Investigating Urban-scale Macroscopic Fundamental Diagram: Simulation Findings for Edmonton's Urban Network

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Urban Analysis | Systems Analytics
Urban Form and Corporate Strategic Development | City Planning

Outline

- Background and Motivation
- Methodology
  - Simulation Framework
  - Simulated Network
- Result Discussion
- Findings and Future Applications

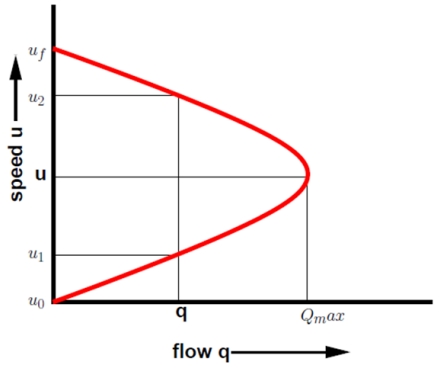
Fundamentals of Traffic Flow

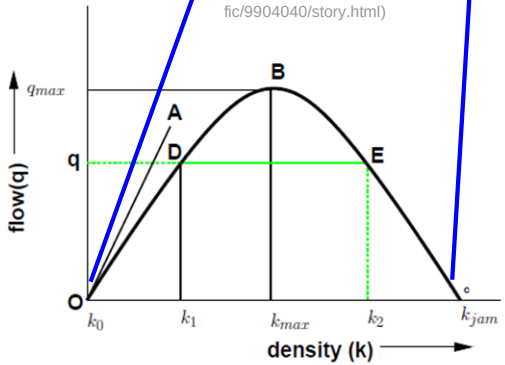
- **Flow = Speed * Density**

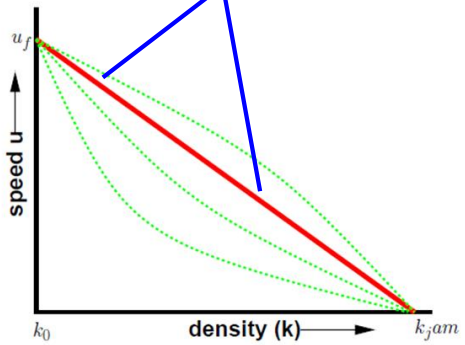
High Density → Low Speed
Highest Volumes → Medium Density
Highest Volumes → Medium Speed
Maximum Density → No speed or flow

(Source:http://www.calgaryherald.com/news/traffic-cameras/Canadian+cities+where+most+likely+stuck+traffic/9904040/story.html)

(Source:http://edmontonjournal.com/news/insight/ring-of-ire-clogged-southwest-henday-fires-up-drivers/)



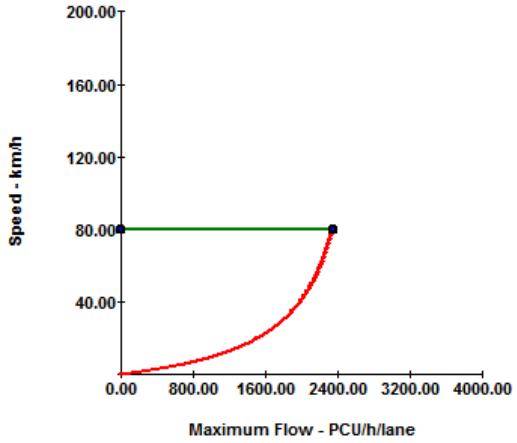




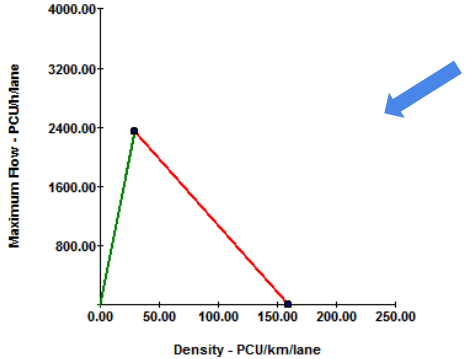
Flow Propagation in Dynameq

- **Car-following: "simplified" car following model**

Speed-flow relationship

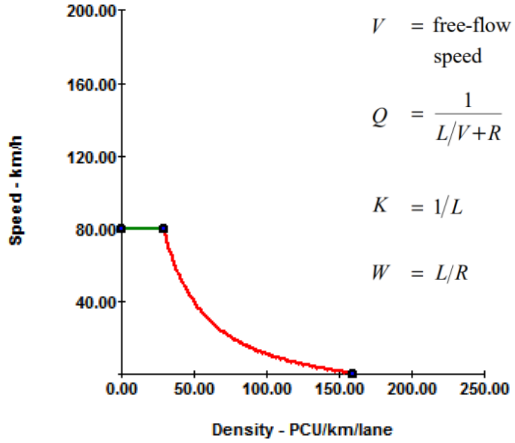


Flow-density relationship



Maximum Flow (PCU/h/lane)	Jam Density (PCU/km/lane)	Wave Speed (km/h)
2351.02	160.00	18.00

