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Traffic and transport consultants

Multi-objective optimization of traffic systems

Luc Wismans Goudappel Coffeng / University of Twente
lwismans@goudappel.nl
0570 666840

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  - External effects
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- Why multi-objective optimization
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Background
Optimization and traffic

- Public transport
- Evacuation
- Allocation of capacity
- Minimization of hindrance during construction work
- Route choice
- Choice of location
- Minimization measurements
- DTM-measures

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Background
External effects

- Congestion
  - Accessibility
- Road damage
- Accident externalities
  - Traffic safety
- Environmental costs
  - Climate
  - Air quality
  - Noise

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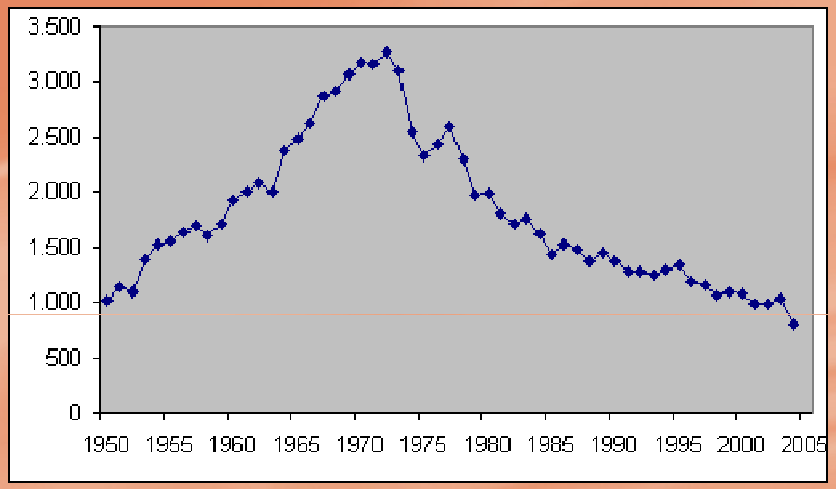
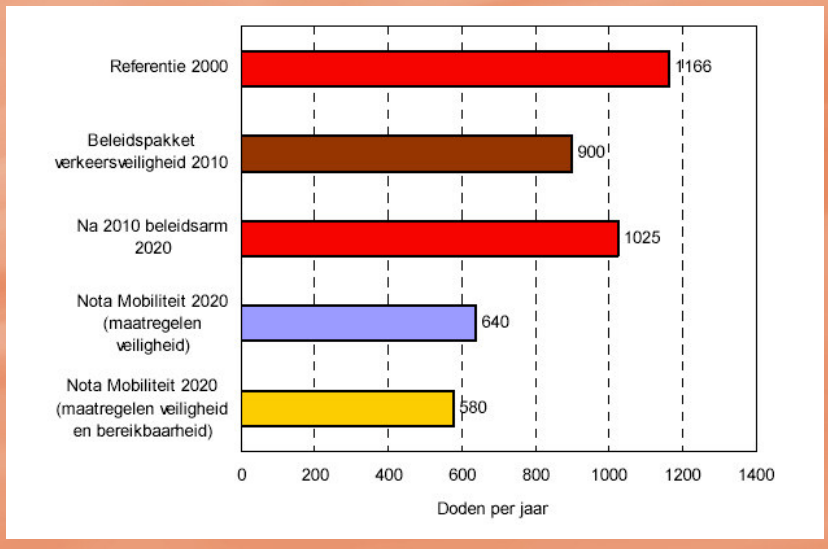
Background
Safety

- Objective safety (fatal, injuries, damage)





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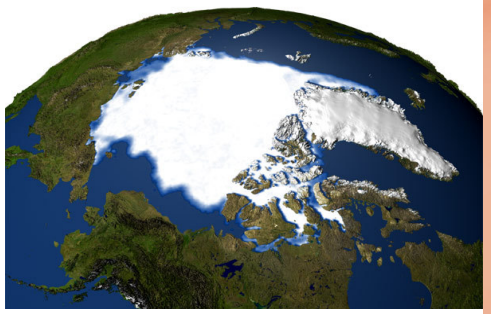
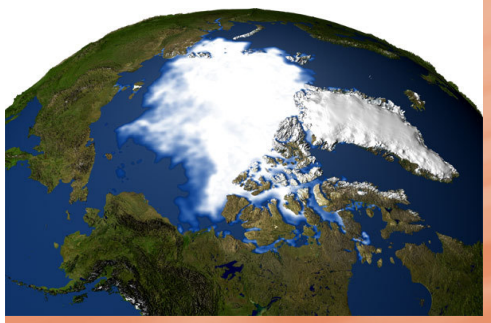
Background
Climate





- Different compounds (H_2O, CH_4, CO_2) absorb infrared radiation
- Global warming acknowledged IPCC 4AR (anthropogenic)
- Kyoto/post-kyoto
- Direct proportional fuel consumption
- Traffic 20%: ~ 40 MTon

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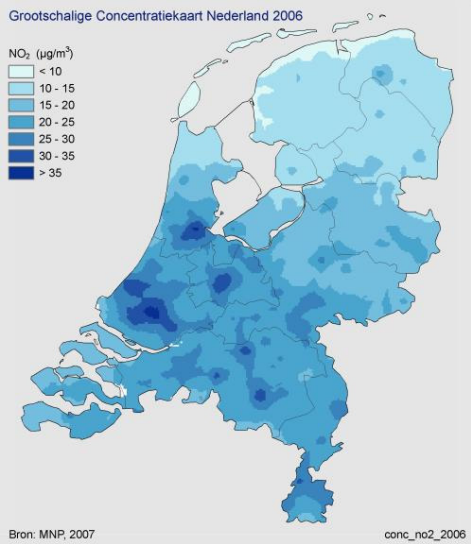
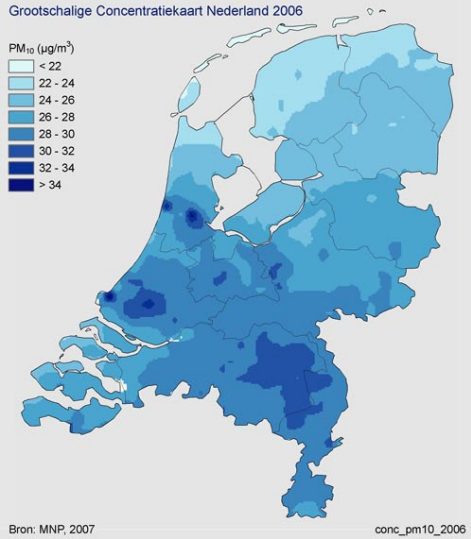
Background
Air quality





- Substances impairing health - pollutants
- Estimates 18,000 premature deaths (NL)
- Traffic important source of pollutants
- NO_x, PM_{10}, CO, SO_2 and HC, and secondary O_3.
- Limit values and emission ceilings by European legislation
- Netherlands has problems with
  - NO_x, endothermic reaction of N_2 and O_2 (60%)
  - PM_{10}, burning fossil fuels, abrasion (20%)

