Recent advancements in network-wide traffic operations

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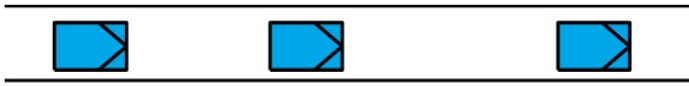
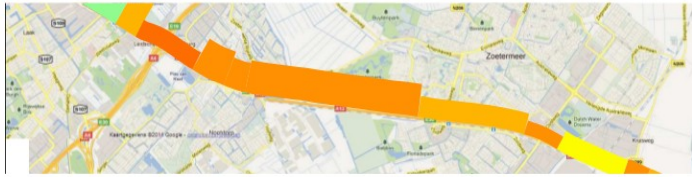
TU Delft

Scales of traffic desciption

- Microscopic: individual level

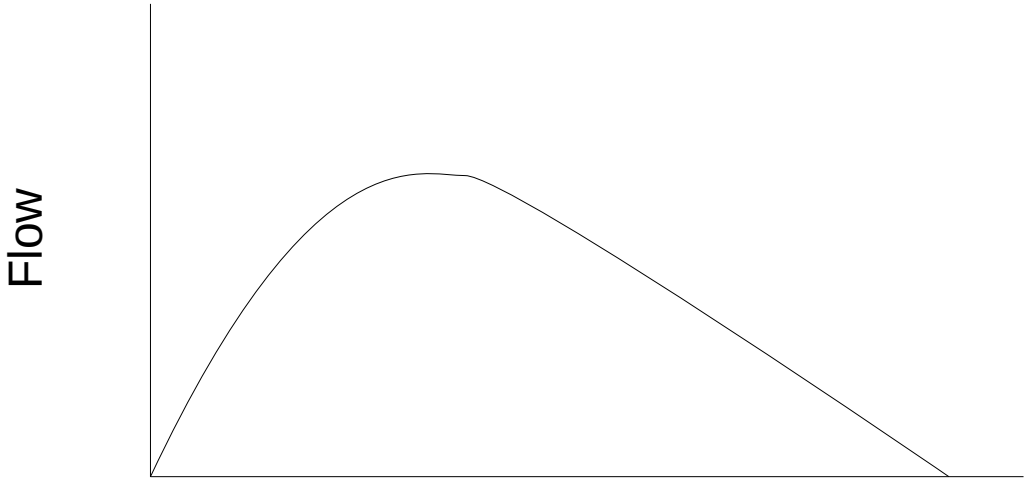


- Macroscopic: road level

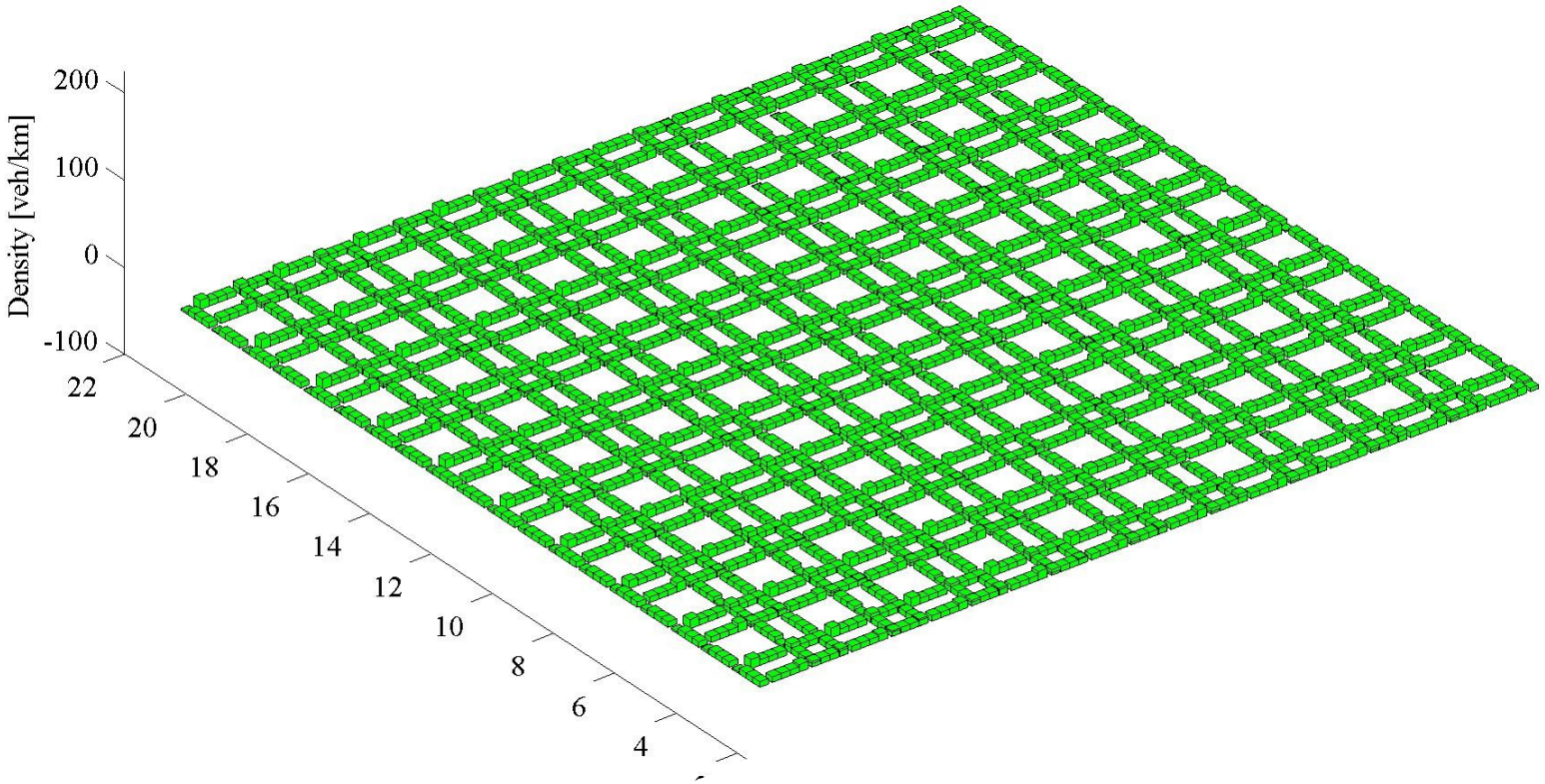


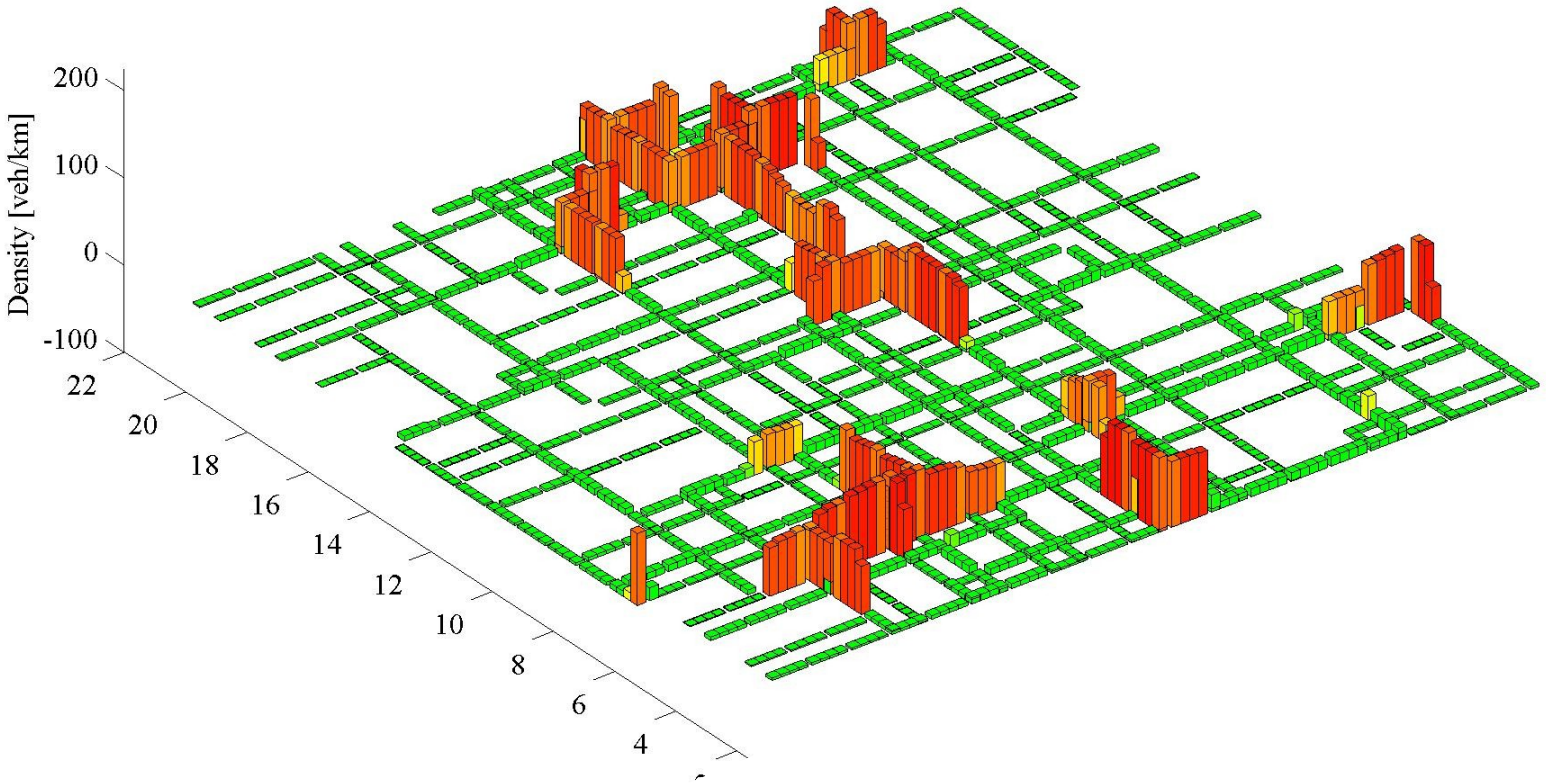
- Higher level: network level

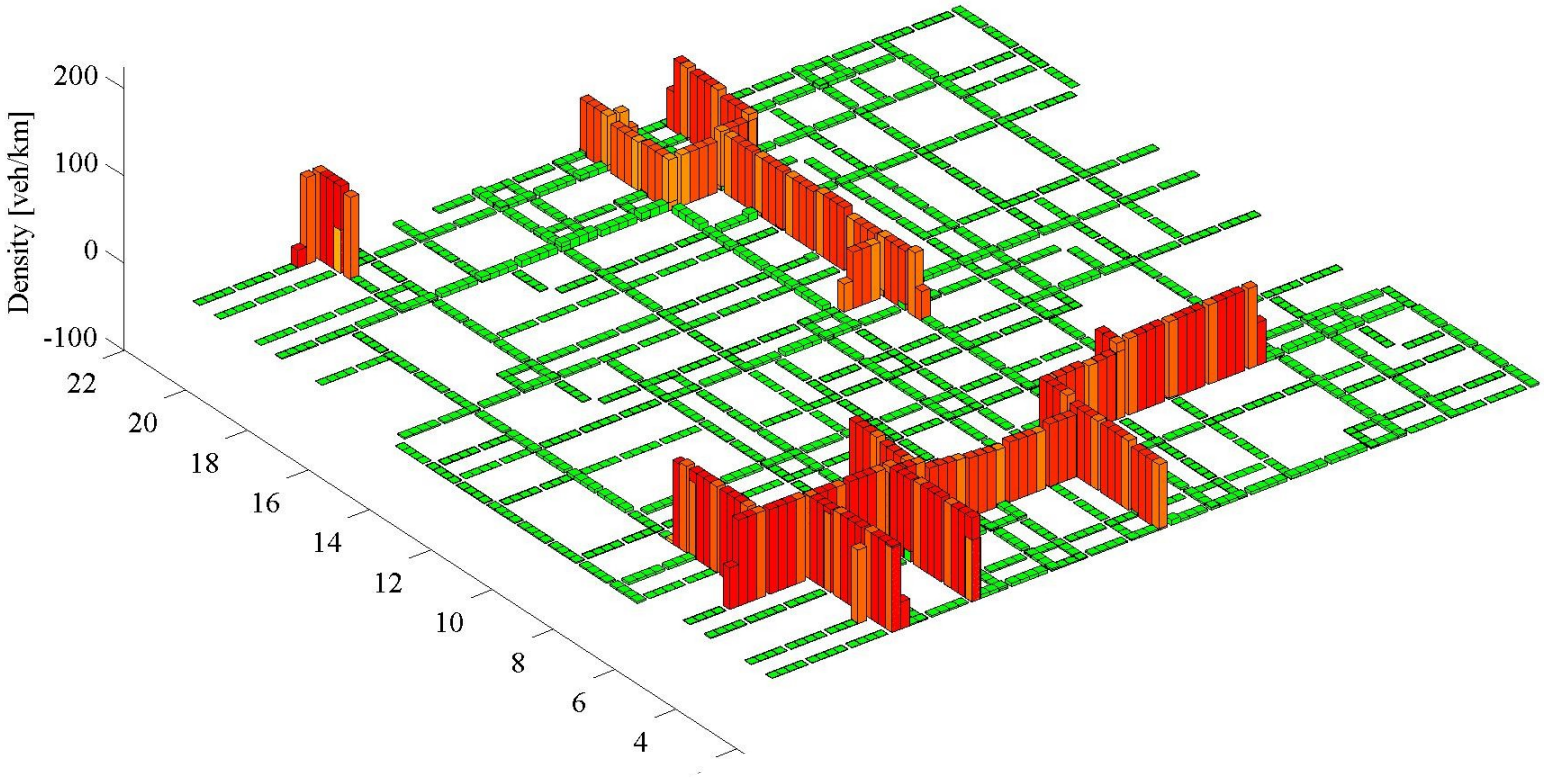
Relationships variables



Build up of congestion

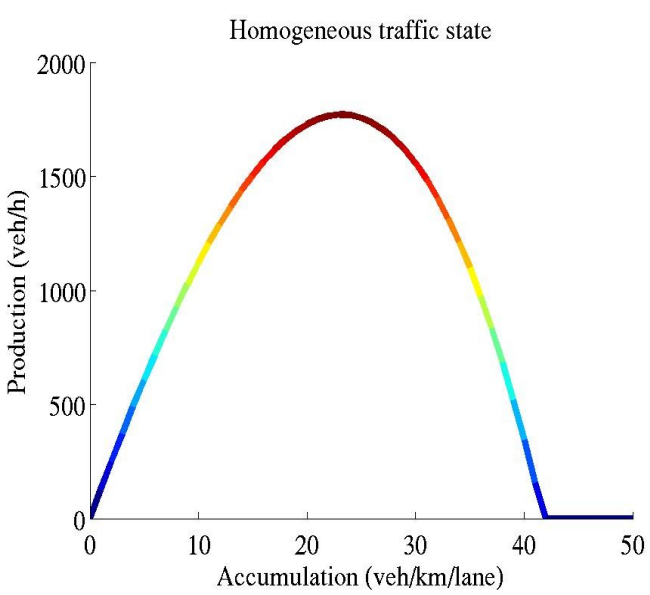



Density [veh/km]
200
100
