Macroscopic Fundamental Diagrams from two different data sources: A case of Brisbane, Australia

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Short CV

Takahiro Tsubota

2006.3 BEng, The University of Tokyo

2008.3 MEng, The University of Tokyo

2008.4 – 2010.6 Pacific Consultants, Co., Ltd.

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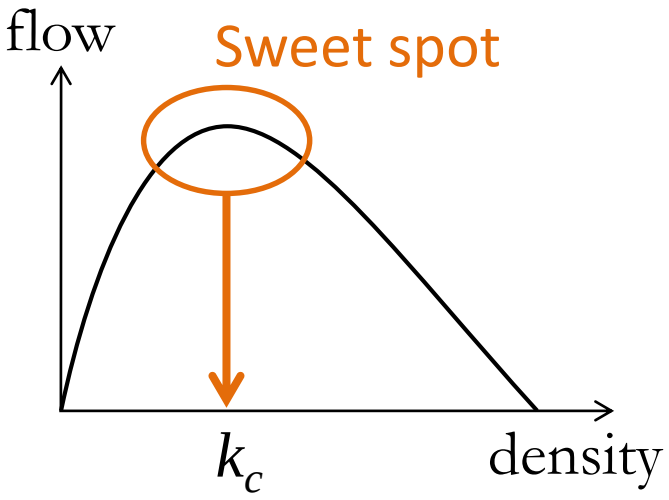
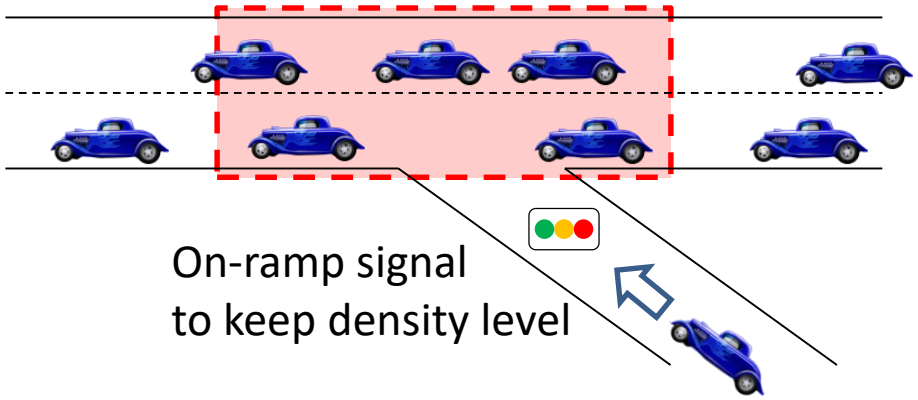
Queensland University of Technology

2016.4 – Assistant Professor, Ehime University

Congestion monitoring and control

- Traffic control and “ideal” traffic states
  - Traffic states (Flow(q), Speed(v), Density(k))
  - Fundamental diagram
  - Control strategy (e.g., local ramp metering)
    - ✓ Inflow control to merging section



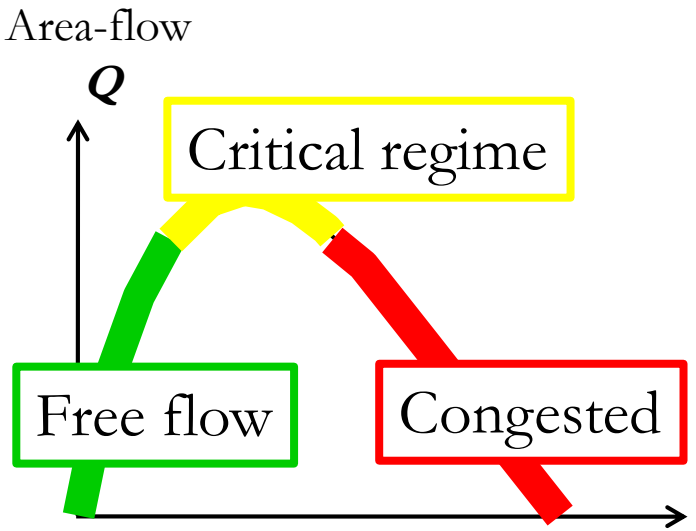


Network-wide traffic monitoring

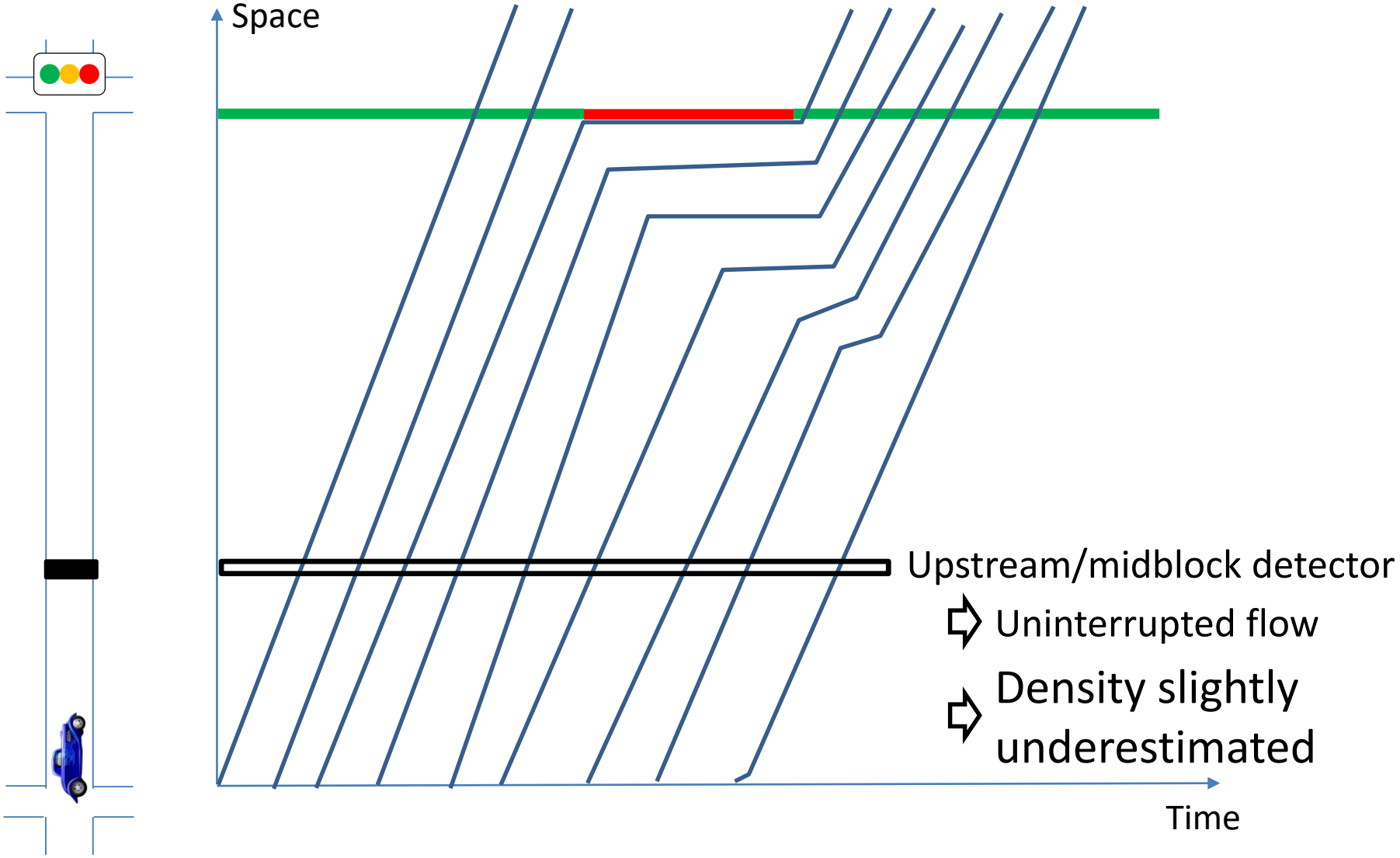
- Macroscopic Fundamental Diagram (MFD)
  - Network-wide aggregated traffic states
  - Well-defined shape in homogeneously congested area
  - Useful for network-wide flow control
    - Inflow control to CBD

