Study of traffic management strategies in the Zürich area

Javier Ortigosa

Kathrin Arnet, Qiao Ge, Monica Menendez

Traffic Engineering (SVT) group

IVT
Institut für Verkehrsplanung und Transportsysteme
Institute for Transport Planning and Systems

ETH
Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

Why cities are often congested?

Jul 7, 2011 - 21:25

Zurich streets among Europe's most congested

Everyone needs to learn to share the streets (Keystone)

RELATED STORIES

- Green groups aim to reclaim cities from cars
- Bumps in road could slow motorway plans
- Move to ban pollutant cars gathers pace

by **Matthew Allen in Zurich**, swissinfo.ch

Zurich car drivers spend more time stuck in traffic jams than in most other European cities, but the city is unrepentant about its pedestrian friendly policy.

A recent survey has revealed that more than a quarter of roads in Switzerland's main business conglomeration are clogged, putting Zurich in 16th place in the list of most congested cities.

The survey by Dutch navigation system maker TomTom comes days after a critical report in the New York Times accusing Zurich of "working overtime in recent years to torment drivers".

The article reports that traffic lights are programmed to favour trams while pedestrian crossings have been moved from underground passages to street level.

The TomTom analysis found that daytime traffic on 27.4 per cent of Zurich city's streets was forced to travel less than 70 per cent as fast as during the night when roads are less busy. Brussels came out worst in the report with nearly 40 per cent of its streets congested.

Why cities are often congested?

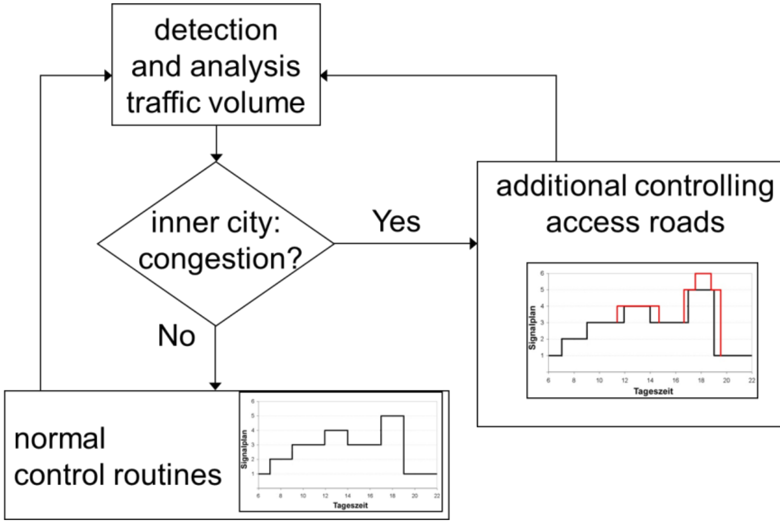
Because the capacity of the street network is not able to cope with all the traffic demand

- Cities concentrate **many activities** in a small area
- **Commuters**, typically, create the biggest traffic problems
- Normally, the worst scenarios happen on working days in the **morning** and in the **evening peaks**
- Traffic congestion has a huge **impact on the quality of living** in cities
- How can we **address** this situation?
  - Better and more rational planning of cities and transport systems
  - Promotion of more sustainable transport modes
  - Pricing strategies
  - **More efficient operations** → **MACROSCOPIC CONTROL OF CITIES**

The city of Zürich employs an innovative traffic access control system

The adaptive control system works in the following way:

- Measurement of the **level of service** (LOS) in certain links in the city
- Detection of a **LOS change**
- Modification of **traffic signal control** in the roads accessing the city



- ▷ This system represents a clear step towards more **efficient urban operations**
- ▷ However, since 2007 **has not been upgraded**
- ▷ A more tailored and **dynamic system** could be implemented

Source: Stadt Zürich, Dienstabteilung Verkehr. Presentation by Christian Heimgartner (2009)

Does it make sense to control the number of cars in a city? What does the research say?