0
-100
22
20
18
16
14
12
10
8
6
4

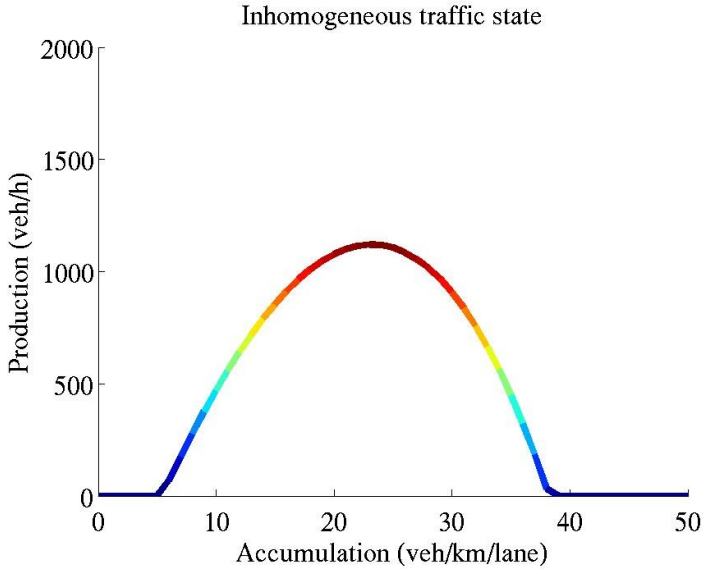

Density [veh/km]
200
100
0
-100
22
20
18
16
14
12
10
8
6
4

Fitting a functional form

P(A)=A*(c1+c2A+c3A2)-c4σ



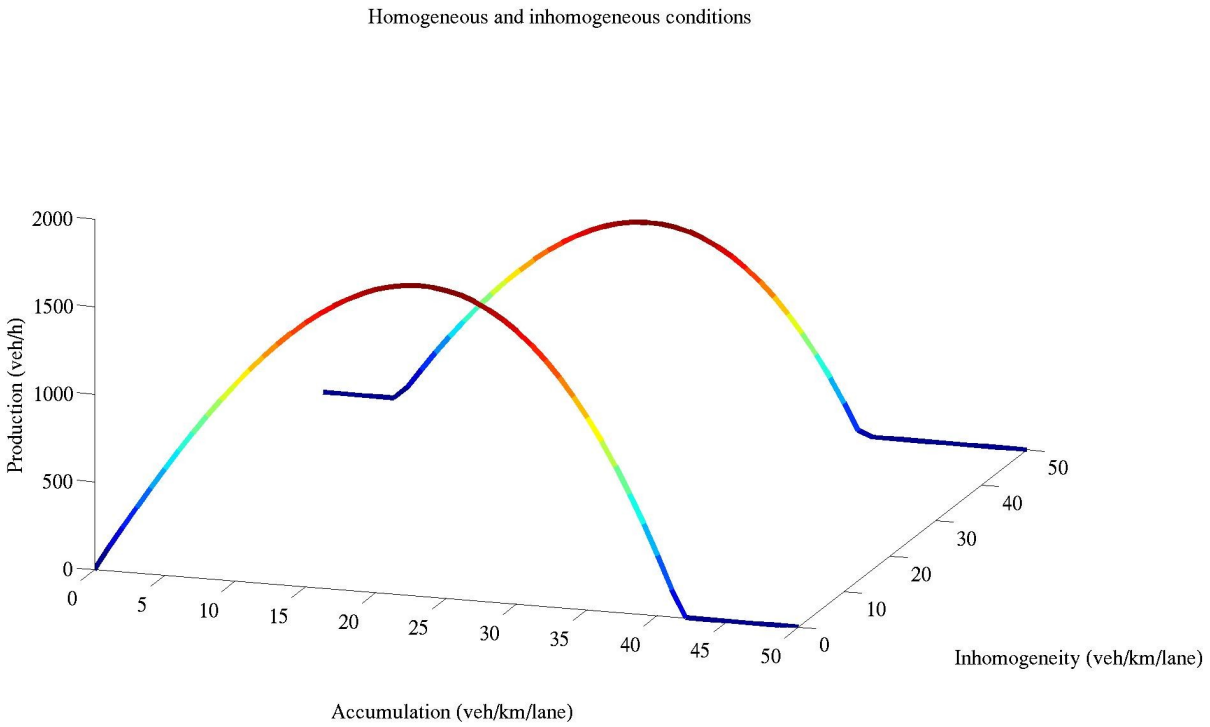
Homogeneous traffic situation



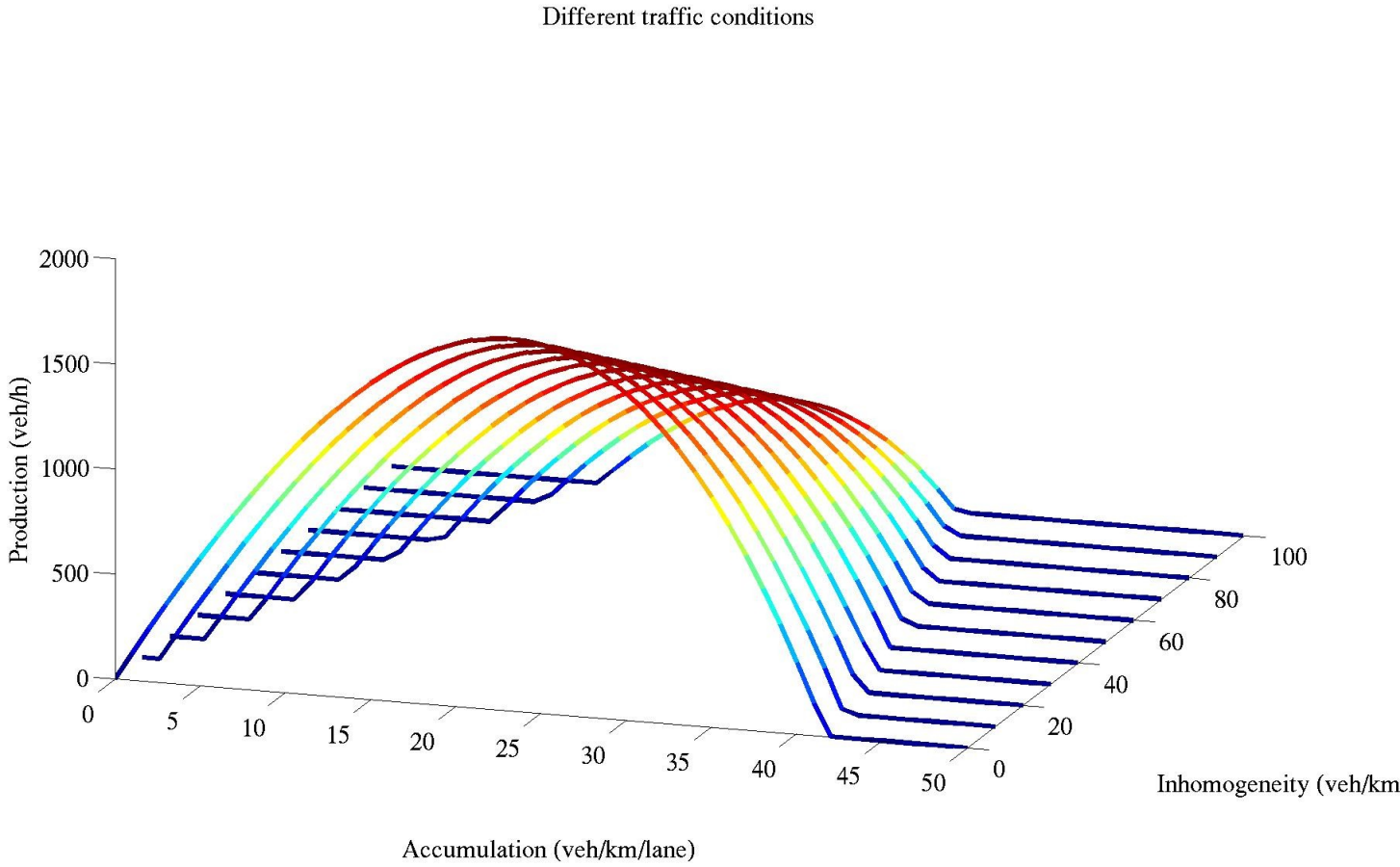
Inhomogeneous traffic situation

Fitting a functional form

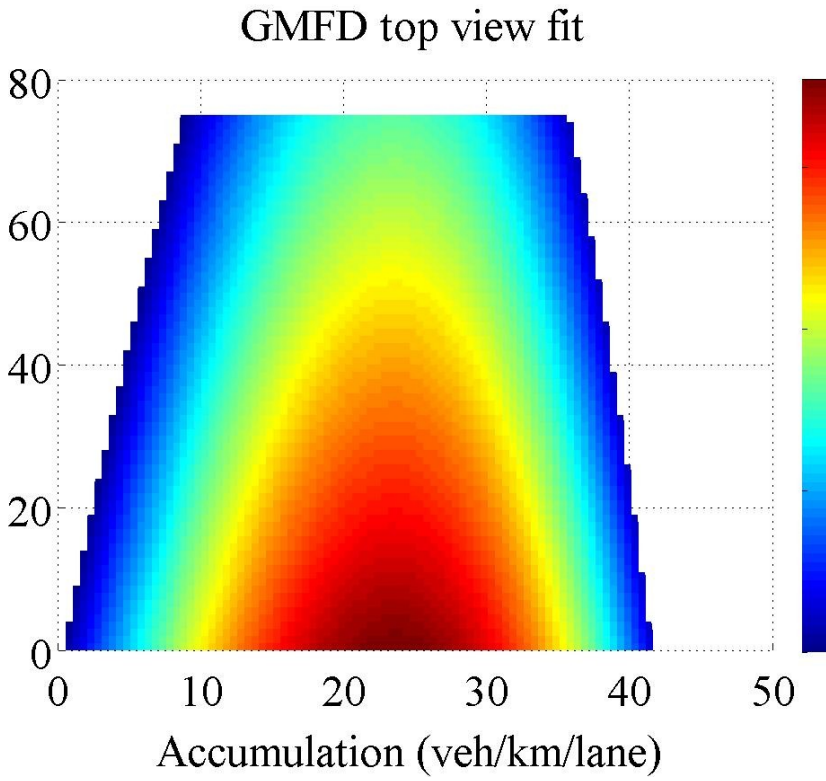
P(A)=A*(c1+c2A+c3A2)-c4σ



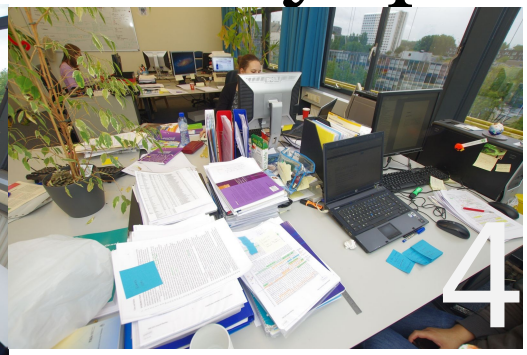
Fitting a functional form

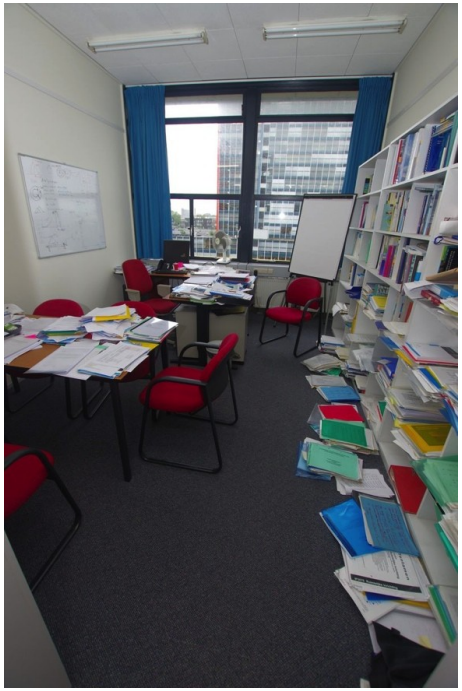


Empirical evidence



Suitable for any queuing application?





