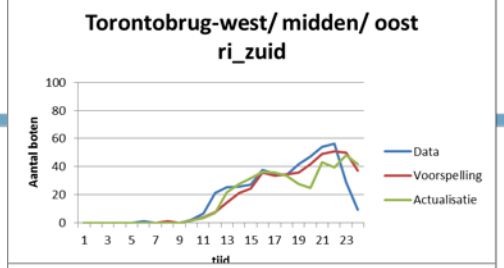
Demand variation
One direction canals
Closures
Speed changes

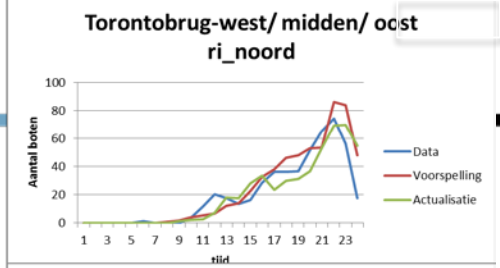
Measures
Scenario
Network
Partial closures
OD-matrices
Route sets
Simulation database

Model run
whole day

Offline simulation model

QUALITY


Torontobrug-west/ midden/ oost ri_zuid
Aantal boten
tijd
Data
Voorspelling
Actualisatie


Torontobrug-west/ midden/ oost ri_noord
Aantal boten
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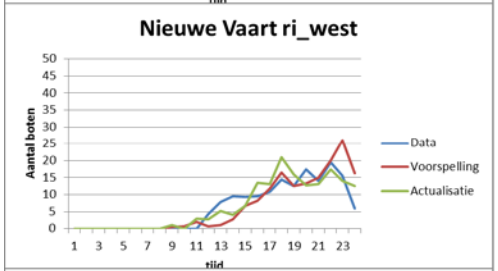
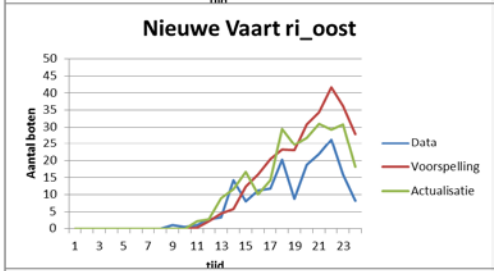
Data
Voorspelling
Actualisatie


Nieuwe Vaart ri_west
Aantal boten
tijd
Data
Voorspelling
Actualisatie


Nieuwe Vaart ri_oost
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Data
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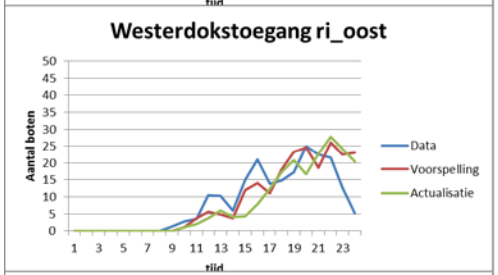
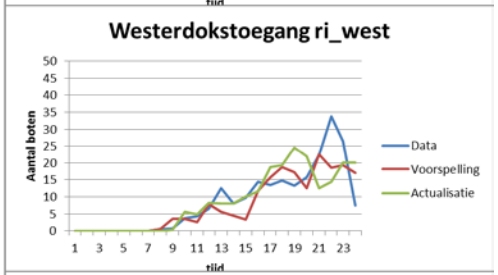
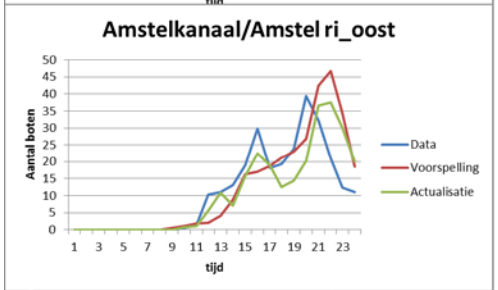
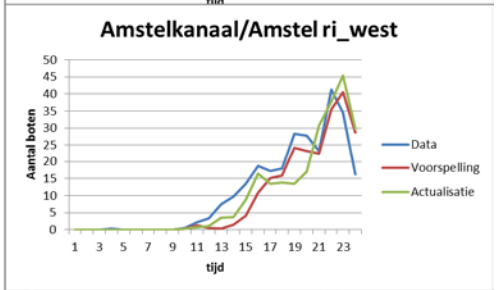

Westerdokstoegang ri_oost
Aantal boten
tijd
Data
Voorspelling
Actualisatie


Westerdokstoegang ri_west
Aantal boten
tijd
Data
Voorspelling
Actualisatie


Amstelkanaal/Amstel ri_oost
Aantal boten
tijd
Data
Voorspelling
Actualisatie


Amstelkanaal/Amstel ri_west
Aantal boten
tijd
Data
Voorspelling
Actualisatie

CONCLUSIONS

- 2 examples of short time prediction models.
- Many new sources of data
- Better starting point for models
- Especially relevant for short term predictions
- May also be used for strategic models

QUESTIONS?

TNO innovation for life

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