A Case Study on Traffic Flow Modelling, Simulation and Control

Sven Maerivoet, Tom Bellemans, Bart De Moor
Department of Electrical Engineering ESAT-SCD (SISTA)
Katholieke Universiteit Leuven

Geographical Location of the Case Study

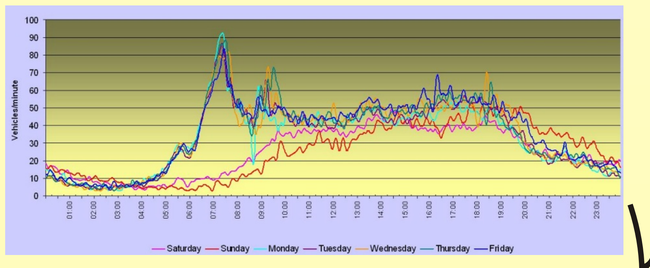
For our case study, we have selected a section of the *E17 highway,* in the direction from Ghent to Antwerp. The section considered, starts at the parking near Kruibeke and ends just before entering the Kennedytunnel which takes traffic under the Schelde. From there on, traffic flows over the ring road R1 round Antwerp.

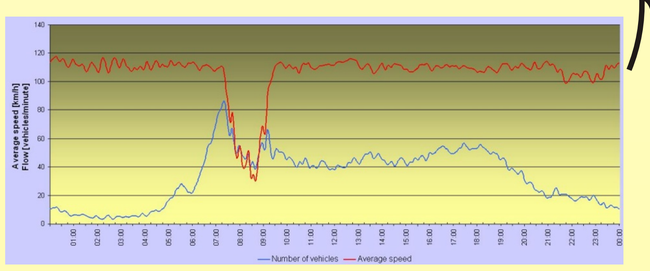
Availability of Real-Life Traffic Data

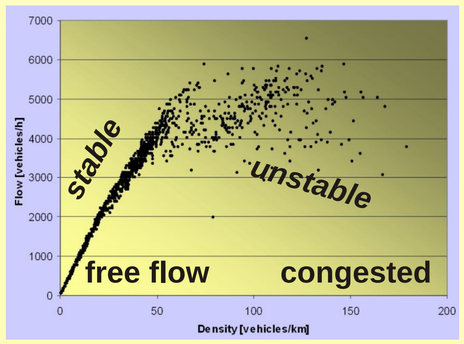
All highways in the Belgian road network are equipped with sensors which collect data that can be converted to the various macrosopic measures (flow, density and average speed). Flanders' Traffic Centre stores this data into a large database which can be queried.

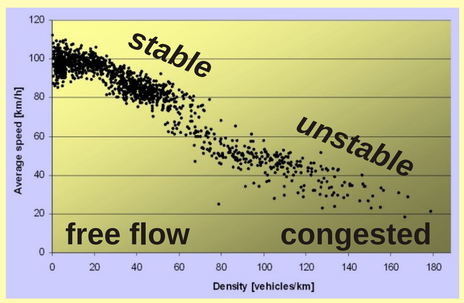
Interpretation of Highway Traffic Data

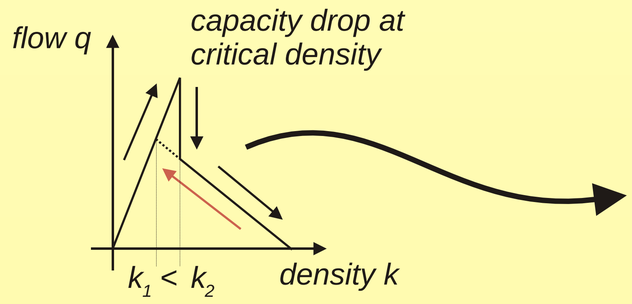
From the time-series obtained by querying the Traffic Centre's database, we can construct the so-called fundamental diagrams which represent empirical relations between the traffic flows' macroscopic measures (flow, density and average speed). In the near future, we will use advanced datamining techniques to analyse all the data.