Further content

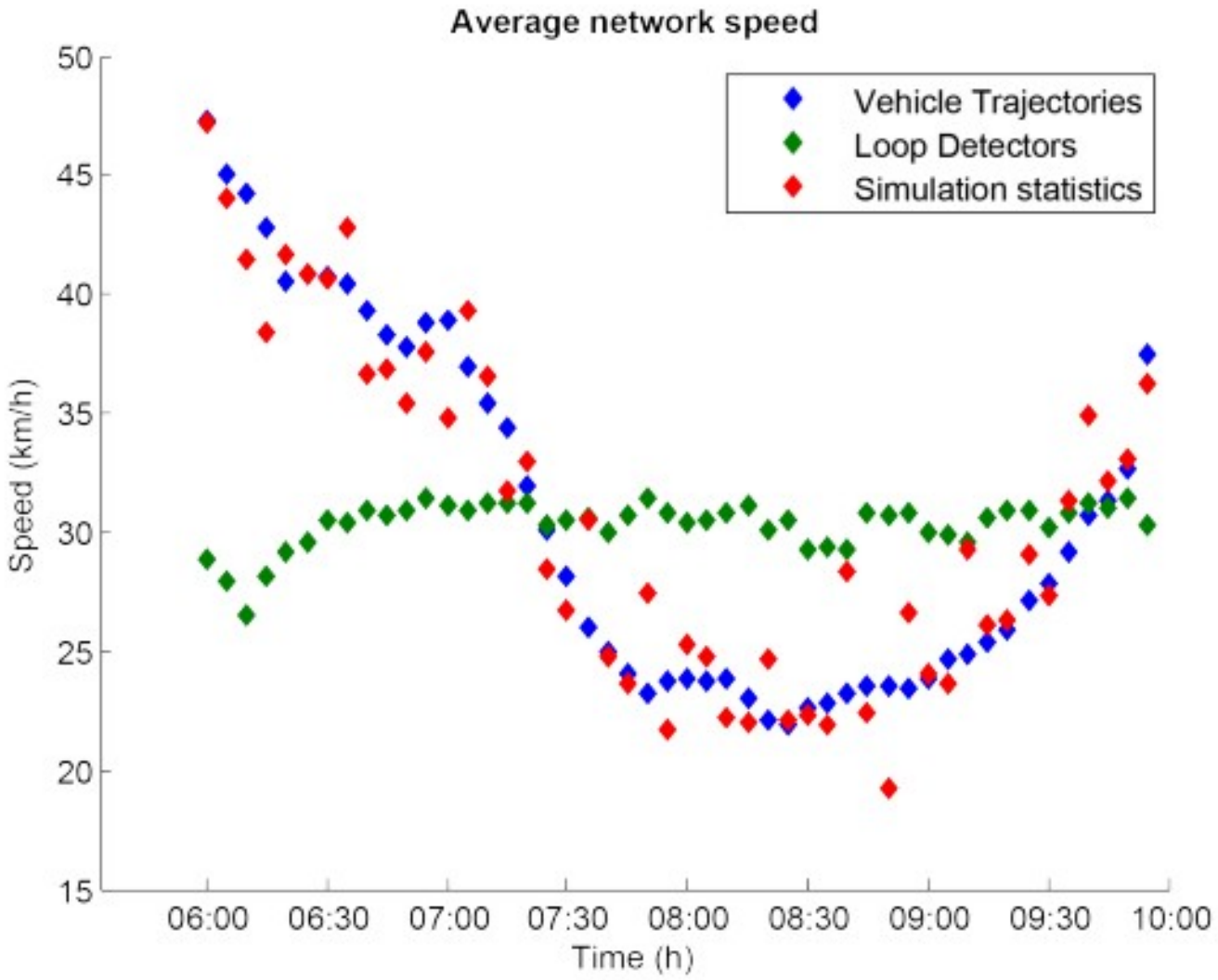
1) State estimation using the MFD
2) Controlling: perimeter control and internal control
3) Further effects: influences of pedestrians

Estimating the traffic state using the MFD

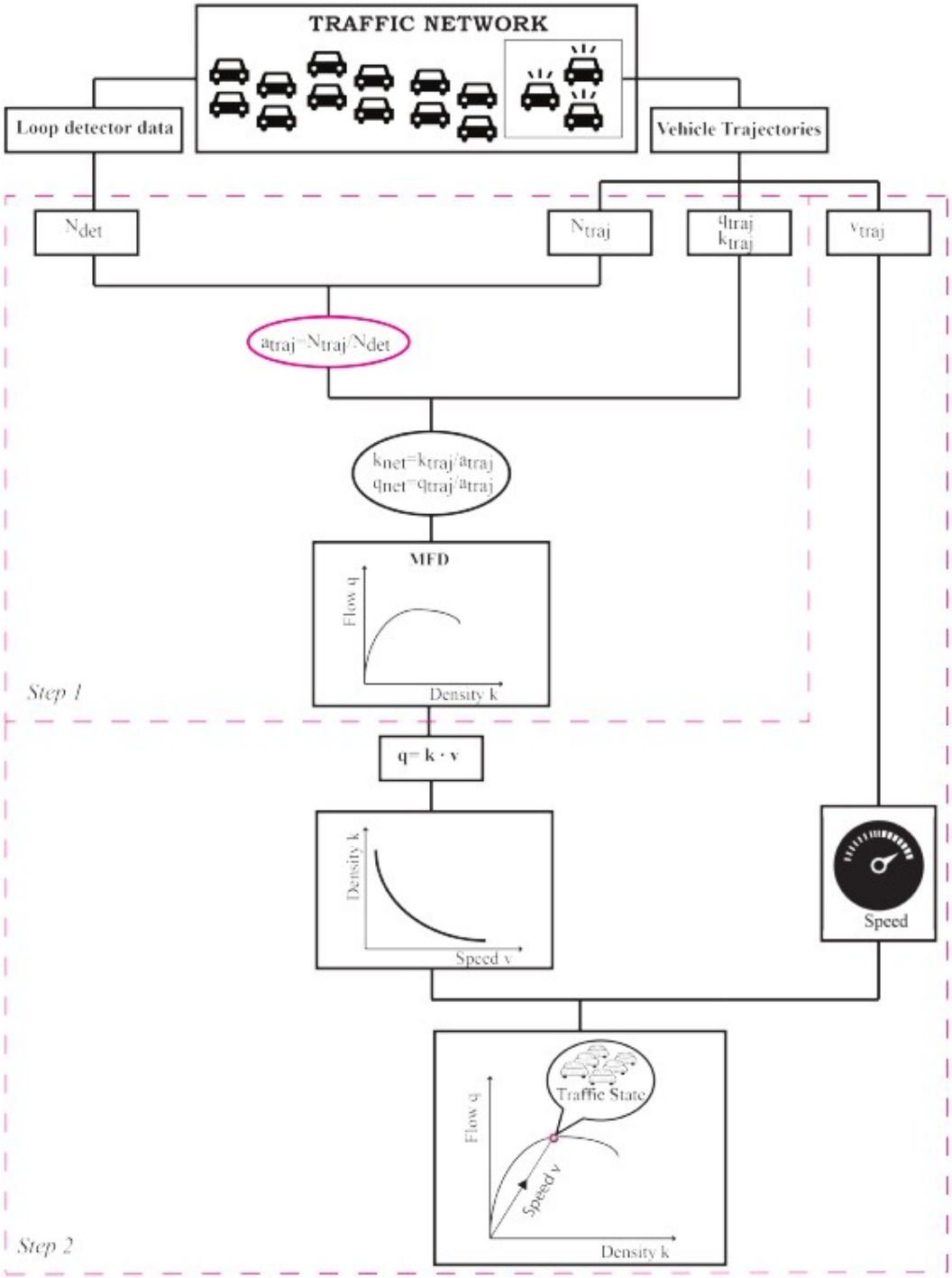
Estimating the traffic state

- Can we use the MFD for estimating the traffic state?
- In real life, not all data are known
- Detector data for some links, and (assume) floating car data for some vehicles

Detector speeds not representative



Method used:



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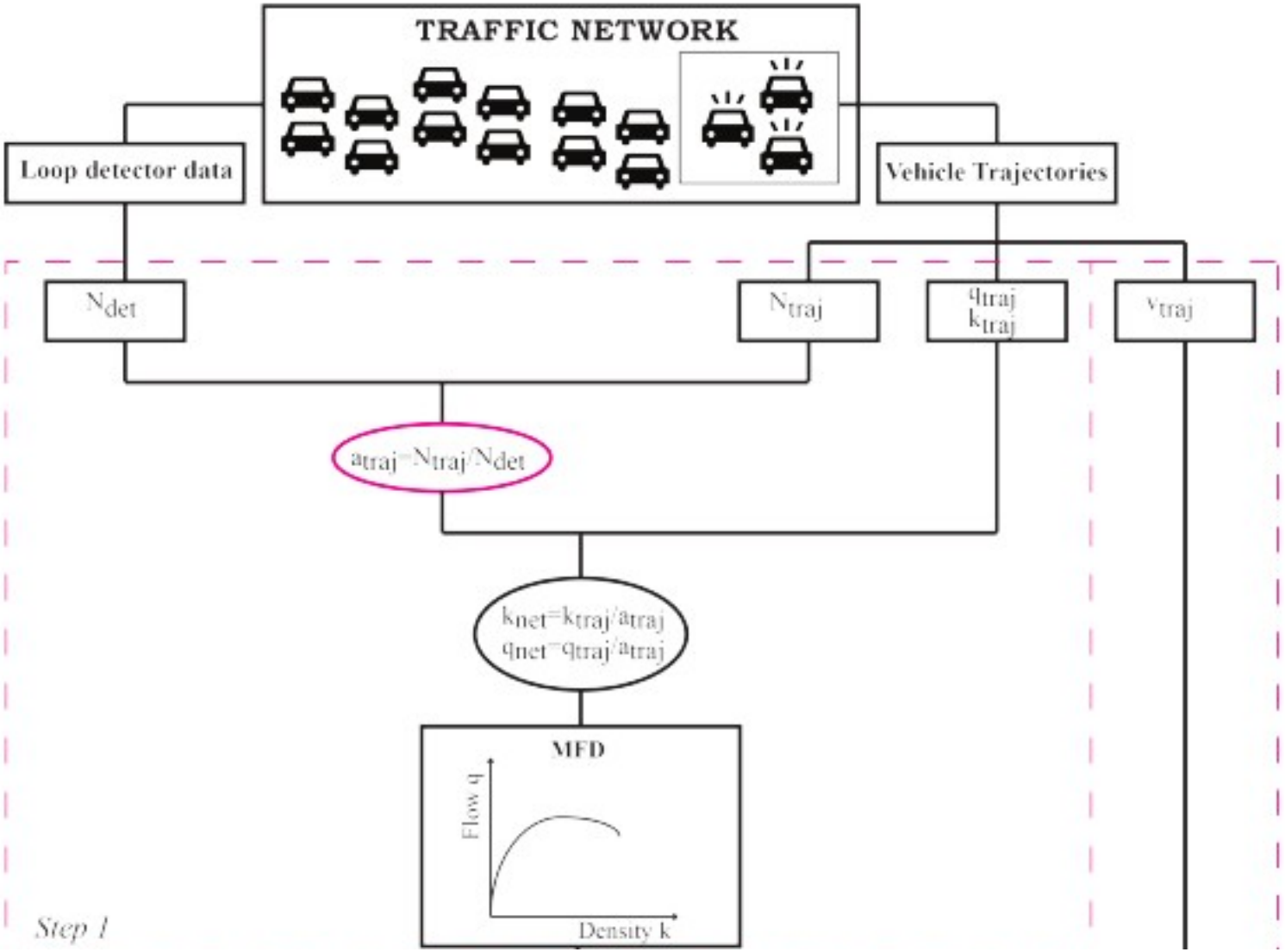
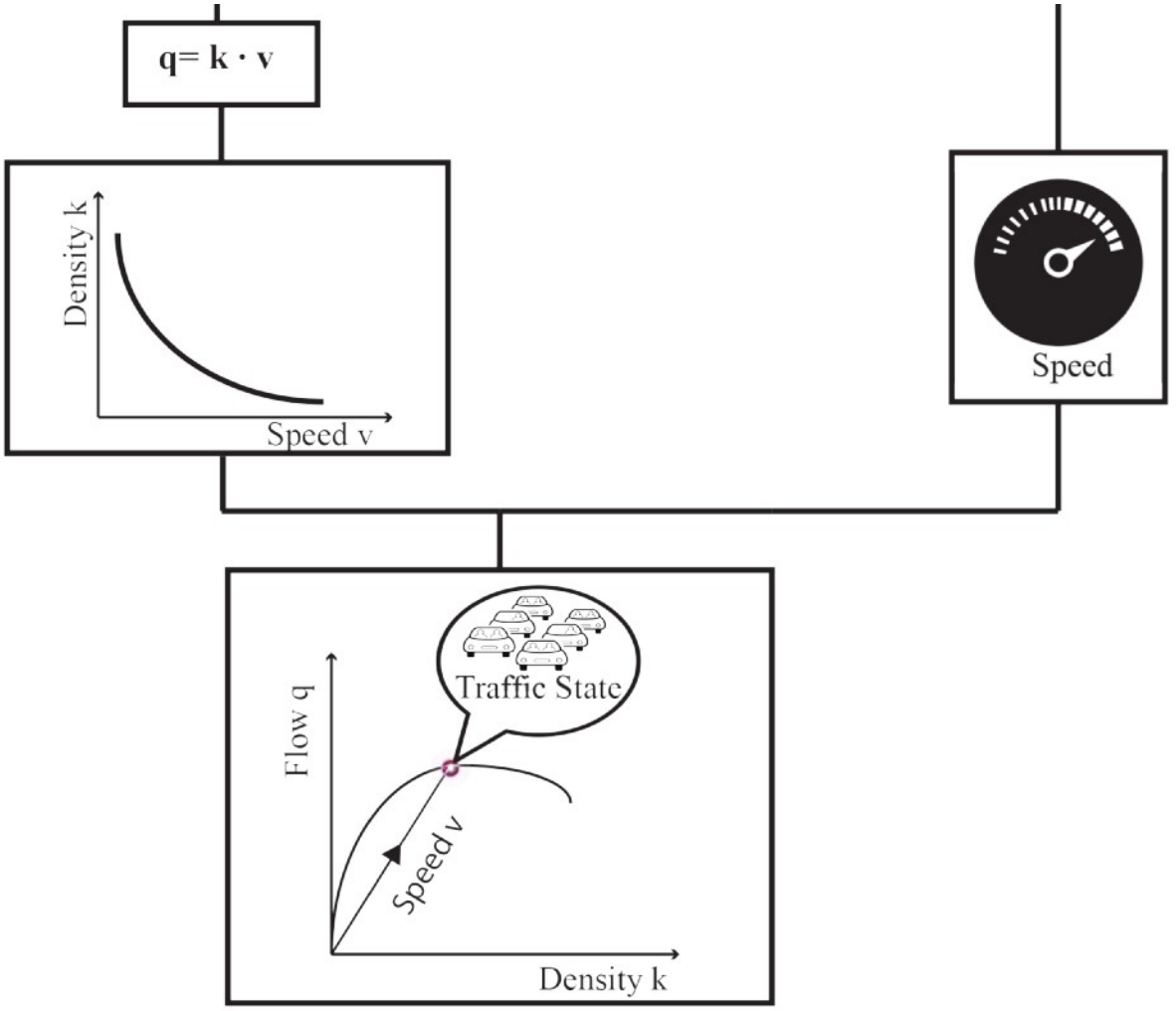
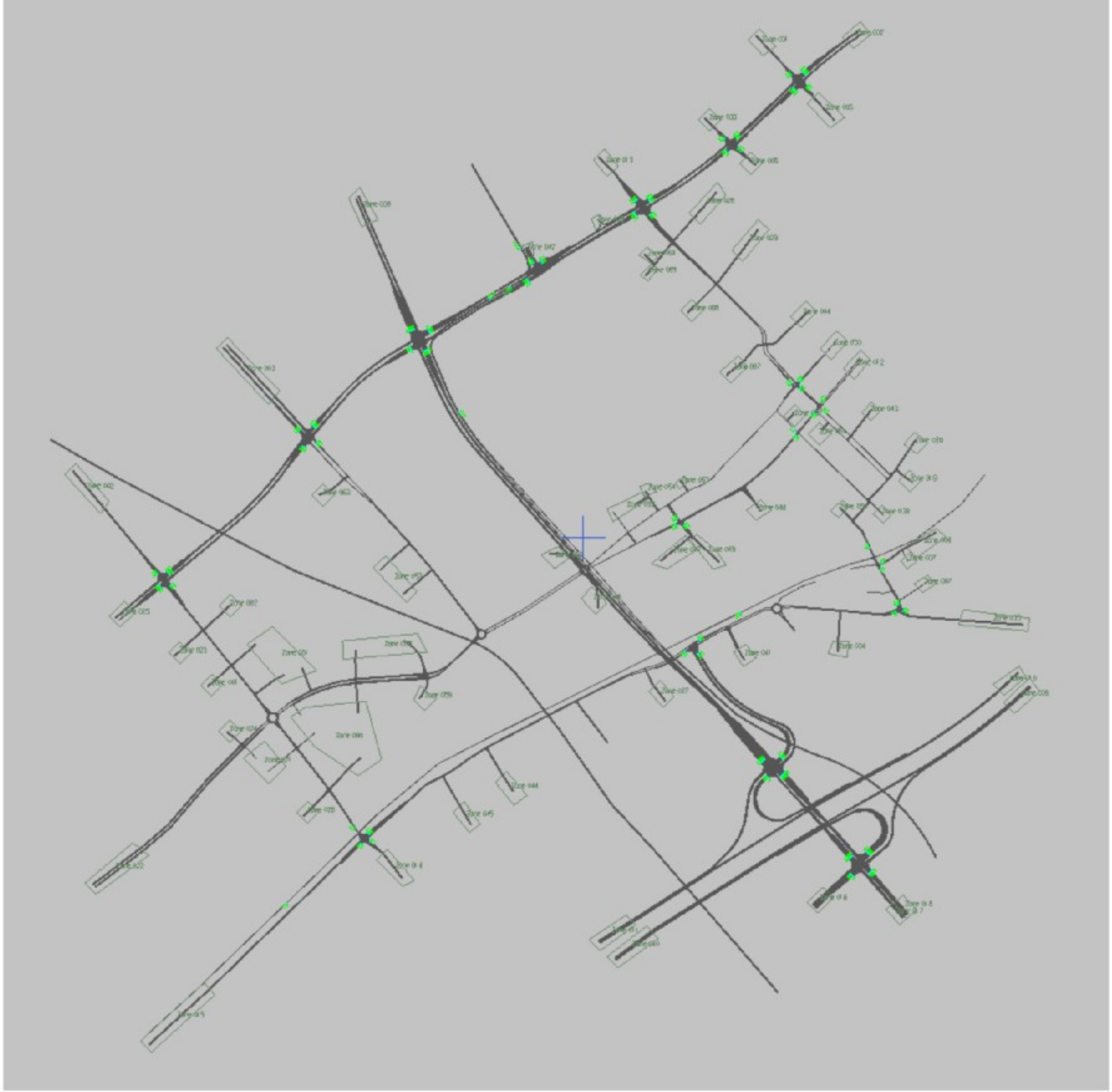
Method used: construct MFD



Method used: find traffic state based on speed





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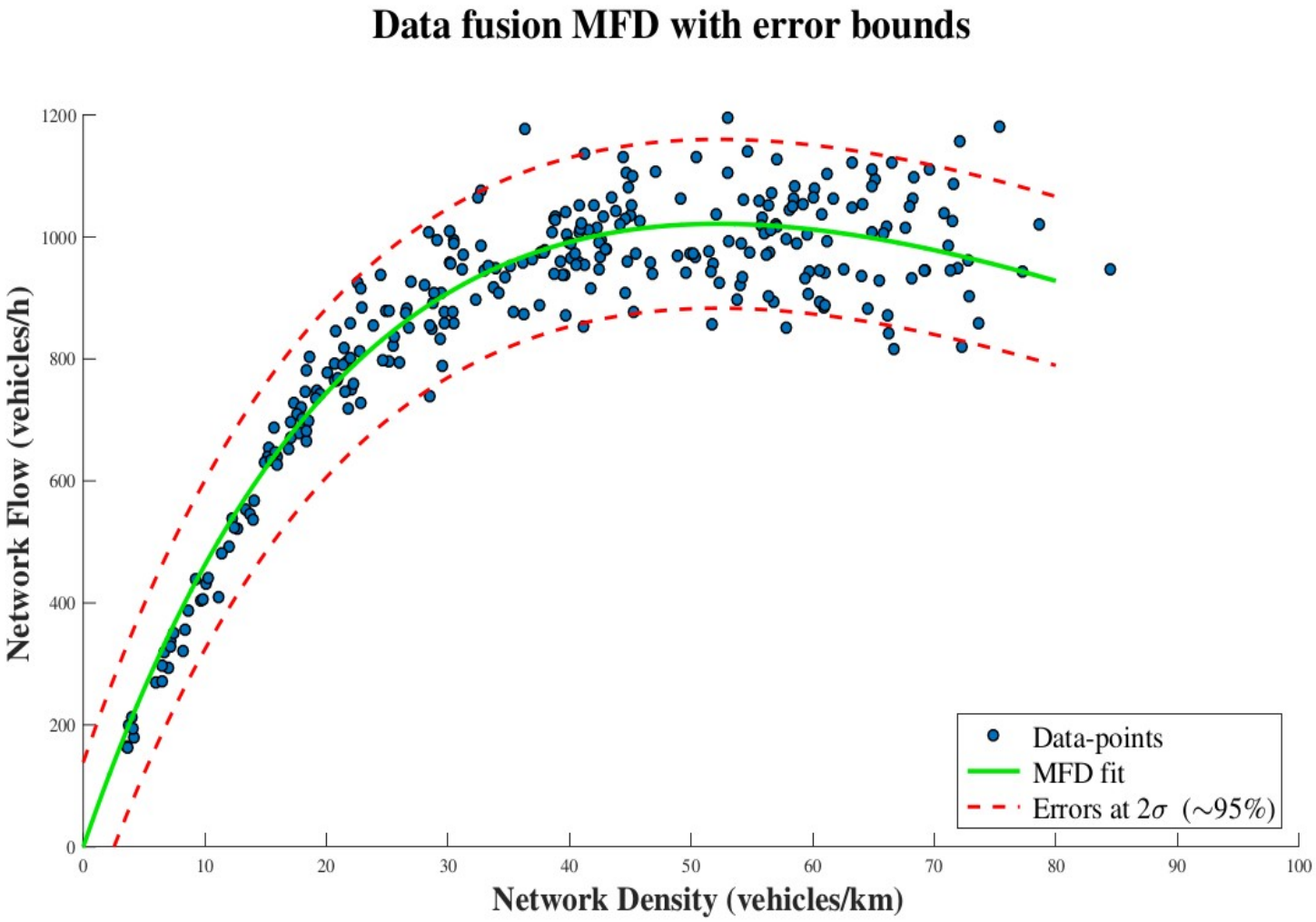
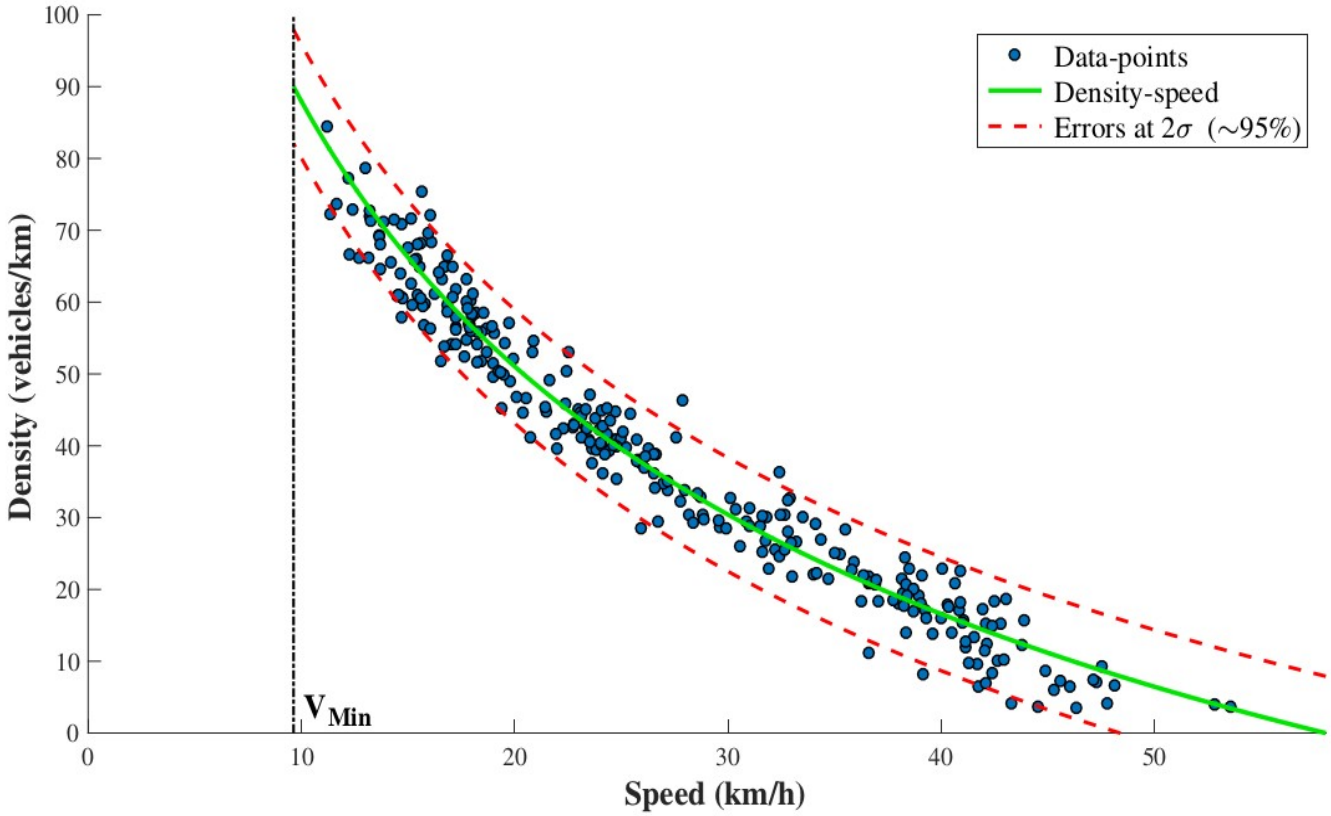
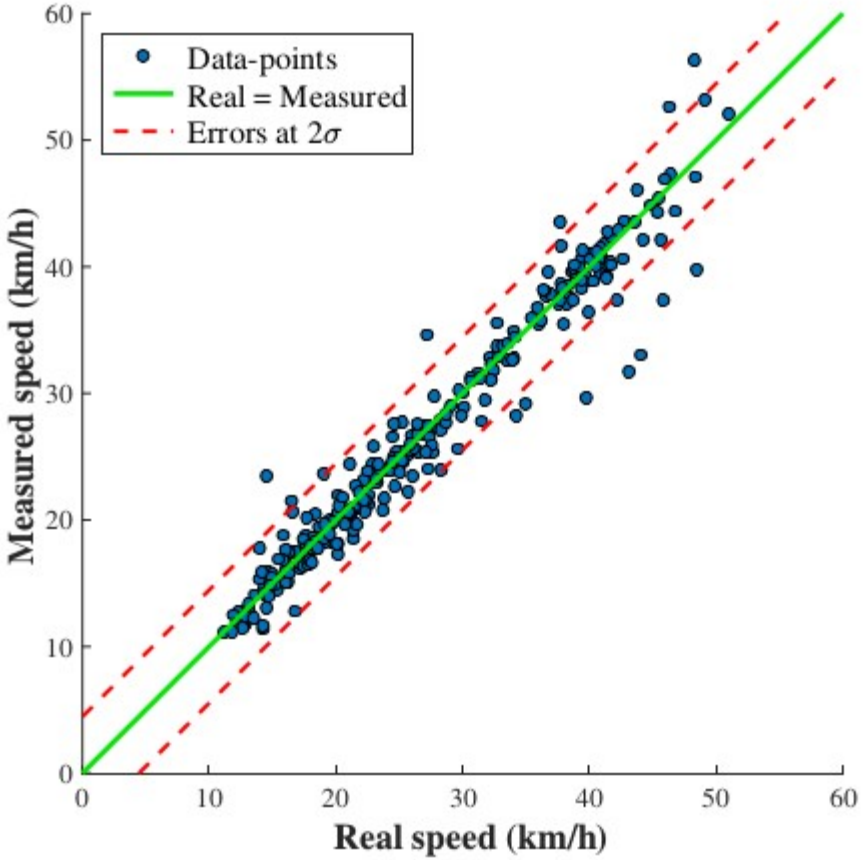
MFD found