Speed-density relationship



V = free-flow speed

$Q = \frac{1}{L/V + R}$

$K = 1/L$

$W = L/R$

(Source:INRO 2010 Training Presentation)

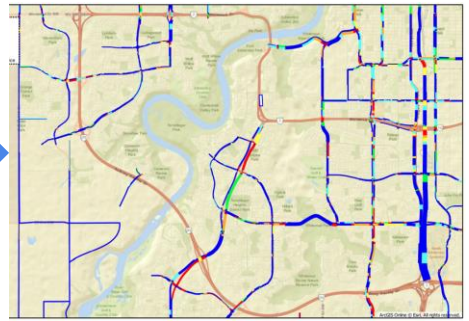
Traffic Performance Measures-Mobility

- Constructing new infrastructure or expanding existing infrastructure
- Active Traffic Management (ATM) and Intelligent Transportation Systems (ITS)

- Roadways and Intersections: speed, delay, traffic volumes, volume/capacity ratio, level of service
- Corridor: Travel Time
- **Localized and Network Wide: ?**

(Source:https://edmonton.skyrisecities.com/news/2017/09/new-walterdale-bridge-opens-traffic)

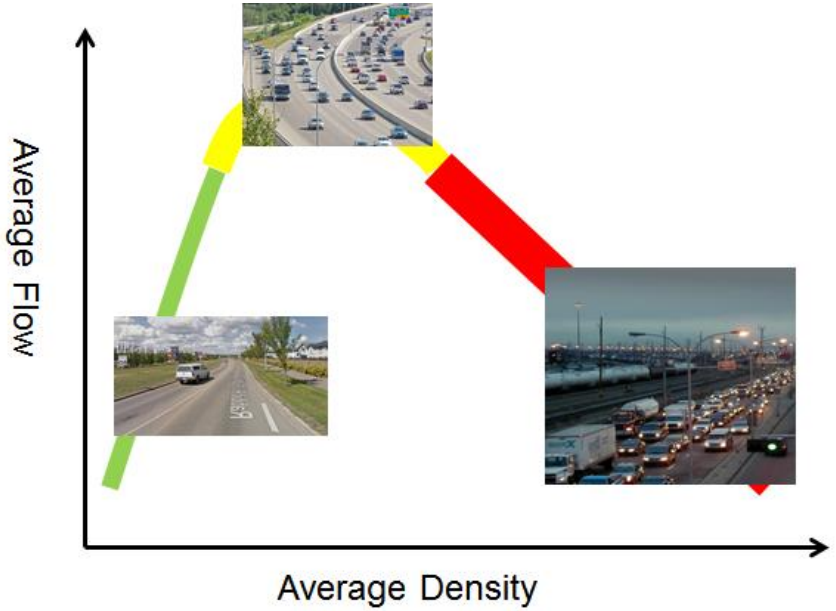
(Source:https://www.taprootedmonton.ca/stories/2017/syncing-traffic-lights-tech-fixes-enduring-challenges/)



Macroscopic Modeling of Urban Network

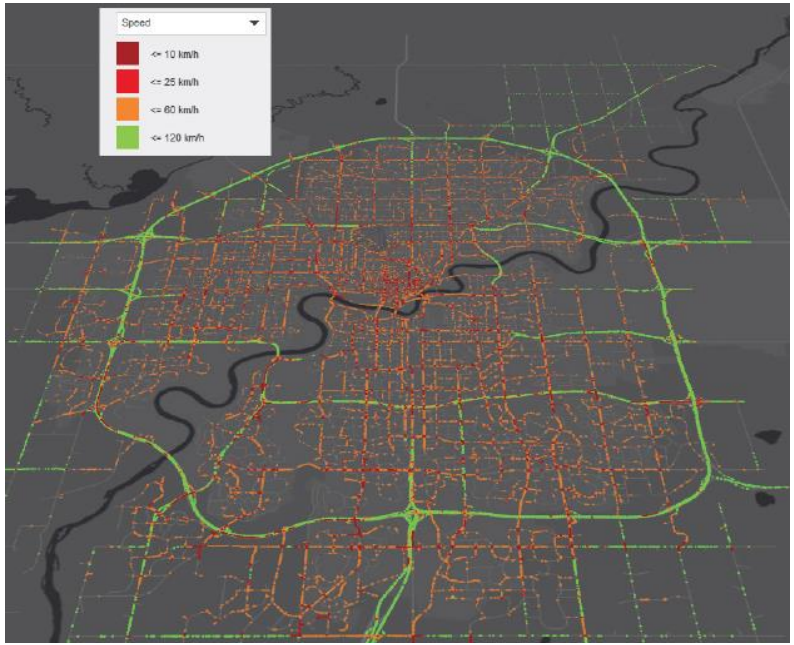
- Macroscopic Fundamental Diagram (MFD)
  - a proper macroscopic description of the traffic flow state in urban network
  - describes the network-average relation between the flow, density and speed
  - a property of the network infrastructure and control.

