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# Strategic transport models and smart urban mobility

Luuk Brederode
DAT.mobility

April 2021

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Seminar 2050 CliMobCity

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# Transport models and smart mobility

- Mobility is the result of people's choices on **how often**, **where** and **how** they want to travel
- Transport models describe the mobility system by modelling these **choices** and their **interactions** for all people using the transport system

→ If we want to include smart urban mobility in transport models, choice behavior of people and their interactions when confronted with smart mobility concepts needs to be included in these models:

  → Choice behavior must be known: **additional data required**

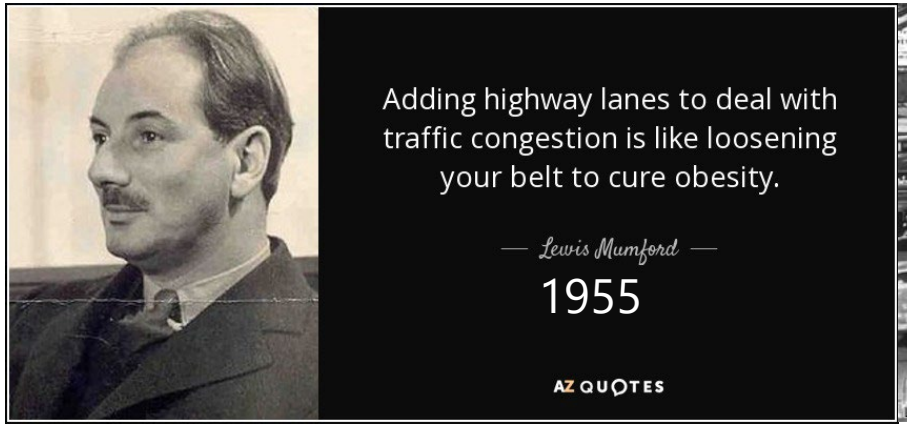
  → Relevant interactions must be included: **different modelling methodology required**

  → New (smart mobility) concepts come with **uncertainty** on their effect

# Modelling methodology

# What makes a transport model strategic? (1)

- Strategic transport models are used to support decision makers on long term decisions
  - ➢ In these models, only the long-term effects (i.e. 5+ years) of policy decisions matter
- Long-term effects may be (totally!) different from short term effects
  - ➢ We've known this from quite some time…




# What makes a transport model strategic? (2)

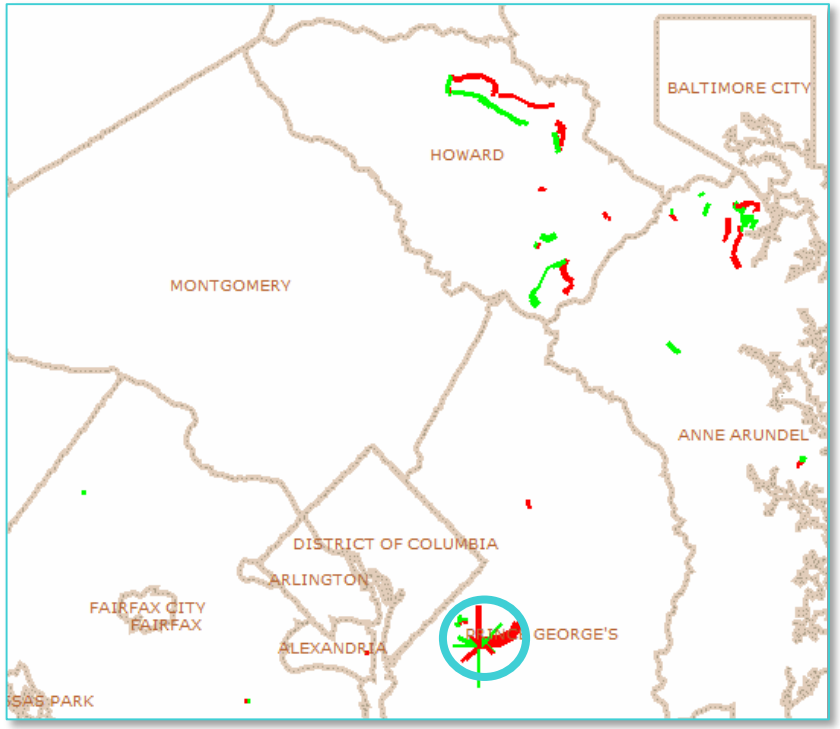
To evaluate a set of policy measures, model outcomes of a reference run are compared to model outcomes of a run with policy measures.