Data fusion MFD with error bounds
Network Flow (vehicles/h)
Network Density (vehicles/km)
0
200
400
600
800
1000
1200
0
10
20
30
40
50
60
70
80
90
100
Data-points
MFD fit
Errors at 2σ (~95%)

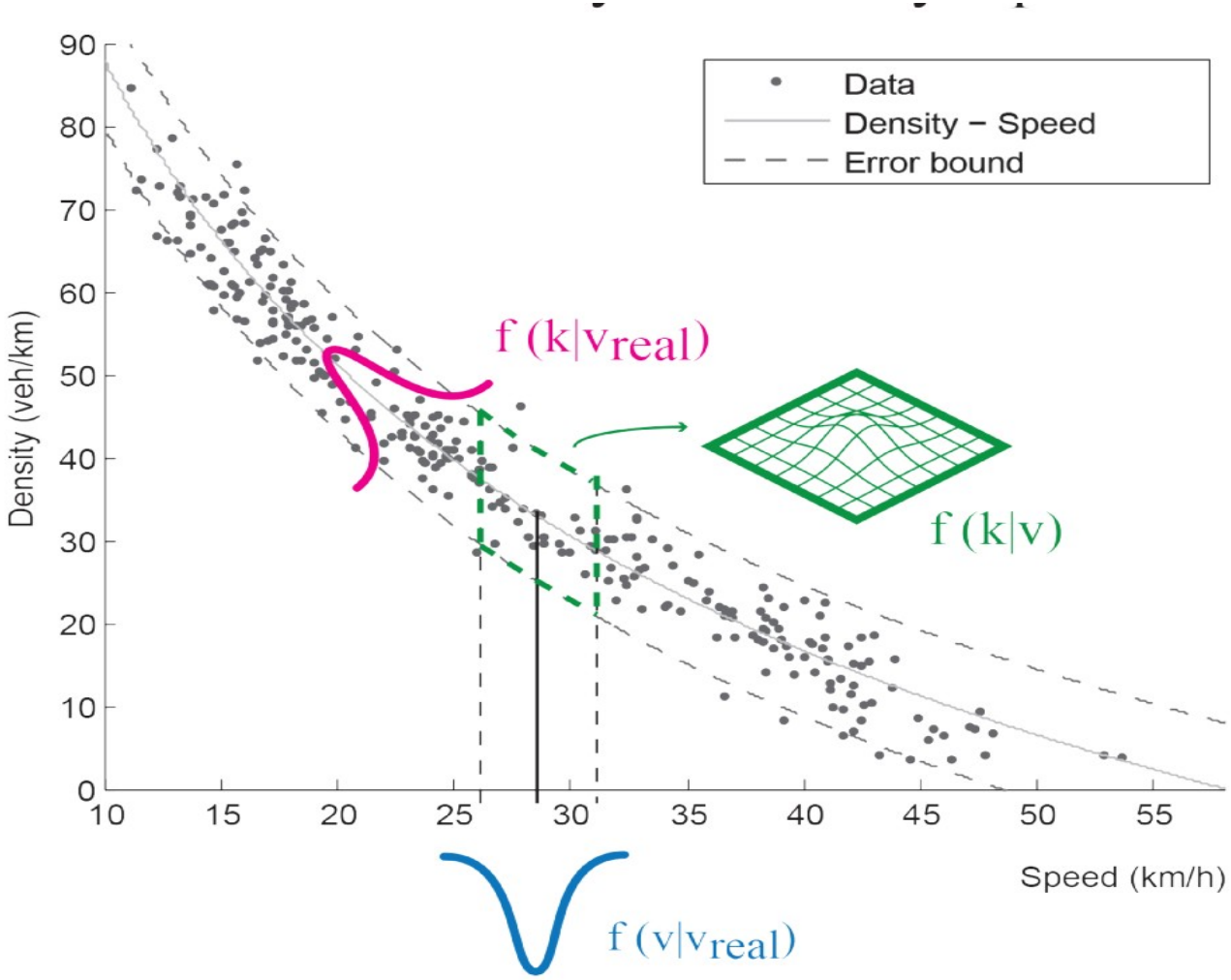
MFD found


Data-points
Density-speed
Errors at 2σ (~95%)
Density (vehicles/km)
Speed (km/h)
V Min
0
10
20
30
40
50
60
70
80
90
100