*The fundamental diagrams exhibit **metastability** !*

*recovery from congestion shows **hysteresis** phenomenon*

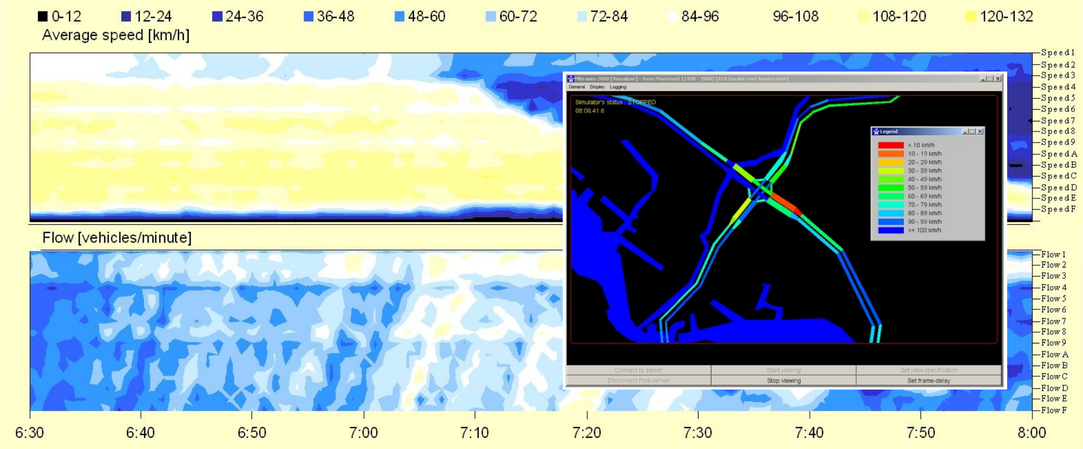
Different Classes for Modelling Traffic Flows

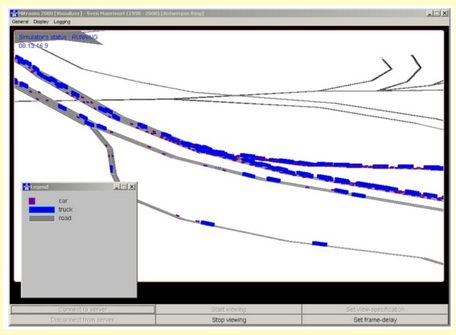
There are mainly two kinds of modelling classes used in traffic flow theory:

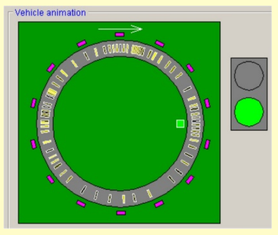
macroscopic models : consider a complete section of the road as a whole and discretize the road in sections of approximately 500m. The model is applied e.g. every 5 minutes. These models are based on *partial differential equations* and can be second-order in nature (e.g., Papageorgiou's METANET). They can be evaluated rather fast, resulting in efficient on-line implementations.

microscopic models : consider each vehicle in a traffic stream individually and regard the road as being continuous. The model is applied every tenth of a second, the *car-following* and *lane-changing* dynamics need to be explicitly modelled. These models are highly computationally intensive, making on-line usage rather difficult. A practical solution is the use of traffic cellular automata.

