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Joint Deployment of Infrastructure-Assisted Traffic Management and Cooperative Driving around Work Zones

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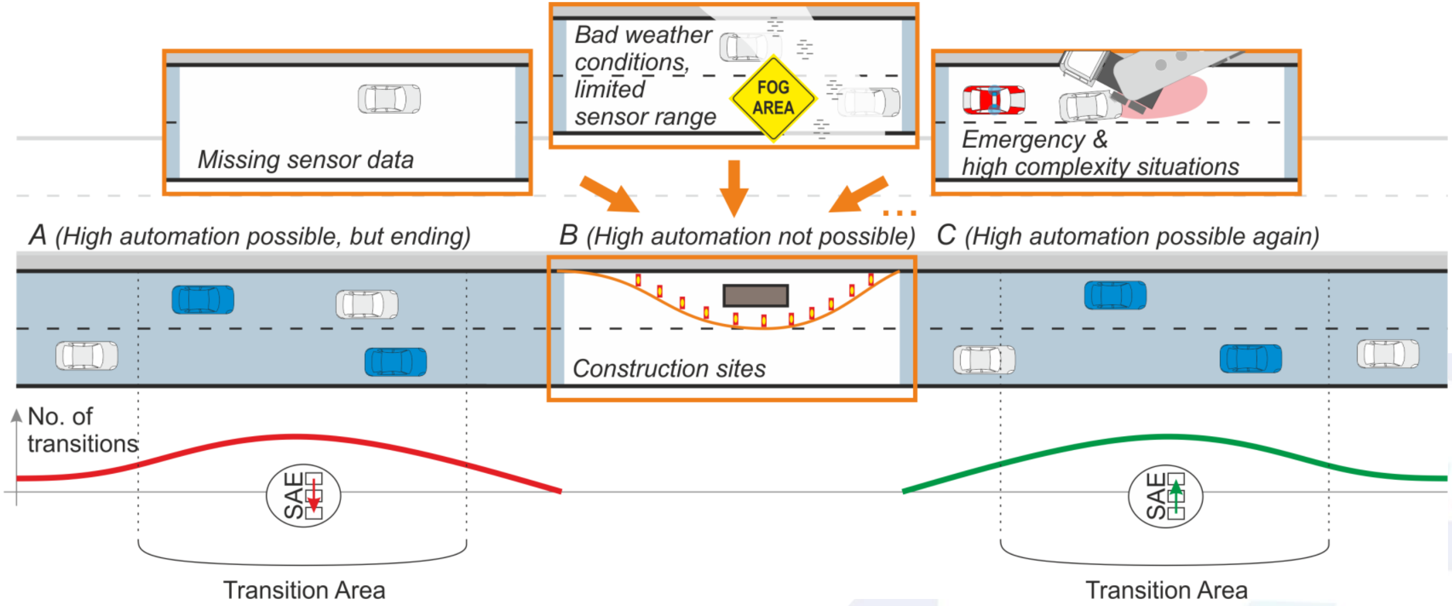
Transition Areas



"Transition Areas" are areas on the road where many highly automated vehicles (blue) are changing their level of automation due to various reasons.

Vehicle/Driver Models for (C)AVs

- **Car-following**
  - Adaptive Cruise Control (ACC)
  - Cooperative Adaptive Cruise Control (CACC)
- **Lane changing**
  - Parametrized SUMO lane change model → Automated Vehicles (AVs)
  - Cooperative lane changing → Cooperative and Automated Vehicles (CAVs)
- **Control Transitions (automated ↔ manual)**
  - Transition of Control (ToC) process → Downward & Upwards transitions
  - Minimum Risk Maneuver → Unsuccessful ToCs

