Strategic traffic assignment model for automated driving impacts

Open STAD Event
10 May 2019

TU Delft

Introduction

- SP6: Intregrated Model for the Impacts of Automated Driving

- This workshop:
  - Functional description of traffic assignment model
  - Formulation of AD scenarios to feed into the assignment model

mobility consultants

Goudappel Coffeng

Smart Mobility

Voorbeeldscenario ‘busbanen’ Strategic network modelling of the impacts of automated driving

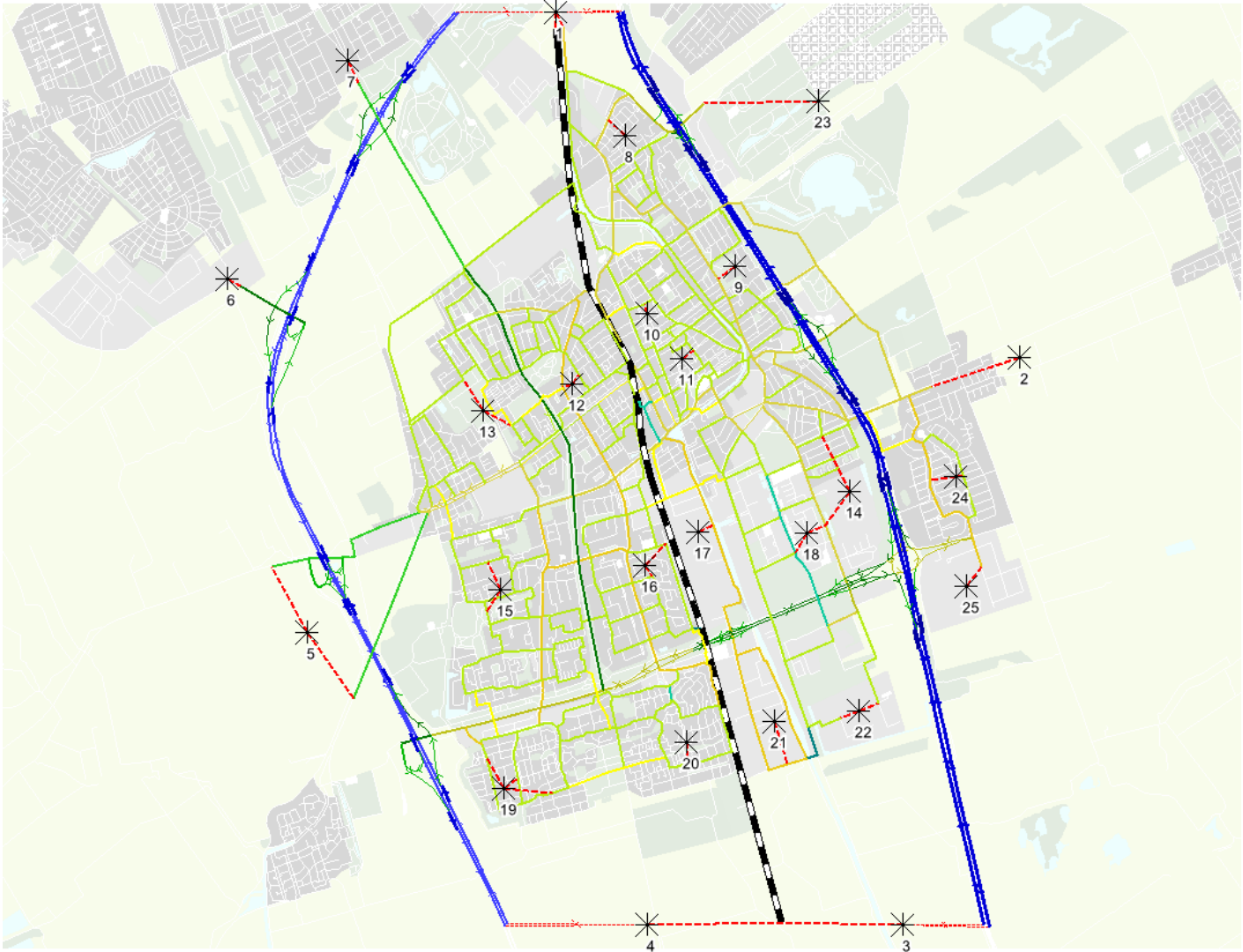
Han Zwijnenberg

10 mei 2019

STAD-open event Provincie Gelderland

Basics of the assignment model

TU Delft



TU Delft

Static Traffic Assignment

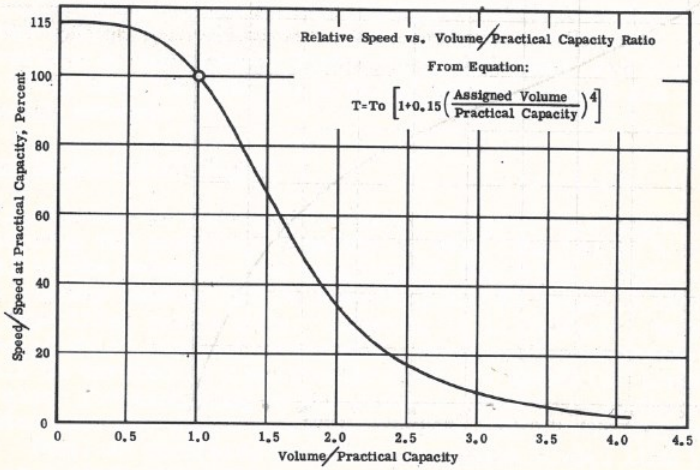
It is assumed that there is a relationship between traveltime (or speed) and the volume peculiar to each link in a highway network which can be expressed by the following equation:

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

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

T_0 = 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)

Quasi-Dynamic Traffic Assignment

- Similarities:
  - No time dimension
  - Instantaneous traffic propagation
  - Link travel time depends increases with link flow
- Advantages:
  - Flow exceeding capacity accumulates in queues
  - Queuing on links before bottleneck links instead of inside bottleneck links
  - Travel times on links with vertical queues calculated using queuing theory

Model input: the road network

TU Delft

Network and vehicle types

- Different network availability per vehicle type
  - E.g. different vehicle types cannot drive everywhere
  - E.g. dedicated roadways/lanes for certain vehicle types
- Different free-flow travel time per vehicle type
  - E.g. different vehicle types have different speed limits

Road capacity may vary

Bottleneck capacities depend on traffic composition

- Useful for various types of automated and cooperative driving and different vehicle types
- Can be different for each bottleneck, e.g. vehicle automation that works in some locations but not everywhere