Challenge in real-world application

- How to estimate the MFD?
- Variables: Flow & Density



Biased measurements from detectors



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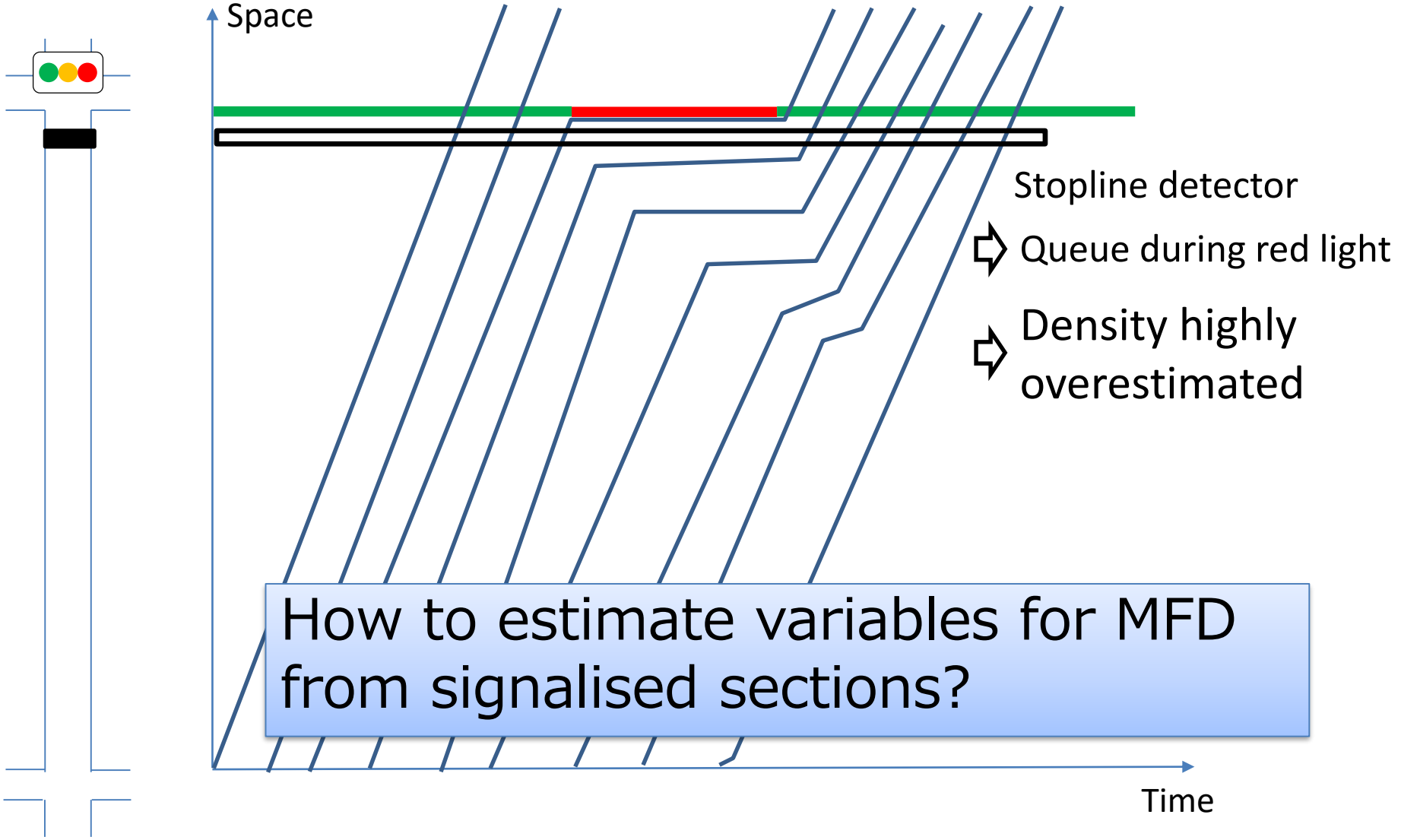

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Traffic density estimation
– Cumulative counts-based method

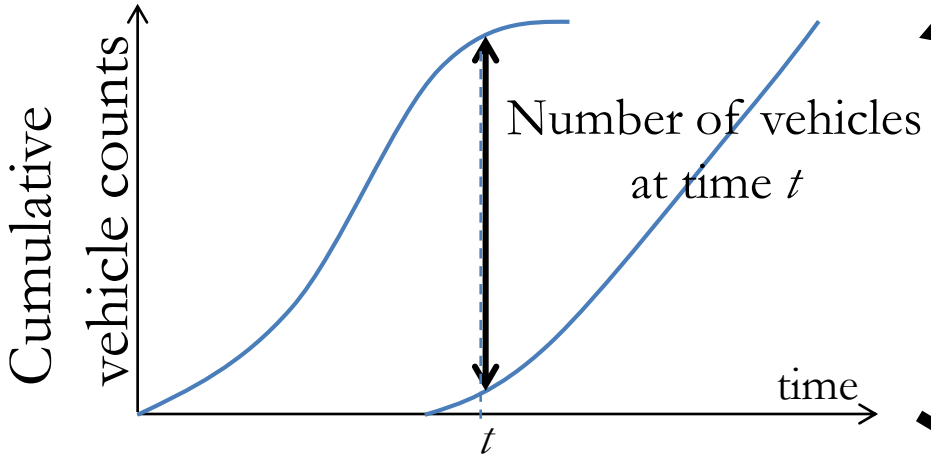
Loop detectors

Signal phase

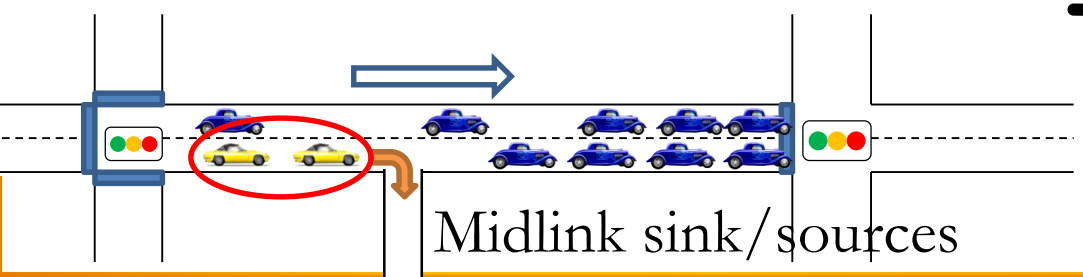
Bluetooth data

Cumulative vehicle counts (up/down stream)