For comparability of outcomes, strategic models employ paradigms that adhere to conditions such as

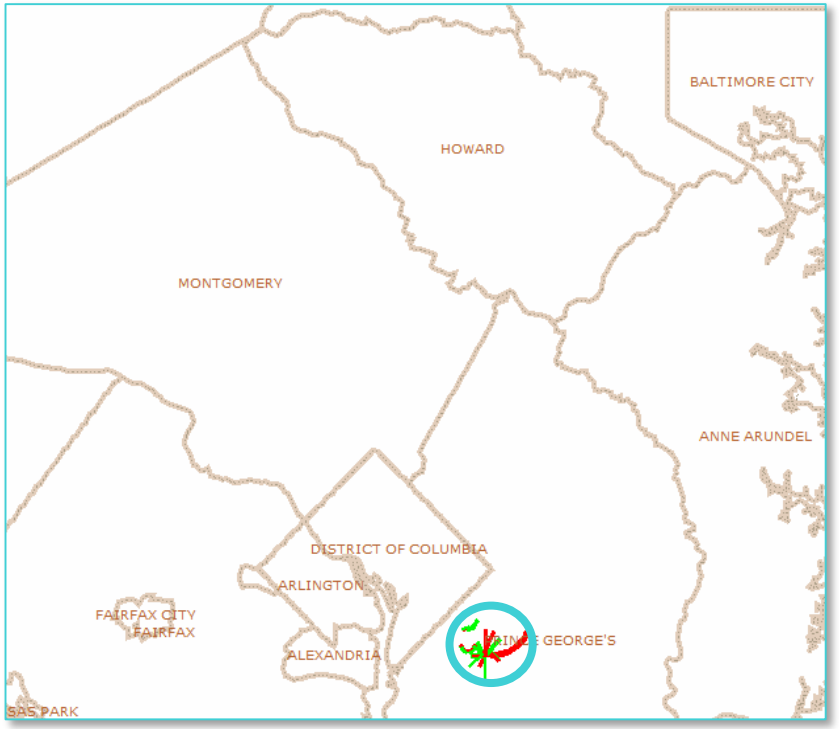
- Maximum entropy (the most likely state of the mobility system, given all uncertainties)
- Maximum utility (the most likely choices of travelers, given a set of available options)
- User equilibrium (a condition that occurs in a stable system when every traveler chooses selfishly)

# Comparability of outcomes

Consider the modelled effects of a set of policy measures in the circled area




Link flow changes > 200 veh/h according to 2 model runs **not in user equillibrium**