Initial macroscopic models linking some city features to flows and speeds:

- Smeed 1966
- Thomson 1967
- Wardrop 1968
- Zahavi 1972

Two fluid models linking the number of vehicles and the speeds

- Herman and Ardekani 1984
- Herman and Prigogine 1979
- Ardekani and Herman 1987

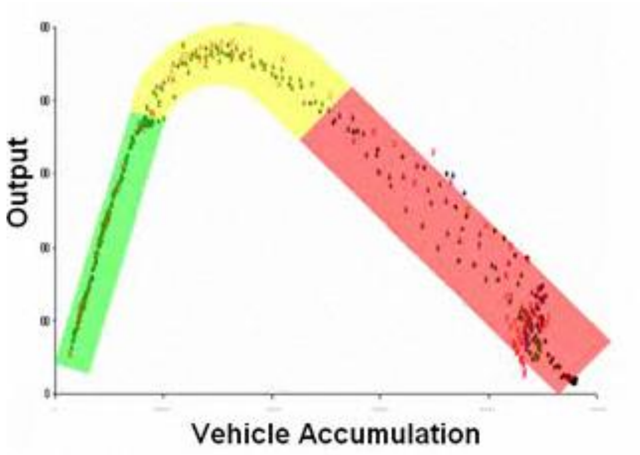
These models were more focused on the uncongested branch of the diagram… **but what happens when we reach congestion?**

Urban Gridlock in cities, definition of the Macroscopic Fundamental Diagram:

- Daganzo 2006
- Geroliminis and Daganzo 2008
- Daganzo and Geroliminis 2008

The Macroscopic Fundamental Diagram (MFD) is an operational scheme for network capacity control

- Certain city areas have a relationship between the accumulation of vehicles and the number of trips ended, following a **Macroscopic Fundamental Diagram (MFD)**



- That allows to know (through **monitoring**) how the urban area is **performing**
- If the perimeter of this area is controlled, the **system** can be moved to more **uncongested scenarios**
- In contrast to ZüriTraffic, the MFD continuously assesses the traffic states within the city and **can adapt easily** to the **capacity** and **traffic requirements**

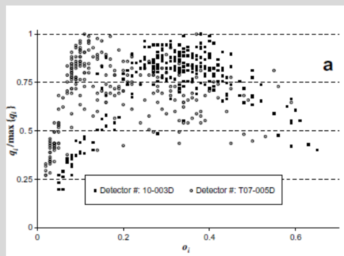
Source: Carlos F. Daganzo, UCB

How do we create a MFD for Zürich?

The **trip production rate** in the network is proportional to the **weighted flows** measured in the loop detectors:

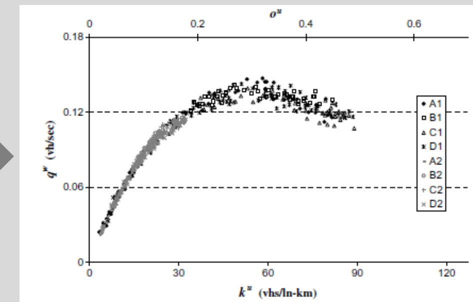
YOKOHAMA EXPERIMENT:
(Geroliminis and Daganzo, 2008)

For every time slice Δt (e.g. 5 min)