TU Delft

PCU values for cooperative driving

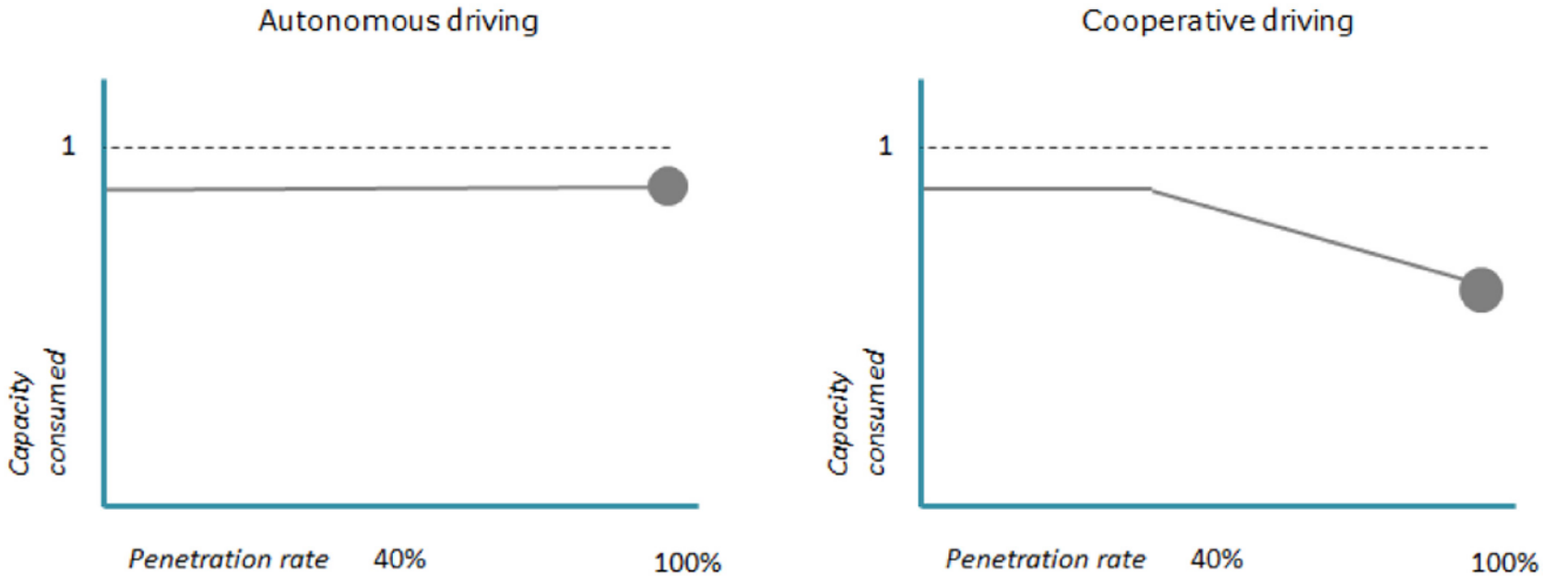


Fig. 2. PCUA value for different penetration rate for autonomous and cooperative driving (van Arem et al., 2006; Arnaout and Bowling, 2011; Ngoduy et al., 2009; Hoogendoorn et al., 2014).

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

Junction specification

- Junction type (e.g. equal priority, give way, traffic lights, roundabouts, tile-based reservation)
- Approach lane configuration and saturation flows

Based on junction description, model can figure out what conflicts between streams exist

Model input: the travel demand

TU Delft

Travel demand

Travel demand can have trips with intermediate stops

- Prevents double-counting of a vehicle in congestion
- E.g. useful for modelling (self-driving) taxis or similar services without fixed routes

Route choice

Utility-based

- Travel time
  - Value-of-time can vary per user class
  - Value-of-time can be location-dependent
- Operation/fuel costs (distance, platooning)
- …

