

Sustainability Effects of Traffic Management Systems

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Overview

- Project background
- Global setup
- Controlling traffic flows
  - Some applicable control measures
  - Characterising sustainability
  - Belgium as a case study ?
  - Optimisation
- Conclusions

Overview

Project background

- Belgian government funding
- Partners involved

Global setup

Controlling traffic

Conclusions

Belgian government funding

- Federal Science Policy.

FSP

- Sustainable production and consumption patterns – *“Cluster Transportation”*.
- **PODO II – DWTC CP/40.**

- Duration: 12/2001 – 11/2004 (three years).
- Budget: approximately 550.000 euro.

Partners involved

- All involved partners are universities:
  - *Katholieke Universiteit Leuven*
    - **Department of Electrical Engineering.**
    - Department of Civil Engineering.
    - Centre for Economic Studies.
  - *Université Catholique de Louvain*
    - Centre for Systems Engineering and Applied Mathematics.
  - *Universiteit Gent*
    - Electrical Energy, Systems, and Automation.
- Reporting to an external usergroup.

multidisciplinary

Global setup

- *"Traffic is dynamic in nature"*

Demand ⟷ **Supply**

Demand → **(travellers/traffic flows)**

Supply → **(road infrastructure)**

⇨ **Optimise** the traffic using the existing road infrastructure !