Collect flow and density for every loop detector

Average these values for all loop detectors



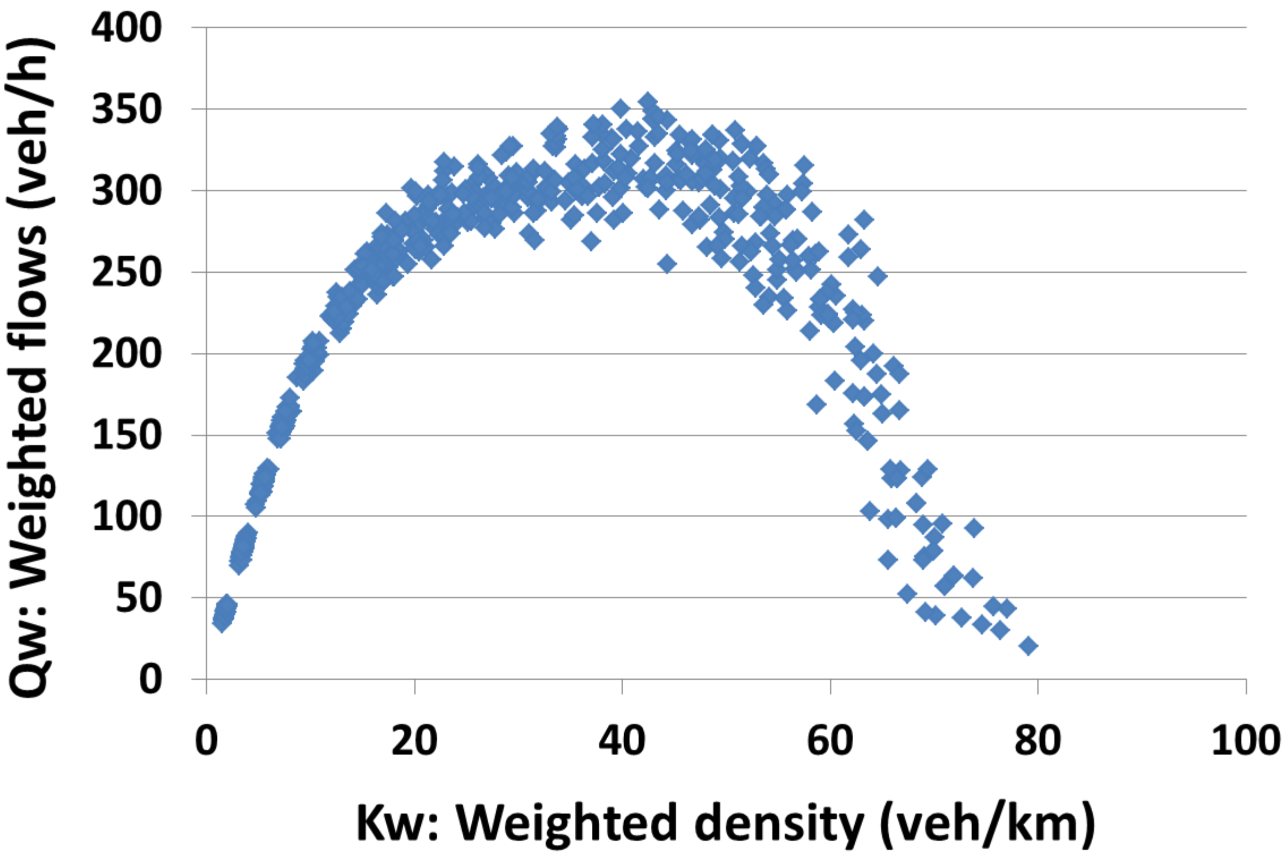
MFD

- The Traffic Engineering group is working with a **VISSIM simulation** of the Zürich inner city
- We have used that model to create **different evening demand scenarios** to build the MFD
- To ensure the existence of a well defined MFD the **city must fulfill certain conditions** of homogeneity

Is it possible to create a MFD for Zürich?
We have used a VISSIM simulation for that

- VISSIM simulates traffic in the inner city of Zürich
- The demand data correspond to the 5-6 pm period on a working day
- All the transport modes interact in the simulation but the counts refer to: cars, vans, trucks and buses
- We store the flow and density of every link in the network for every 5 minutes period
- In order to cover the whole MFD we have considered 17 demand scenarios proportional to the original OD matrix
- Every simulation has been repeated 4 times with different random seeds
- In total, 68 one hour simulations have been carried out

The MFD for the inner city of Zürich from VISSIM:



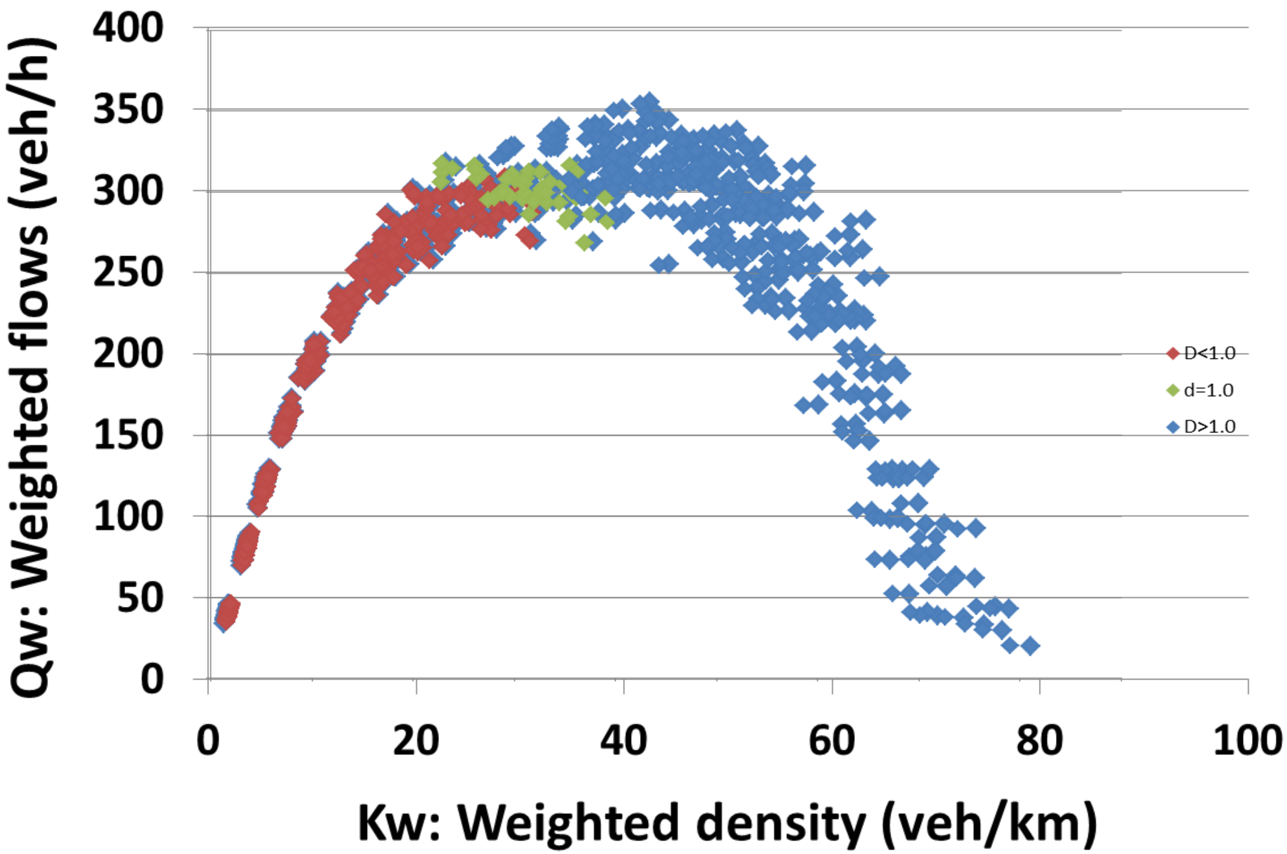
$$q_w = \sum_i q_i \cdot l_i \Big/ \sum_i l_i$$

$$k_w = \sum_i k_i \cdot l_i \Big/ \sum_i l_i$$

qi: flow of the link i
li: length of the link i

ki: density of the link i
li: length of the link i

The MFD for the inner city of Zürich from VISSIM:



$$q_w = \sum_i q_i \cdot l_i \Big/ \sum_i l_i$$

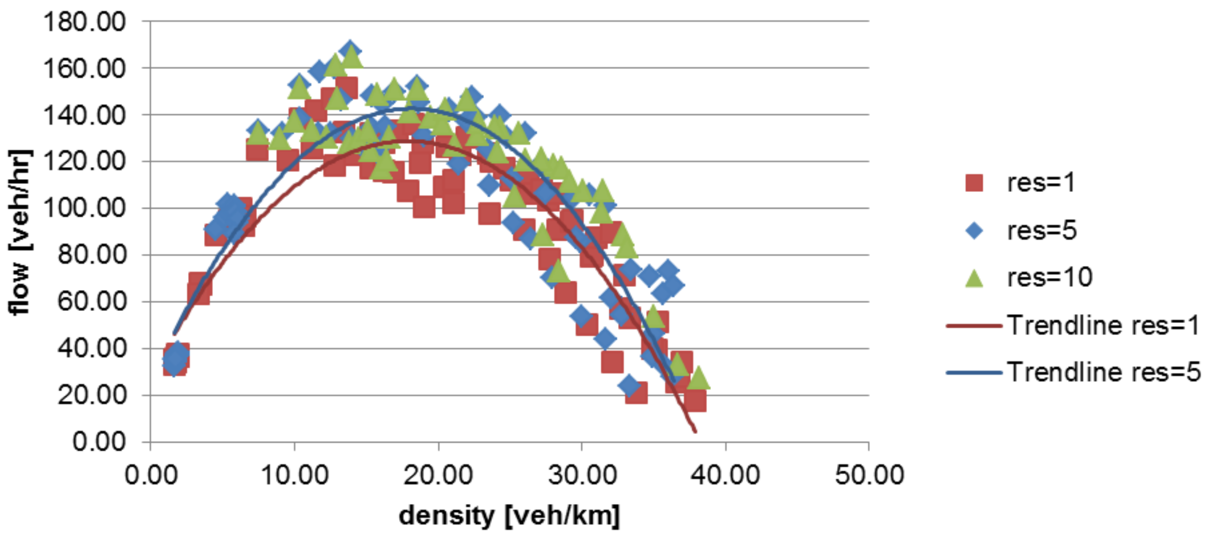
$$k_w = \sum_i k_i \cdot l_i \Big/ \sum_i l_i$$