➔ An MFD exists
➔ 3 regions

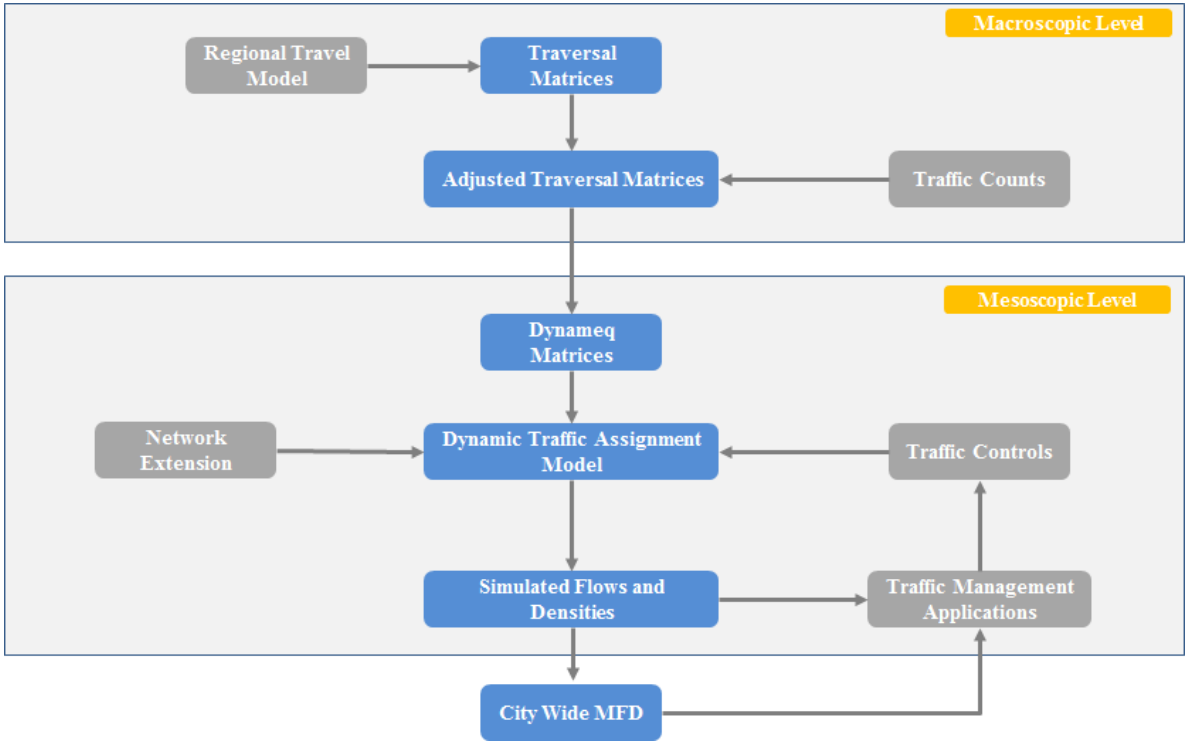


Motivation and Objective

- To investigate the capability of using DTA for new traffic performance measures
  - the existence of a MFD for Edmonton's road network
  - the factors that influence the MFD shape