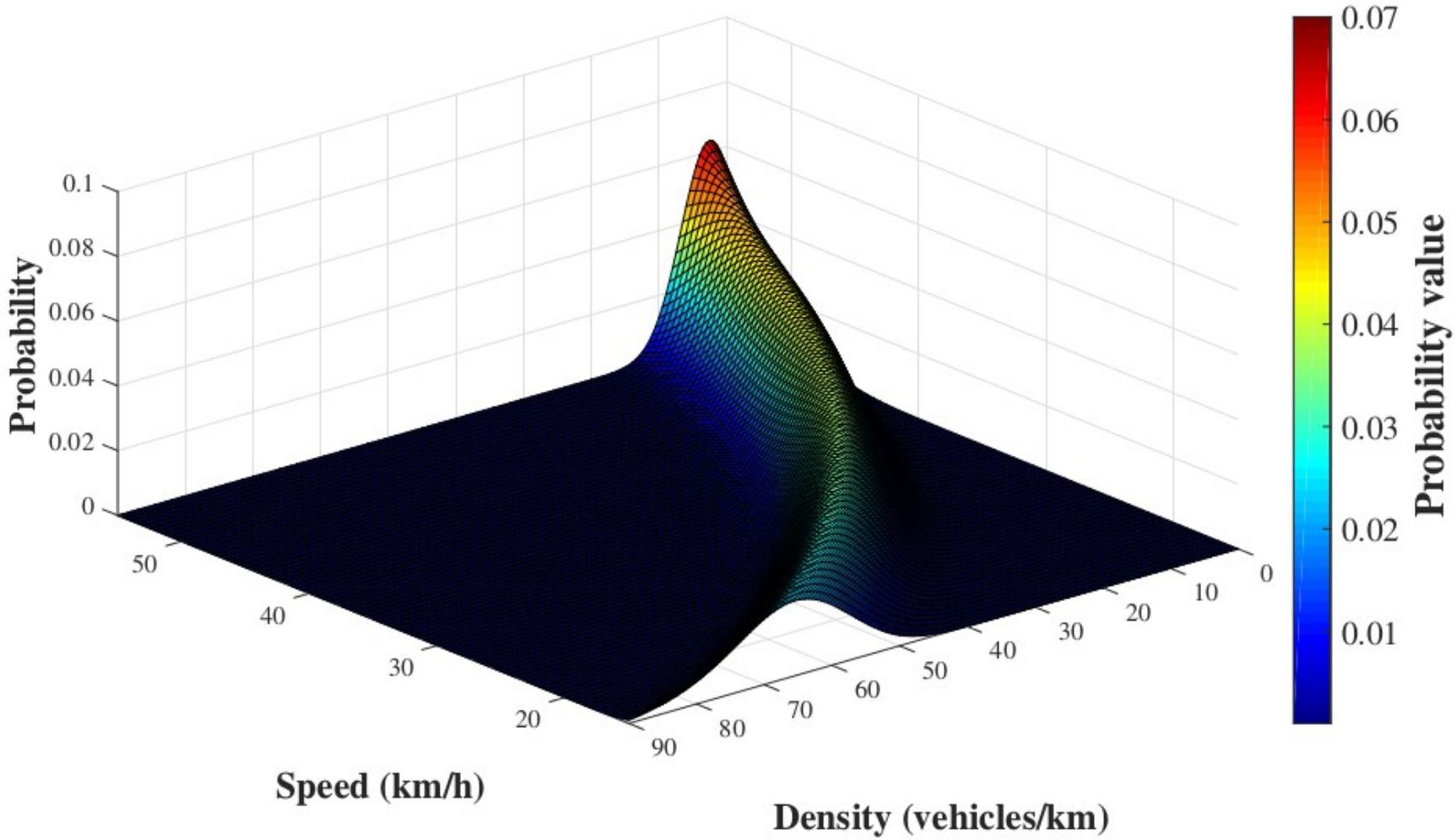
Errors in speed



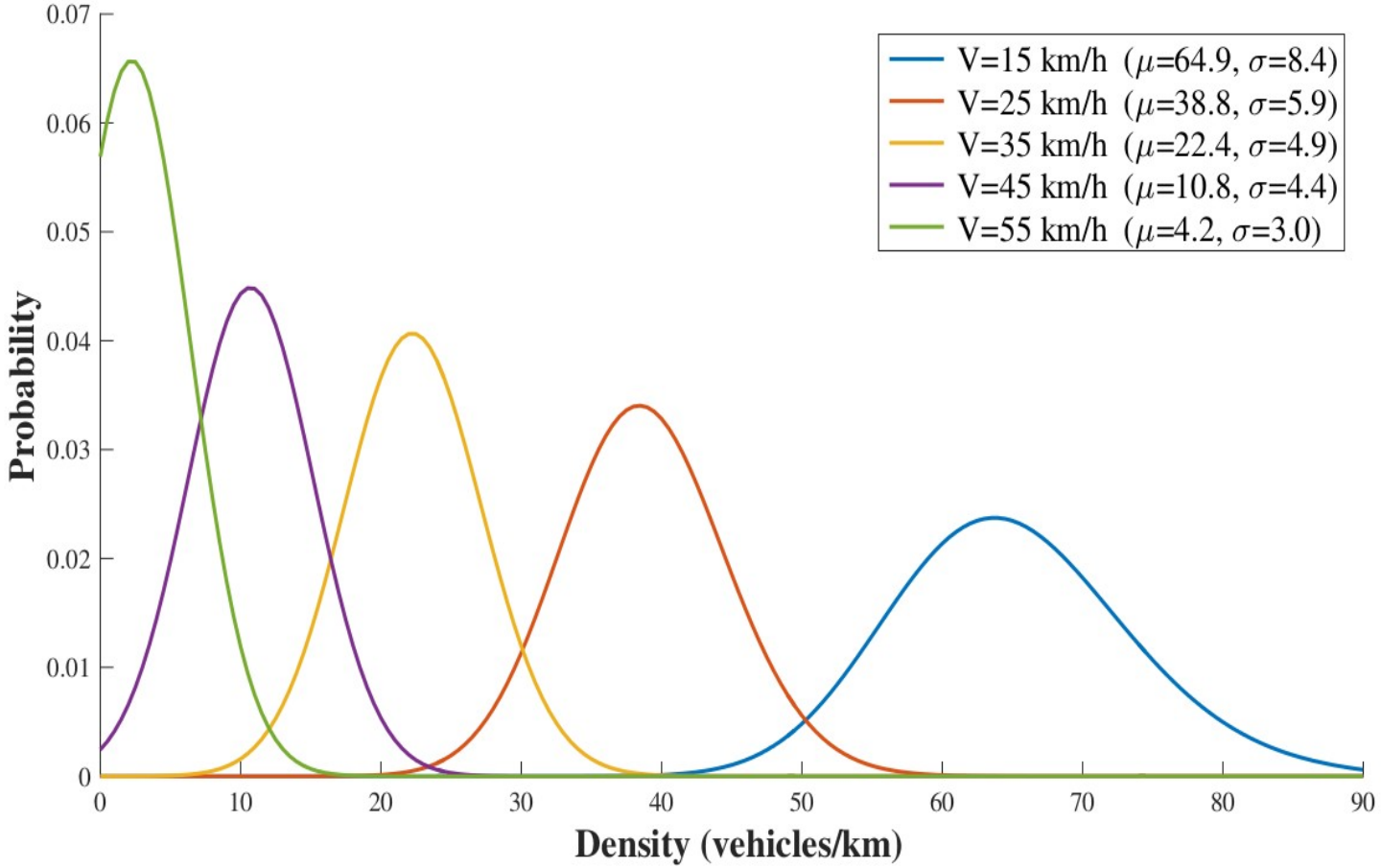
Errors in estimation



Errors in estimation

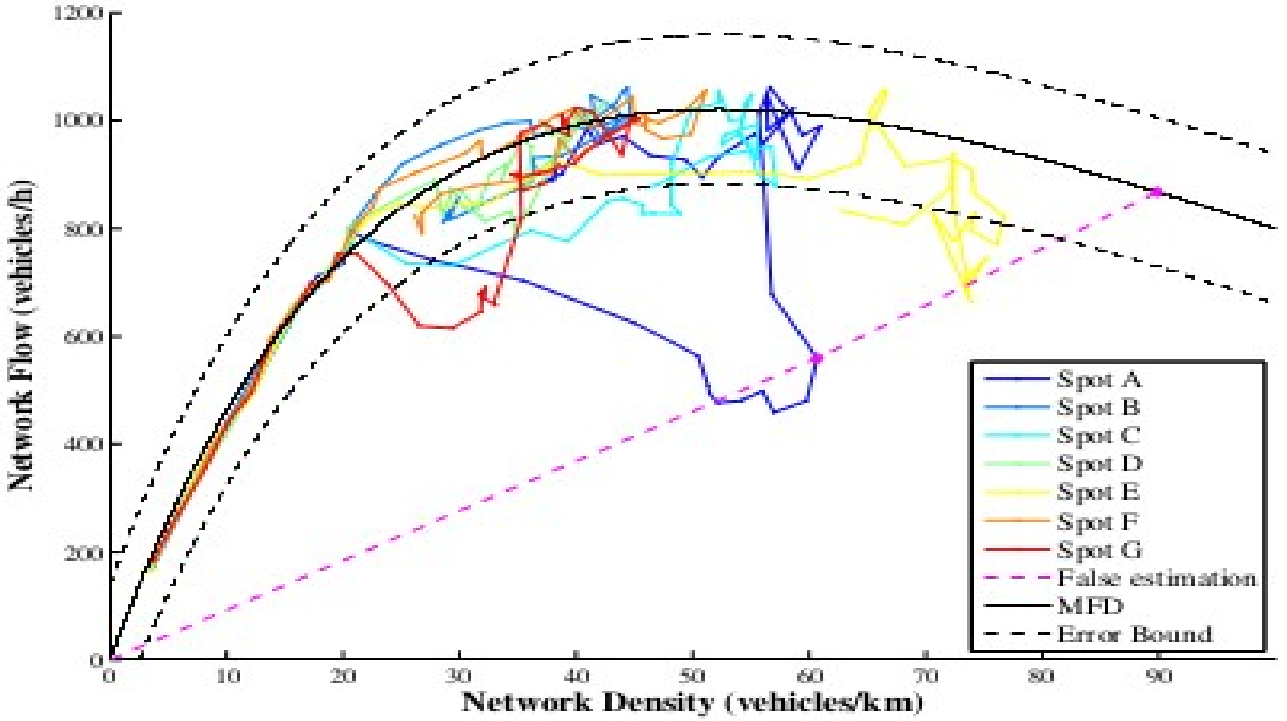


Examples for various speeds



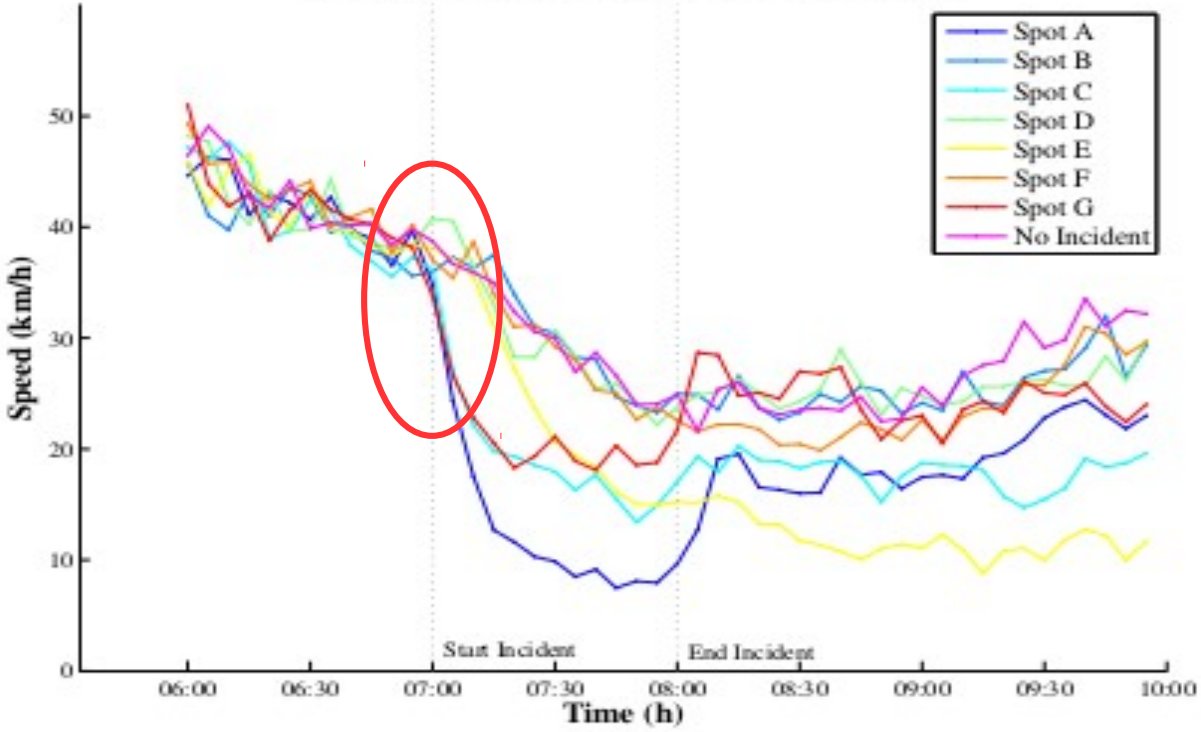
What happens in incidents?

- 6 incidents modelled
- *What would happen to MFD?*
- What would happen to our estimation procedure?



What happens in incidents?

- 6 incidents modelled
- What would happen to MFD?
- What would happen to our estimation procedure?
- How can we find out?



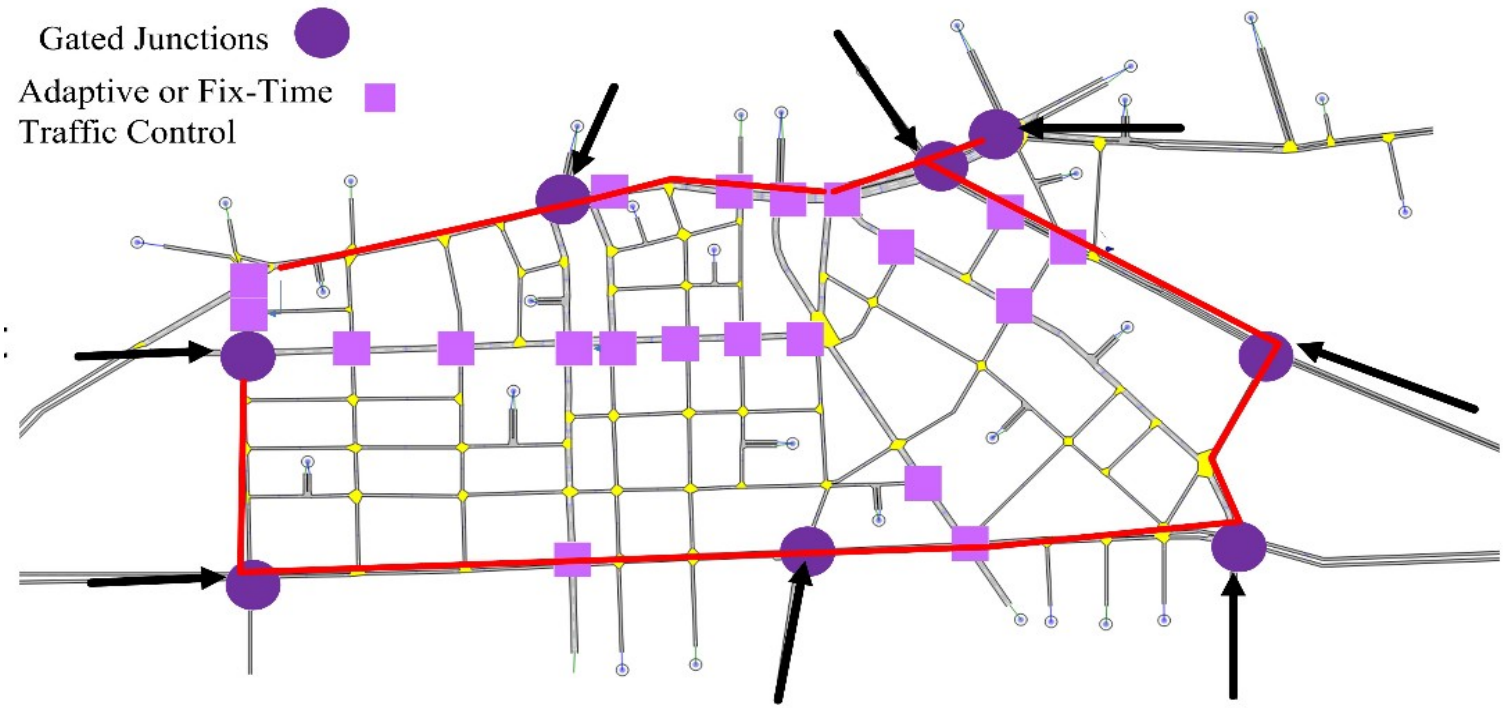
Perimeter control or internal control

Perimeter control?

Perimeter control?