Car-following

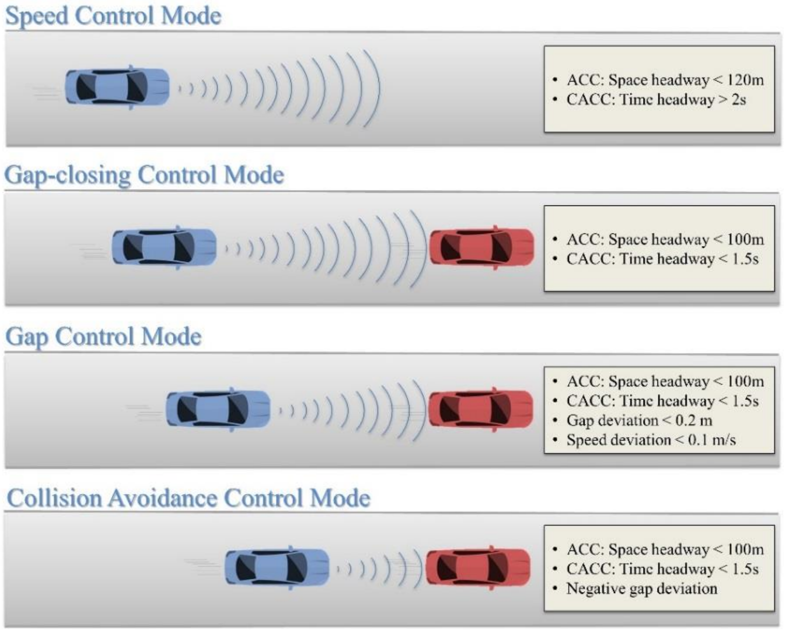
- **(Cooperative) Adaptive Cruise Control – California PATH**

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

ii. **Gap control mode**: aims to maintain a constant space/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.



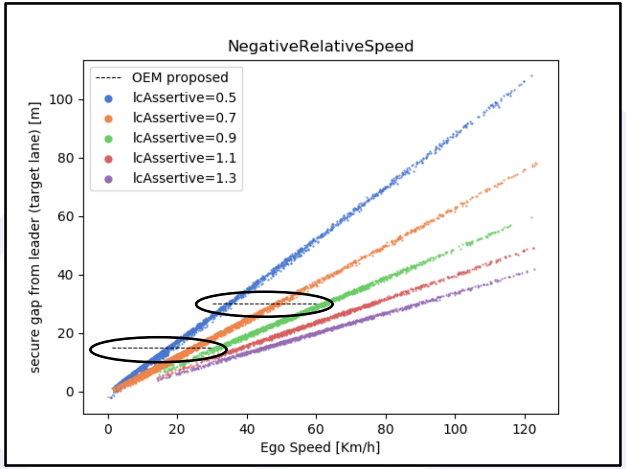
Lane Changing

- **Parametrized SUMO Lane Change Model**

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

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

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 [%]	S_i [%]	ST_i [%]	S_i [%]	ST_i [%]
lcStrategic	0.39	0.62	0.74	2.62	1.14	0.47
lcKeepRight	1.08	0.83	3.32	7.57	1.13	2.26
lcSpeedGain	0.90	8.12	10.92	22.26	0.77	1.37
lcAssertive	59.15	77.03	61.26	80.17	91.40	95.56