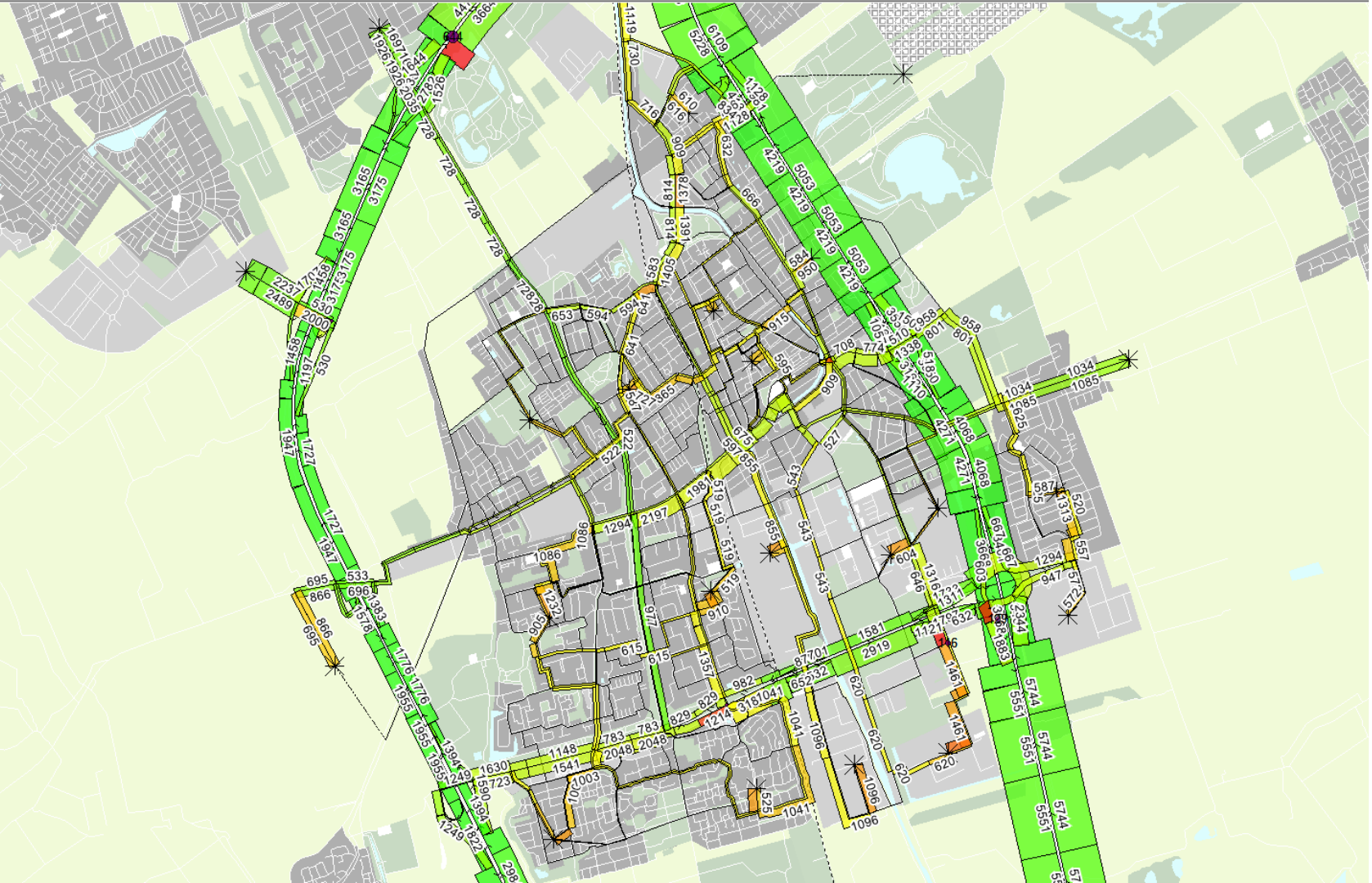
Or predefined routes (e.g. PT)