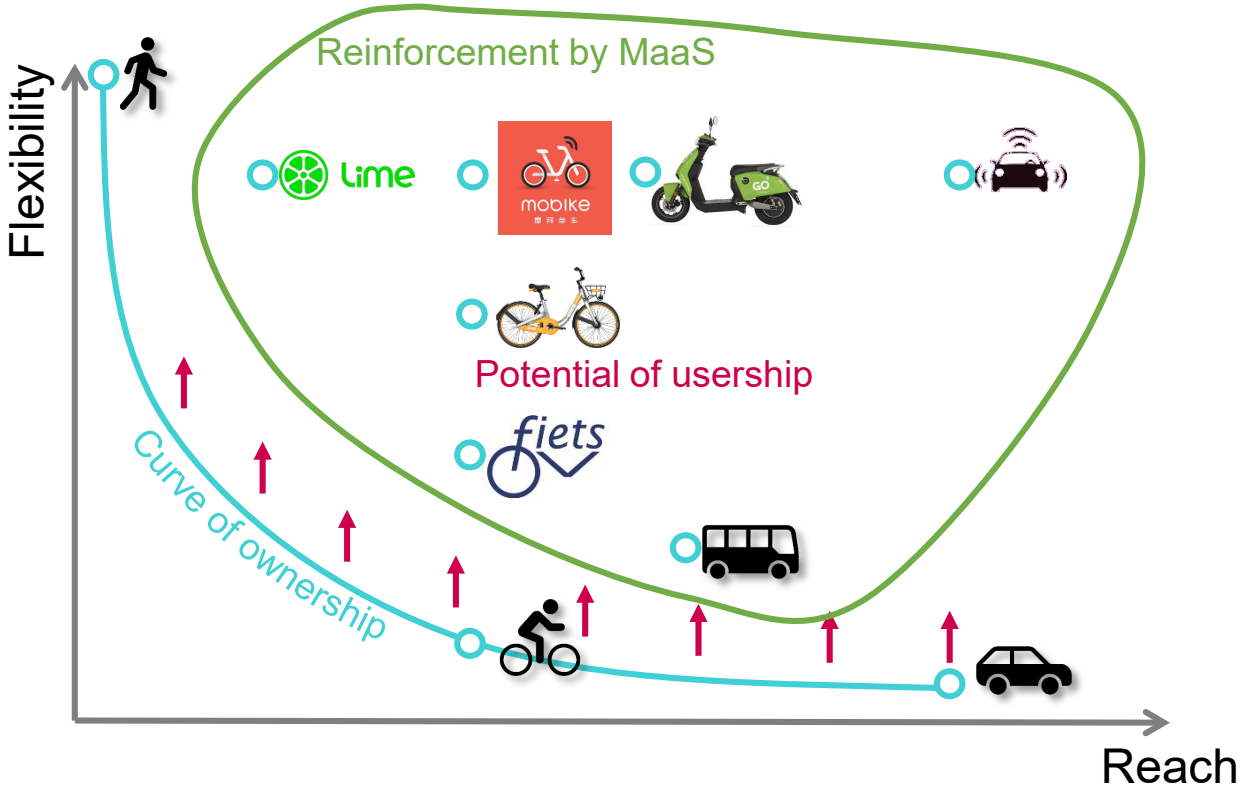



Link flow changes > 200 veh/h according to 2 model outcomes **in user-equillibrium**

**Pictures from:** Caliper. 2010. "What Transcad Users Should Know About Traffic Assignment."

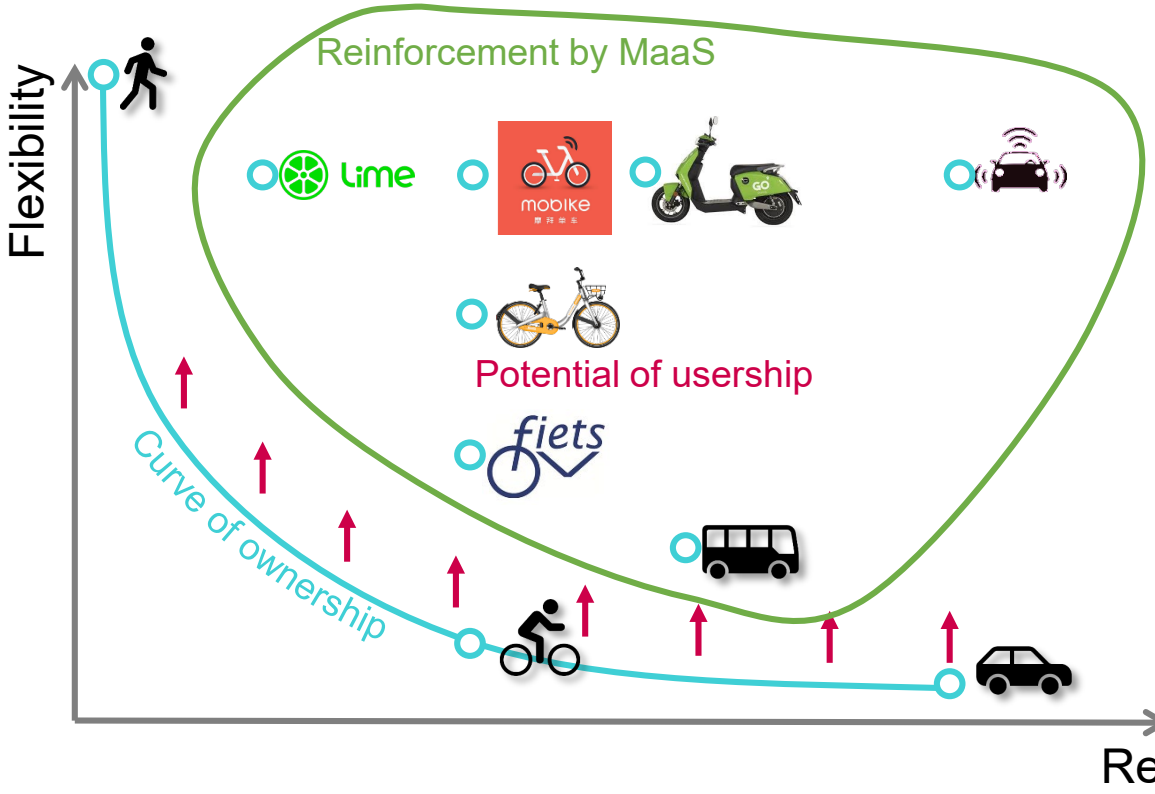
# Why do we expect smart mobility to take off?