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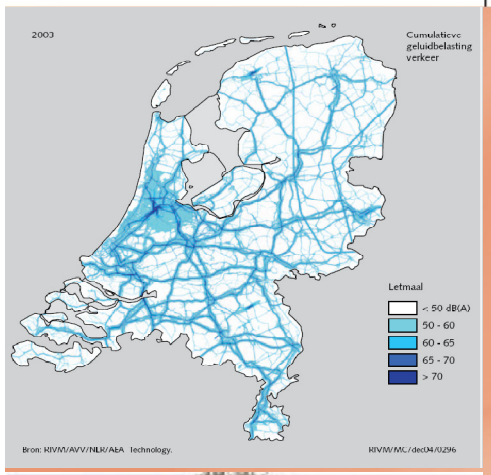
Background
Noise



- Subjective when becomes sound - noise
- Noise impairing health
  - disturbance rest at night
  - hearing impairment
  - high blood pressure
- Propulsion noise and rolling noise
- 30% of Dutch population experience noise pollution
- Indicator: sound pressure level (SPL)
- 75% of all houses experience SPL> 50dB(A)

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Background
Traffic modelling

- Traffic models: mathematical descriptions of behaviour, used to predict effects of changes in demand for and supply of infrastructure
- To evaluate quality of traffic system
  - Traffic models deliver output (q, v, k)
  - Effect models use output to determine external effects

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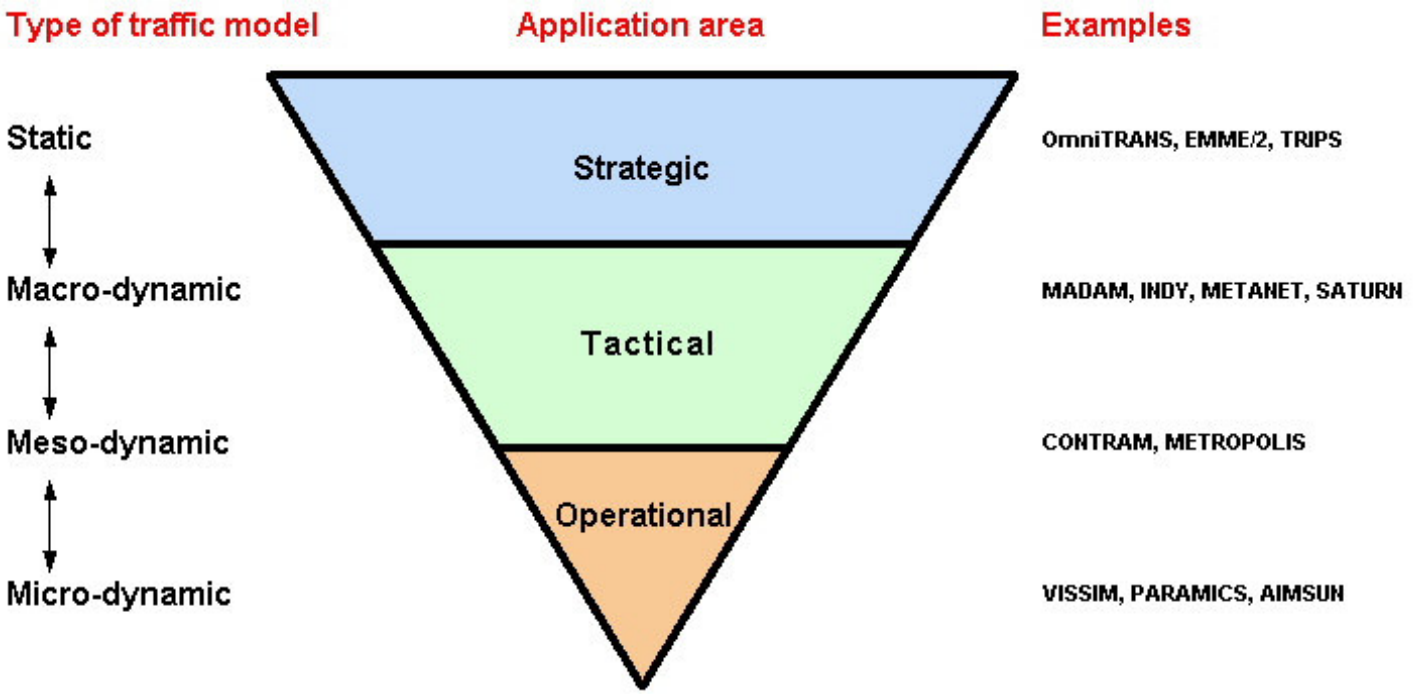
Background
Traffic modelling

- Static traffic models
- Dynamic traffic models
  - Macroscopic, Mesoscopic, Microscopic
- Originally planning and traffic efficiency



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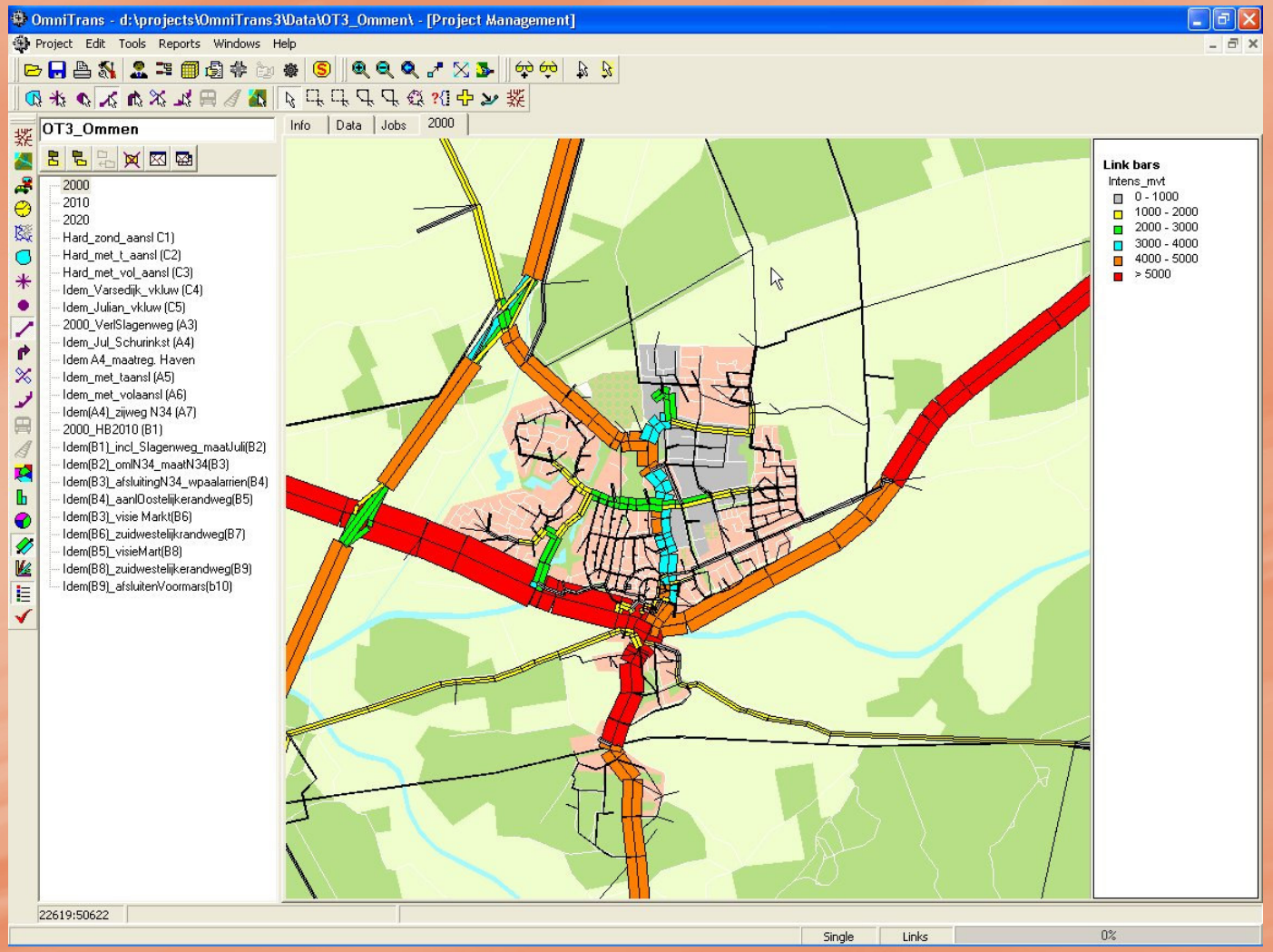
Background
Traffic modelling