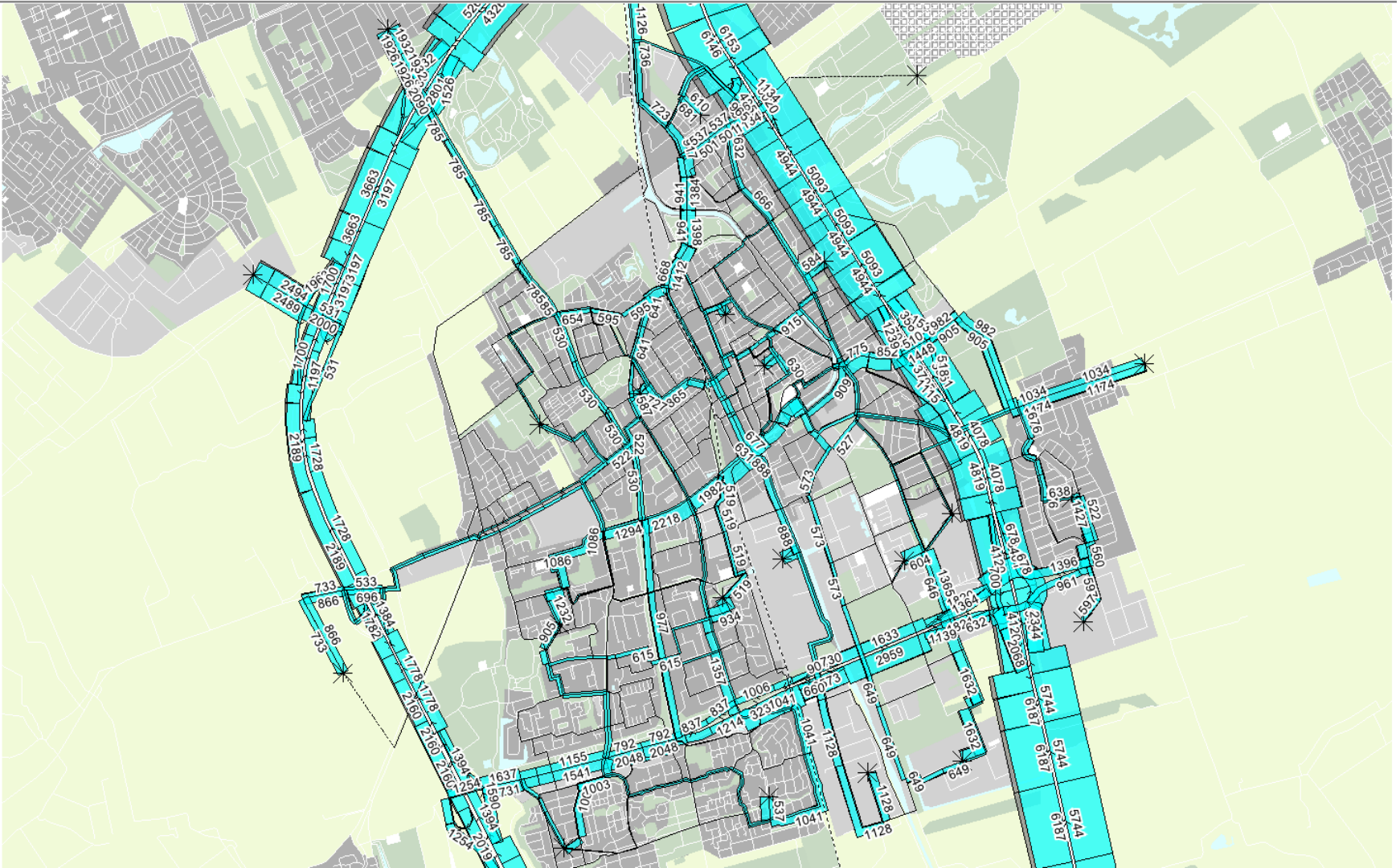
Model output

TU Delft

Model output

- Flows and travel times
  - Per origin, destination
  - Per route
  - Per link, turn (incl. dedicated lanes)
  - Per vehicle type
- Bottleneck information
  - Demand, capacity
  - Traffic lights: critical conflict group, cycle time, green fractions
  - Queue size, delay





Using the model output

- Aggregation of results:
  - Total distance travelled
  - Total time spent
  - Total congestion delay
  - Total disutility of travel

- With further post-processing of results:
  - Emissions estimates
  - Traffic safety assessment
  - Cost-benefit analyses

With multiple model runs

- Comparison of variants
  - Optimisation (trial and error)
  - Sensitivity analyses
- Multiple time-of-day periods
  - Parking space utilisation
- Interactive use with demand model
  - Traveller's responses to automated driving