★ Tools for optimisation ? ⟶ **adaptive control strategies**

★ Optimisation criterion ? ⟶ **sustainable cost function**

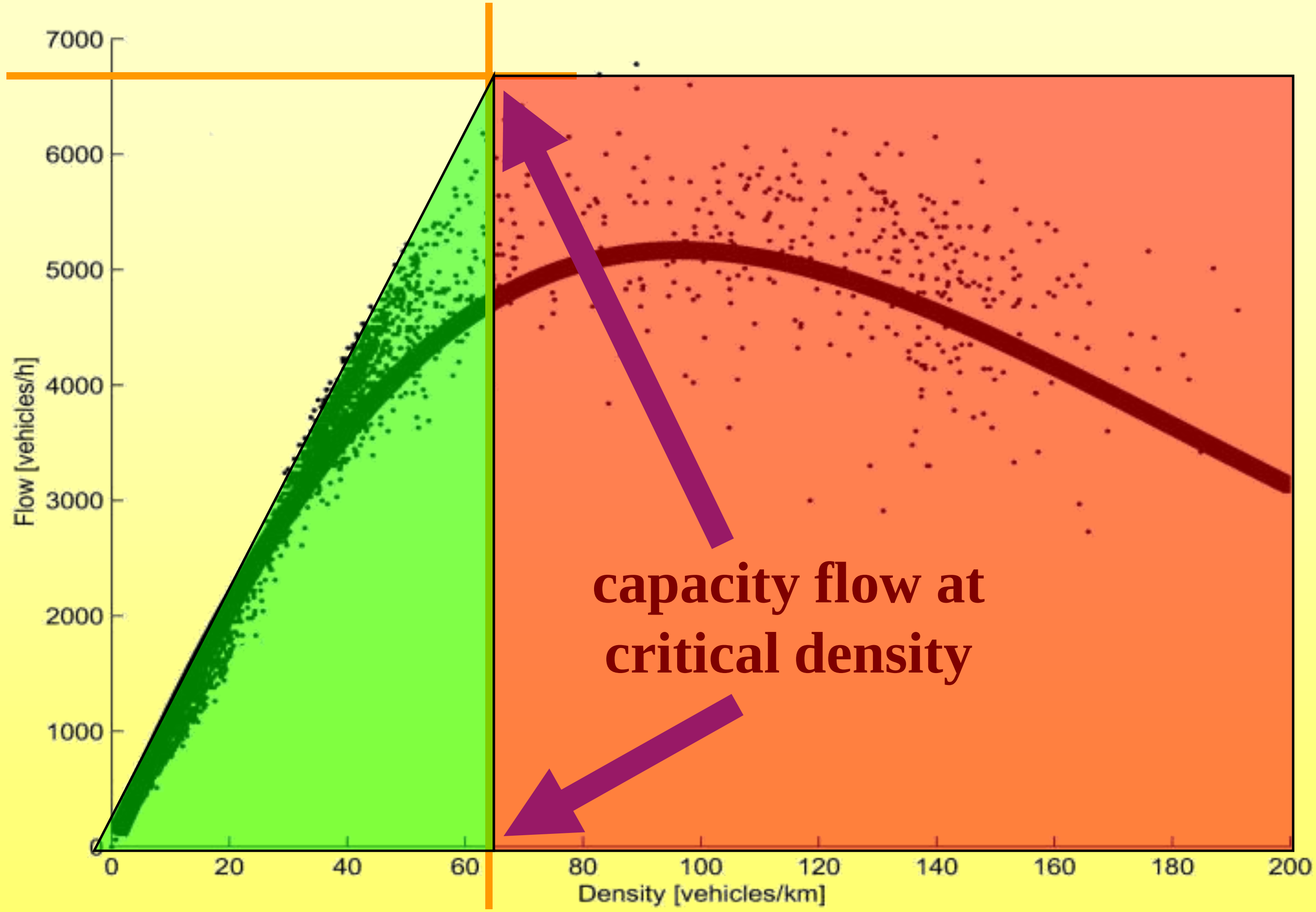
Some applicable control measures

- Change the number of departing trips.
- Change the departure time of drivers (i.e., leave earlier/later).
- Influence the drivers' route choice.
- Congestion pricing.
- Overtaking prohibitions for trucks.
- Use ATMS:
  - ramp metering,
  - speed harmonisation,
  - ...