Study Methodology

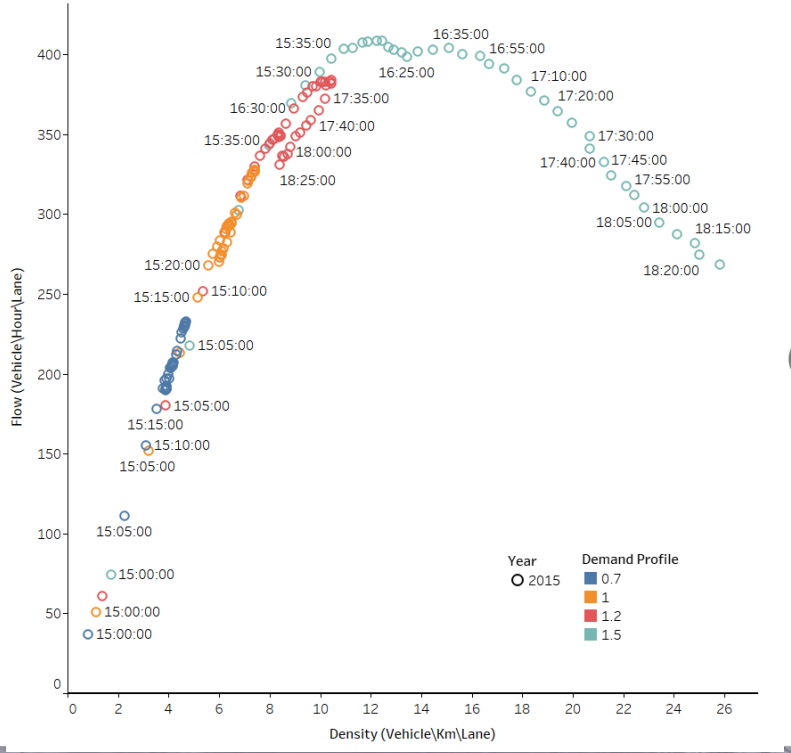


Simulated Network

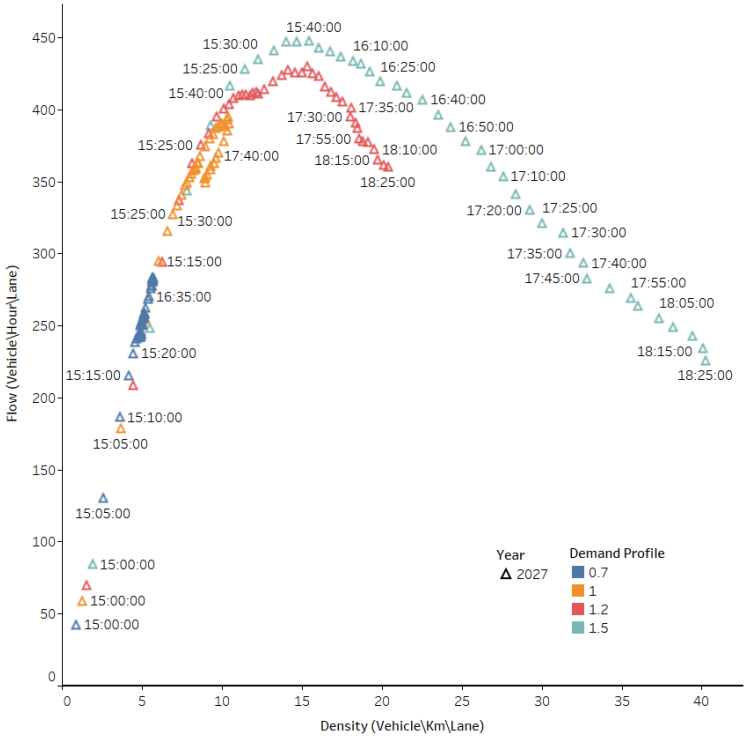
Year	Network	Centroids	Nodes	Links	Signalized	Unsignalized
2015	City Wide	1119	11647	29749	1064	10583
2027	City Wide	1125	11979	30623	1127	10852
2027	Central Area	210	1456	3949	232	1224

- Another three demand scenarios are composed, including 70%, 120% and 150% demand profiles.

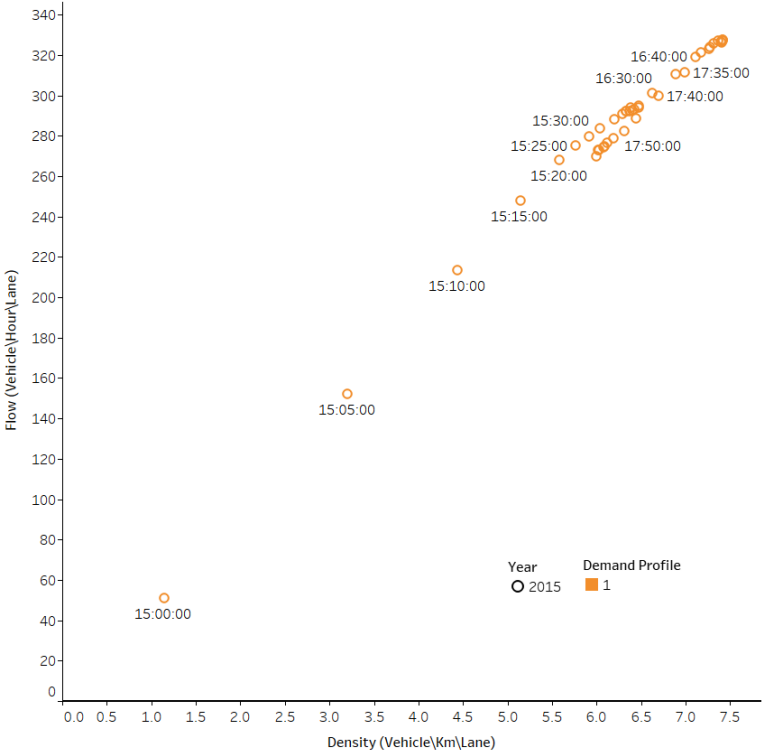
Result Discussion-MFD (1)



