SMART - Simulation and Modeling of Automated Road Transport

CTR-day 2021

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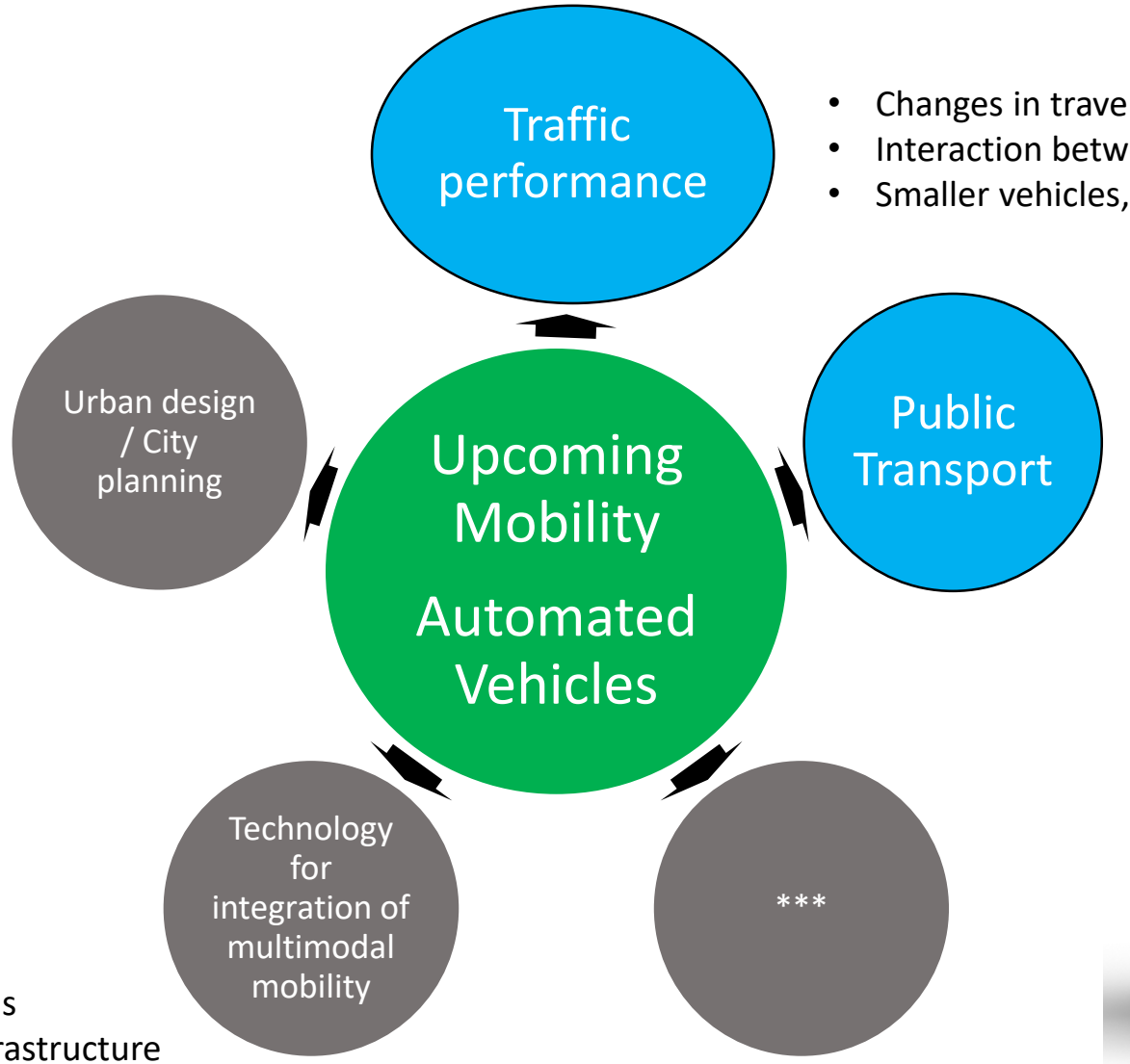

- Changes in travel behavior
- Interaction between automated and non-automated vehicles
- Smaller vehicles, increased heterogeneity

- MaaS
- Smaller public transport vehicles
- Demand-driven services
- New transport solutions