qi: flow of the link i
li: length of the link i

ki: density of the link i
li: length of the link i

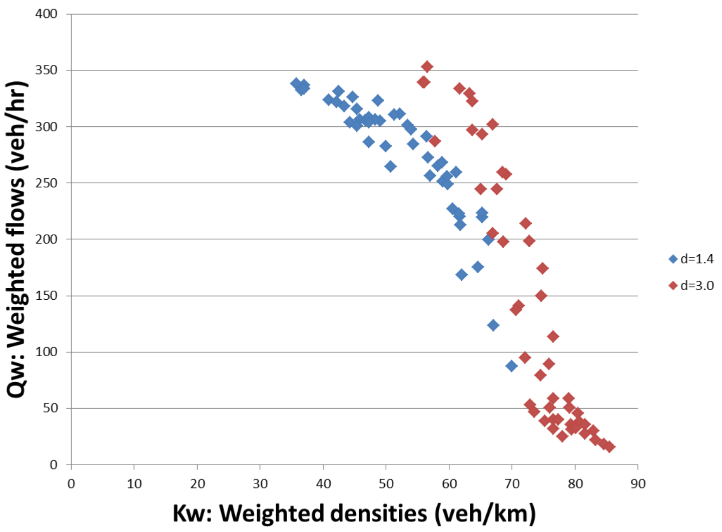
Which factors have influenced the shape, size, and accuracy of this MFD?

- Non realistic links
- Resolution
- Random seed
- Warm-up time
- VISSIM calibration
- Fixed traffic light scheme
- Demand factors

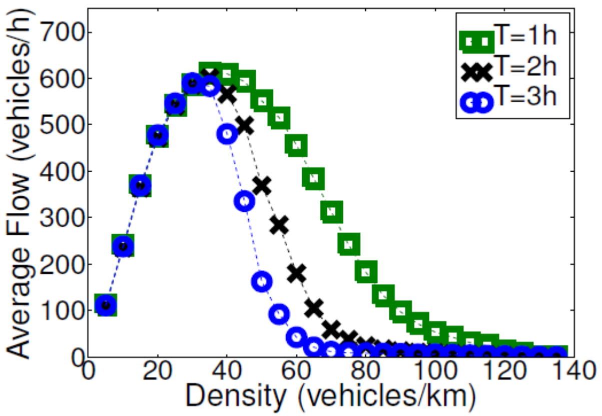


The MFD presents some scattering in the congested part

- We consider **different demand factors** (e.g. times 3) but keeping the **same route choice** model
- **Increasing the demand** also increases the **disappearance** rate of the system
- The **congestion propagation** has clear effects on the **heterogeneity** of traffic states



Mazloumian, Geroliminis and Helbing (2009) analyzed the effect that the variability of the congestion spread has on the MFD