Timestamps at up/down stream



Correct the errors in cumulative counts



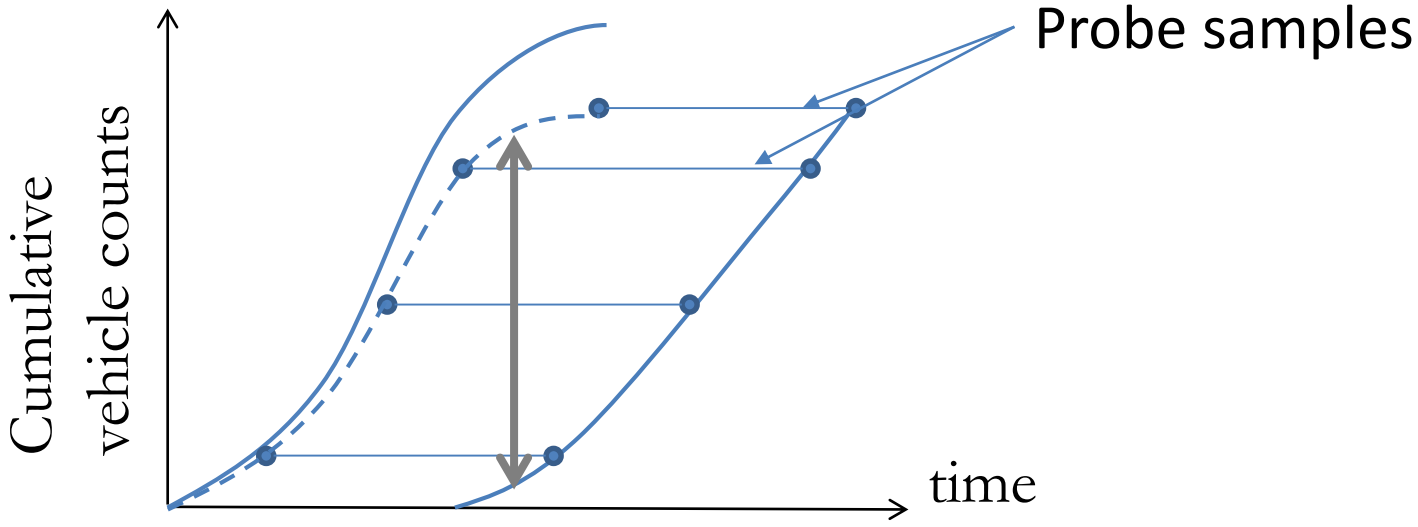
Correction of the cumulative curves

Probe samples that traverse the whole section

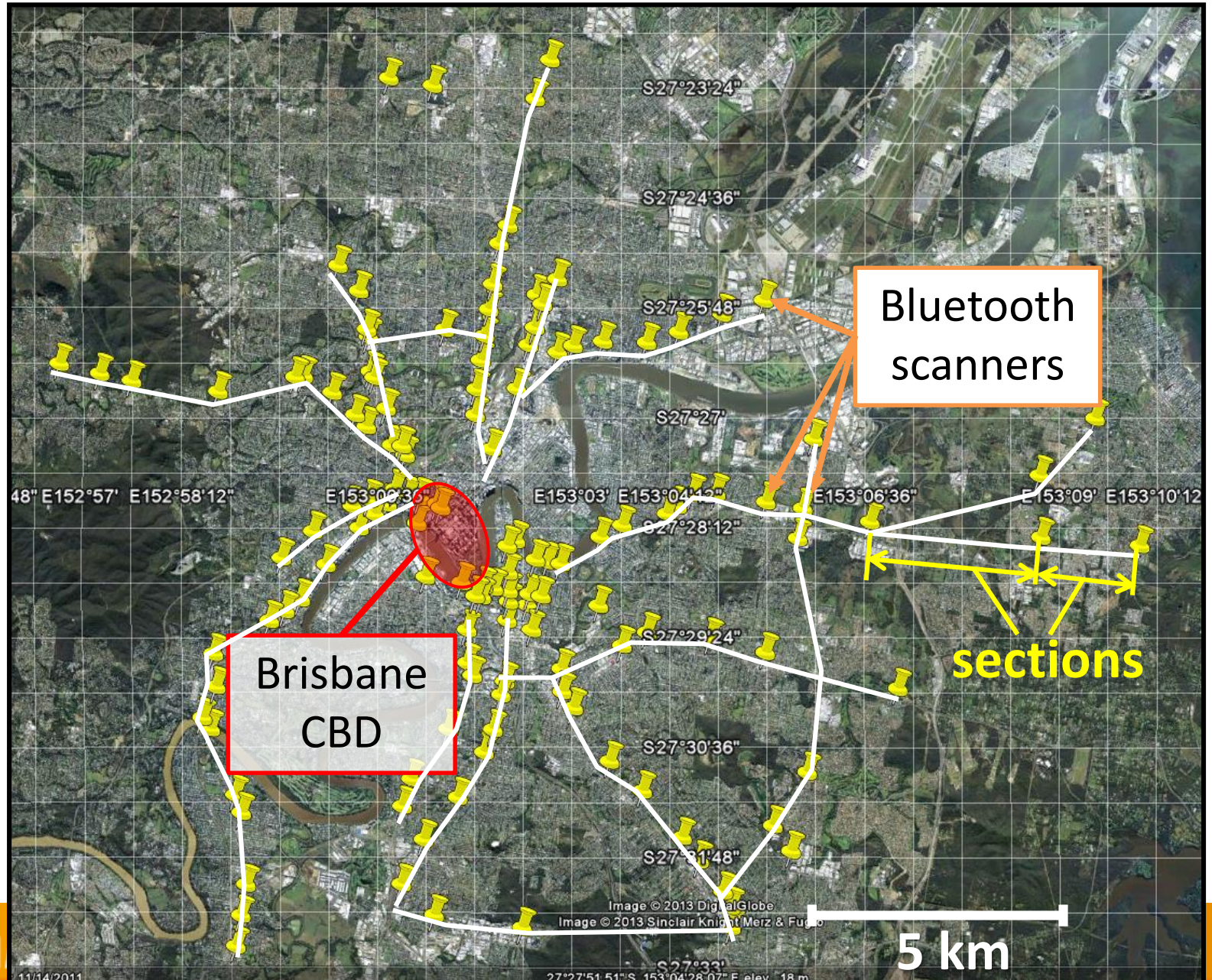
The section travel time of individual vehicles