- Redistribution of space
- Parking spaces

- Service platforms
- Cloud-based infrastructure

The purpose of the SMART project

- Identify the limitations of current traffic models to include automated vehicles
- Further develop current traffic models to enable analysis of traffic systems including automated vehicles
- Evaluate the effects on traffic systems due to vehicle automation for two application cases
- Contribute to long-term knowledge building

SMART consists of two doctoral projects

Public Transport

Traffic simulation of fleets with automated vehicles

- David Leffler
- *Wilco Burghout*
- *Erik Jenelius*
- *Oded Cats*

- New public transport solutions
  - Real-time control strategies
  - Automated vehicles in flexible feed traffic
- Modeling and effects of multimodal public transport systems
  - Effects of competing versus cooperating fixed and flexible public transport systems
  - Modeling of traveler behavior

Traffic Performance

Microscopic traffic simulation of automated vehicles

- Ivan Postigo
- *Johan Olstam*
- *Clas Rydergren*

- Traffic effects of mixed traffic
  - Transition to automated roads
  - Heterogeneity of automated vehicles
- Modeling of automated driving
  - Differences in perception and reaction
  - Compliance to real-time control strategies
  - Effects of digital infrastructure

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Microscopic Modeling of Automated Vehicles

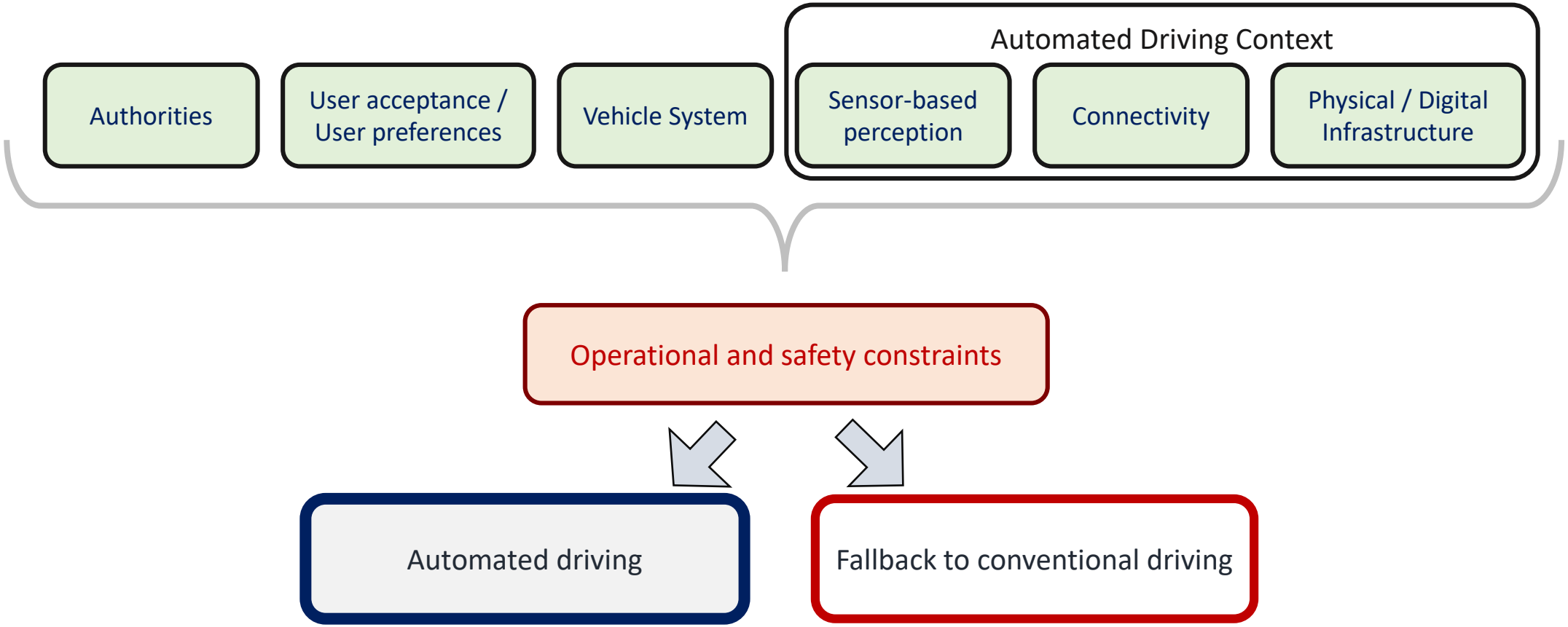
Research questions:

- How to model automated driving?
- How will the interaction between conventional and automated vehicles affect traffic systems?

