From Automated to Manual - Modeling Control Transitions with SUMO

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TransAID - Transition Areas for Infrastructure-Assisted Driving

Outline

- A Model for Automated Vehicles
- Transitions of Control and a Model for human driving
- Traffic Management in Transition Areas – Two Use Cases

Models for automated vehicles

- ACC Car-Following Model [Milanés et al., 2014]

i. **Speed control mode**: is designed to maintain the by the driver chosen desired speed,

ii. **Gap control mode**: aims to maintain a constant time gap between the controlled vehicle and its predecessor,

iii. **Gap-closing control mode**: enables the smooth transition from speed control mode to gap control mode,

iv. **Collision avoidance mode**: prevents rear-end collisions.

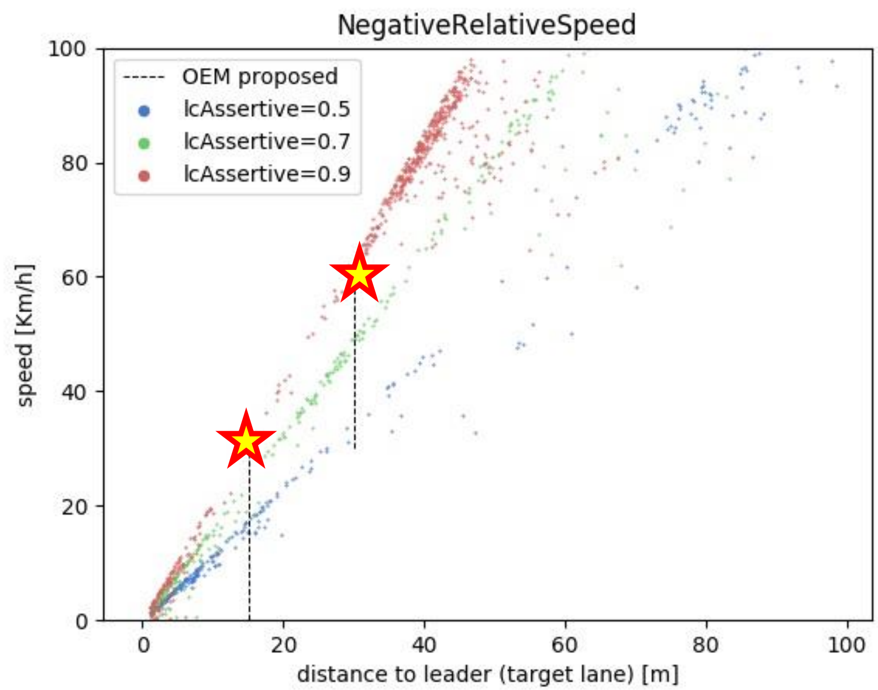
Parametrized Lane Change Model

i. Variance based sensitivity analysis
→ Influential lane change calibration parameters

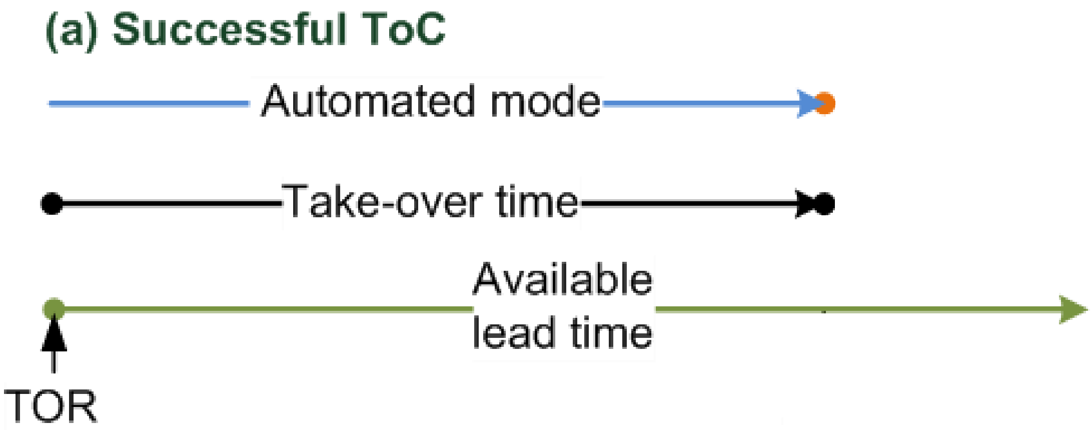
Speed Range [0, 100] (km/h)