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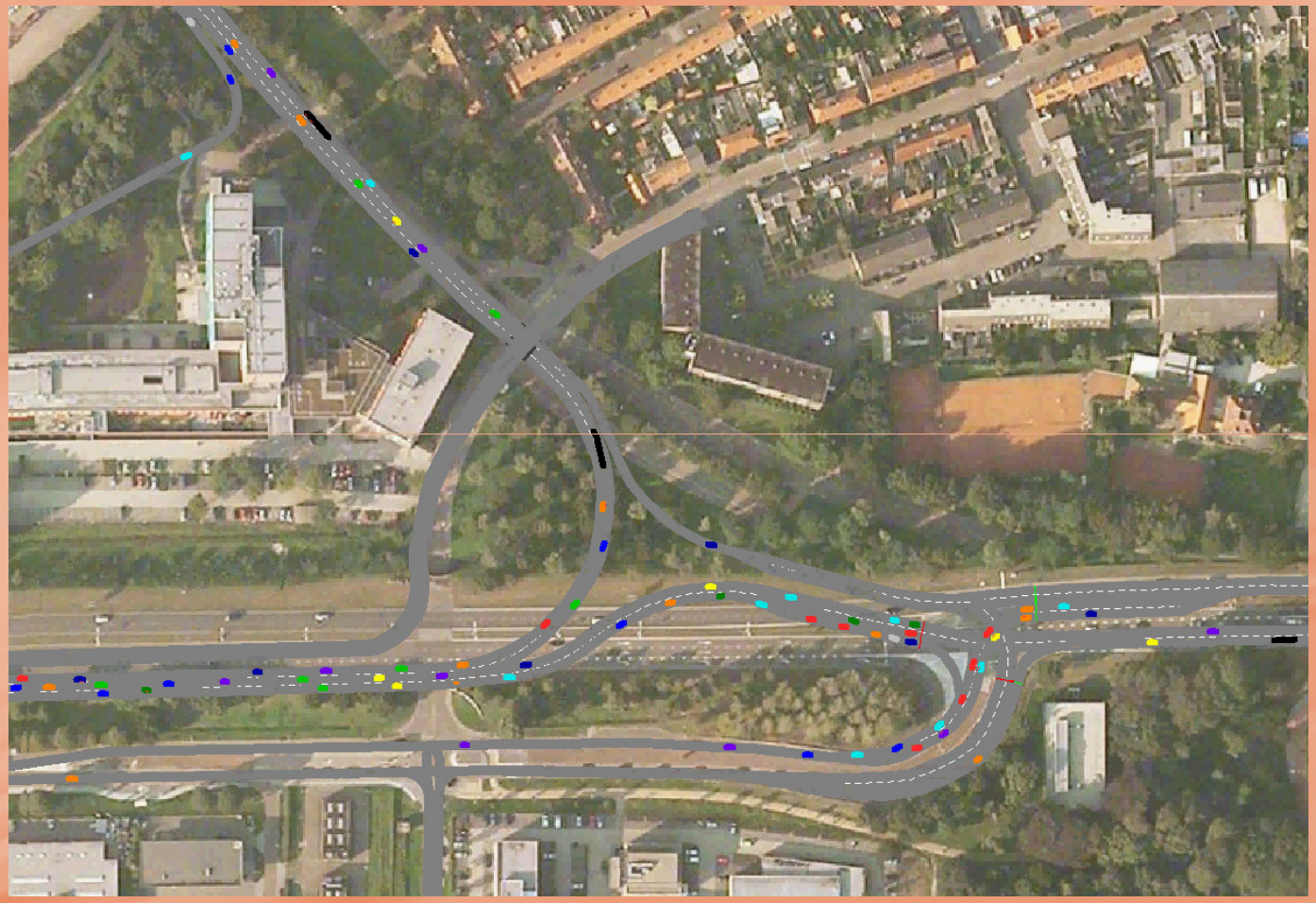
Background
Traffic modelling