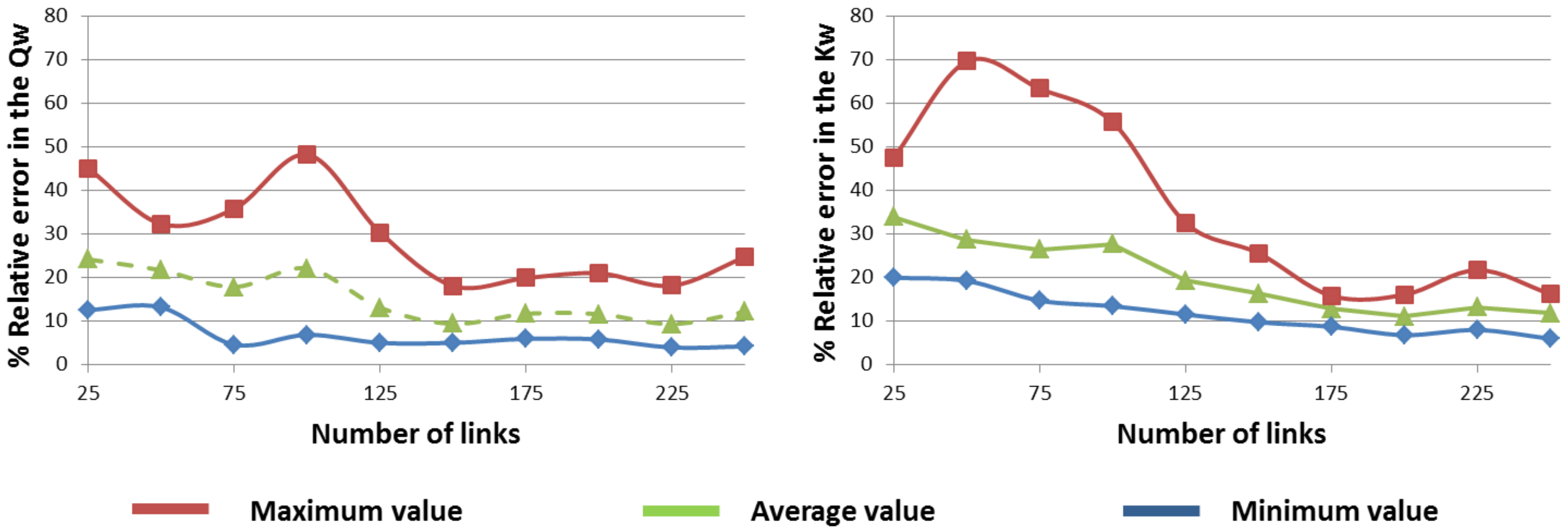
How can a MFD with real data be obtained?

Obtaining the MFD from the microsimulation model presents certain inaccuracies, which could be avoided with real data.

- The real data needed to obtain a consistent MFD is provided by traffic measures at **loop detectors**
- It is necessary that the **loop detector network** is **dense** and homogeneous enough so all the network is measured
- The city of **Zürich has 3500 loop detectors**, a rather large number for a city of its size

How many detectors would be necessary?

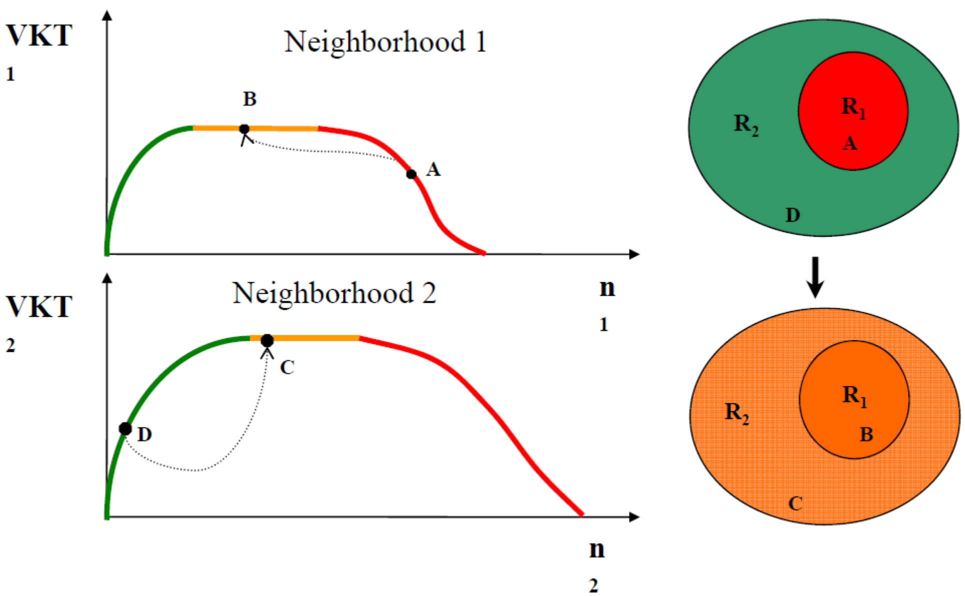
- **VISSIM** considers **1707 links** to build the MFD
- We have chosen **6** different **combinations** of **25, 50, 75, 100, 125, 150, 175, 200, 225, and 250** random links…
- …To see how a MFD created with a **limited number** of detectors could look **compared** to the one obtained monitoring **all links**



- With **less than 150** links the **variability** might be considerable

How can we use the MFD?