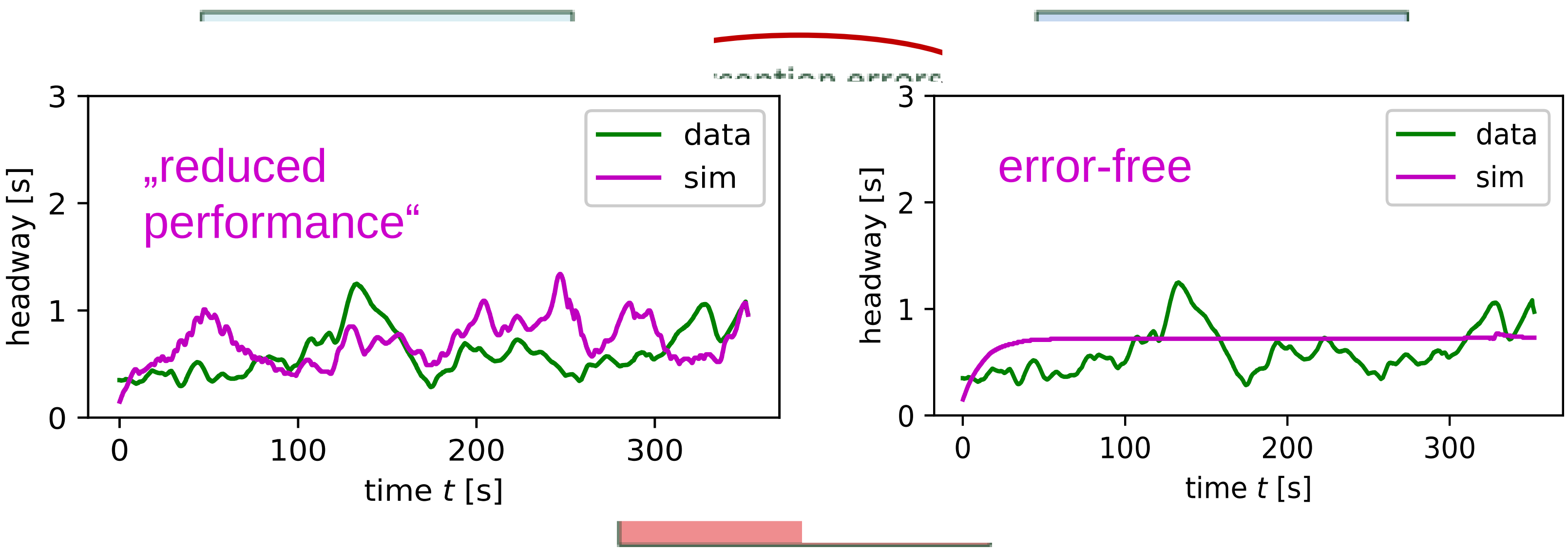
Parameter	Leader gap (ego lane)		Leader gap (target lane)	Follower gap (target lane)
Sensitivity Index	S_i [%]	ST_i [%]		
lcStrategic	0.39	0.62		
lcKeepRight	1.08	0.83		
lcSpeedGain	0.90	8.12		
lcAssertive	59.15	77.03		

ii. SUMO lane change output
vs **HMETC lane change data**
→ Reconciliation



ToC / MRM Model





Imperfect Driving

General CF Model:

$$\dot{x}(t) = v(t)$$

$$\dot{v}(t) = a(\Delta x(t), \Delta v(t))$$

Perceived quantities:

$$\Delta\tilde{x} = \Delta x + \eta_x$$

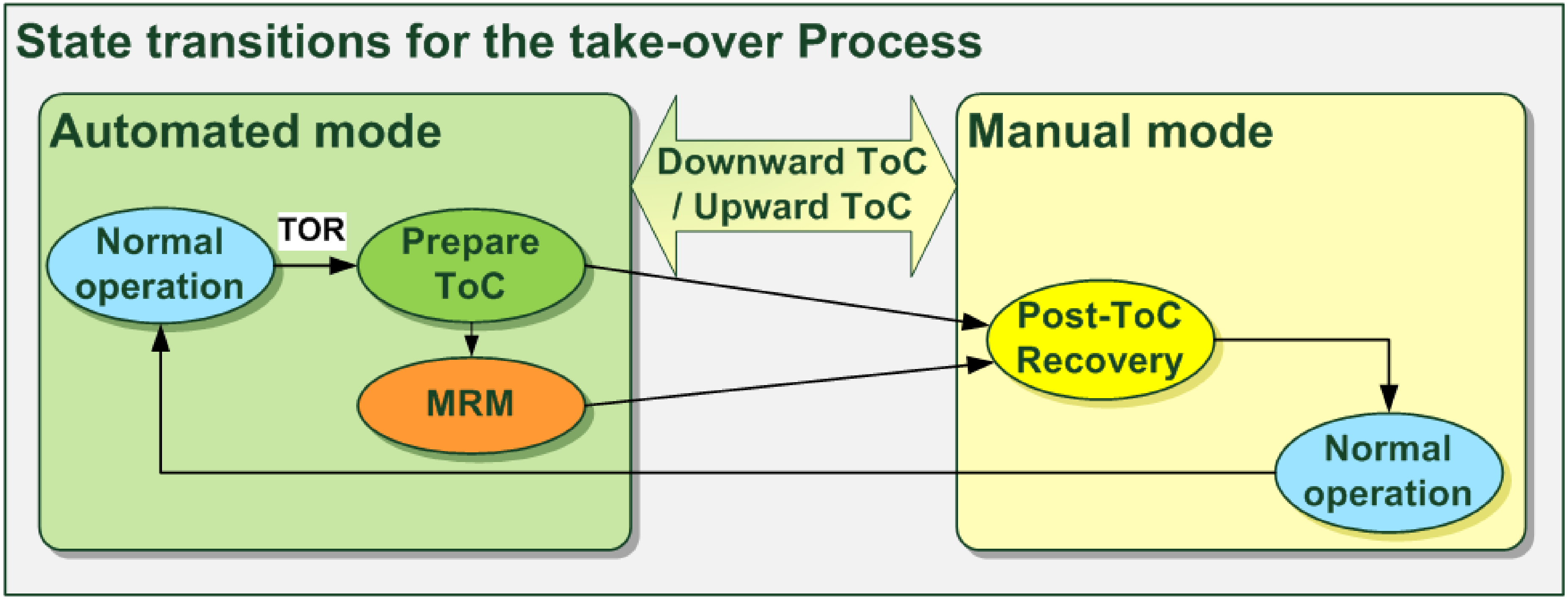
$$\Delta\tilde{v} = v + \eta_v$$

Erroneous CF Model:

$$\dot{x}(t) = v(t)$$

$$\dot{v}(t) = a(\Delta\tilde{x}(t), \Delta\tilde{v}(t))$$

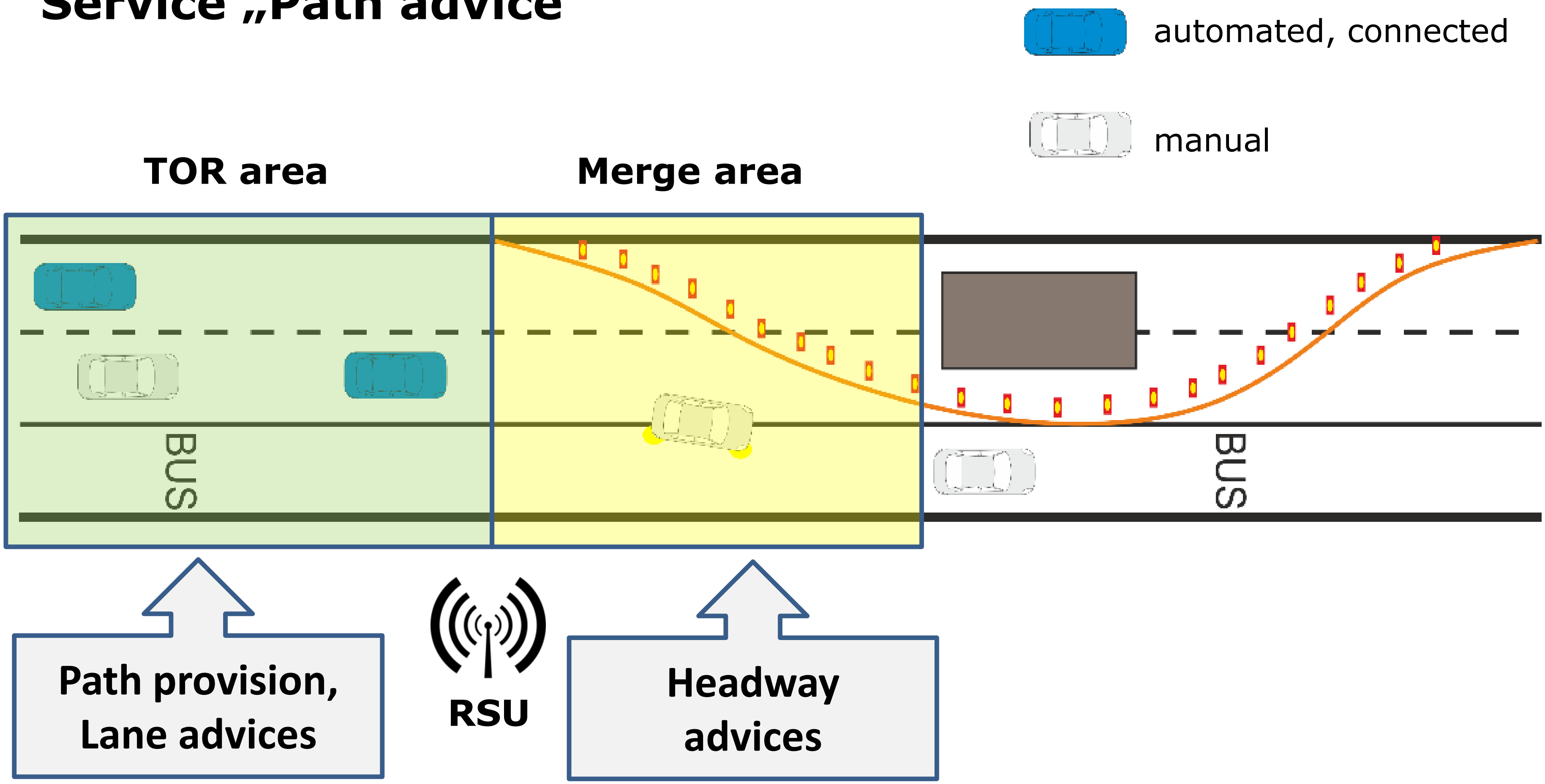
ToC / MRM Model



- https://sumo.dlr.de/wiki/Car-Following-Models/ACC
- https://sumo.dlr.de/wiki/ToC_Device
- https://sumo.dlr.de/wiki/Driver_State