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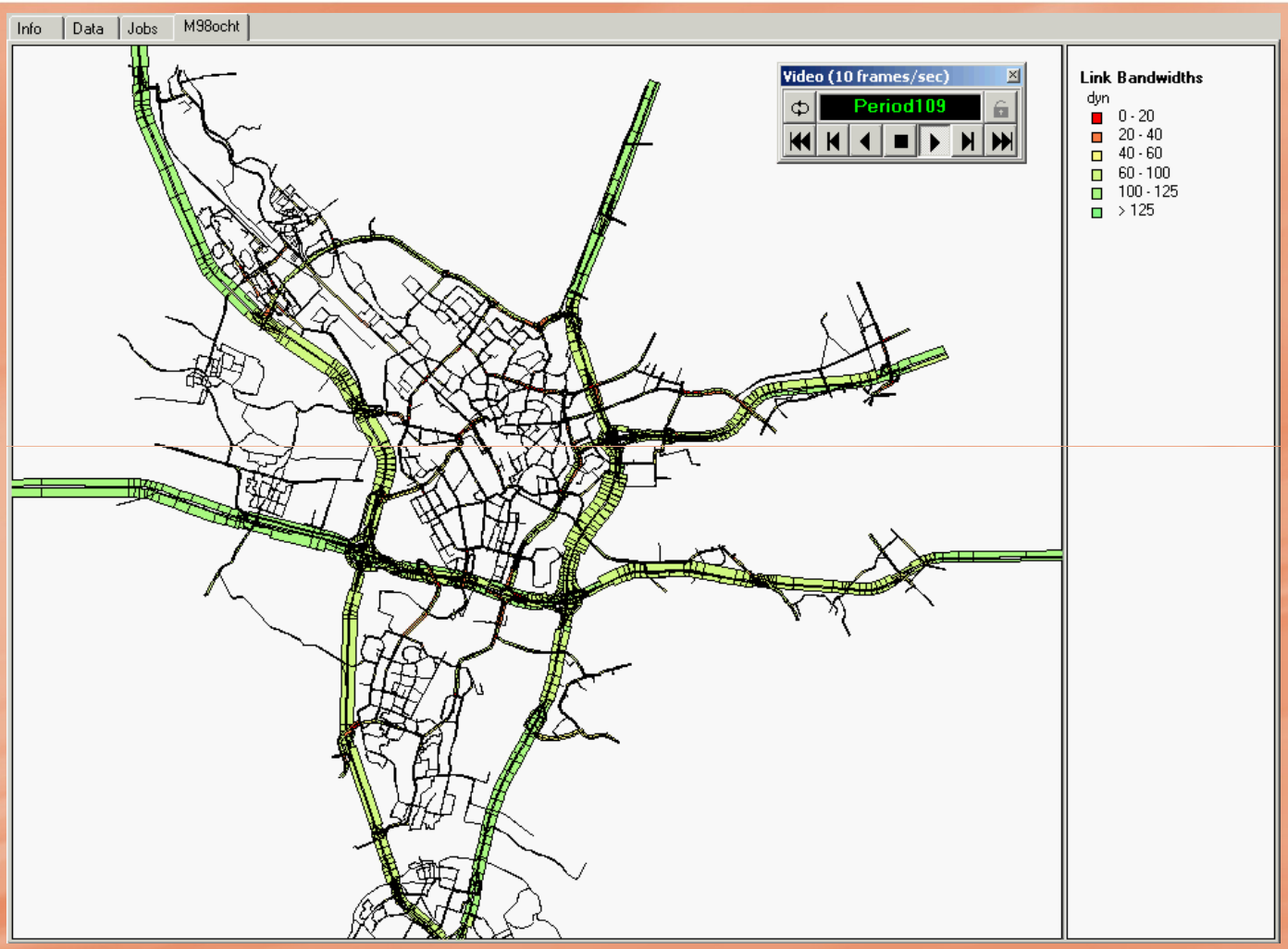
Background
Traffic modelling



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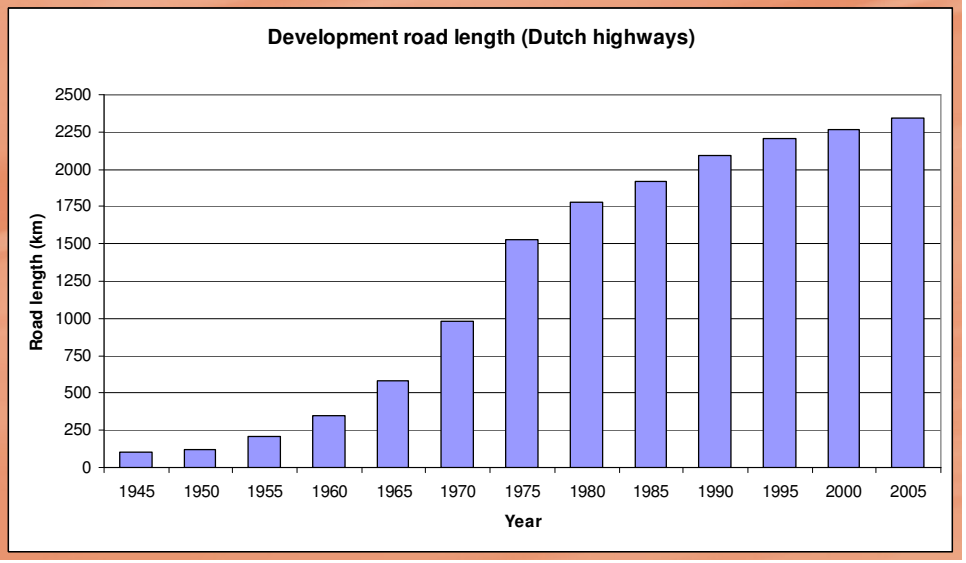
Why multi-objective optimization

- Development problem approach
  - Optimisation – extension
  - Local – network
  - Accessibility – external effects/ sustainability



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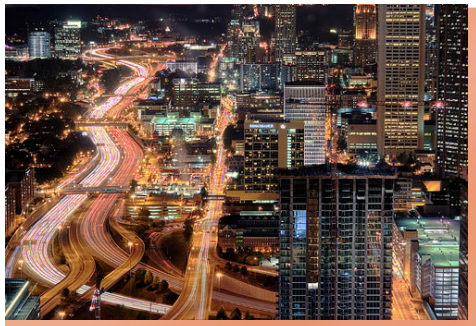
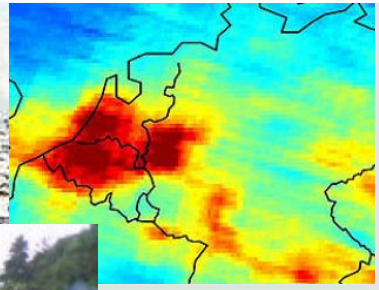
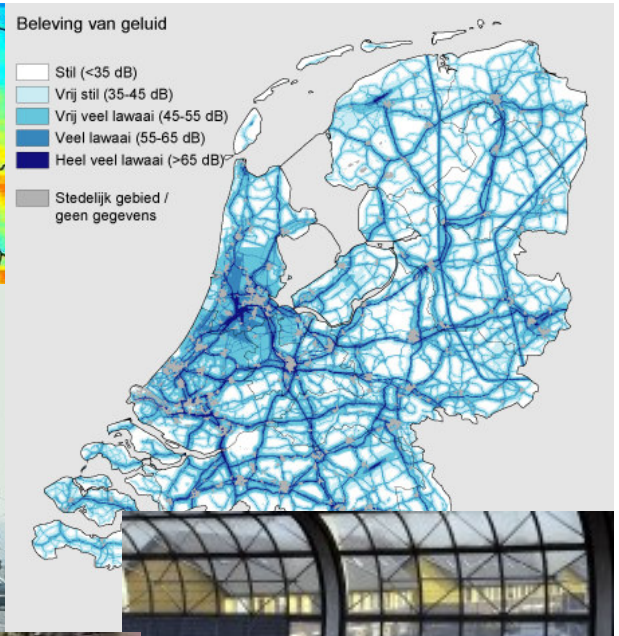
Research:
Goals

