### Modelling automated driving impacts using what we know

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Milakis et al. (2017)

# What is the road network?







## How does capacity work?



#### Capacity

- Capacity is inverse of minimum headway
- Minimum headway may depend on vehicle type
- Minimum headway may depend on vehicle type in front of you
- Vehicle types depend on penetration rates of various forms of automated driving
- Queue before bottleneck if capacity is insufficient



#### Poll

### In a future with automated vehicles, is capacity higher or lower?

- A: higher
- B: lower



#### Autonomous and cooperative driving



Fig. 2. PCUA value for different penetration rate for autonomous and cooperative driving (van Arem et al., 2006; Arnaout and Bowling, 2011; Ngoduy et al., 2009; Hoogendoorn et al., 2014).

Puylaert, Snelder, Van Nes, Van Arem (2018)

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#### Intersections

- One can geometrically determine conflict groups that cannot go at the same time
- If signalised, their signals cannot be green simultaneously
- There are switching costs!
- Yielding arms of unsignalised intersections are at a disadvantage



## How do travel times work?



#### **BPR** function

It is assumed that there is a relationship between traveltime (or speed) and the volume peculiar to each link in a highway network which can be expressed by the following equation:

$$T = T_0 \left[ 1 + 0.15 \left( \frac{\text{Assigned volume}}{\text{Practical capacity}} \right)^4 \right]$$

where: T = Traveltime at which assigned volume can travel on the subject link.

T<sub>0</sub> = Base traveltime at zero volume = traveltime at practical capacity x 0.87.

This relationship is shown graphically in figure V-15.



Bureau of Public Roads (1964)



#### A single-link vertical queue





#### Queues in a general network





#### Intersection waiting time

- Deterministic oversaturation delay (previous sheet)
- Random oversaturation delay
- Deterministic undersaturation delay dependent on green time and red time
- Fixed delay for deceleration and acceleration when yielding



### How do dedicated lanes/roads work?



#### **Dedicated lanes/roads**

- Dedicated lanes/roads have their own capacity
- Dedicated lanes/roads have their own travel time
- Dedicated lanes at intersections can be used to bypass queues
- Dedicated lanes can have priority green to skip waiting time
- Regulations determine which vehicle types are allowed to drive where
- In case of multiple options, users choose where they drive



How do users make travel choices?



#### **Travel choices**

Utility-based model

- Travel time
  - Value-of-time in free-flow
  - Value-of-time in congestion
- Operation/fuel costs (distance)
  - Cost-of-distance

Or predefined routes (e.g. PT)

Or determined by another algorithm (e.g. automated taxis)



# Where does this lead to?



#### Model for scenario analyses

- Quasi-dynamic traffic assignment based on road network
- Includes proper model of junction capacities and travel times
- Solid theoretical basis where possible
- Efficient for large networks
- Limited data needs



#### Future work

Case studies assessing the impacts of automated driving in practical scenarios

For example:

- Comparisons with results from previous presentations
- Impacts of automated vehicles on bus lanes
- Impacts of automated taxi systems
- Your research question here? J.P.T.vanderGun@tudelft.nl