Background

- Traffic simulation is an important tool used for traffic analysis.
- Microscopic traffic simulation models describe the movements and interactions of all individual vehicles or travelers.
- Typical use of microsimulations is to investigate how changes in the infrastructure impact the traffic flow.
- With the introduction of automated vehicles, there is a change on the vehicle population.
- Several studies have used microscopic traffic simulation to investigate the impact caused by automated vehicles.

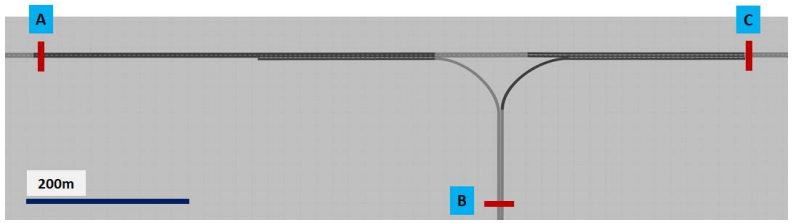
Aspects to consider for modeling automated driving

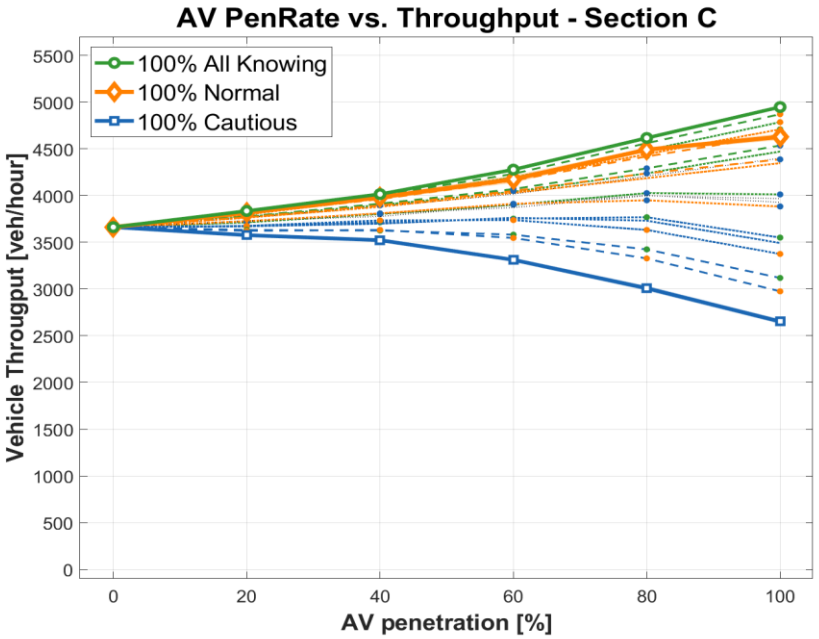


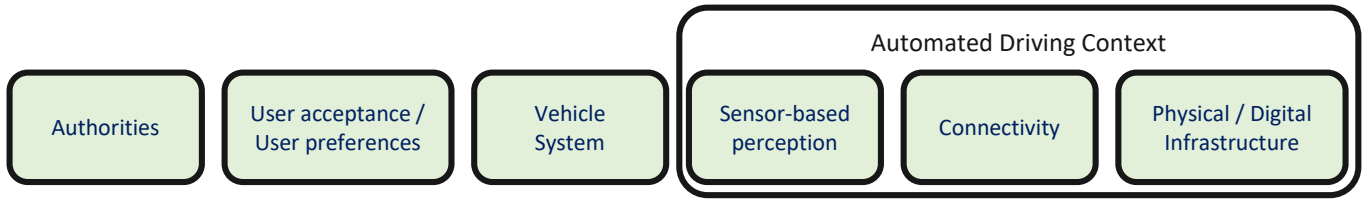
Effects on Traffic Performance due to heterogeneity of Automated Vehicles

A first study was done based on microscopic traffic simulations:

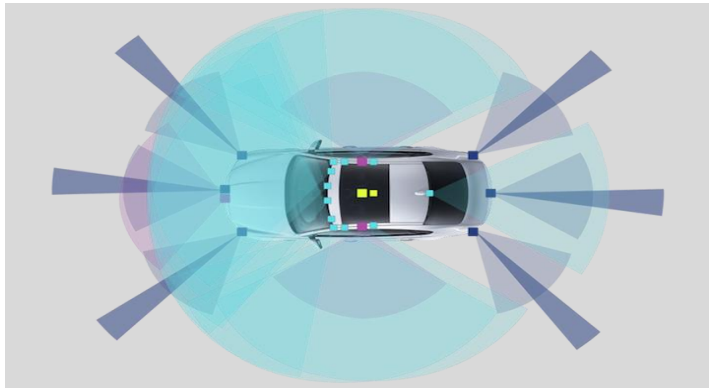
- Over time AVs will become more advanced and improve their driving capabilities and,
- Different generations of AVs will coexist on the roads → AV heterogeneity.

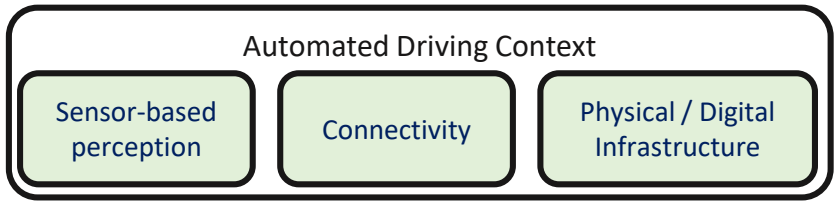






Modeling Perception for Automated Driving

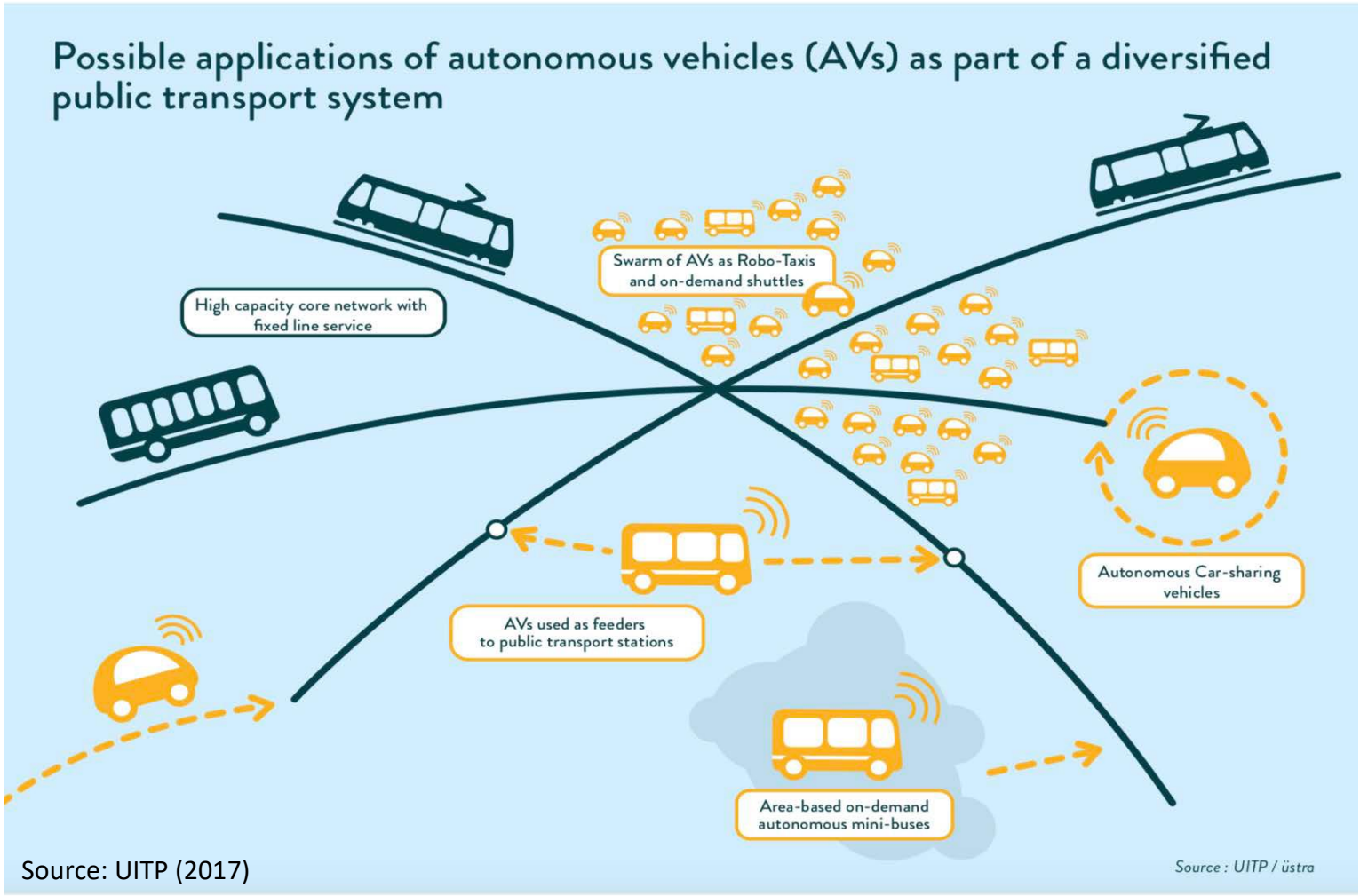




- Which vehicles/objects can be perceived?
- What type of information?
  - Position
  - Speed
  - Intentions (route, desired lanes, desired speed)
  - ...
- When is the information obtained?
  - Frequency
  - Latency