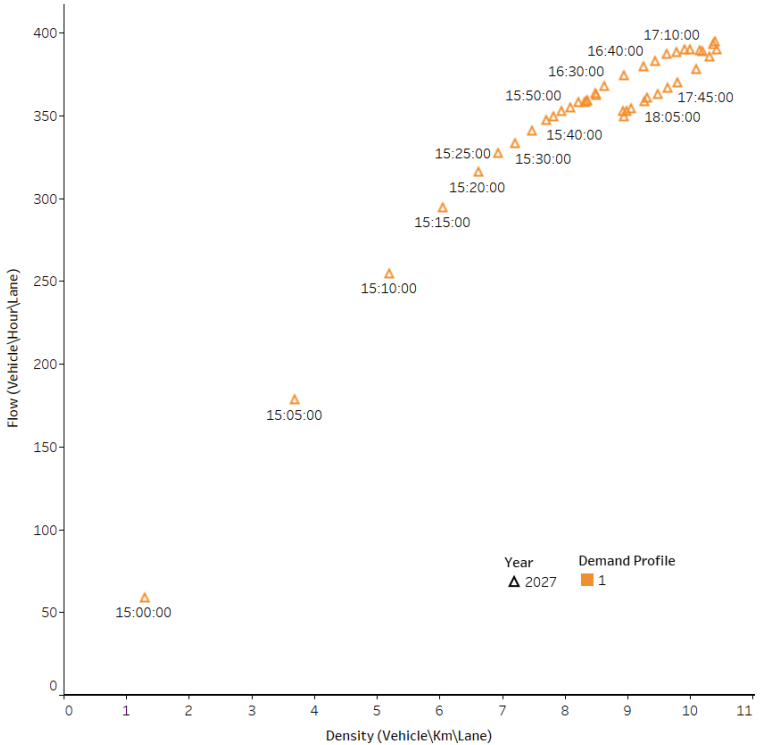
(a) City Wide Network



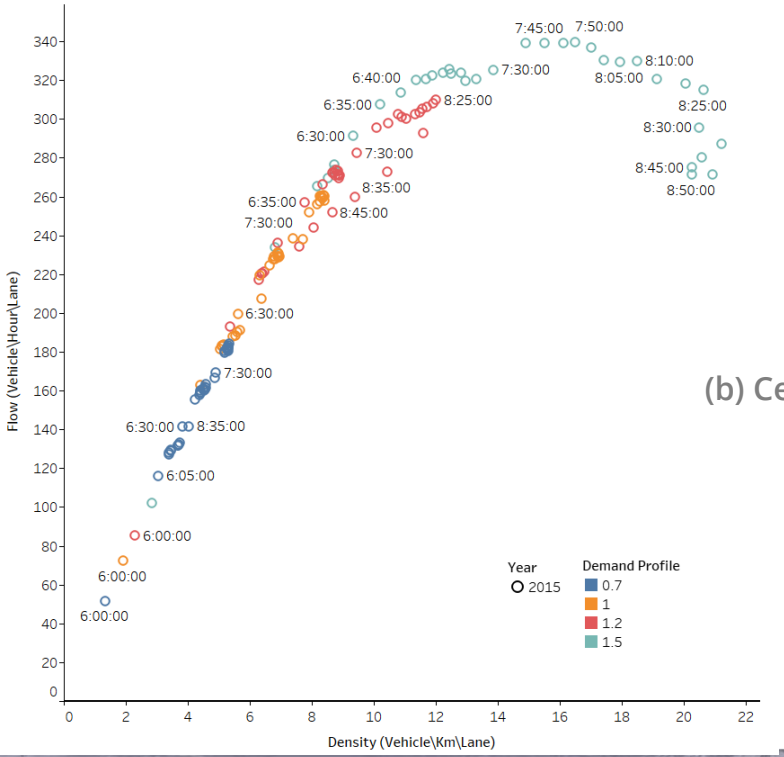
Result Discussion-MFD (2)