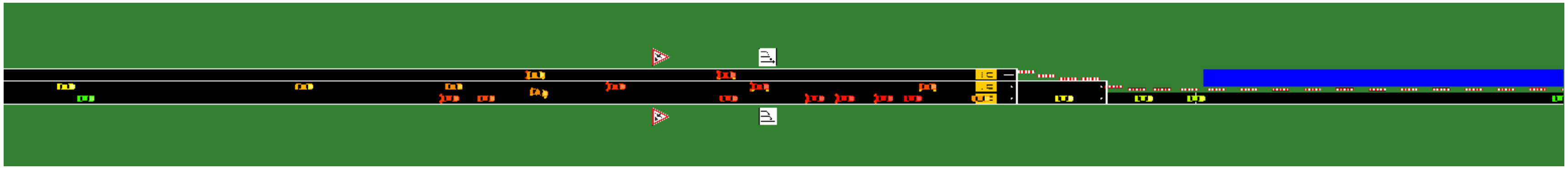
Traffic management in Transition Areas Scenario 1

Service „Path advice“

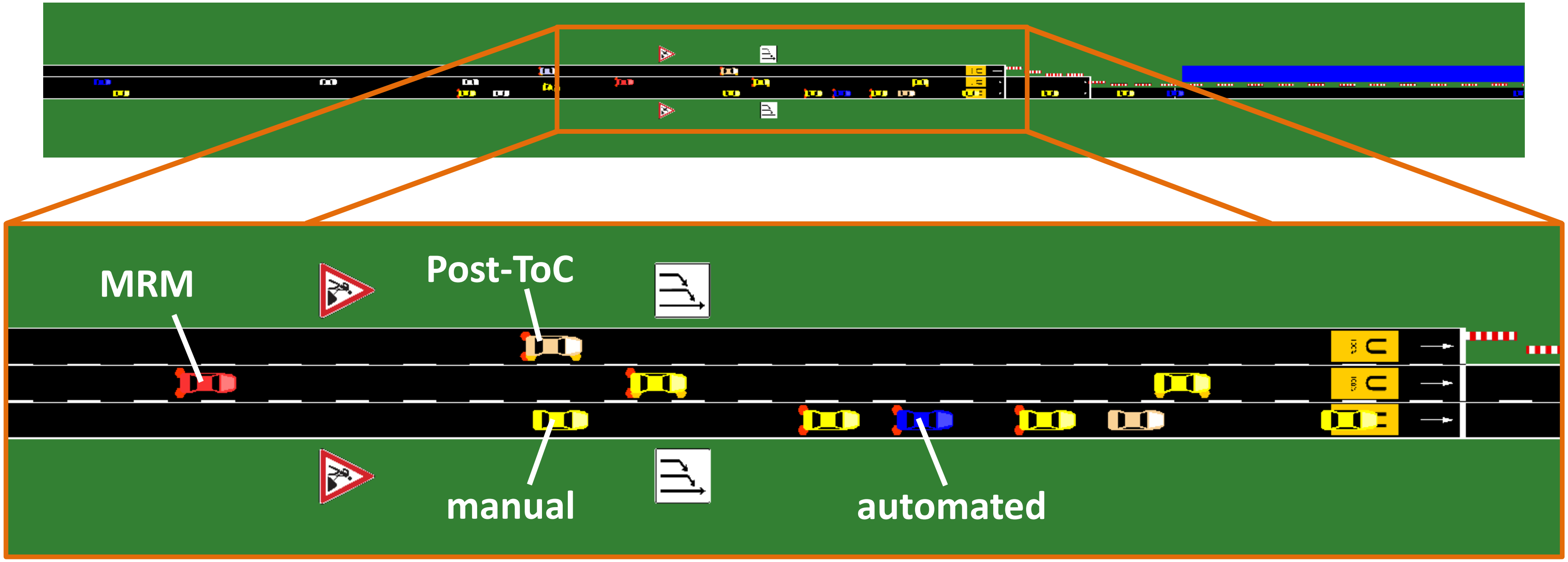


Traffic management in Transition Areas Scenario 1

Color ~ speed



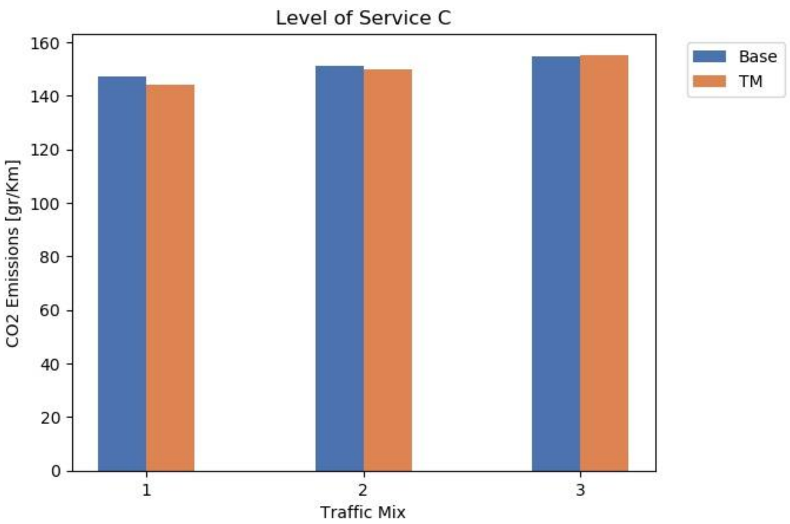