- How is the information obtained/what are the sensing capabilities?
- Focus on the developing a generic model of perception including quality, range and latency.
- Capture in a consistent way the key differences between human perception, sensor based perception and connectivity based perception.

Automated vehicles in public transit

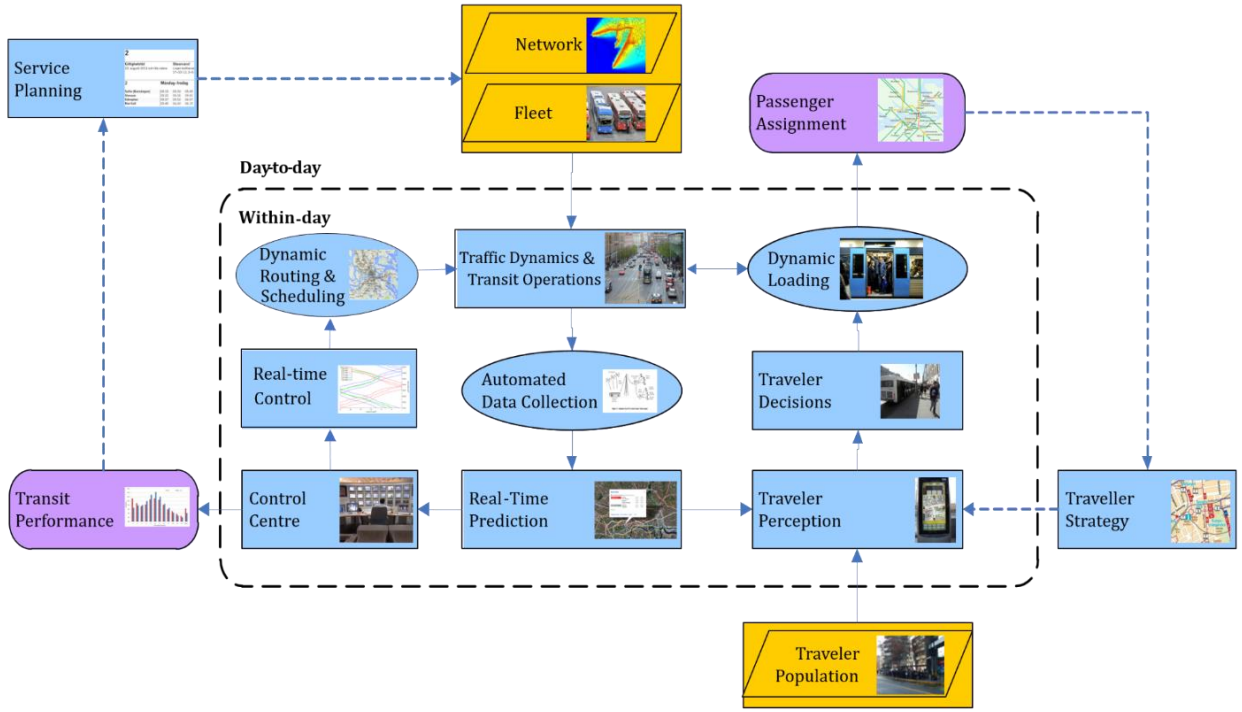
- Automated transit services integrated with traditional public transit services
- Limited real-life data and experience of such systems
- *Our focus:*
  - Real-time control of fixed transit
  - Flexible feeder services