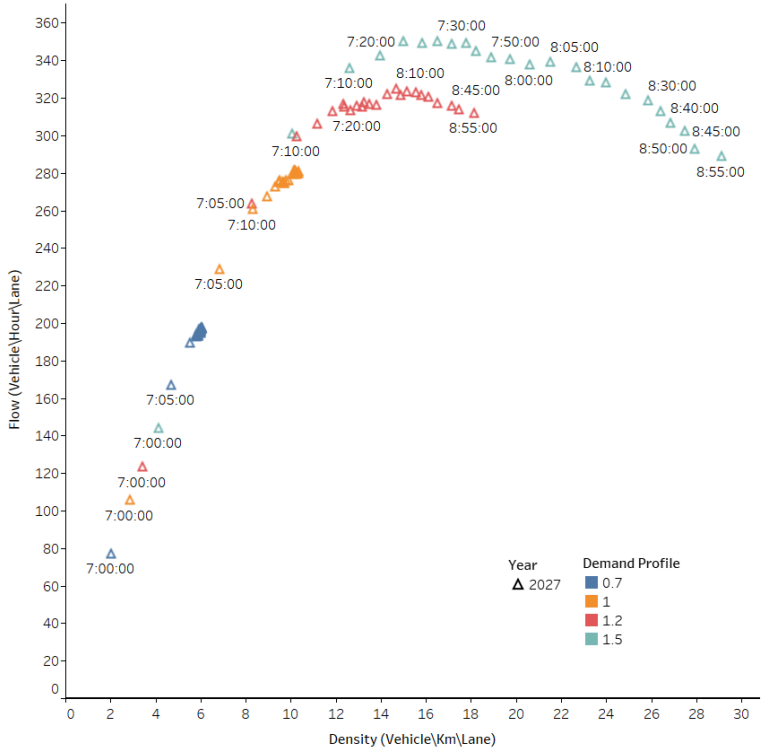
(a) City Wide Network



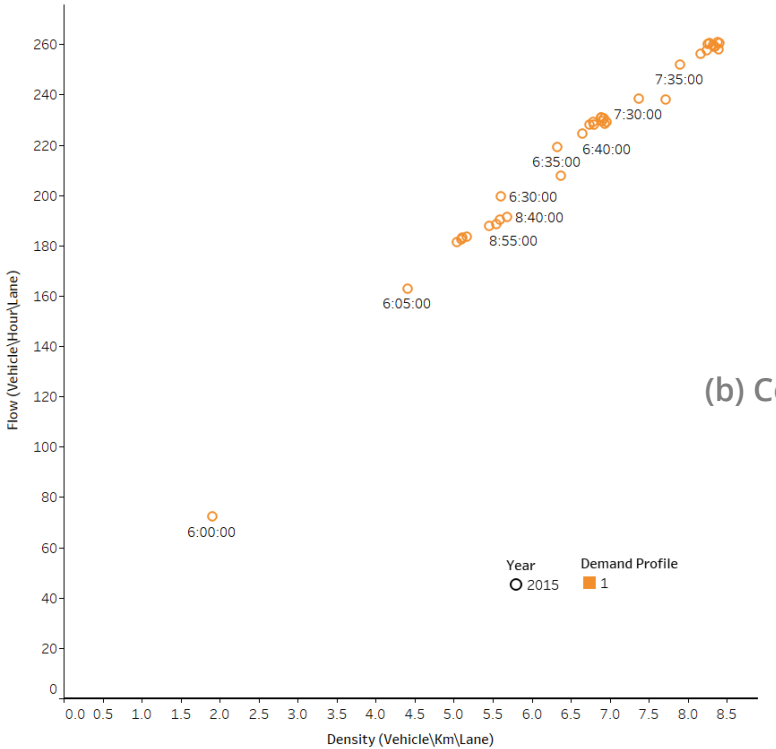
Result Discussion-MFD (3)