It can provide a better **balance** between **reach** and **flexibility** for the user



# Why strategic transport models struggle with smart mobility…

Paradigms underpinning traditional strategic transport models limit their usage to on/around the curve of ownership.

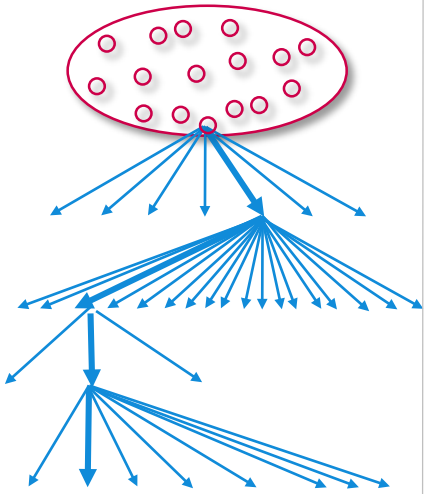
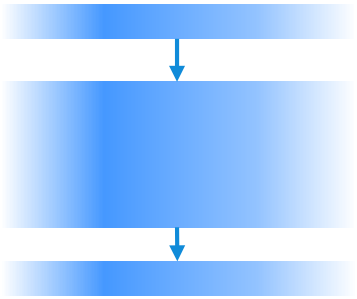
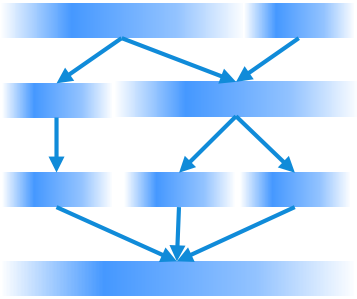



Paradigms in traditional strategic transport models dictate:

- Vehicle and service availability in space and time are exogenous to the model (the 'average' availability)
- The set of considered modes by travellers is fixed per traveller type
- Dependencies between sequential choices made by travellers are not considered

→Smart mobility requires a different type of demand model.

# Types of demand models and capabilities

| | Macromodel (aggregated) | Macromodel (disaggregated) | Micromodel |
|---|---|---|---|
| **Model components** | | | |
| Population synthesizer |  |  |  |
| Trip/tour generator |  |  | |
| Destination choice | | | |
| Mode choice | | | |
| Departure time choice | | | |
| **Availability of alternatives may be dependent on:** | | | |
| Person/Household characteristics | | ✓ | ✓ |
| Choices of other people | | | ✓ |
| Choices made earlier | | | ✓ |