Macroscopic and Microscopic Simulations

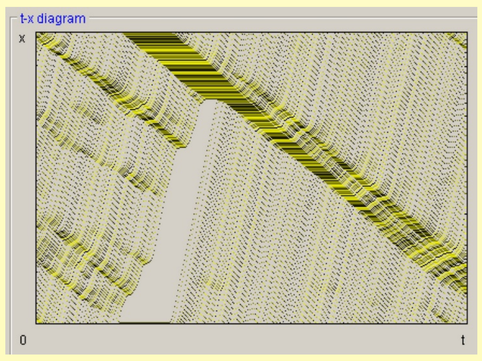


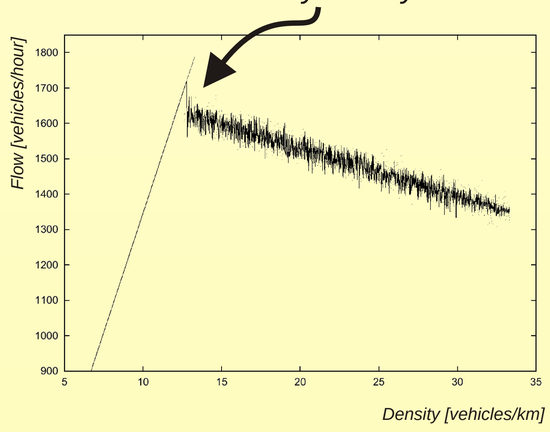




*Using **cellular automata** for microsimulation is computationally feasible for large-scale networks.*

The simulators exhibit metastability and hysteresis.

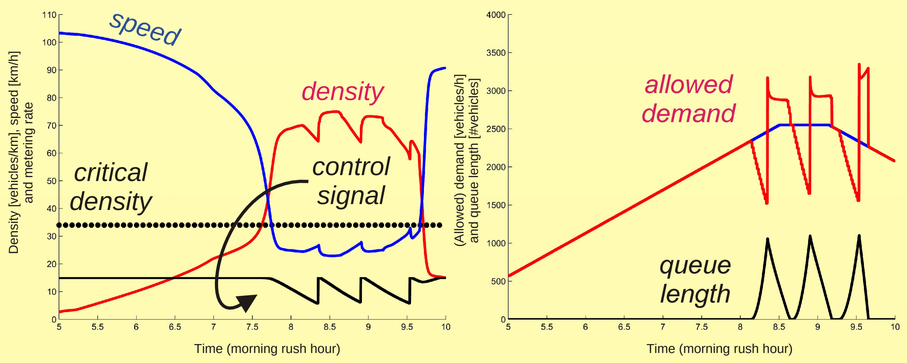




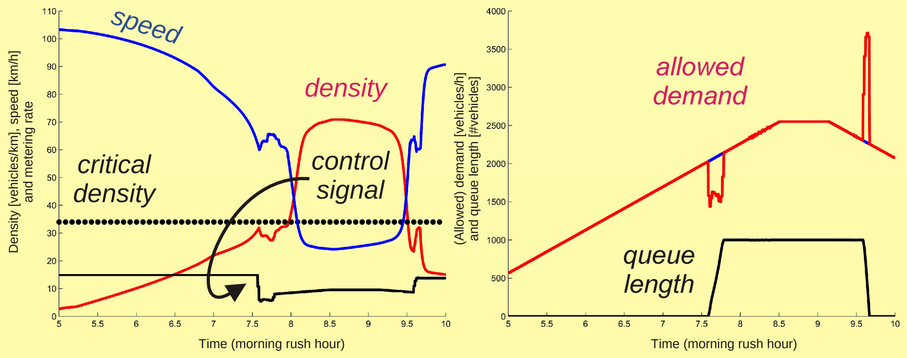
Ramp Metering using Model Predictive Control

In order to keep the traffic flow in the stable region, ramp metering can be implemented as a measure to try to prevent congestion due to the onflow of an on-ramp. The control signal can change each minute, the prediction horizon used typically lies around 10 minutes. The cost function takes into account the total time spent (TTS) of all the vehicles in the network.

ALINEA (default algorithm)



MPC (model predictive control)



DWTC-CP/40

We're also involved in a project, funded by the Belgian Government. The research is about *"Sustainability Effects of Traffic Management Systems"* and is carried out with four other partners (KUL-Department of Civil Engineering, KUL-Center for Economical Studies, UCL-Center for Systems Engineering and Applied Mathematics and RUG-Electrical Energy Engineering).
For more information, please refer to **`http://dwtc-cp40.dyns.cx`**

For further information

`{sven.maerivoet,tom.bellemans,bart.demoor}@esat.kuleuven.ac.be`
Department of Electrical Engineering ESAT-SCD (SISTA)
Katholieke Universiteit Leuven
Kasteelpark Arenberg 10
B-3001 Leuven (Heverlee), Belgium

SISTA

KATHOLIEKE UNIVERSITEIT LEUVEN