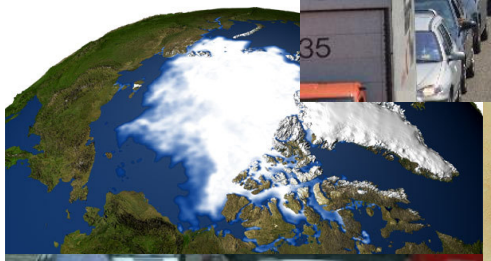


- Objectives aligned and/or opposite
- Optimal solutions differ using different objective functions (other objectives, combined objectives)
- Robustness of optimal solutions


BRANDWEER
POLITIE
connexxion
ACTROS
6
5
9
8
7
4
3
2
1




Beleving van geluid
Stil (<35 dB)
Vrij stil (35-45 dB)
Vrij veel lawaai (45-55 dB)
Veel lawaai (55-65 dB)
Heel veel lawaai (>65 dB)
Stedelijk gebied / geen gegevens



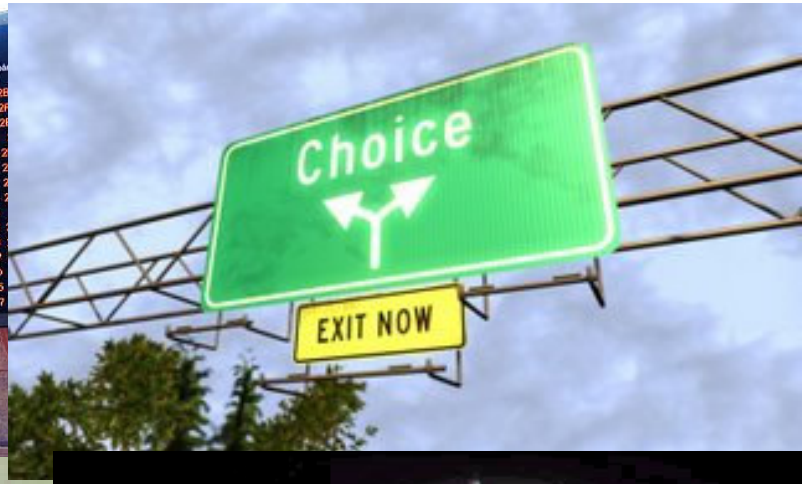

AN ANDERHALVE KILOMETER LANGS D

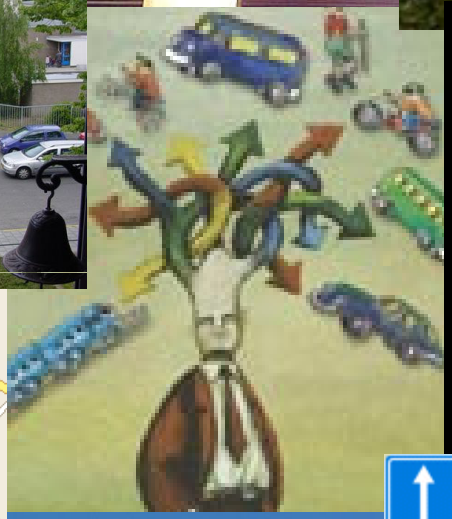

Langs de snelweg A2 wordt gewerkt aan een anderhalve kilomete
nieuwe wijk Terwijde in de Leidsche Rijn, nabij Utrecht, gaan besch

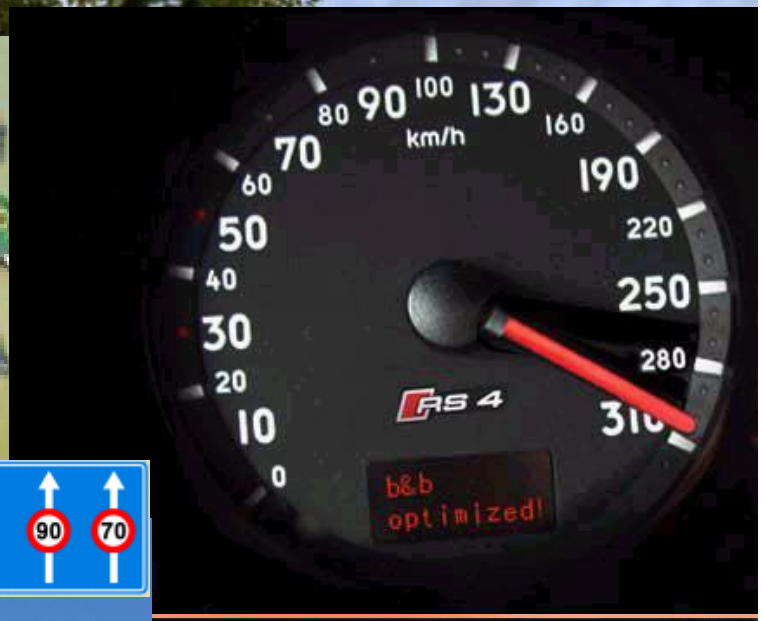

転換
Traffic Shift
料金A
Toll A
料金B
Toll B
住宅地等
Residential area
湾岸部等
現行
Present
料金A＝料金B
Toll for route A = Toll for route B
将来
Future
料金A＞料金B
Toll for route A > Toll for route B
A8
Coenplein
A4
Info A10
Amstel
A1
Morsche
Hoef
Looiseind
Bolst
Erp
Dijk
Heesakker
ZONE
3062
Parkeer-automaat
1612
P-ticket
Dagelijks
185
120
ERP
In Operation
Halenseestraße >> Hubertusallee
450m
0:08
4.6km
21:09
Zurück
Start
harman/kardon