# Types of demand models and capabilities

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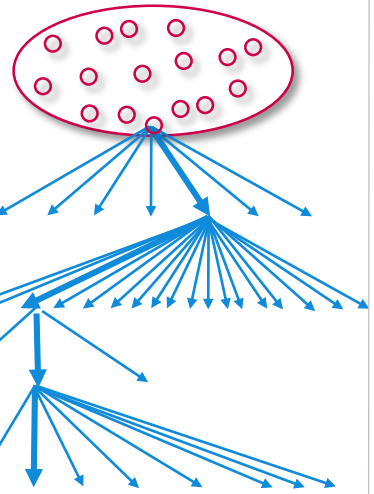
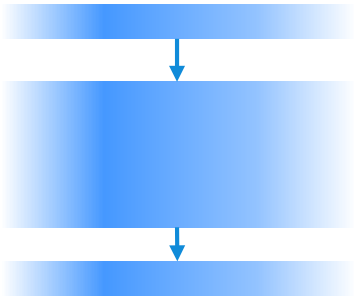
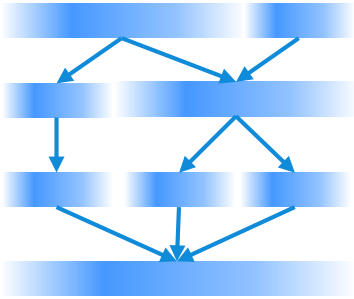
| Population synthesizer |  |  |  |
| Trip/tour generator |  |  | |
| Destination choice | | | |
| Mode choice | | | |
| Departure time choice | | | |
| **Availability of Car Driver may be dependent on:** | | | |
| Person/Household characteristics | | ✓ | ✓ |
| Choices of other people | | | ✓ |
| Choices made earlier | | | ✓ |

**Car Driver available only if:**

- Agent has drivers' license -AND- the household has a car
- No other household member is using the car

# Types of demand models and capabilities

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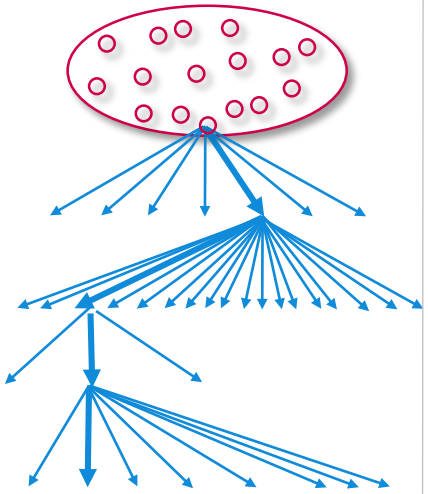
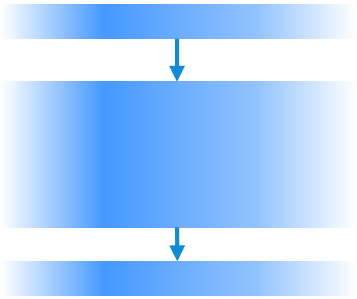
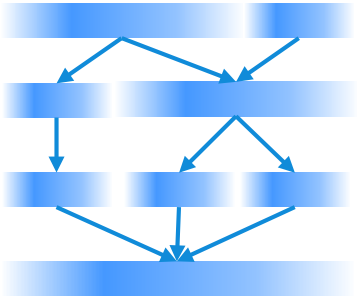
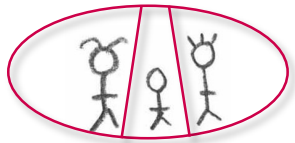
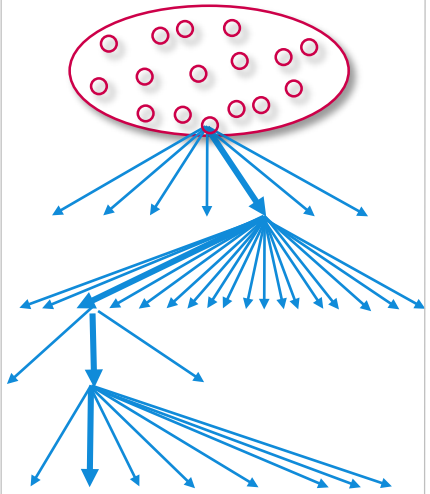
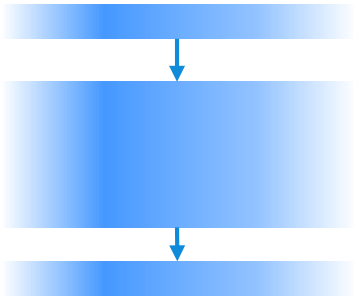
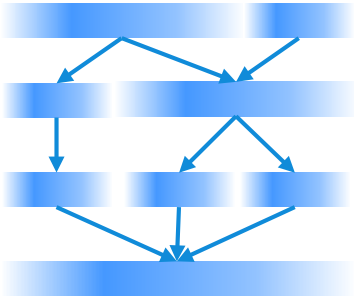
| Population synthesizer |  |  |  |
| Trip/tour generator |  |  | |
| Destination choice | | | |
| Mode choice | | | |
| Departure time choice | | | |
| **Availability of Car Passenger may be dependent on:** | | | |
| Person/Household characteristics | | ✓ | ✓ |
| Choices of other people | | | ✓ |
| Choices made earlier | | | ✓ |