Color ~ ToC state

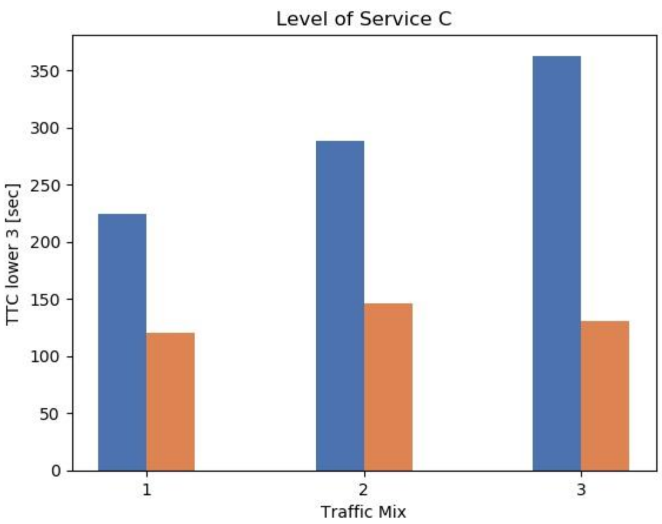


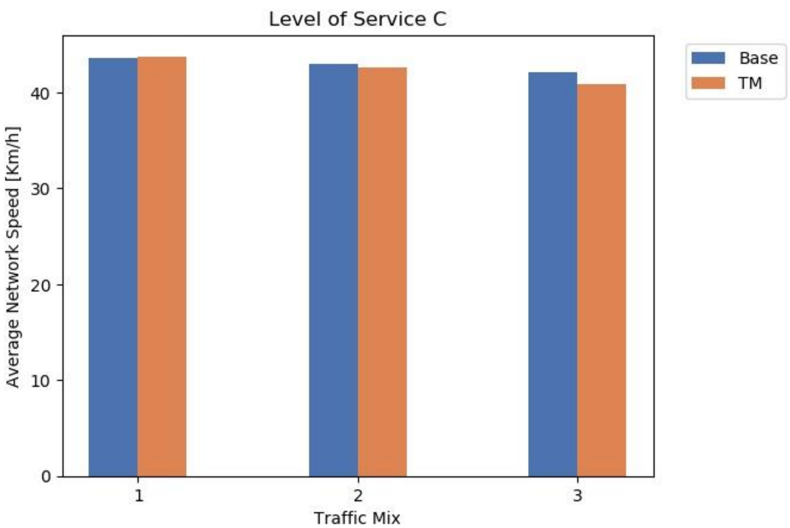
Traffic management in Transition Areas Scenario 1

Results

- 1h random vehicle flow (LoS C ~ 1155 veh/h)
- Fleet mixes (MV-AV):
  mix 1: 70-30
  mix 2: 50-50
  mix 3: 20-80