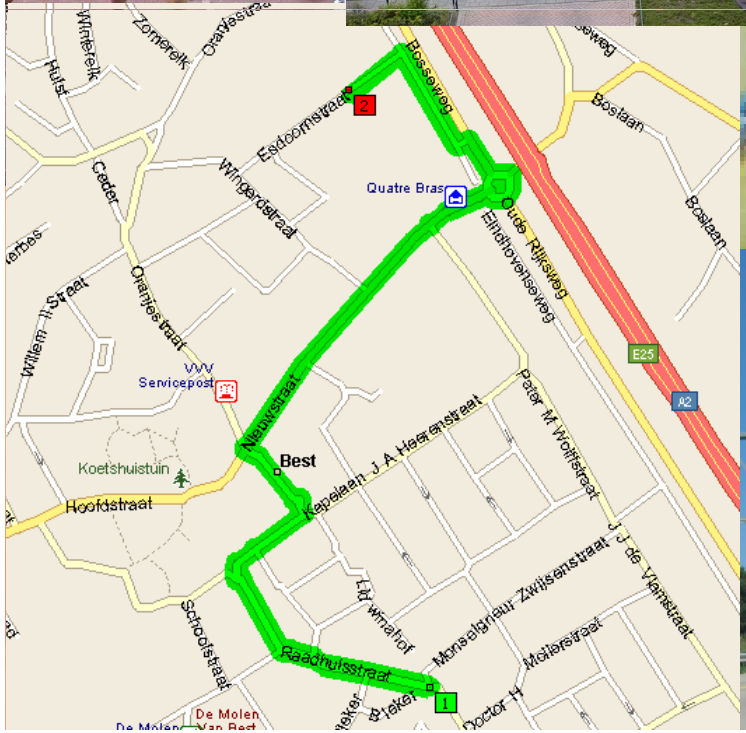

Destination
Productions/attraction


Avgående bussar
Avgående tåg


Choice
EXIT NOW

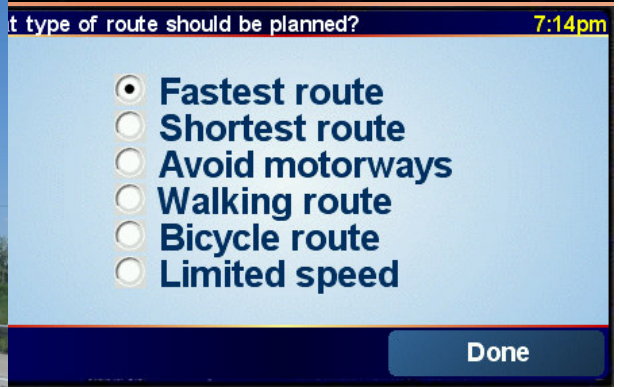



km/h
RS 4
b&b
optimized!


Quatre Bras
Best
Servicepost
Koetshuistuin
Hoofdstraat
Raadhuisstraat
Kapelaan J A Heeregraat
Nieuwstraat
Oude Rijksweg
E25
A2


EXIT 12
85 NORTH
Brighton
Greeley
76 EAST
Fort
Morgan

90
70


t type of route should be planned?
7:14pm
Fastest route
Shortest route
Avoid motorways
Walking route
Bicycle route
Limited speed
Done

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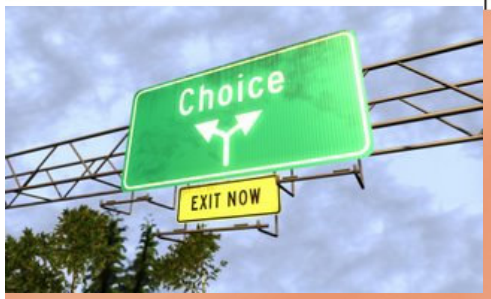
Research:
Choices



- Measures
  - Use of DTM measures affecting supply
- Optimization of objectives combined road authorities:
  - Accessibility
  - Air quality
  - Climate
  - Noise
  - Traffic safety
- Use of Bi-level approach:
  - Upper level objective function
  - Lower level behavioral effects road users
- Use of macroscopic dynamic traffic model
- Use of heuristics in optimization process

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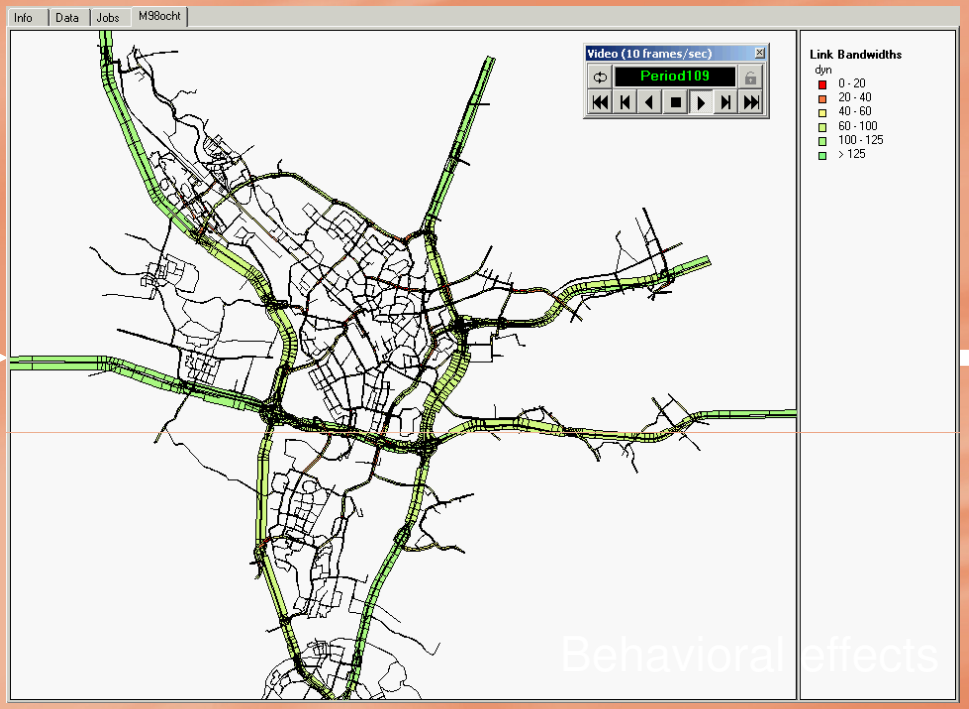
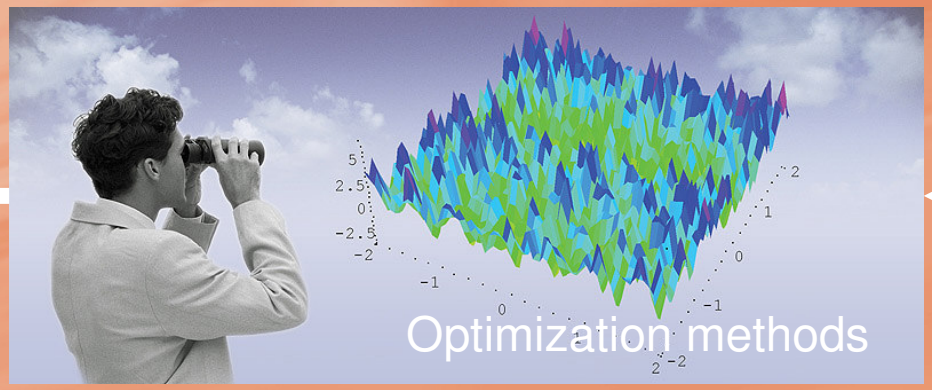
Research: Framework