Ramp metering

- *"Try to control the inflow by drops"*

The idea behind ramp metering



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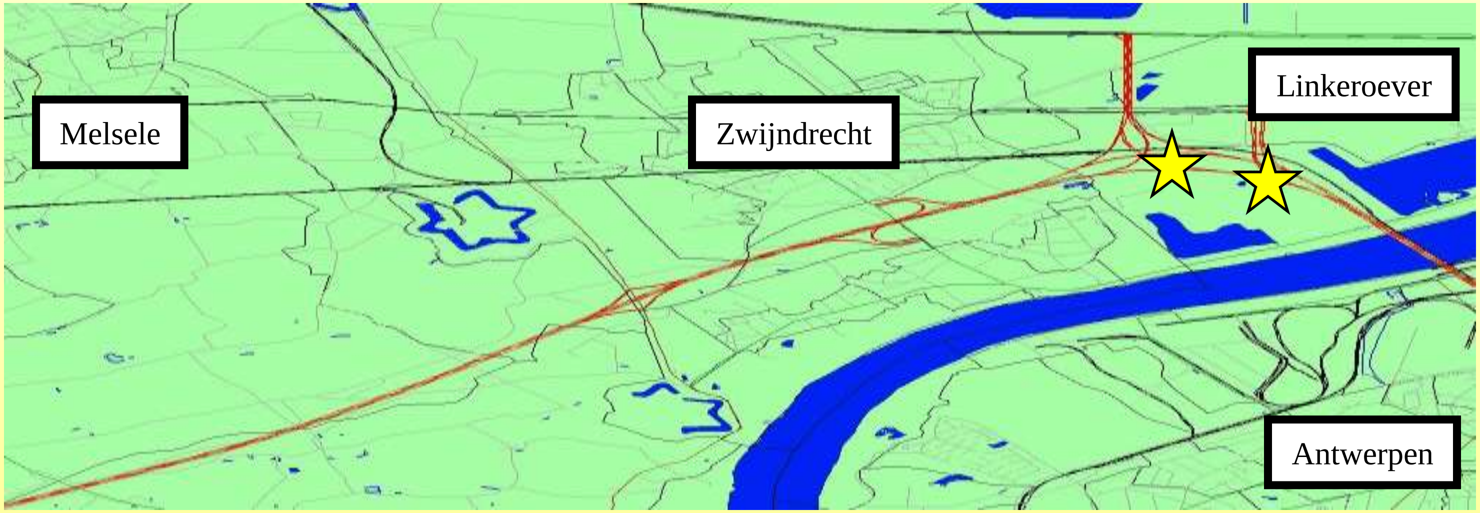
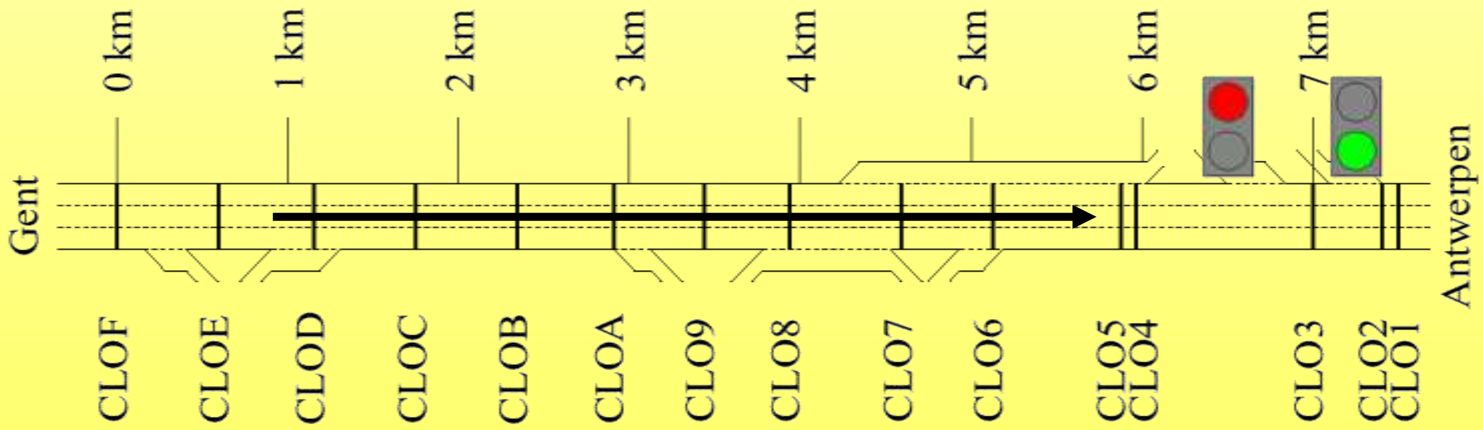
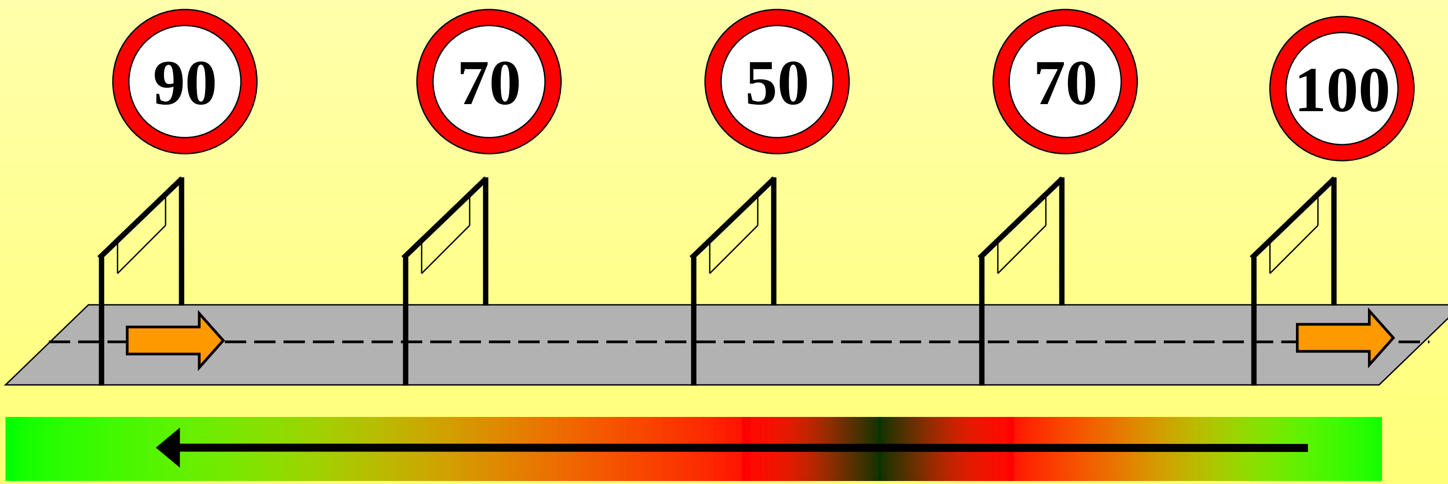
RM-MPC versus ALINEA