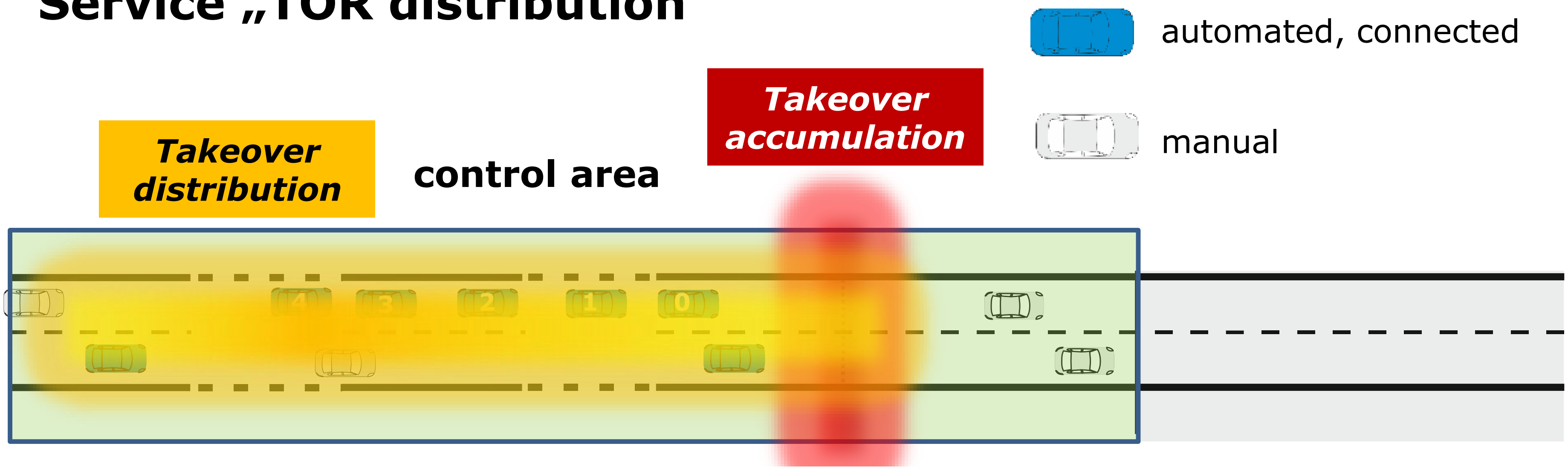


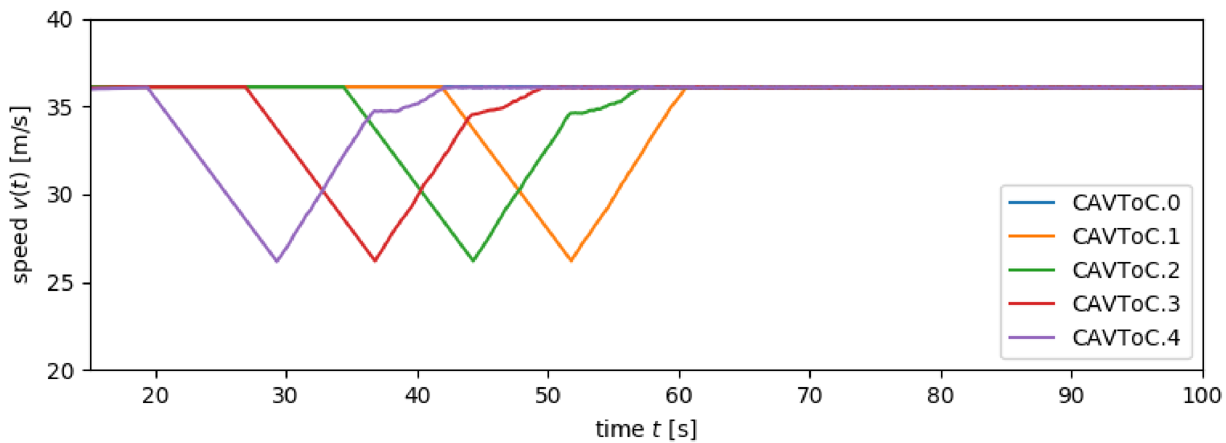




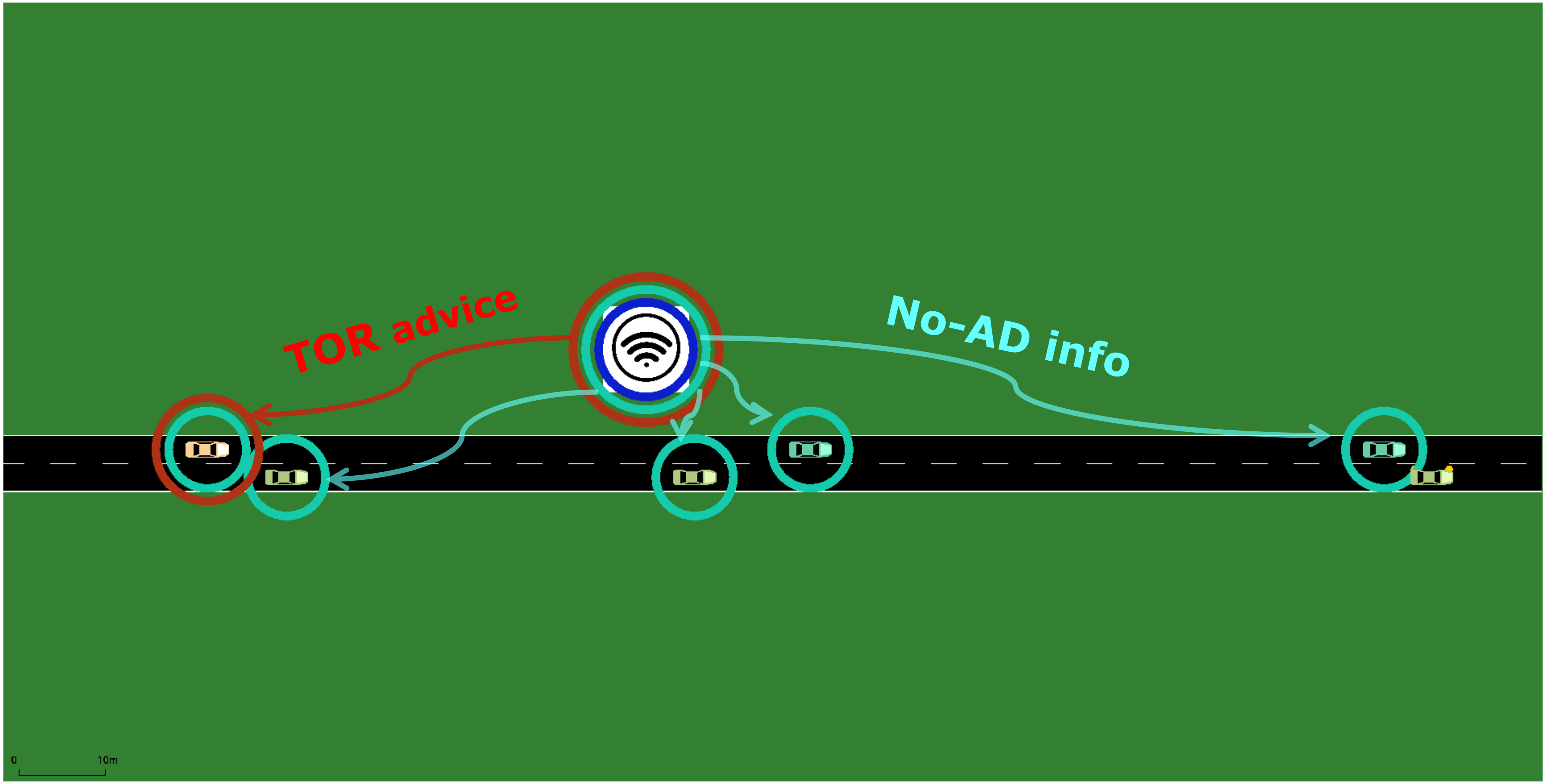
Traffic management in Transition Areas Scenario 2