**Car Passenger available only if:**

There is a person with drivers' license in the household
-AND-
the household has a car

No other household member is using the car
-AND-
A car driver is available

# Types of demand models and capabilities

| | Macromodel (aggregated) | Macromodel (disaggregated) | Micromodel |
|---|---|---|---|
| **Model components** | | | |
| Population synthesizer |  |  |  |
| Trip/tour generator |  |  | |
| Destination choice | | | |
| Mode choice | | | |
| Departure time choice | | | |
| **Availability of Shared car service may be dependent on:** | | | |
| Person/Household characteristics | | ✓ | ✓ |
| Choices of other people | | | ✓ |
| Choices made earlier | | | ✓ |

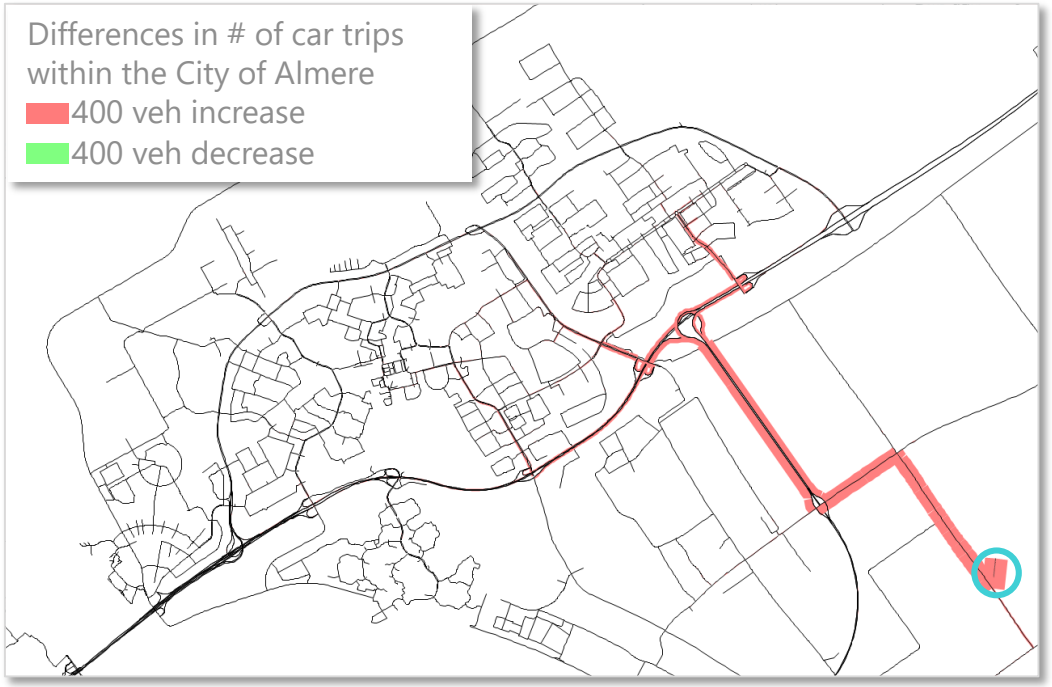
**Shared car service available only if:**