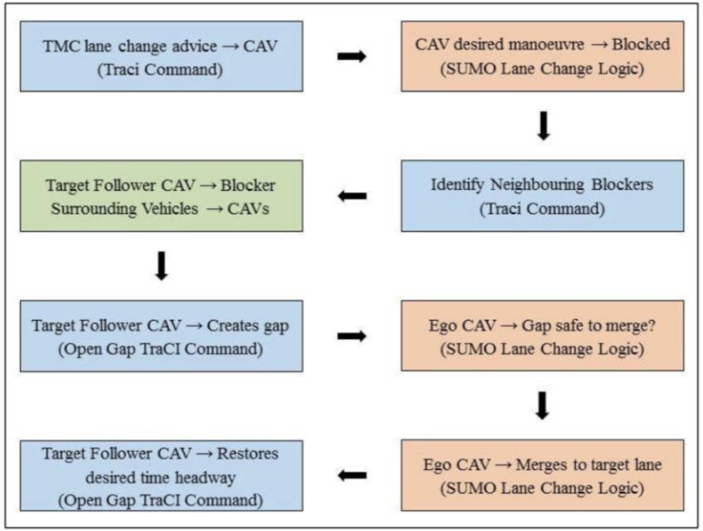


Cooperative Lane Changing

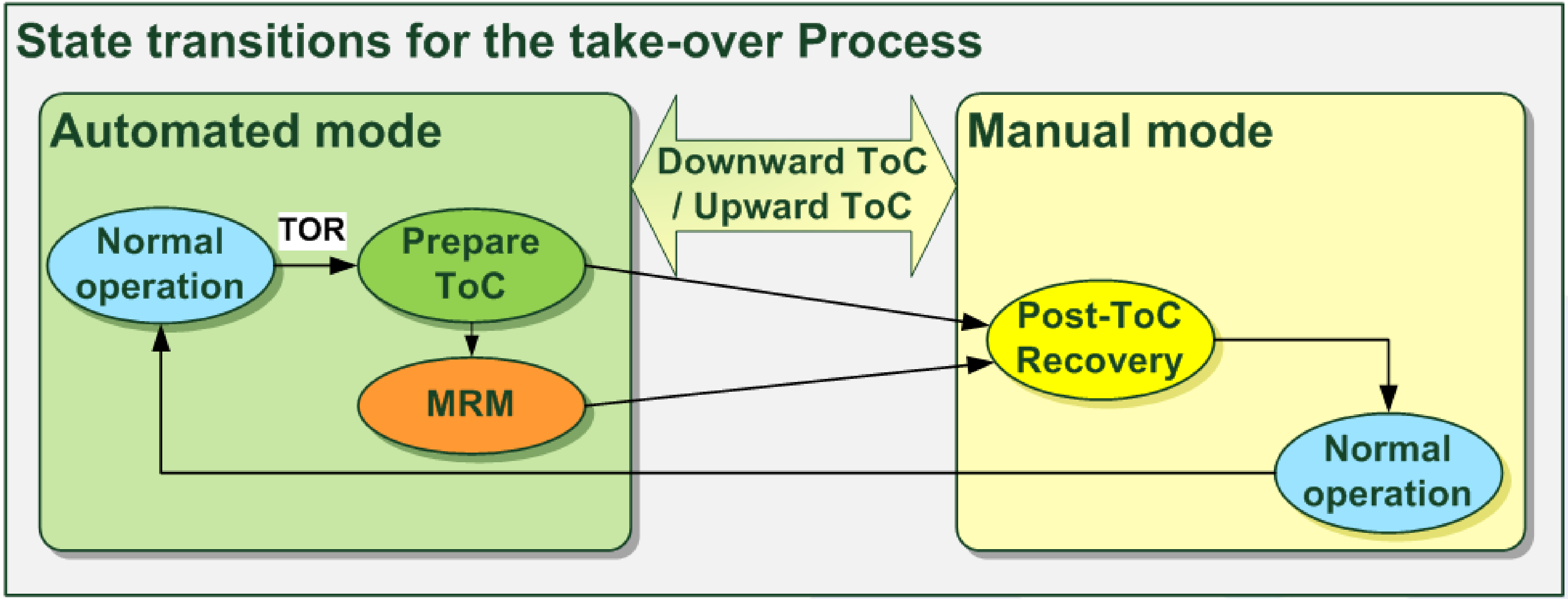
- Decentralized approach
- Cooperation between ego CAV & target follower CAV → **Gap Creation**
- **openGap TraCI function** → https://sumo.dlr.de/wiki/TraCI/Change_Vehicle_State#open_gap_.280x16.29