Service „TOR distribution"





Traffic management in Transition Areas Scenario 2



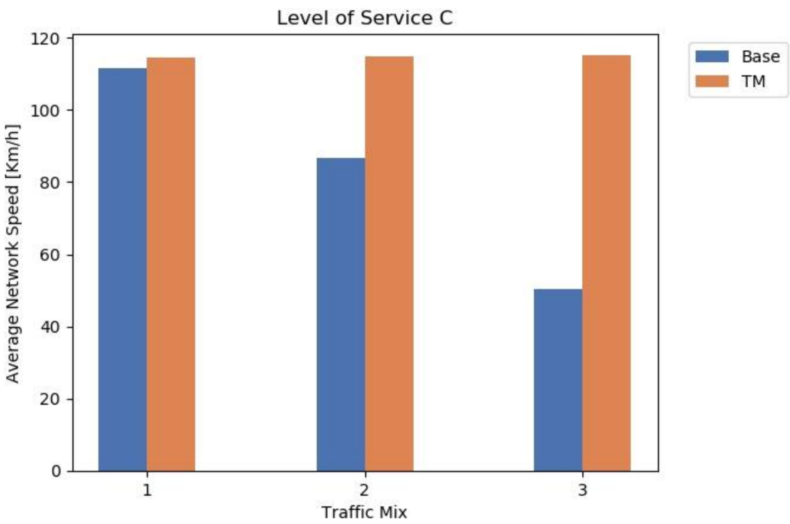
https://sumo.dlr.de/wiki/TraCI/Change_Vehicle_State
https://sumo.dlr.de/wiki/TraCI/Change_PoI_State
https://sumo.dlr.de/wiki/TraCI/Change_Polygon_State