- Agent has a subscription for the service
- Shared car is not in use by other travellers
- No private mode was used for access; -OR- Private mode is to be picked up again

# Why a micromodel cannot be used naively

Microsimulation causes statistical noise…


Effect of 180 additional inhabitants in circled area – **microsimulator applied naively**




Effect of 180 additional inhabitants in circled area – model **microsimulator with statistical noise eliminiation**

**Pictures from:** Brederode et al 2020. "Development of a microscopic tour based demand model without statistical noise" - European transport conference 2010; https://www.slideshare.net/LuukBrederode/development-of-a-microscopic-tour-based-demand-model-without-statistical-noise2

# Conclusion on modelling methodology

To include smart mobility in strategic transport models:

- Dependencies between the available choice alternatives and person/household characteristics, choices of other people and choices made earlier should be included
  - This advocates for a **micromodel**
- Outcomes of the model should still adhere to predefined conditions
  - This advocates for **statistical noise elimination**[1]

[1]statistical noise elimination is not covered in this presentation, see https://www.slideshare.net/LuukBrederode/development-of-a-microscopic-tour-based-demand-model-without-statistical-noise2 for a more extensive description of this concept.

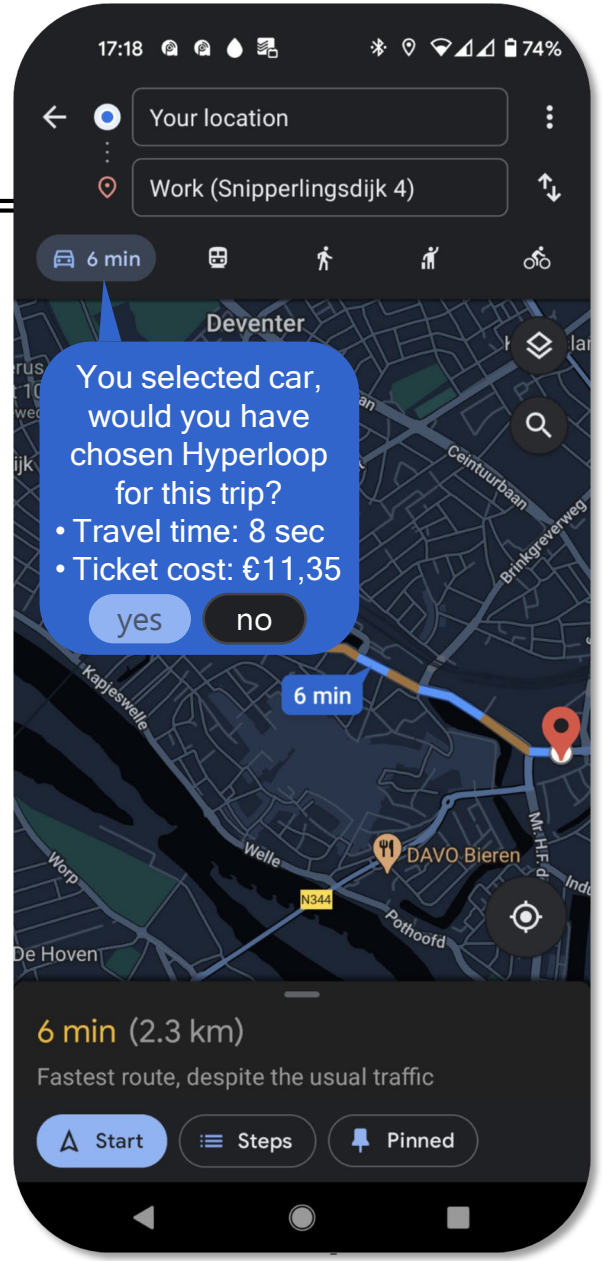
# Data requirements

# Additional data required

- For each relevant choice or interaction, a dataset including observed (or stated) choices or outcomes is required
- Relevant choices and interactions are
  - The ‘traditional 4’: travel frequency, destination choice, mode choice, route choice’
  - ‘Less traditional’: departure time choice, car competition interaction,  MaaS subscription choice, shared mode availability, etc
- To derive choice models from these data, conventional methods may still be used
  - Logistic regression, log likelihood minimization, entropy maximization, etc
- Machine-learning methods can be used to increase model fit, but these may not all lead to models adhering to predefined conditions!
  - Decision trees, random forests, artificial neural networks, support vector machine, etc

# Additional data required

- Big data (e.g. chipcard info, detector data, camera data, etc) is very usefull for model calibration or validation, but mostly not usable for choice model estimation due to lack on information about the traveller