TU Delft

Example Scenario

Autonome voertuigen op busbanen casus Brainport (Eindhoven)

mobility consultants
Goudappel Coffeng

- **is het een goed idee om**
  - **personeel richting luchthaven brengen vòòr aanvang dienstregeling**
  - **passagiers voor Eindhoven airport vraaggestuurd te vervoeren, en**
  - **aantrekkelijk, hoogwaardig shared vervoer naar bedrijfsterreinen (ASML)**
    - **wel/niet stoppen op haltes, wel/niet afwijken van route**
- **casus: bestaande infrastructuur busbanen benutten voor automatisch rijden**
  - **infrastructurele veiligheidsvoorzieningen, interactie met ander verkeer**
  - **gebruiken hub functie van stations, gebruiken bestaande lijnen**
  - **hogere bezettingsgraad materieel, hogere opbrengst (economische haalbaarheid)**
  - **optie: benutten infra als incentive voor elektrisch stadslogistiek**
- **KPIs/interessante aspecten**
  - **globaal: verandering reistijden, verandering in congestie op andere wegen door intensiever gebruik busbanen**
  - **specifiek: interactie met vluchten (geen constante vraag, maar wel goed voorspelbaar)**
  - **specifiek: vertragingen door trucks op busbanen, veilige oversteek kruispunten bij haltes bij overzijde kruispunten**

mobility consultants

Goudappel Coffeng

Input parameters voor scenario

SAE level of automation (0-5):

1. .....
2. .....

Road types suitable for automated or cooperative driving:

1. .....
2. .....

Value of time for travellers:

1. .....
2. .....

Road types vehicle is allowed to drive:

1. .....
2. .....

Capacity effects of automated or cooperative driving:

1. .....
2. .....

Cost of vehicle operation:

1. .....
2. .....

Predetermined lines or routes this vehicle uses (if applicable):

1. .....
2. .....

Size of travel demand, market segment:

1. .....
2. .....

area considerated Key Performance Ind

- .....
- .....
- .....

mobility consultants
Goudappel Coffeng

uitgangspunten voor scenario (input parameters)

1=kolom 1: case busbanen
2=kolom 2: + trucks

SAE level of automation (0-5):

1. SAE L4
2. SAE 2-4

Road types suitable for automated or cooperative driving:

1. Ove worden
2. Alleen op busbanen, de first/last mile op gewone wegen = SAE L2

Value of time for travellers:

1. €14/uur voor reizigers
2. -12% arbeidskosten omdat chauffeur andere taken kan doen

Road types vehicle is allowed to drive:

1. Busbanen, parkeerplaatsen op airport terminal
2. Busbanen, gewone wegen (first/last mile)

Capacity effects of automated or cooperative driving:

1. Bottlenecks als gevolg van halteren
2. -20% volgafstand door CACC; geen effecten op gewone wegen

Cost of vehicle operation:

1. Brandstof: - 10% door automatisch rijden
2. Brandstof: - 5% op gewone wegen
   -20% op busbanen

Predetermined lines or routes this vehicle uses (if applicable):

1. Bestaande routes van buslijnen
2. Geen voorgeschreven routes

Size of travel demand, market segment:

1. OV-gebruikers + buiten dienstregeling
2. 90% van logistiek binnen de stad, inclusief overslag van hubs buiten de stad

area considered
Key Performance Indicators

- Effecten op congestie
- Veilige kruispunten door haltes
- .....
  ...

mobility consultants
Goudappel Coffeng

Vragen?

mobility consultants
Goudappel Coffeng

Scenario name: Expanding capacity inner city of Eindhoven using bus lanes

Vehicle types present in this scenario:

 Vehicle name:	Automated bus	Electric logistics vehicle	
SAE level of automation (0-5):	4	2-4	
 Road types vehicle is allowed to drive:	Bus lanes / remise / parking ground at terminal Eindhoven Airport	Bus lanes / ordinary roads (first/last mile)	
 Predetermined lines or routes this vehicle uses (if applicable):	Following predetermined routes of the bus line	No predetermined routes; preference for bus lanes in route choice	
 Road types suitable for autonomous or cooperative driving:	Everywhere it is allowed to drive	Bus lanes only (first/last mile on ordinary roads are level 2)	
 Capacity effects of autonomous or cooperative driving:	No significant change in bus pcu value expected due to automation; same bottlenecks at intersections and stops as now	Headways on bus lanes 20% lower due to cooperative driving (if not blocked by stopping buses); no capacity effect on ordinary roads	

TU Delft