Point to pass

Cumulative plots is modified
and the counting inconsistencies are cancelled

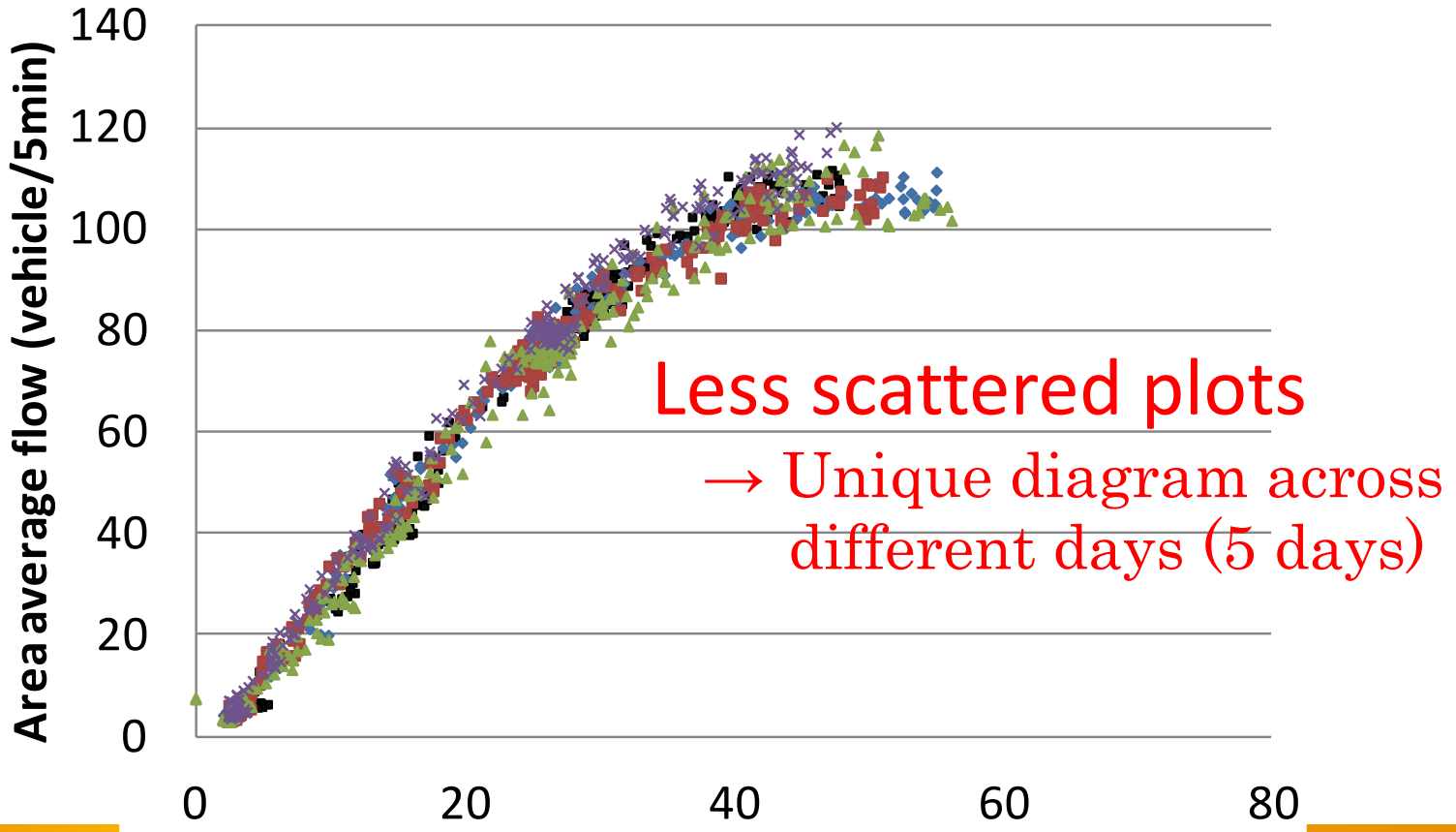


Study site – Brisbane network

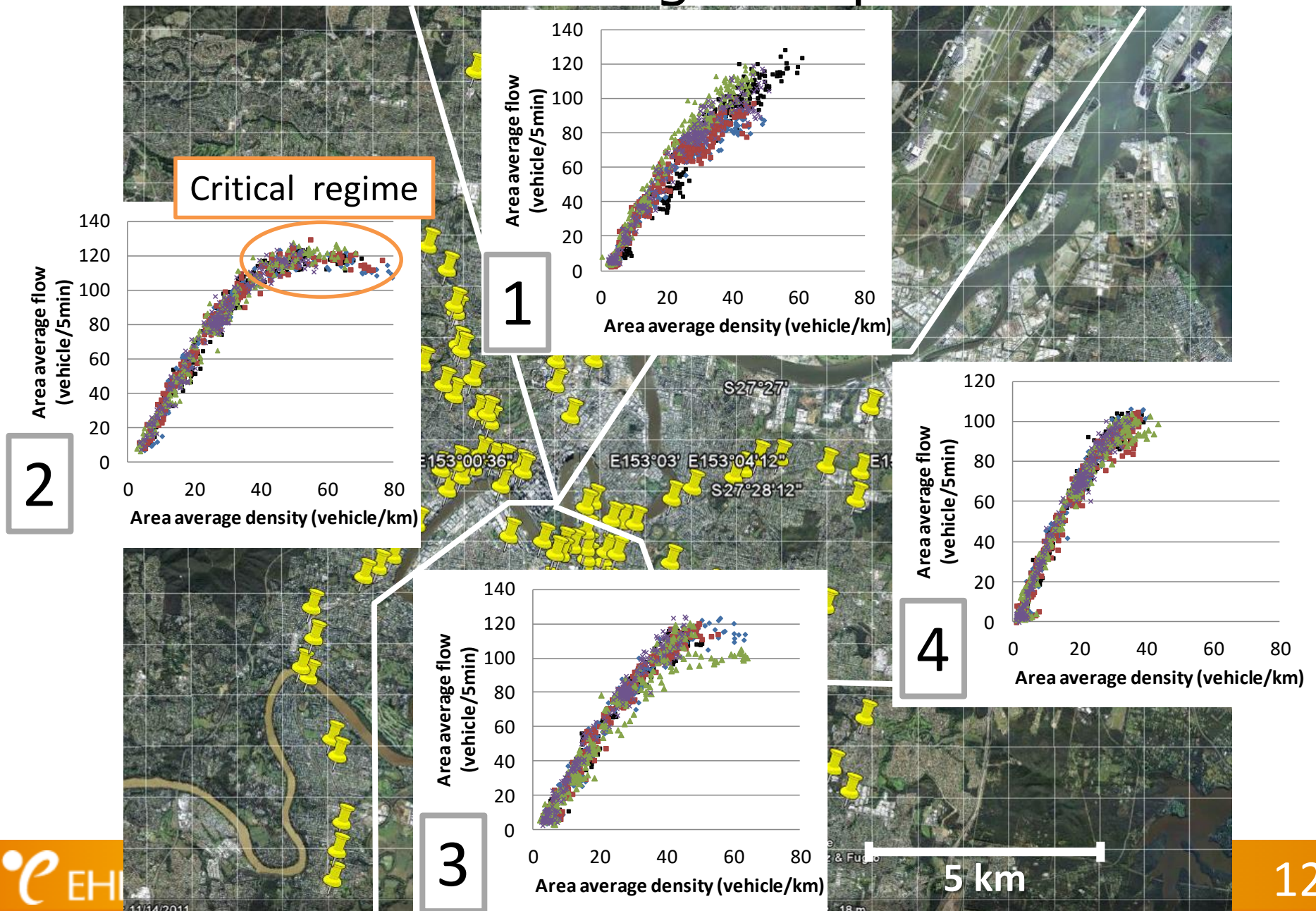


Brisbane MFD for 5 days
(Mon 22nd Oct – Fri 26th Oct, 2012)

- Different colours represent different day's plots