- The optimal data source would be a smartphone app tracking people in a panel (for longitudinal revealed preference data), that also allows to send participants pop-quizz questions (for stated preference data)
- An example in the Netherlands is our own Nederlands VerplaatsingsPanel (https://www.dat.nl/nvp/)



# Uncertainty

# Origins of uncertainty – model input

Backcasts show that it is not the model error, but mainly the 'error' in the scenario input that causes differences in model outcomes.

This will not change soon, and with this you have to take into account when applying models.

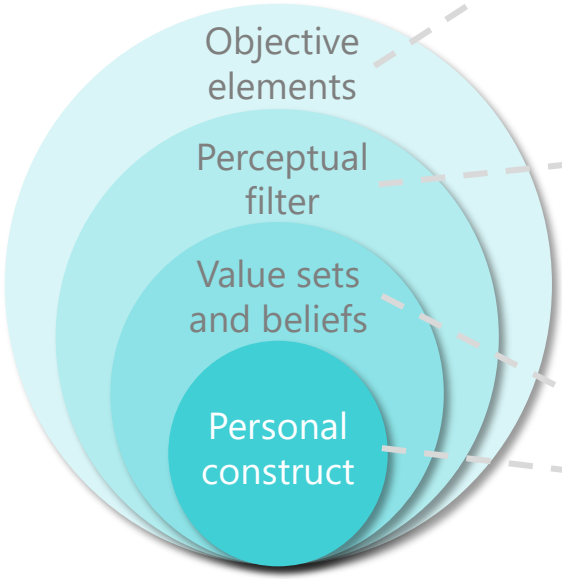
Uus of models for long-term analysis:

- Analyze relative differences to choose between scenarios : ok

- Analyze absolute effects to test externalities : not ok

the text on this slide has been translated from Dutch and slightly modified past presentation by Arjan van Binsbergen

# Origins of uncertainty – within the model




Variables describing the journey, the destination or the traveler
e.g.: travel time, cost, vehicle availability, household size, age

Directly measurable
– aggregated model suffices

Variability of (objective) variables across the population
e.g.: value of time, value of reliability, experienced comfort

Indirectly measurable through surveys
– requires disaggregate or micro model

Personal preferences
e.g.: public transport adepts, status-driven car drivers, etc

Implicitly measurable through actual choices of people
– requires micro model to make it an explicit variable

**Left part of figure adapted from**: Alexandra Kershaw - A Generational Approach to Understanding Mobility Behaviour & Lifestyles - "Mobility Footprints" (horizon2020 – mind sets project; presentation)

# New (smart mobility) concepts imply uncertainty

- to assume that parameters and preferences will be constant into the future, has proven to be unrealistic. SNET allows you to change not only parameters, but also preferences.
- because it is impossible to predict how parameters and preferences will change I would suggest applying a microsimulation with SNET in a system-dynamics like approach

the text on this slide has been translated from Dutch and slightly modified past presentation by Arjan van Binsbergen

# Conclusions

# Conclusions

Modelling smart urban mobility for strategic applications requires:

1. A microsimulator that can produce outcomes that adhere to predefined conditions is required
2. An online panel that can provide accurate longitudinal revealed preference data and stated preference data
3. A system-dynamics application approach to deal with uncertainties