Dynamic speed limits (with MPC)

- Research from T.U. Delft (The Netherlands).



upstream moving shockwave

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Characterising sustainability
Air pollution
Noise
Accident risks
Travel times
Belgium as a case study ?
Optimisation
Conclusions

Characterising sustainability

- Characterise the concept of *'sustainability'*:

SCF = *emissions (air, noise)* → **environment**
\+ *incident risks* → **supply**
\+ *travel times* → **personal**
\+ *resource costs*
– *tax receipts*

€

- **Important:** the SCF involves a *trade-off* !

environment friendly ⟷ capacity throughput

Air pollution costs

- Typically, pollution effects are site specific:
  → construct a dispersion model and use exposure-response curve to determine costs.
  ➡ **Too expensive and time consuming !**
- Our methodology consists of:
  – determine the **fleet mix**: diesel and petrol cars, light and heavy goods vehicles, and buses,
  – specify the **speed related emission factor** for all pollutants (e.g., carbon monoxides, benzene, …),
  – **calculate total emissions** on each link of the network and convert to monetary units.

Noise costs

- Similar to air pollution costs, in that they are site specific.
- Calculate **noise exposure** (in dB) above a given reference level:
  - using traffic flow variables and housing density.
- All based on long term (annual) data and at a country wide scale with little data for Belgium:
  - **disaggregate** to Belgium road network.

Accident costs

- *Economic cost of an accident:*
  - users' **willingness to pay** for safety,
  - friends' and relatives' WTP for the user,
  - and the costs to the rest of the society (police, …).
- *Number of accidents:*
  - affected by many factors (speed, weather, …),
  - expected **U-shaped function** of traffic variables.
- Difficult to apply theoretical forms and to generalise from empirical studies:
  - calculate accident risks w.r.t. a **reference flow**.

Time costs

- Are a **significant component** of the SCF.
- The used traffic flow model returns the travel times:
  - convert to VOT (**value of time**).
- Incorporate time costs for **early and late arrivals**.
- Currently we distinguish between:
  - passenger cars, trucks, and buses.
  - A future extension is to include income effects.