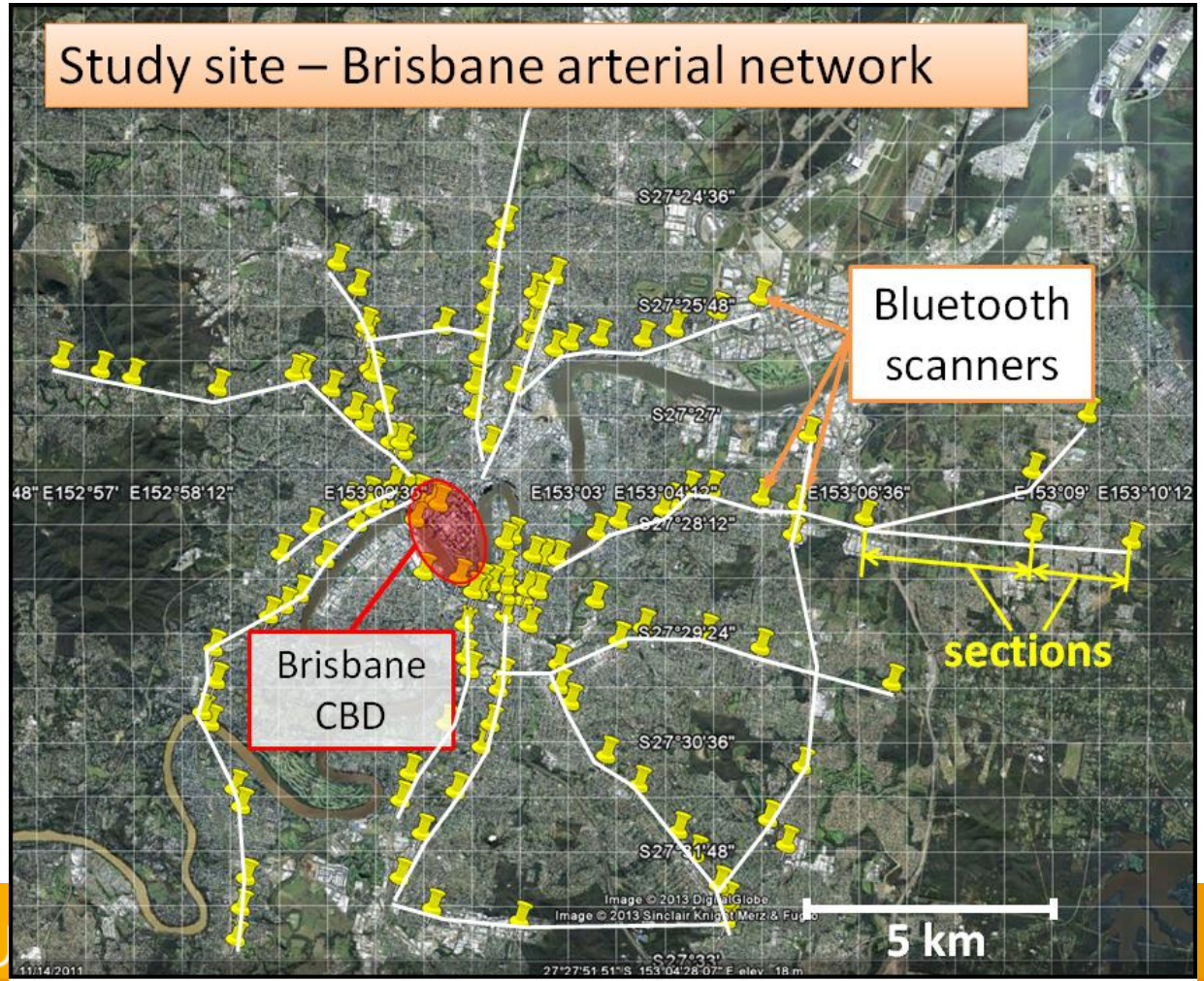


Brisbane network – regional performance



Limitation of Stop-line loop & Bluetooth

- Spatial coverage of Bluetooth scanners
- Estimated MFD represents only a subset of network



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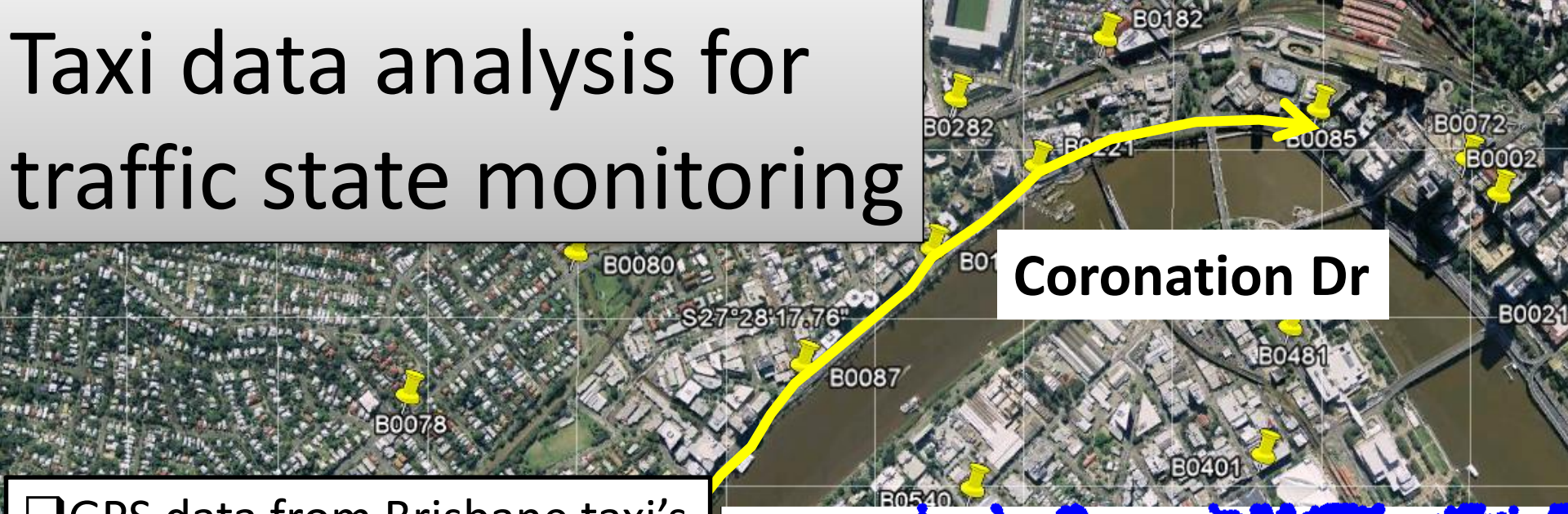
MFD from GPS probe data