Source: UITP (2017)

BusMezzo

- **Transit simulation** model with extensions
- **Agent-based**, models individual passenger's route and mode choices
  - within-day (short-term adaptation)
  - day-to-day (learned from experiences)
- Extended with functionalities to model **demand-responsive** services and alternative assignment strategies



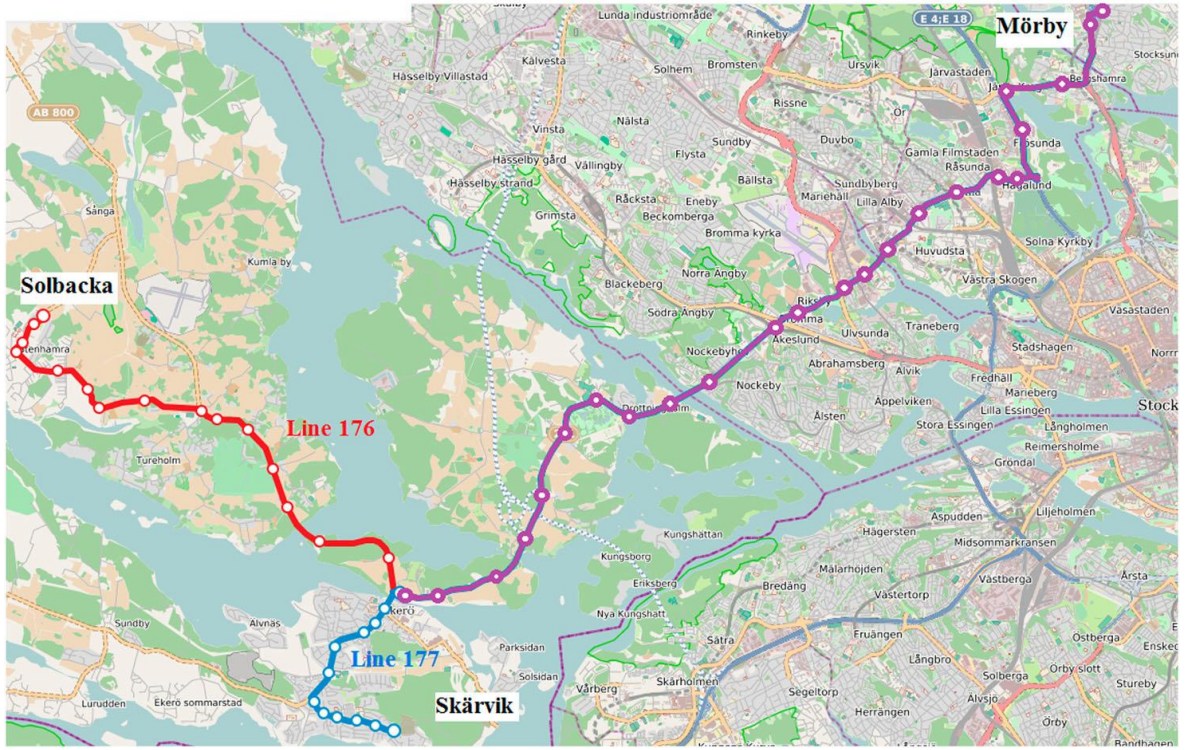
On-demand feeder to fixed case study

Case description:

- Simulate **replacement of branches** with **shared on-demand vehicles**
- **Passenger** and **operator costs** for collection direction (on-demand branch to fixed corridor)

Proposed contribution:

- Demonstrate **flexible transit simulation framework** to evaluate a ‘real-life’ scenario
- Conceptualize and experiment with **evaluation metrics for collaborative on-demand feeder** to fixed transit systems



Stockholm bus lines 176 & 177
Branches to/from Solbacka/Skärvik (Ekerö) that merge into a common corridor toward Mörby C through Solna

Based off of the paper:
Georgios Laskaris, Oded Cats, Erik Jenelius, Marco Rinaldi & Francesco Viti (2018): Multiline holding based control for lines merging to a shared transit corridor, Transportmetrica B: Transport Dynamics, DOI: 10.1080/21680566.2018.1548312

Scenario variations

Scenario	Fixed fleet	DRT fleet	DRT capacity	Algorithm
Fixed	38	0	-	-
26x20 maxR	28	26	20	#Requests
50x20 maxR	28	50	20	#Requests
100x10 maxR	28	100	10	#Requests
26x20 cumWT	28	26	20	CumulativeWait
50x20 cumWT	28	50	20	CumulativeWait
100x10 cumWT	28	100	10	CumulativeWait
26x20 maxR-rb	28	50	20	#Requests+Rebalancing
50x20 maxR-rb	28	50	20	#Requests+Rebalancing
100x10 maxR-rb	28	100	10	#Requests+Rebalancing
26x20 cumWT-rb	28	26	20	CumulativeWait+Rebalancing
50x20 cumWT-rb	28	50	20	CumulativeWait+Rebalancing
100x10 cumWT-rb	28	100	10	CumulativeWait+Rebalancing

Measured effects:

- Passenger level-of-service per OD category
  - Branch-to-branch, Branch-to-corridor, Corridor-to-corridor
- VKT, Fleet utilization

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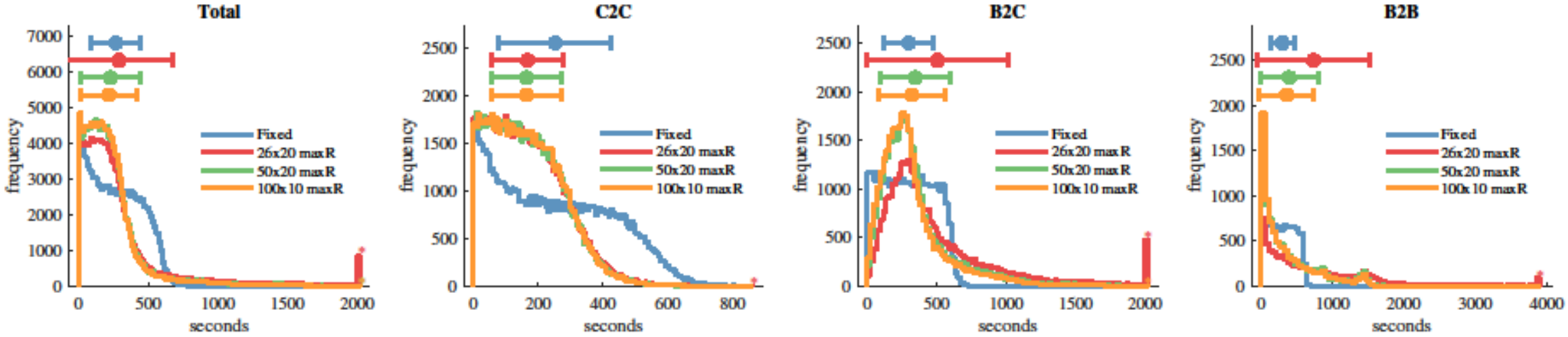
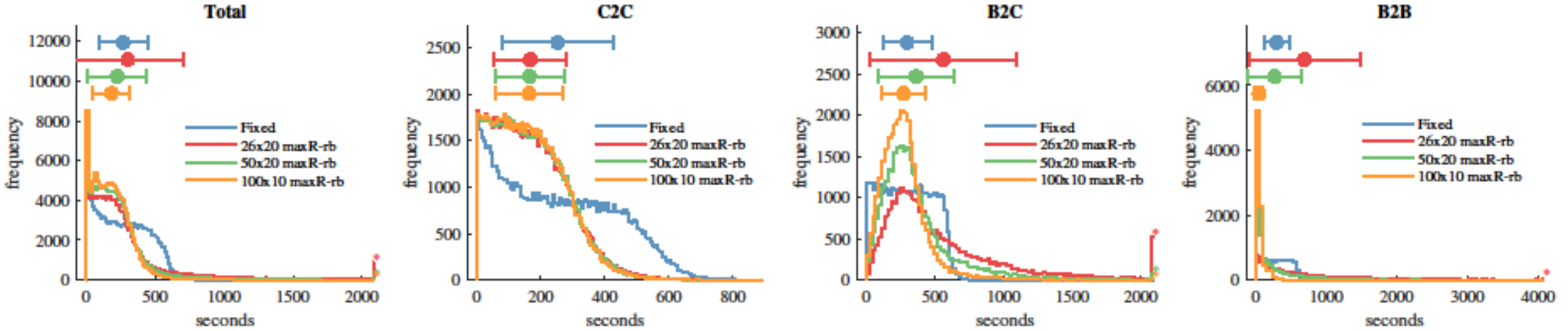
Algorithm: #Requests