Open Gap Function

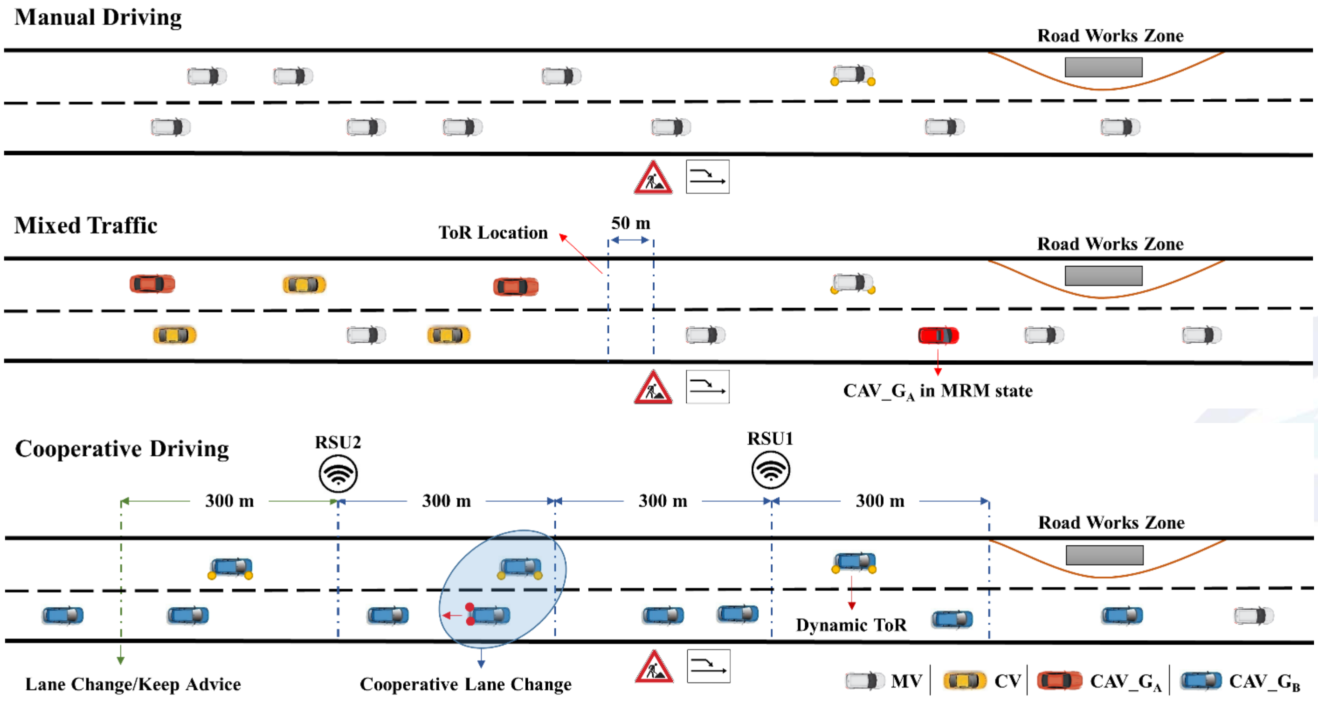
Parameter Name	Value	Description
newTimeHeadway	4 s	The vehicle's desired time headway will be changed to the given new value with use of the given change rate.
newSpaceHeadway	15 s	The vehicle is commanded to keep the increased headway for the given duration once its target value is attained.
duration	5 s	The time period in which the time and space headways will be changed to the given new values.
changeRate	0.5	The rate at which the new headways' effectiveness is gradually increased.
maxDecel	1 m/s^2	The maximal value for the deceleration employed to establish the desired new headways.
referenceVehicleID	ID #	The ID of the reference vehicle.