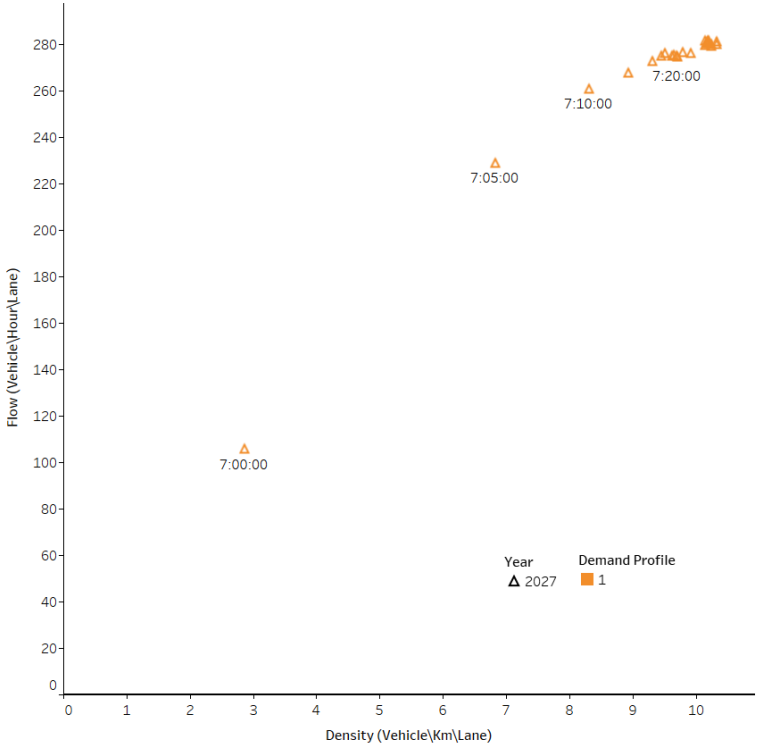
(b) Central Area Network



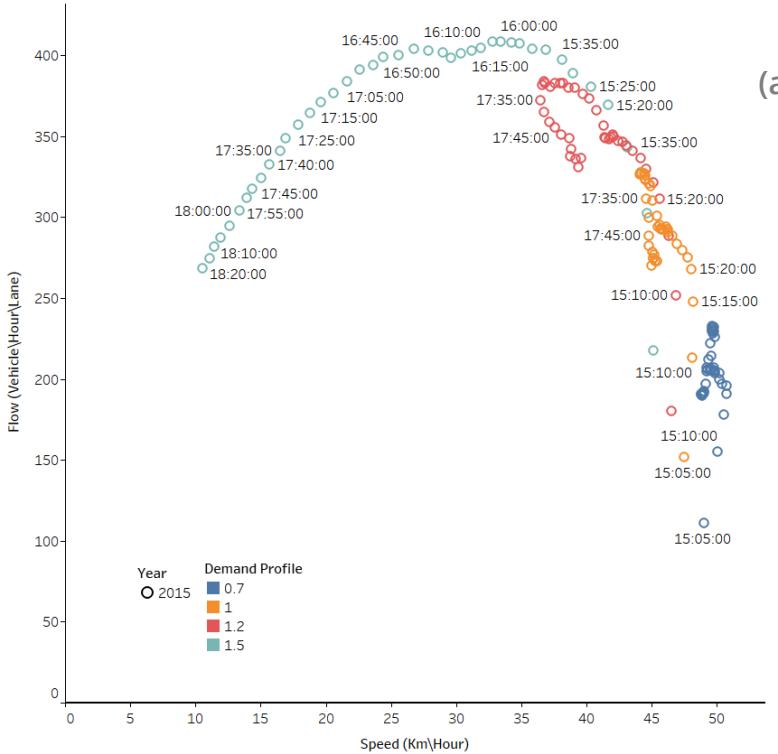
Result Discussion-MFD (4)



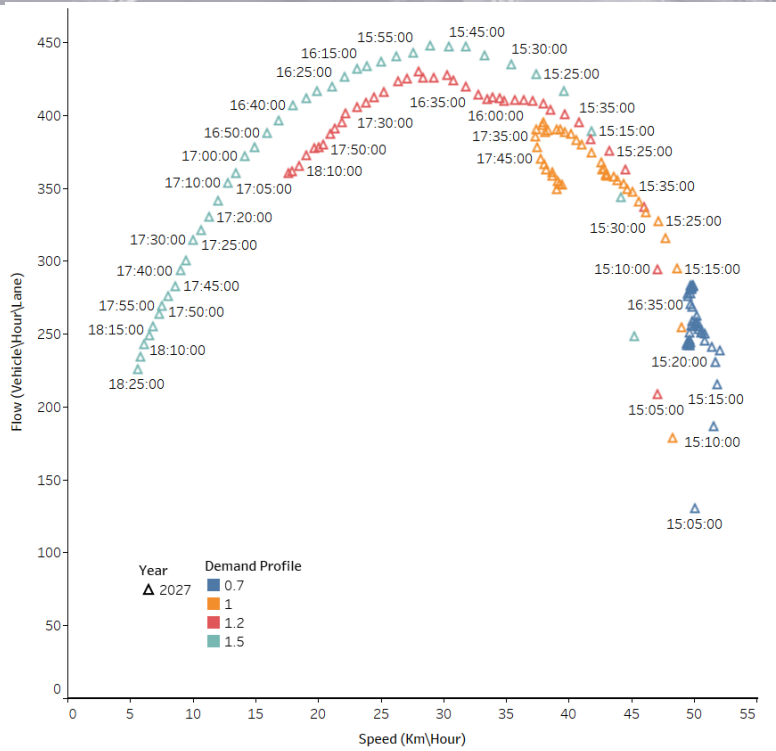
(b) Central Area Network



Result Discussion-Speed vs Flow (1)