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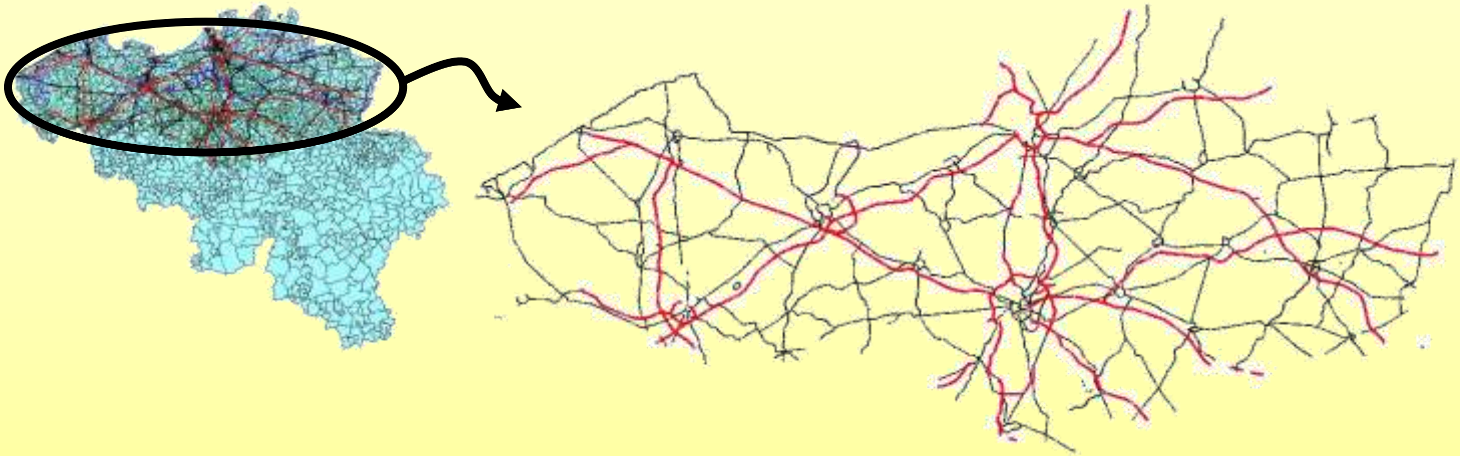
Belgium as a case study ?



- Tackling the entire (highway) road network is too ambitious !

→ **Reduce the scope to a *simplified* topology.**

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  - Test bed network topology
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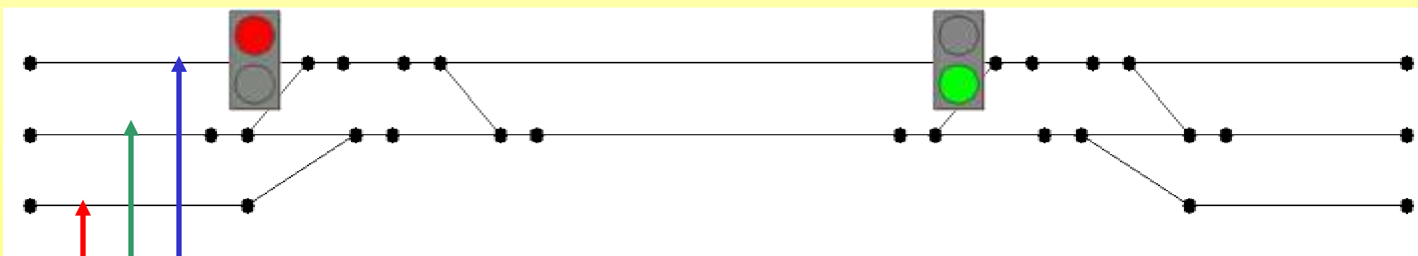
Test bed network topology

- Total length of the network is some **11.4 km** (a vehicle traverses 7 minutes at 100 km/h).

3 origins → **3 destinations**



highway (3 lanes, 120 km/h)

urban road (2 lanes, 90 km/h)

city region (1 lane, 70 km/h)

Optimisation

- Determine the steady state distribution of the flows (this is the **set point**), using:
  - the sustainable cost function,
  - equality constraints:
    - conservation of vehicles,
    - origin/destination matrices,
  - inequality constraints:
    - positive flows,
    - maximal flows.

  } **system equilibrium**
- Try to achieve the set point using control measures ***(current research)***.

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- Most important aspect:
  - **sustainable cost function**.
- Modular setup:
  - incorporate SCF in traffic control methodology.
- During the project, we have also developed:
  - **heterogeneous** extension of the **LWR**-model,
  - **particle filter** approach for incomplete data,
  - **congestion charging** and queue spill-back effects,
  - investigate an **overtaking prohibition** for trucks,
  - distributed **traffic cellular automata** *(in progress)*.