Algorithm: #Requests+Rebalancing



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Main takeaways

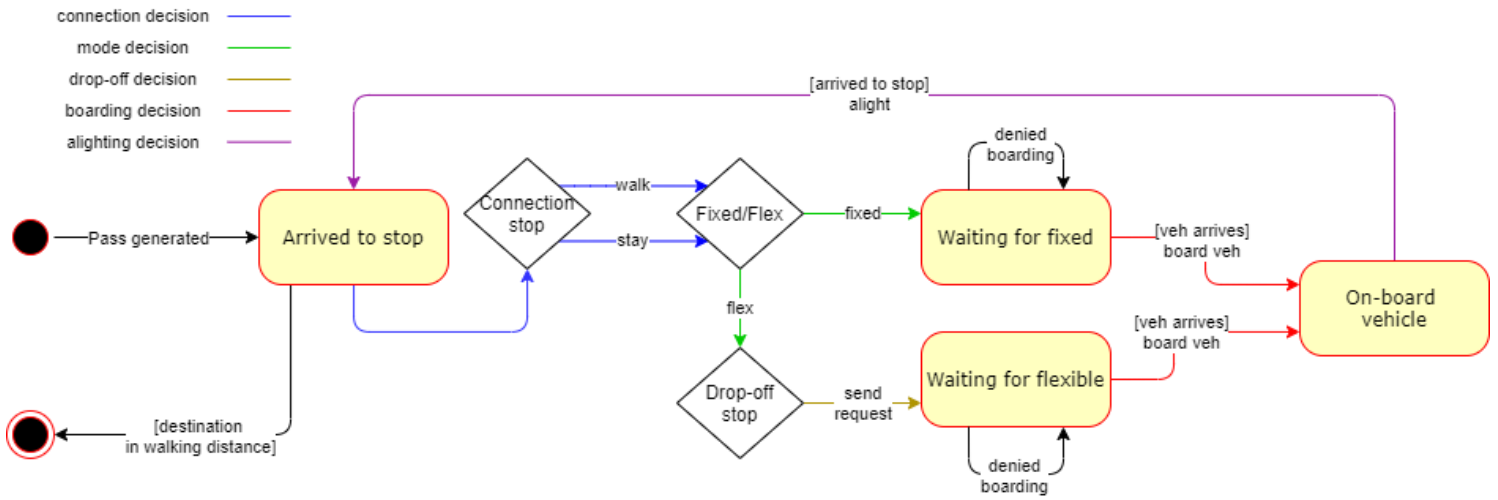
- **Shortening and simplifying** the **fixed** service while maintaining the same frequency **improves LoS** for travelers on the **corridor**
- The effects of **rebalancing** are **positive for the largest fleet** of smaller vehicles, however can also have **negative effects for smaller fleets** (in this case mainly for transferring travelers)
- **Median waiting times improve** for all DRT scenarios, however it is difficult to compete with the fixed service without transfers in terms of **reliability and equity of waiting times**

Future work

- **Work potentially benefits operators, planners, policy-makers: experiment with different conditions, to improve planning these types of services prior to implementation**
- **Next steps are to further integrate the flexible transit framework with the day-to-day learning framework of BusMezzo**

Modeling traveler behavior for multimodal trips:

- Walking
- Fixed transit
- Flexible transit



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