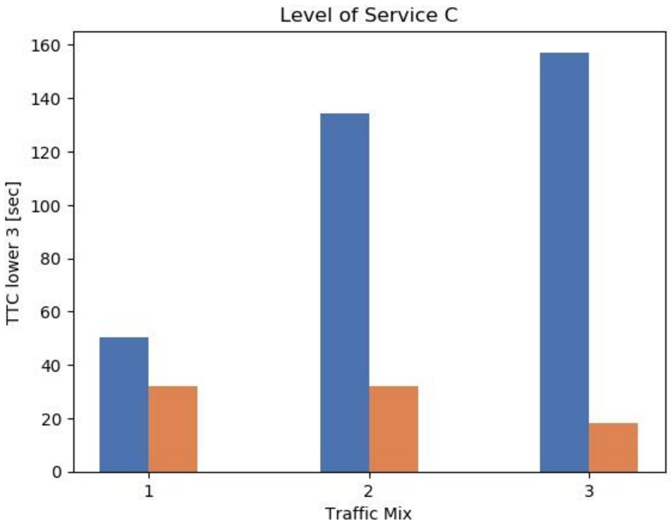
Highlighting & polygon dynamics

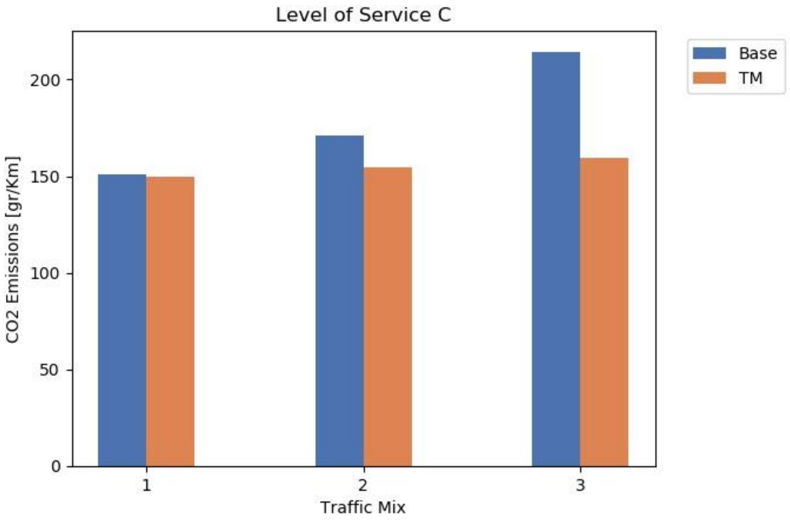
Traffic management in Transition Areas Scenario 2

Results

- 1h random vehicle flow (LoS C ~ 3234 veh/h)
- Fleet mixes (MV-AV):
  mix 1: 70-30
  mix 2: 50-50
  mix 3: 20-80



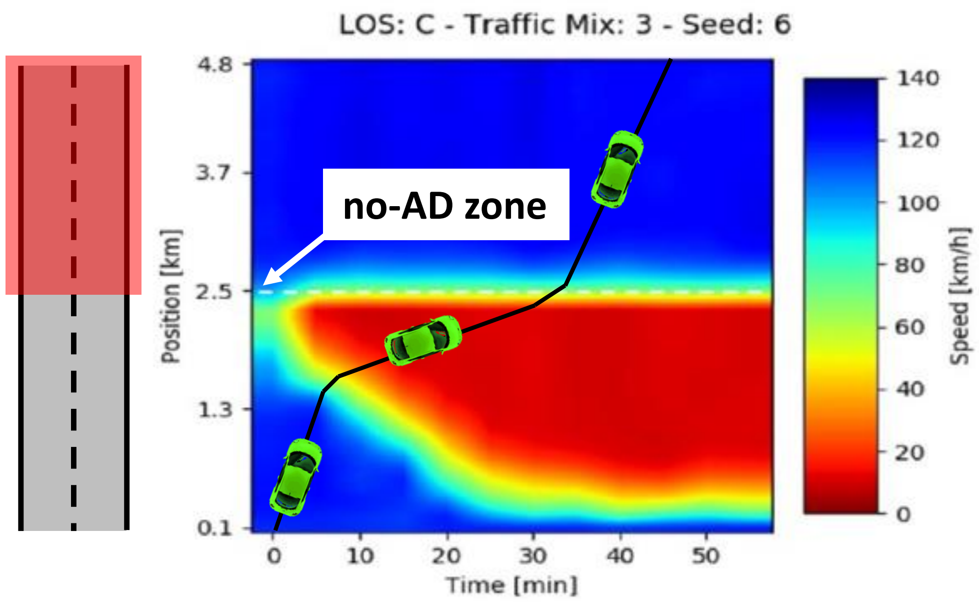




Traffic management in Transition Areas Scenario 2

Results

Without traffic management



Summary

- Models:
  - New models for automated vehicles (CFModels *ACC* + *CACC*)
  - New model for simulation of control transitions
  - Driver State model
- Assessment of TM procedures:
  - Safety improvements for smoother flows at lane drops
  - Reducing perturbances by distribution of ToCs
- Upcoming:
  - Realistic simulation of communications
  - Combination of TransAID Services
  - Real world feasibility assessment

Thank you!

See also:

- Mintsis et al. 2018, *TransAID Deliverable 3.1*
- Maerivoet et al. 2018, *TransAID Deliverable 4.2*

www.transaid.eu

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EU H2020, GNo 723390

Imperfect Driving 1

General CF Model:

$$\dot{x}(t) = v(t)$$

$$\dot{v}(t) = a(\Delta x(t), \Delta v(t))$$

Perceived quantities:

$$\Delta\tilde{x} = \Delta x + \eta_x$$

$$\Delta\tilde{v} = v + \eta_v$$

Erroneous CF Model:

$$\dot{x}(t) = v(t)$$

$$\dot{v}(t) = a(\Delta\tilde{x}(t), \Delta\tilde{v}(t))$$

Imperfect Driving 2

Perception errors:

$$\eta_x(t) = c_x \cdot \Delta x(t) \cdot \mathrm{H}_t$$

$$\eta_v(t) = c_v \cdot \Delta x(t) \cdot \mathrm{H}_t$$

Error base process:

$$d\mathrm{H}_t = -\theta_t \cdot \mathrm{H}_t \cdot dt + \sigma_t \cdot dW_t$$

Base process coefficients:

$$\theta_t = c_\theta \cdot A(t)$$

$$\sigma_t = c_\sigma \cdot \big(1 - A(t)\big)$$

$A(t)$ = „awareness“

Erroneous CF Model:

$$\dot{x}(t) = v(t)$$

$$\dot{v}(t) = a(\Delta\tilde{x}(t), \Delta\tilde{v}(t))$$

Imperfect Driving 3