Measures



Effect models

Objective function(s)
Constraints



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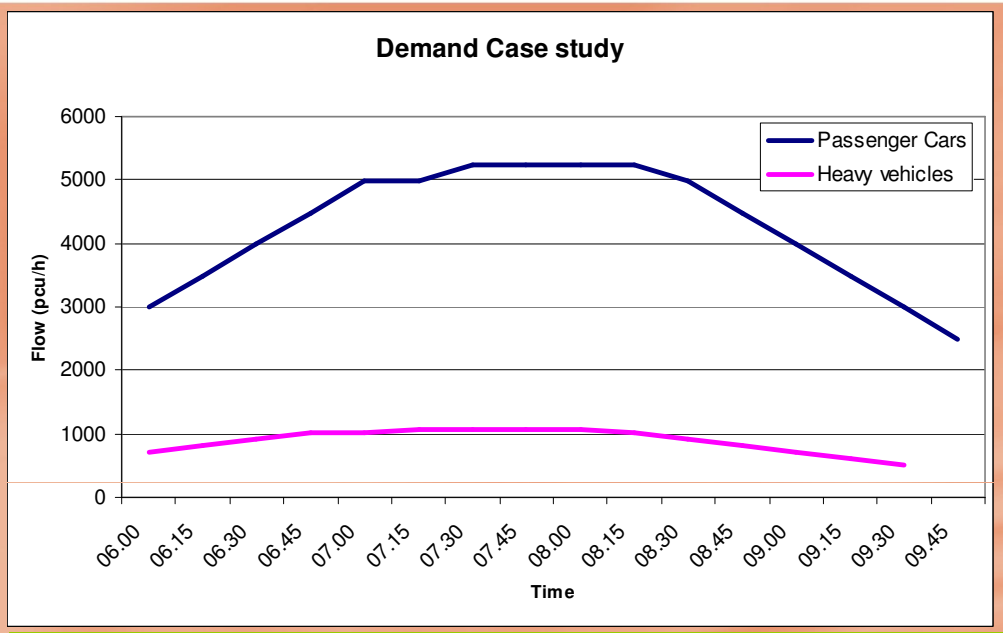
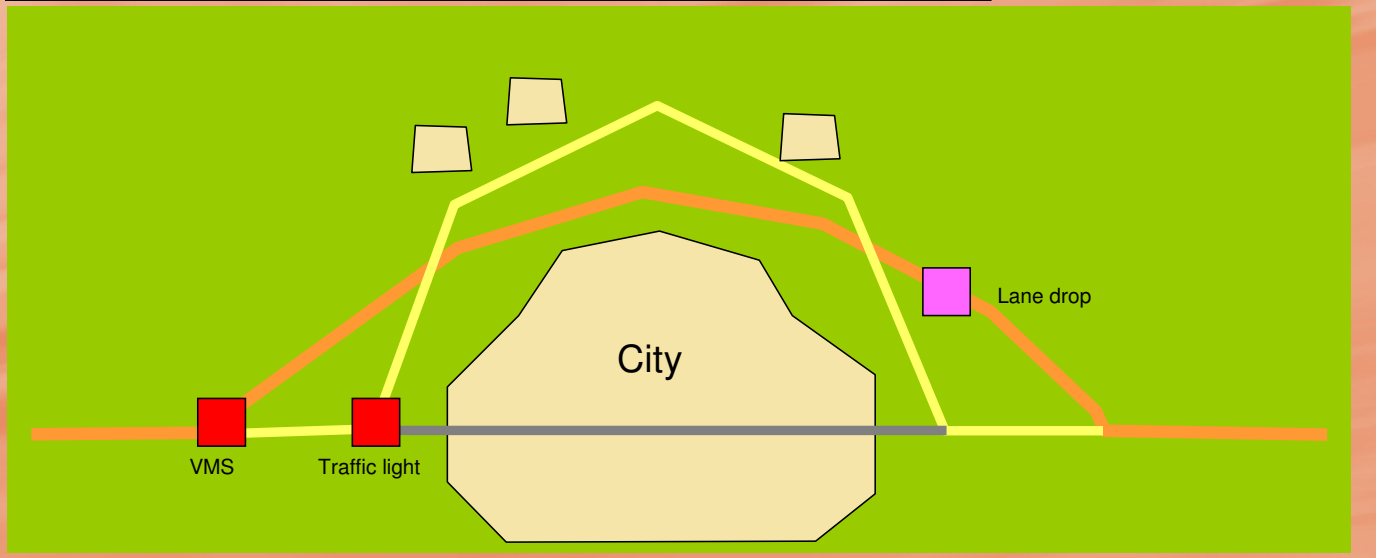
Test case
Contents





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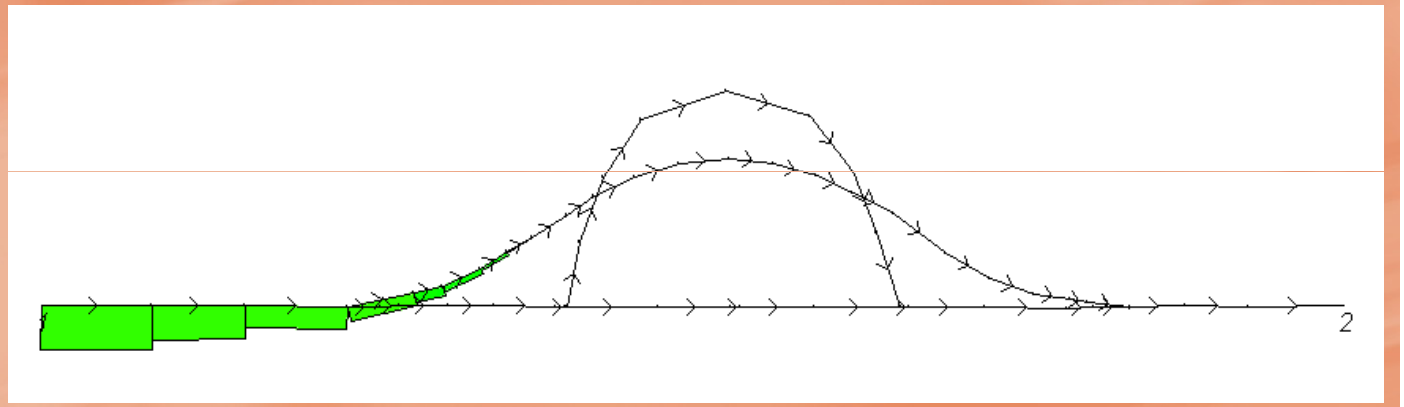

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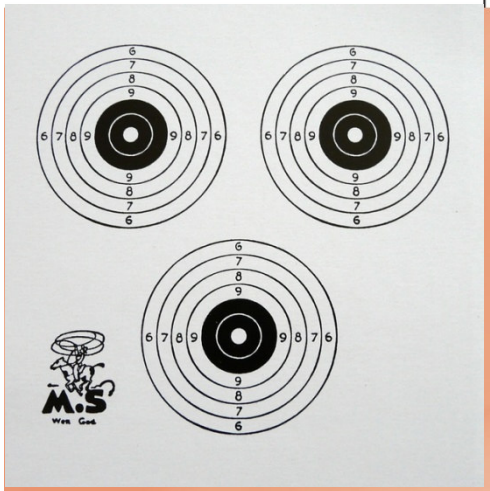
Test case
Objectives



Objective	Measure
Accessibility	Total travel time (Hours)
Traffic safety	Total number of injuries
Climate	Total amount of CO_2-emissions (Ton)
Air quality	Total amount of NO_x emissions (Kg)
	Total amount of PM_{10} emissions (Kg)
Noise	Average sound power level at the source/ emissions (dB(A))