Control

- Lights for perimeter control
- Lights for internal control



Control schemes

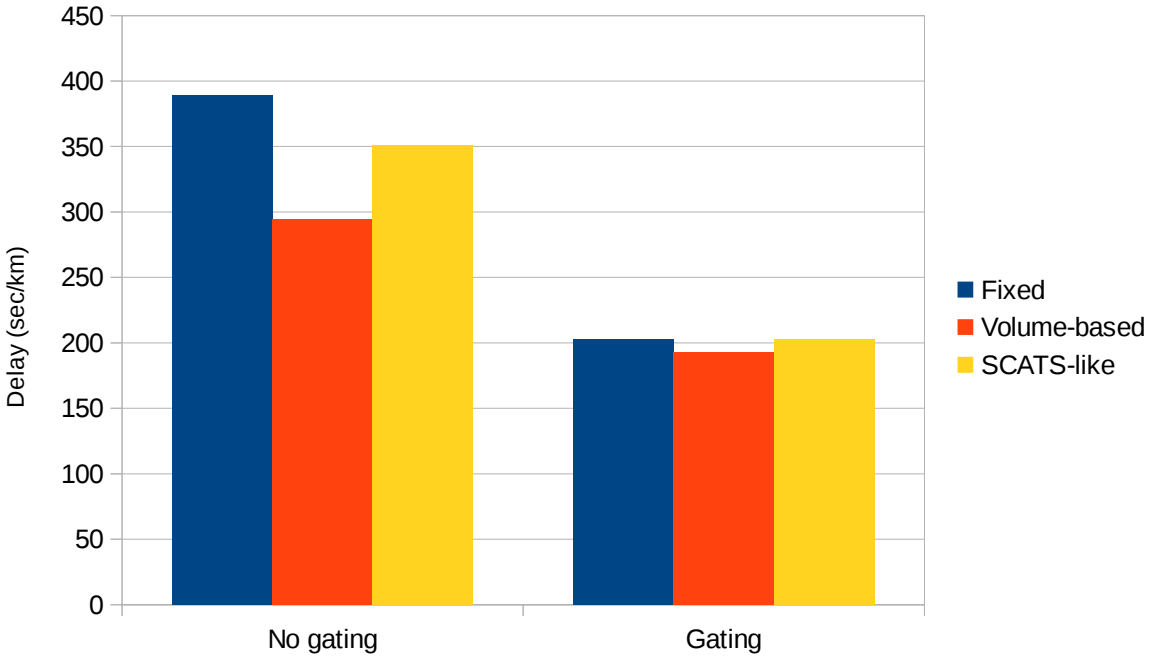
- Perimeter control: do not let too many vehicles in:

$$q_g(k) = q_g(k-1) - K_P\left[TTS(k) - TTS(k-1)\right] + K_I\left[T\hat{T}S - TTS(k)\right]$$

- Lights for internal control: three versions
  - Fixed time
  - Volume-based
  - SCATS-like (adaptive)

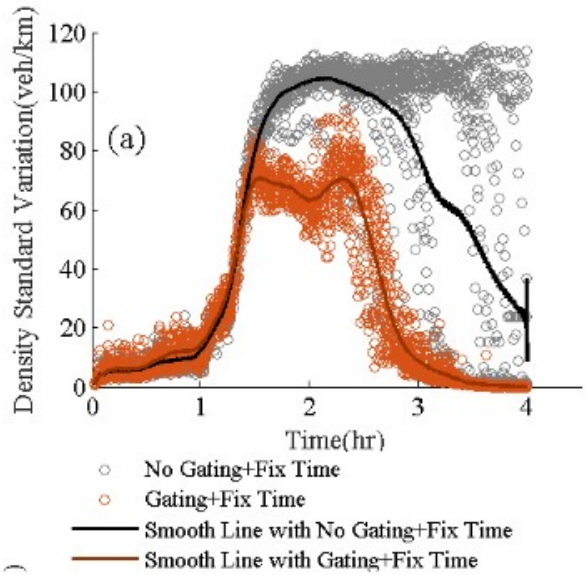
Results

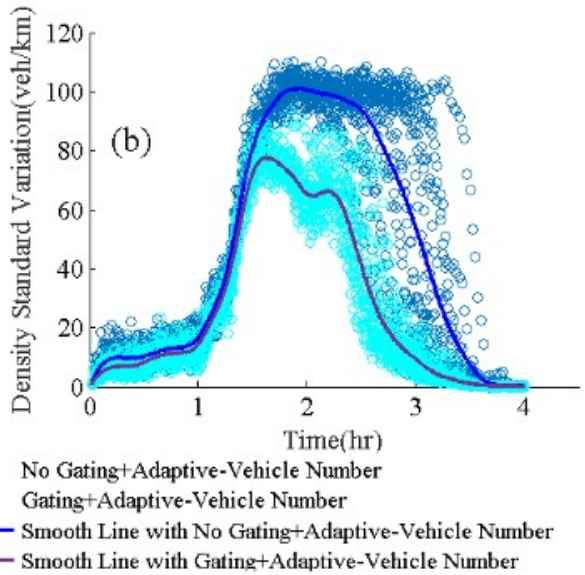
- Delays are lower for the gating situation
- Gating first, the rest comes later :-)