A Macroscopic perimeter control is a flexible and responsive mechanism to ensure a certain congestion state in the city



Congested central area and **uncongested** surroundings

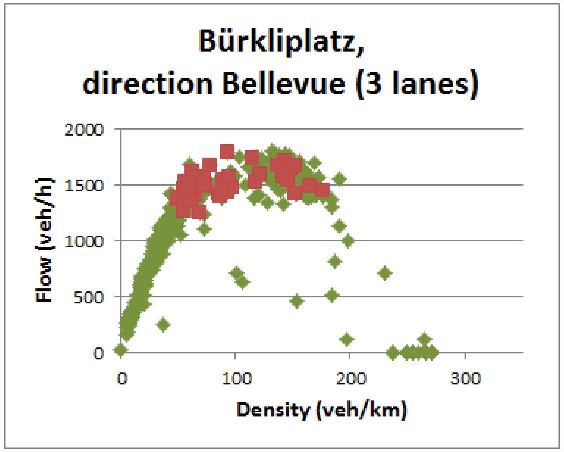
Traffic more **homogeneously** distributed

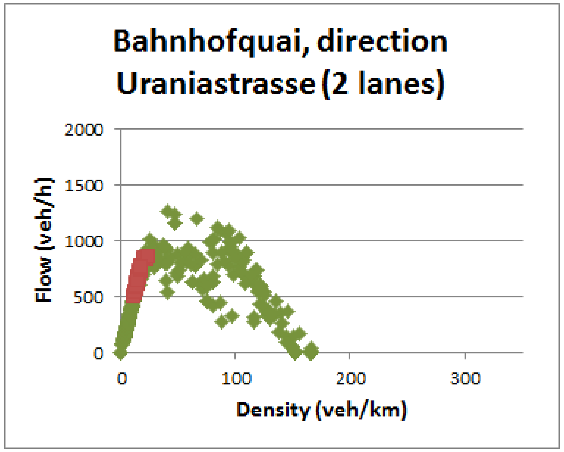
Let’s compare it to the adaptive control system!

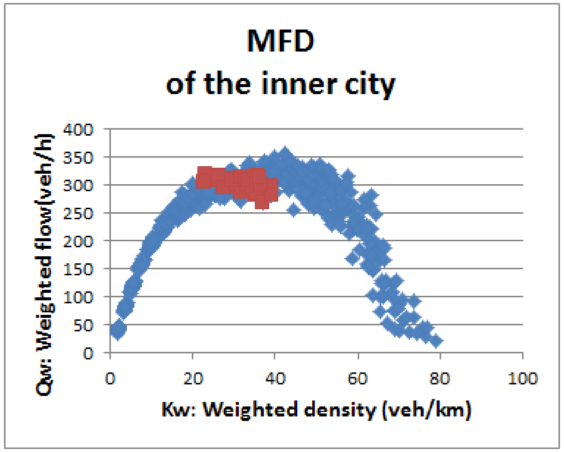
Source: Nikolas Geroliminis, EPFL

How similar are the MFD and the adaptative control strategies?

We have chosen **2** of the **links** that are measured by **Züritraffic,** and we plot their **individual fundamental diagrams** with the VISSIM simulation data:







Demand for 5-6 pm

- The two links present **different shapes** and **reach congestion** at **different** times

The MFD, in contrast to the Züritraffic, might provide a better global view of the system

What steps the city of Zürich can take towards more efficient traffic management?

- The city of **Zürich has 3500 loop detectors**, a rather large number for a city of its size
- The **monitoring** scheme needs very **efficient IT systems** to bring and process the information **at real time**
- With a better data gathering and more focus on the analysis of these data, **innovative traffic management techniques could be applied** (MFD as a ground for the ZüriTraffic)
- That amount of detectors not only is enough for building a MFD, but if the data was efficiently collected, new traffic management techniques and **cutting edge research could be carried out**

↓

ZürichLAB

Questions?

Thank you!