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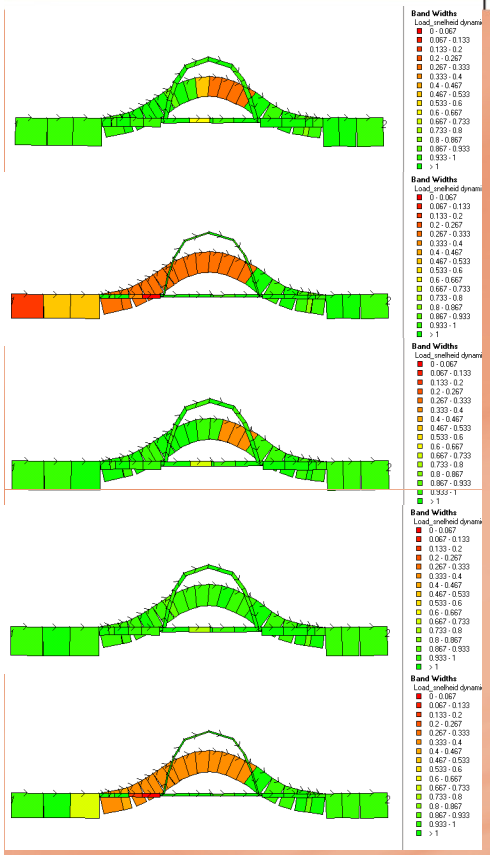
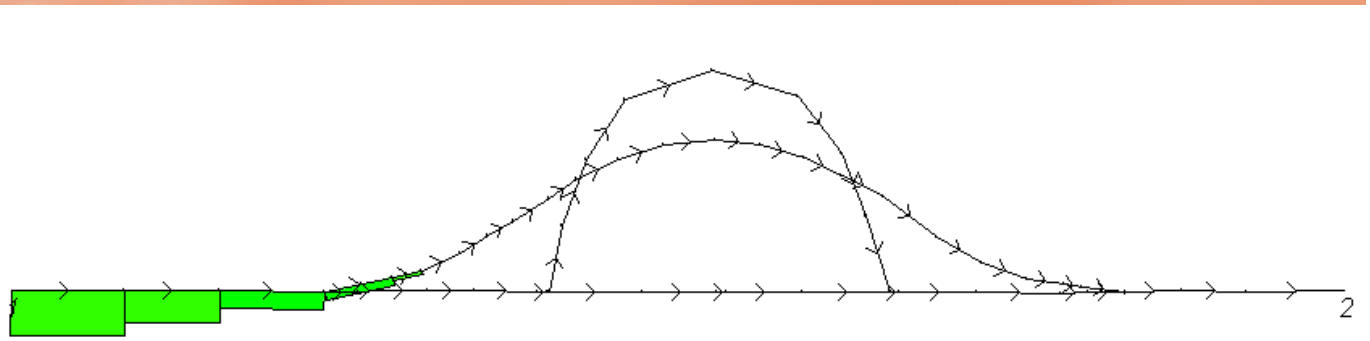
Test case
Results



- Different ‘global’ optima for different objective functions
- Multiple optima present
- There are solutions improving all objectives, when comparing to the reference case
- When combining objective functions, solution is close to optimum climate



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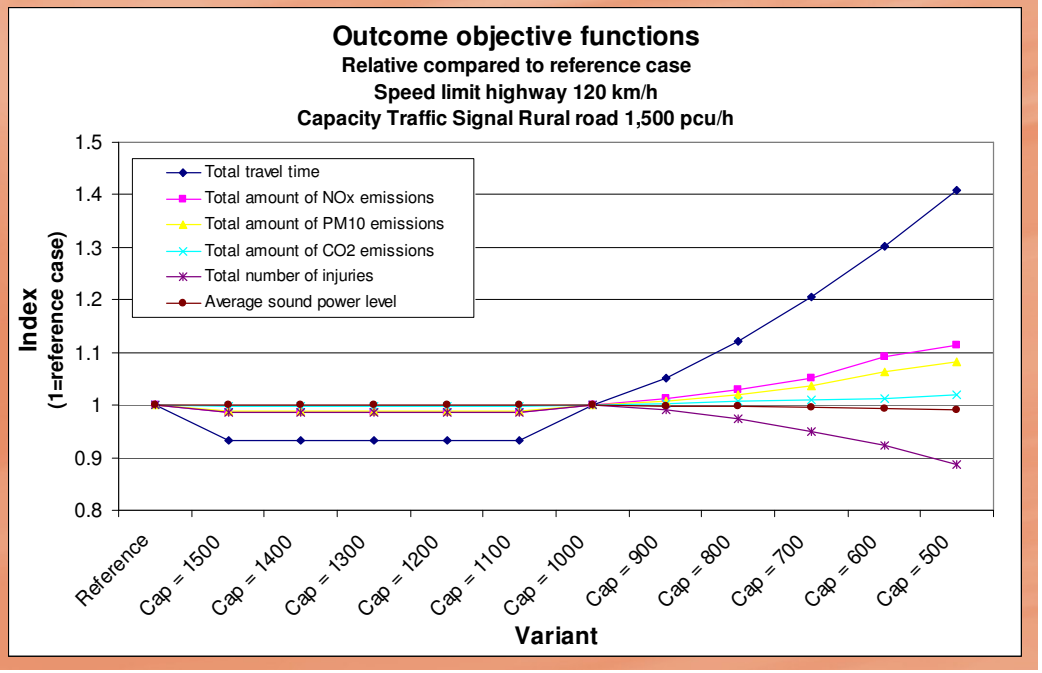
Test case
Results

- Objectives can be opposite and can be aligned
- Dependent of measure and network
- Optimizing traffic systems is ultimately a public policy decision



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Further research

- Fine tuning measures/individual objective functions
- Combining objectives
- Optimization
- Extending case study
  - more dynamics
  - more measures
  - larger network/other networks

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Questions

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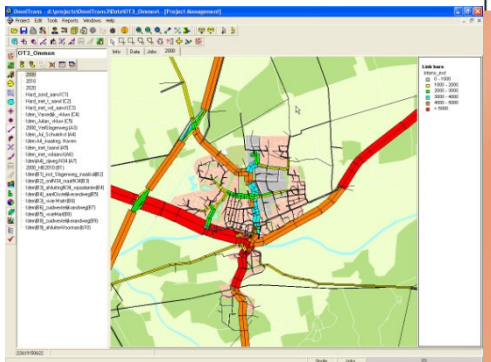
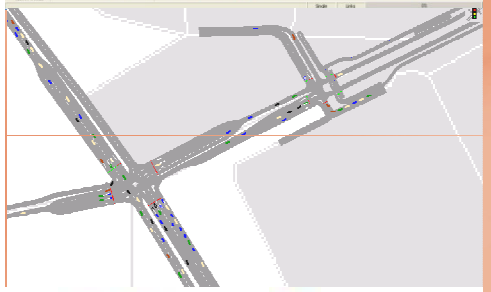
Background
Traffic modelling





- Connection with effect-models
  - Safety – APM/crash rates, surrogate safety measures
  - Climate – Emission factors, fuel consumption
  - Air quality – Emission factors (different types):
    - Emission modeling
    - Dispersion modeling