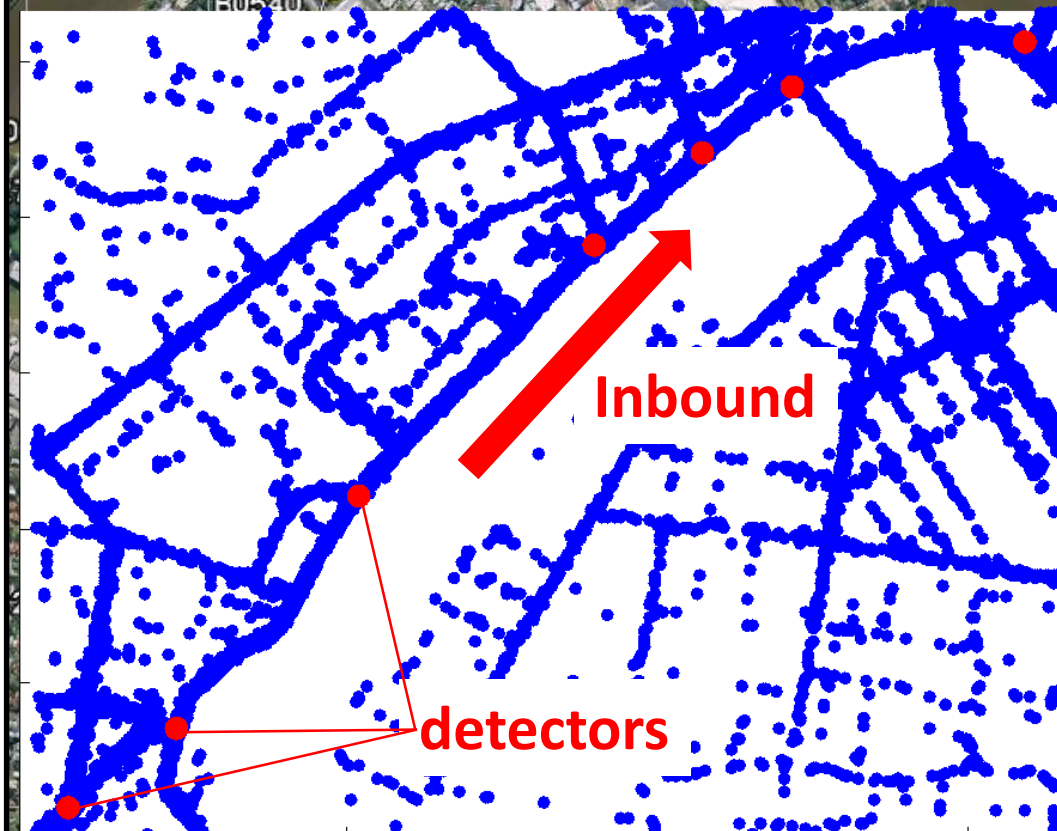
- Vehicles equipped with GPS works as moving sensors
- High spatial coverage
- Detailed trajectory data within sections
  - GPS tells its location every uplink interval (i.e., every 30 seconds)

- Any limitations/problems in GPS data?

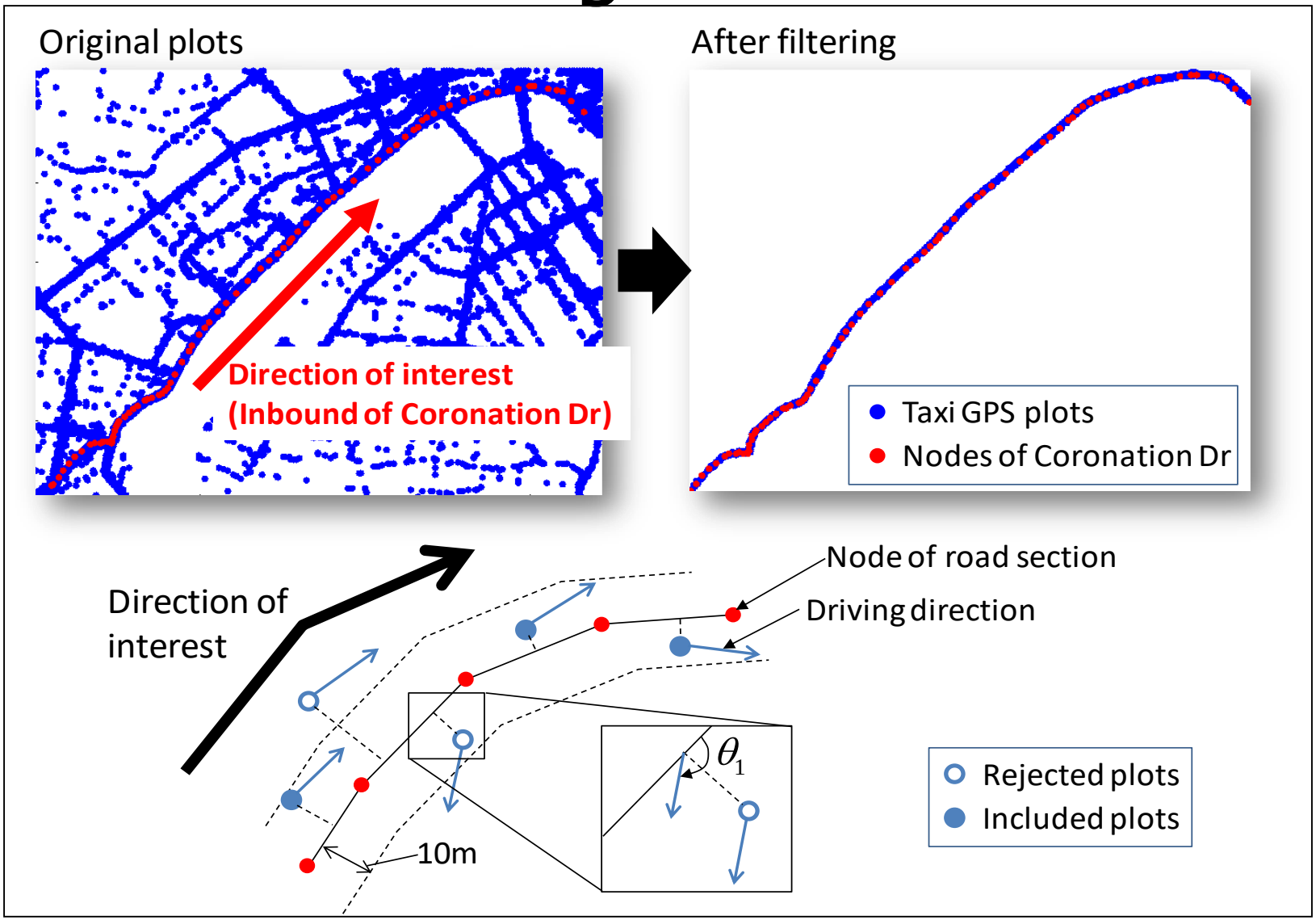
Taxi data analysis for traffic state monitoring