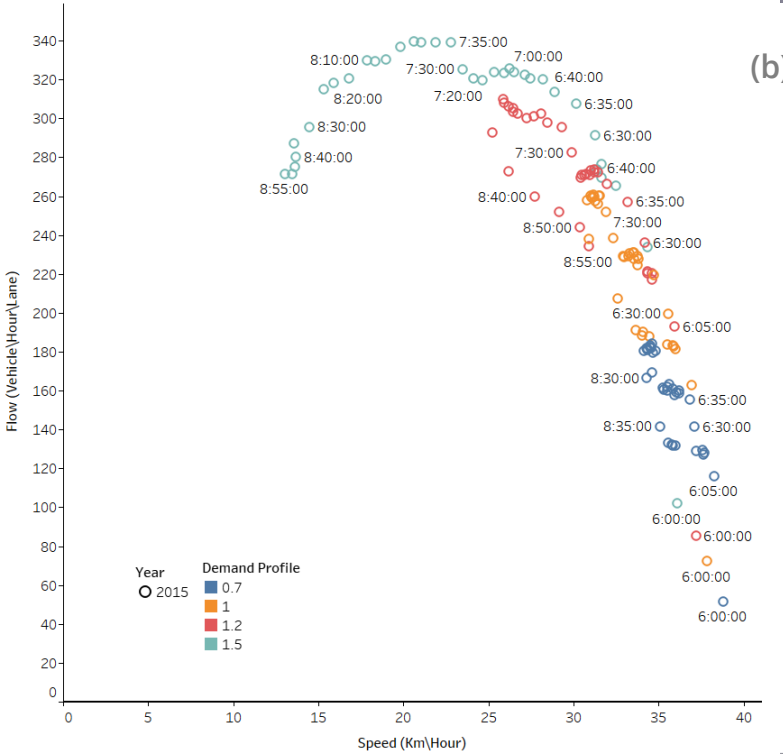


(a) City Wide Network



Result Discussion-Speed vs Flow (2)

(b) Central Area Network

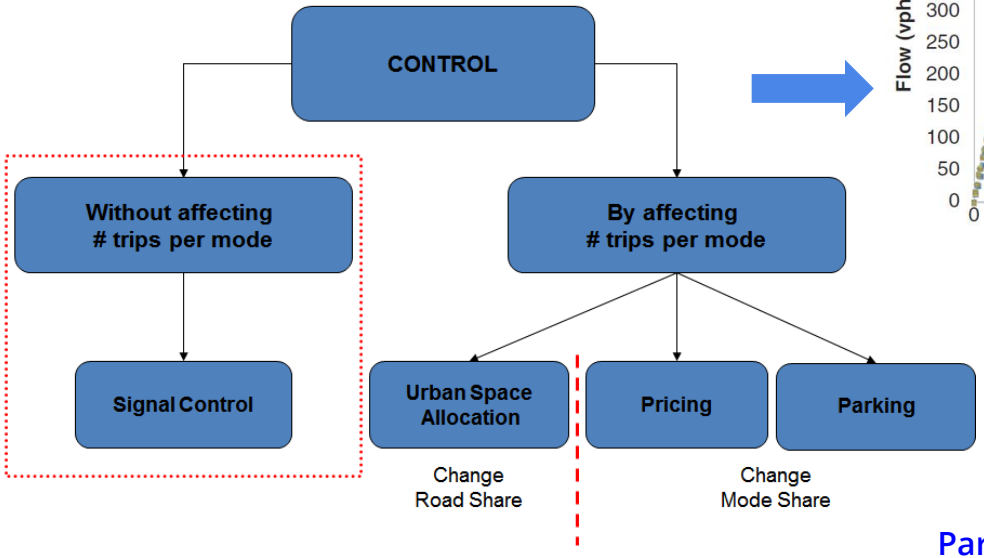


Findings

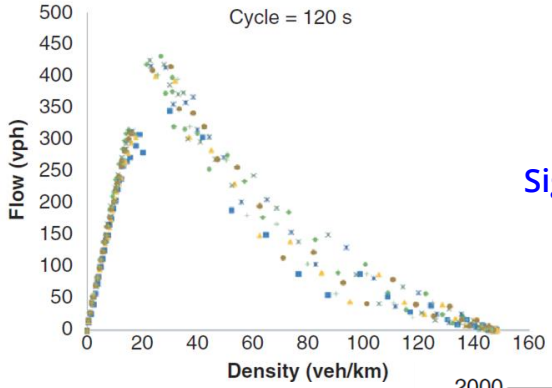
- Edmonton’s city wide network and central area network had a clearly defined density-flow MFD
- Its shape was sensitive to the total traffic demands and network layout.
- This MFD can be used as a tool for traffic control and accessibility improvement in the central area and city wide area.

Potential Applications of MFD

Management Options: Control

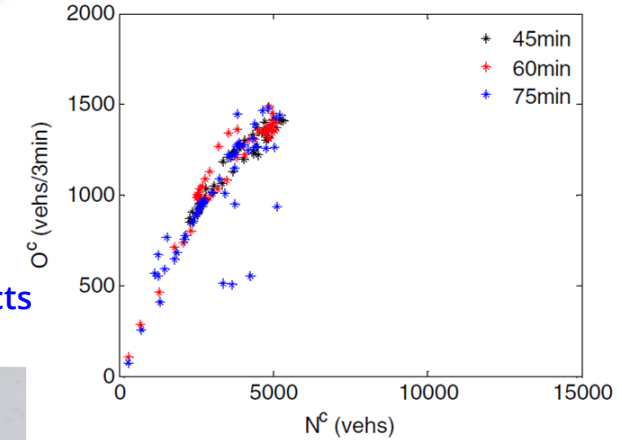


(Source Nikolas Geroliminis et al., 2009)



Signal coordination impacts

(Source Girault et al. 2016)



Parking pricing impacts

(Source Zheng and Geroliminis , 2016)

Thank you.

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