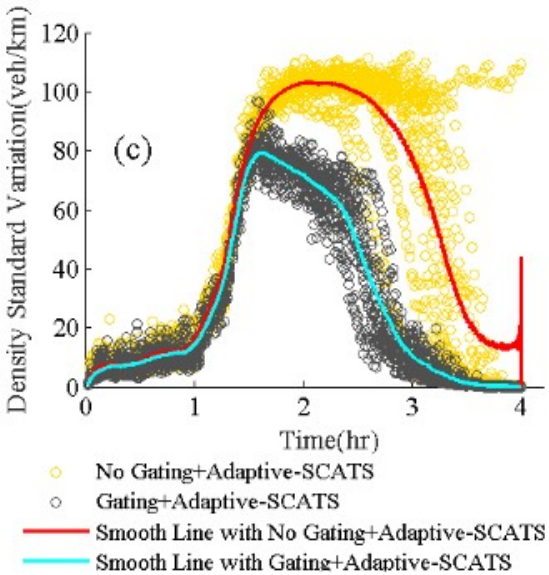


Traffic states

- Limiting the flow also helps having an equal spread

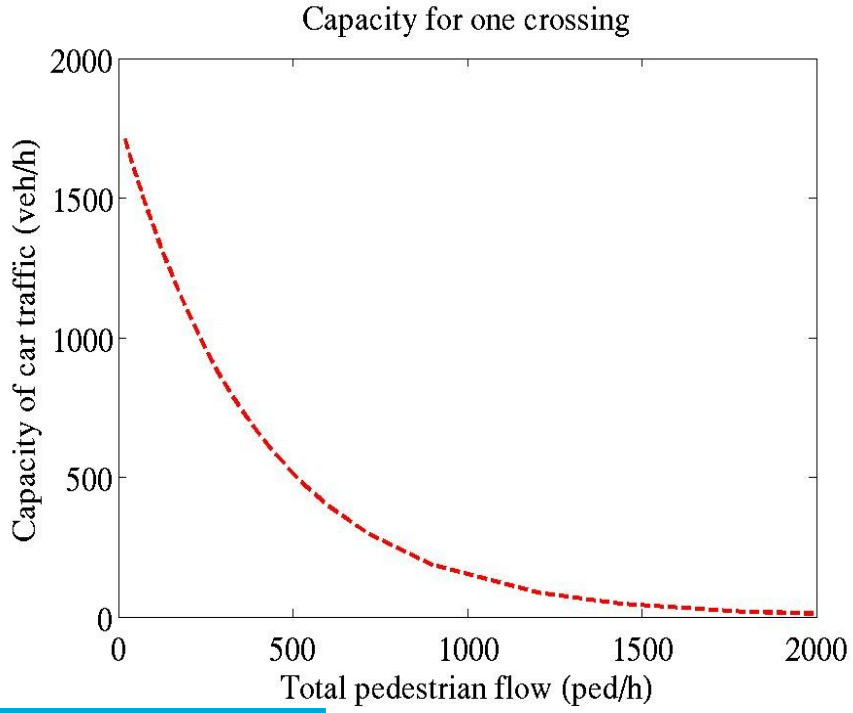


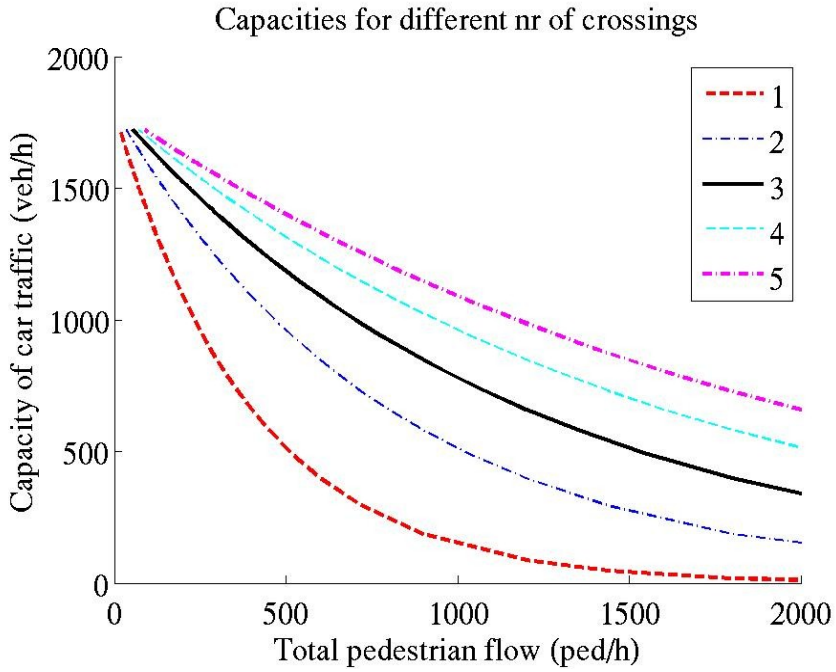




Influences of pedestrians

Vehicular capacity with pedcrossings



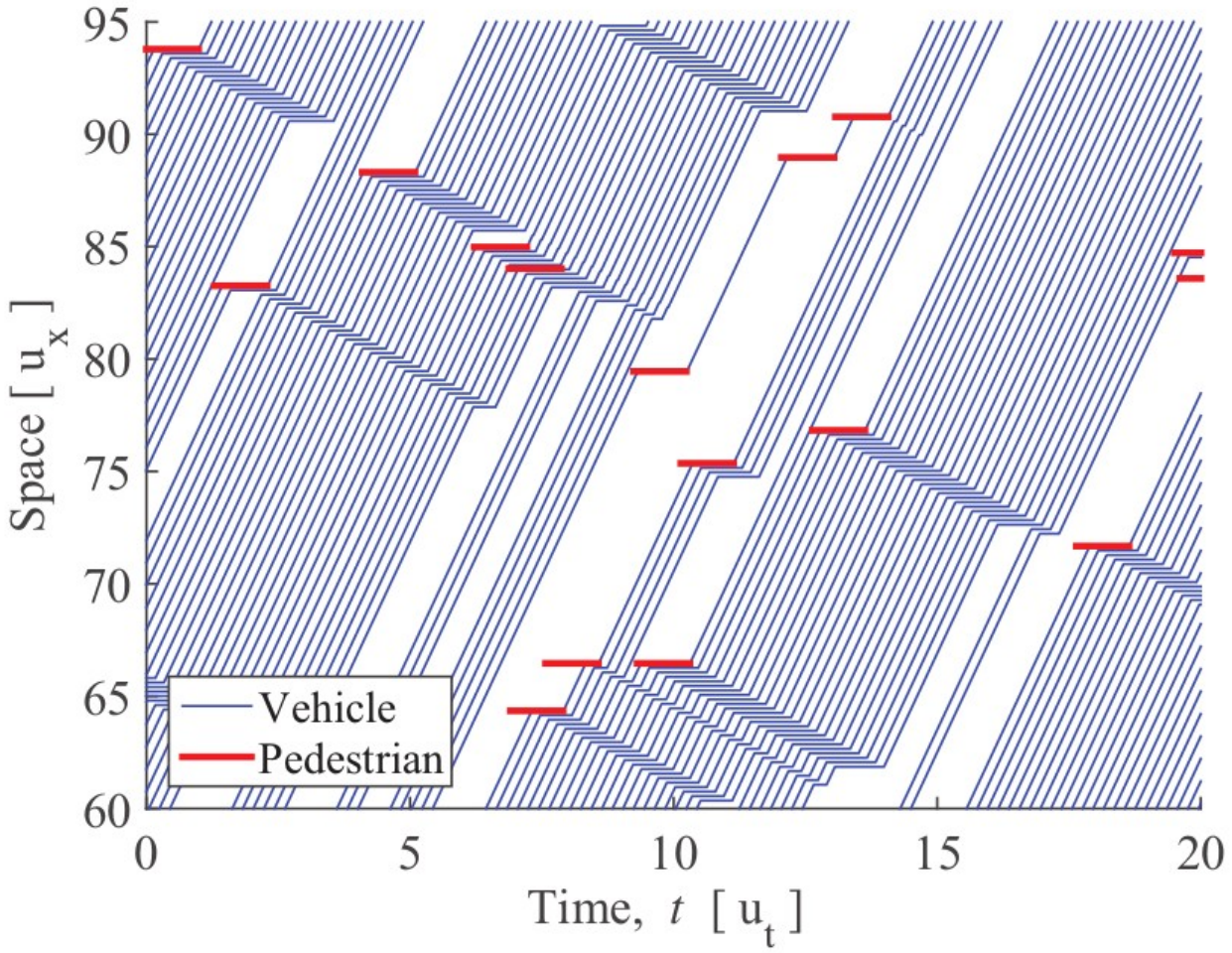


- More crossings help
- No interaction effects taken into accout

Spreading pedestrian load

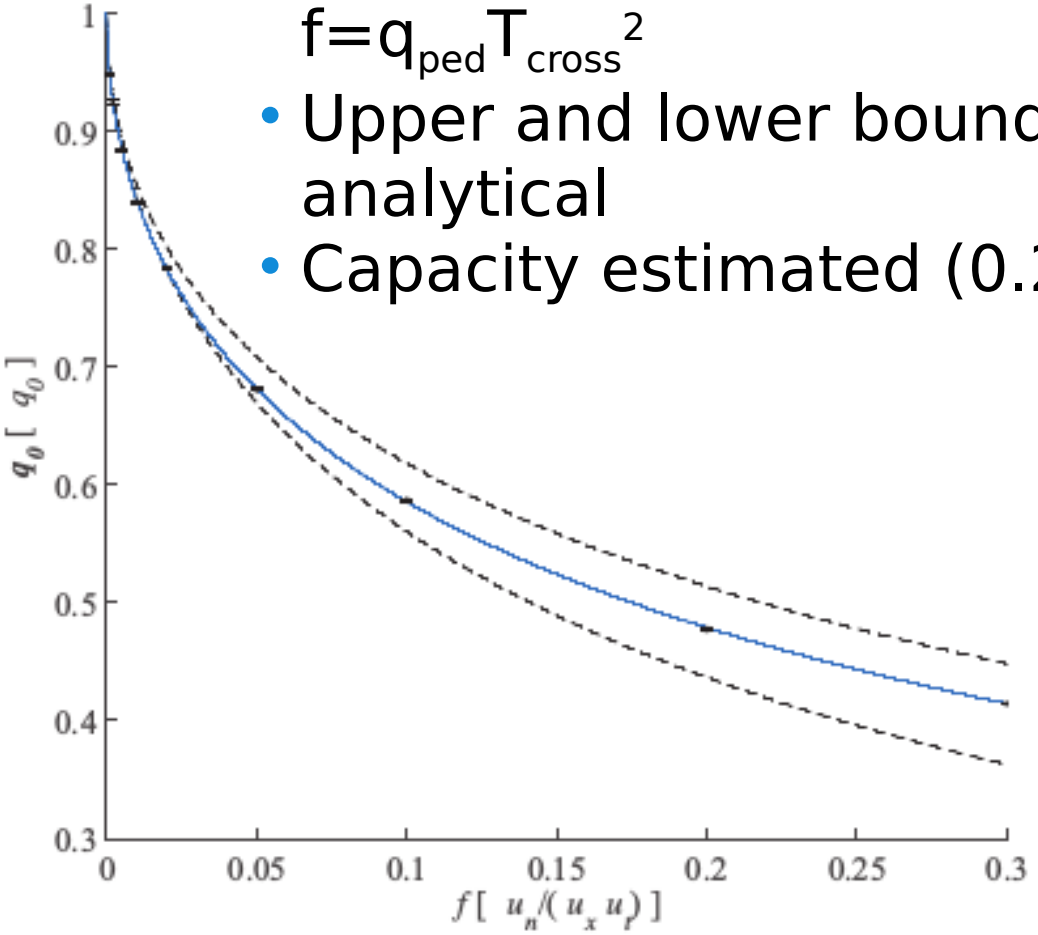
- Spreading pedestrian load over more pedestrian crossings benefits drivers and pedestrians
- Extreme case: infinite number of pedestrian crossings, i.e. pedestrians can cross anywhere
  (but still have priority)

Pedestrian crossings



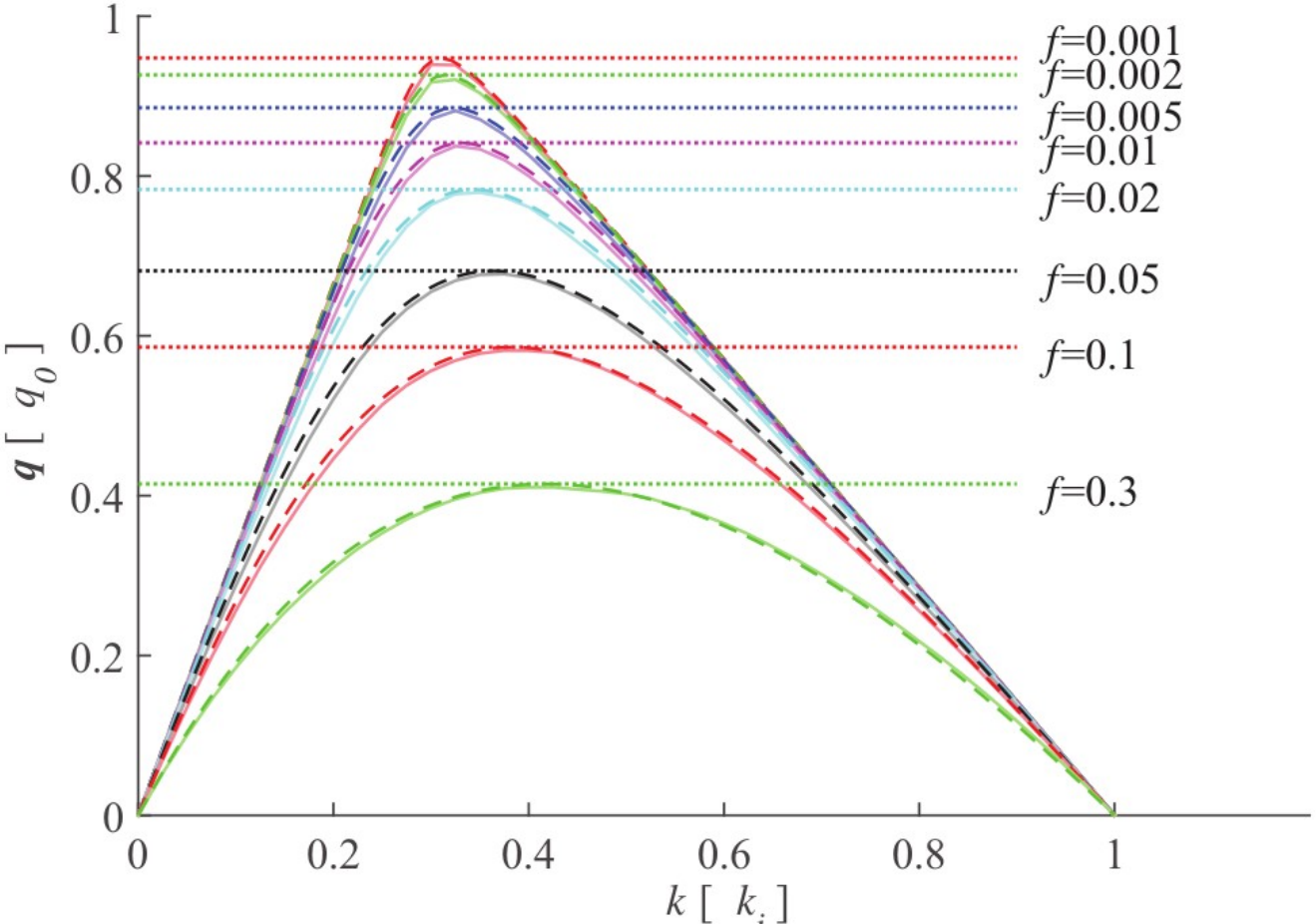
Analytics

- Capacity decreases with pedestrian flow and duration: $f=q_{ped}T_{cross}^{2}$
- Upper and lower bound analytical
- Capacity estimated (0.2% off)



Simulation and estimation

- Various levels of pedestrian load
- Simulation and estimation
- Very accurate estimation



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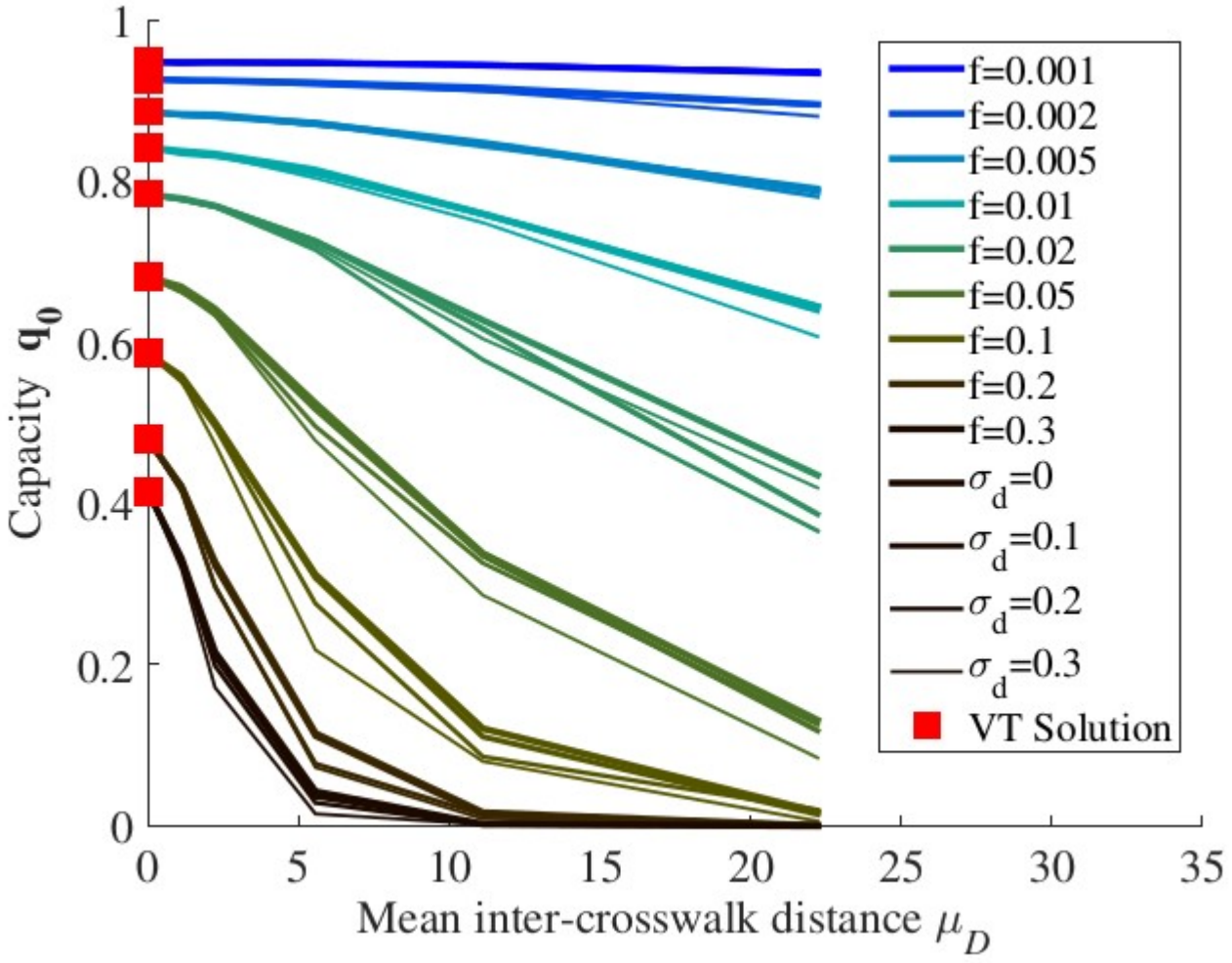
Crosswalks

- Non-perpendicular crossing increases the time on the road, so should be avoided => Use crosswalks
- Variables:
  - Average spacing between crosswalks
  - Std of spacing between crosswalks
  - Pedestrian flow

Result with crosswalks



Concluding remarks

Conclusions

- MFD is a very rich and promising field of research and application
- Next steps:
  - Include more modalities (cyclists?)
  - Build MFDs from data
  - Further work on dynamic modelling, and validate
  - Get it to work in practice!

Thanks to:

- Ludovic Leclercq
- Marianthi Mermygka
- Mehdi Keyvan-Ekbatani
- Carlos Daganzo
- Vikash Gayah
- Serge Hoogendoorn
- NWO, ERC, TU Delft, Licit

Further reading:

- Knoop, V.L., Van Lint, J.W.C., and Hoogendoorn, S.P. (2015), Traffic Dynamics: its impact on the Macropscopic Fundamental Diagram, Physica A, Volume 438, November 2015, pp. 236-250
- Network-wide Traffic State Estimation using the Macroscopic Fundamental Diagram: A data fusion approach Marianthi Mermygka, TU Delft MSc thesis, 2016
- Keyvan-Ekbatani, M., Gao, X, Gayah, V. and Knoop, V.L. (2016), Combination of Traffic-Responsive and Gating Control in Urban Networks: Effective Interactions. Paper presented at the 95th Annual Meeting of the Transportation Reseach Board
- Daganzo, C.F. and Knoop, V.L. (2016) Traffic Flow at Pedestrianized Streets. Transportation Research part B, Volume 86, Pages 211-222
- Knoop, V.L. and Daganzo, C.F. (2017) The Effect of Pedestrian Crossings on Traffic Flow. In proceedings of the 96th Annual Meeting of the Transportation Research Board, 8-12 January 2017