- GPS data from Brisbane taxi's
- Uplink frequency: 30 seconds
- Data fields
  - Geolocation
  - Timestamps
  - States: Meter ON/OFF
  - Speed and Angle
- Meter ON (Occupied) is used for analysis
- Geolocation and Angle for map maching



Taxi data filtering



Flow and Density estimation from Taxi

Total Distance Travelled (*TDT*) and Flow (*q*) of Taxi samples

$$TDT = \sum_i d_i \qquad q = TDT / DT$$

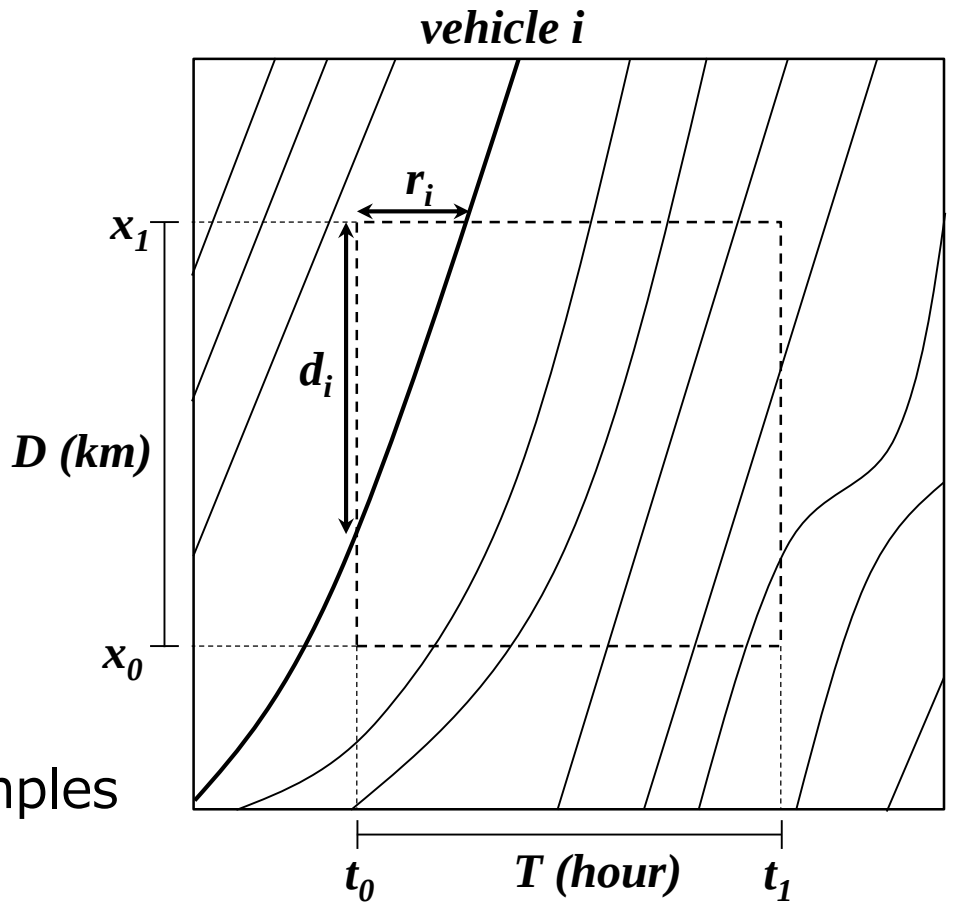
Total Time Spent (*TTS*) and Density (*k*) of Taxi samples

$$TTS = \sum_i r_i \qquad k = TTS / DT$$

Expansion to full traffic (*Q*, *K*)

Given the proportion of taxi samples to full traffic (*P*)

$$Q = q / P \qquad K = k / P$$

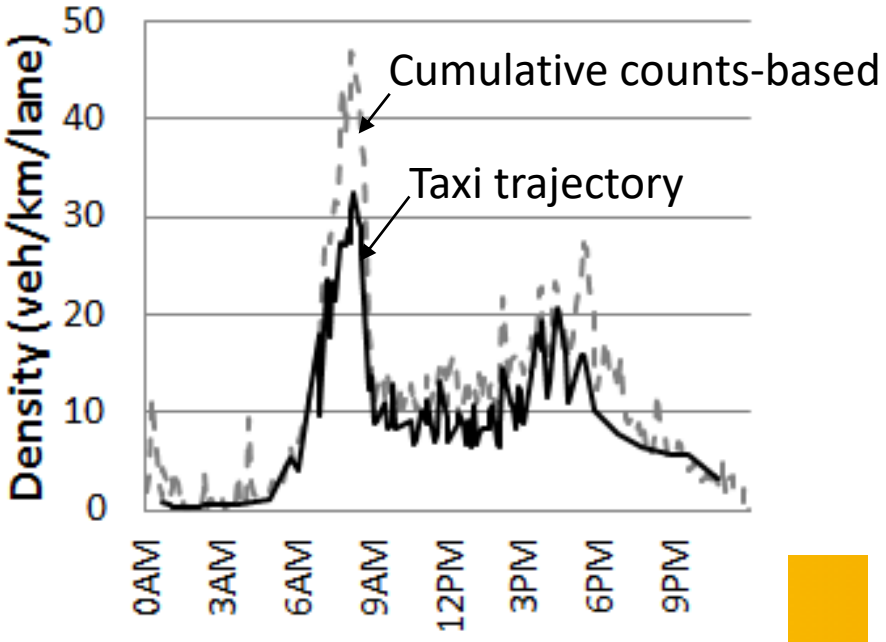


Results

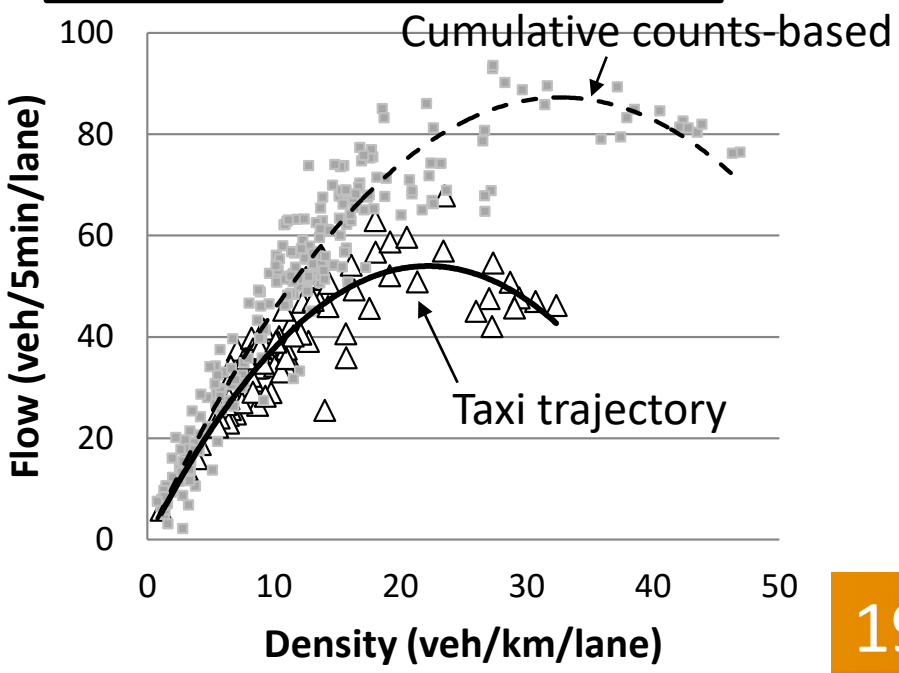
– comparison of trajectory-based and cumulative counts-based methods

- Trajectory based method captures peak/offpeak
- However, trajectory based method always underestimates the variables

Comparison in density estimation



Comparison in the corridor MFD



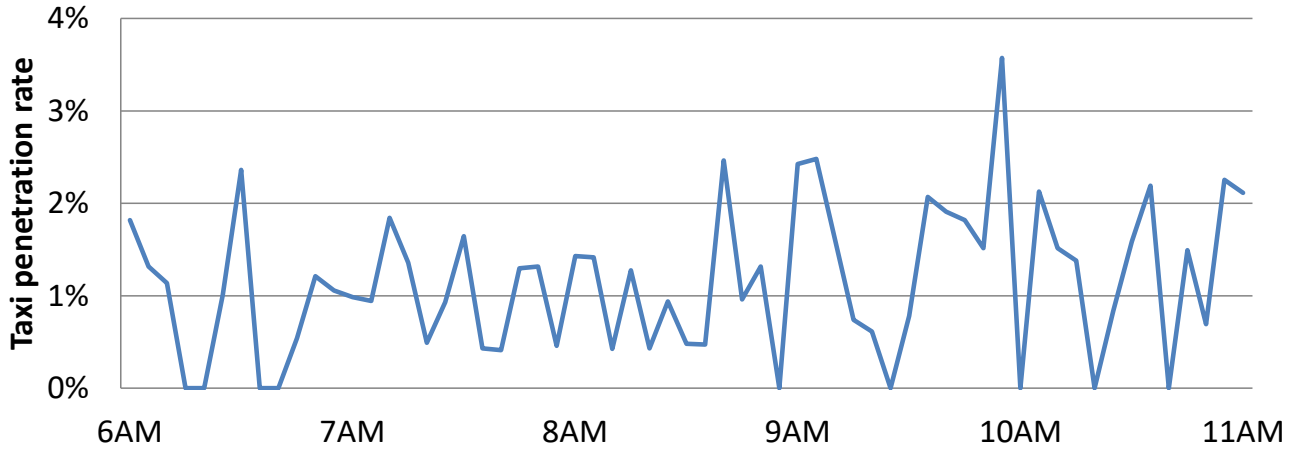
Quality and Quantity of trajectory data

370m section without sink/source

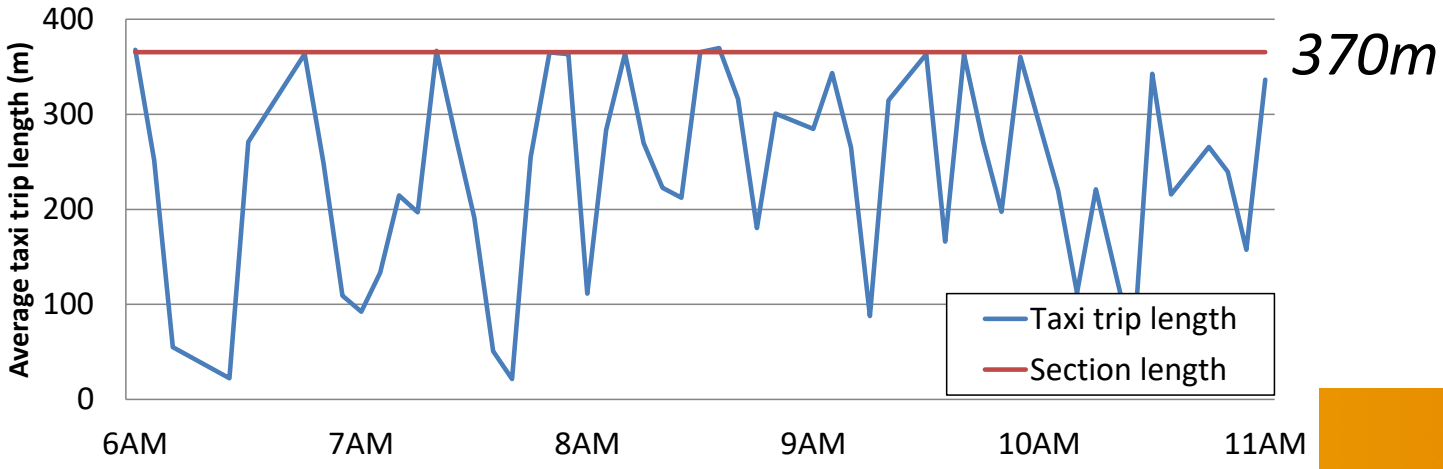
- Taxi penetration rate
- Average taxi trip length

Quality and Quantity of trajectory data

Penetration rate: < 3% during morning peak hours



Average trip length vs section length: many incomplete trip data



Summary

- Brisbane MFD is estimated using cumulative counts-based method
  - The MFD with an unique shape exists in Brisbane arterial network
- Trajectory based method is successful in estimating peak/offpeak of traffic congestion
- Trajectory data has problems both in quality and quantity
  - Causes underestimation of the variables
  - May cause challenges in practical use

Thank you

Data provided by

Brisbane City Council

Department of Transport and Main Roads, Queensland

Black & White Cabs