Control Transitions



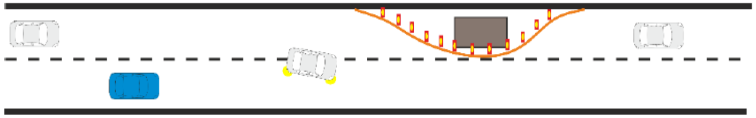
Simulation Scenarios



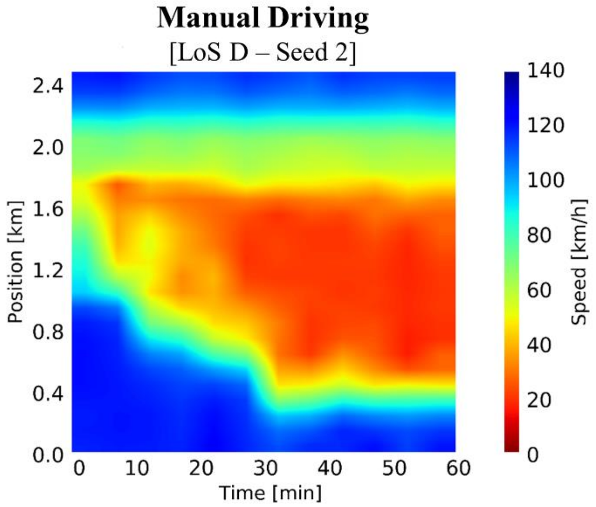
Scenario Name	Vehicle Type			
	MV	CV	CAV_G$_A$	CAV_G$_B$
Manual Driving	100 %	0 %	0 %	0 %
Mixed Traffic	50 %	25 %	25 %	0 %
Cooperative Driving	0 %	0 %	0 %	100 %

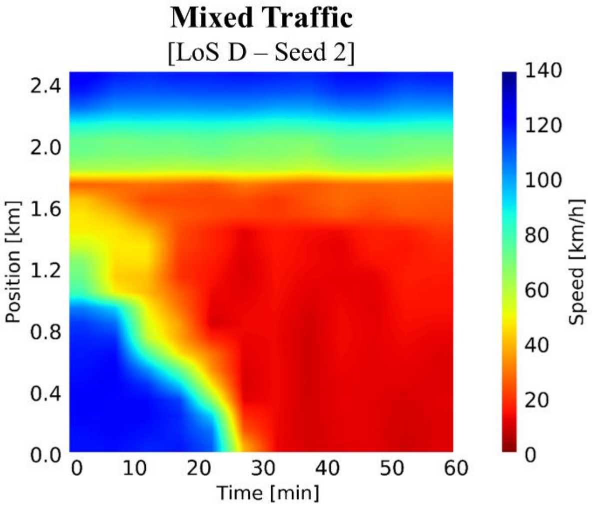
Results

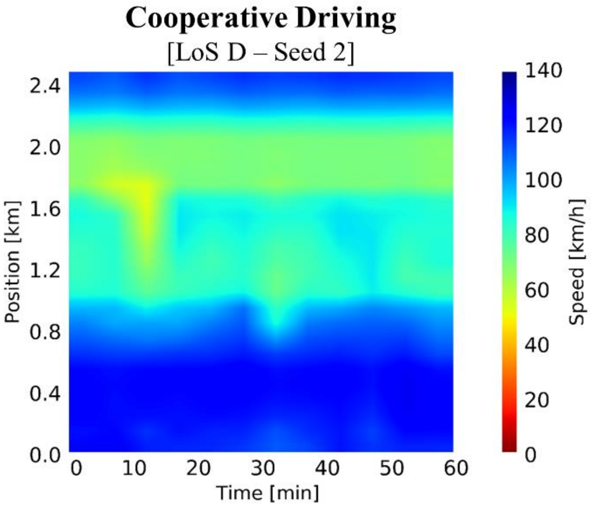
- **Work Zone Use Case** → Motorway Network



➢ **Impacts of vehicle disengagements on Traffic Efficiency**

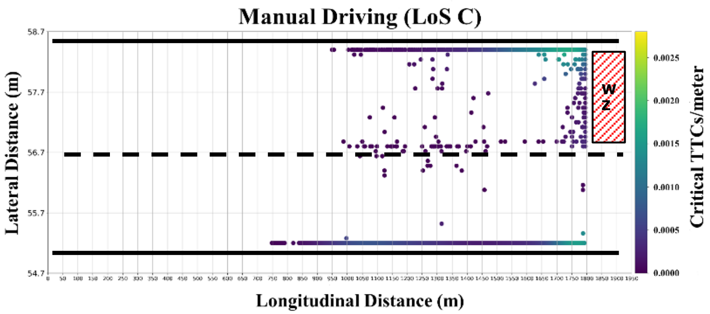


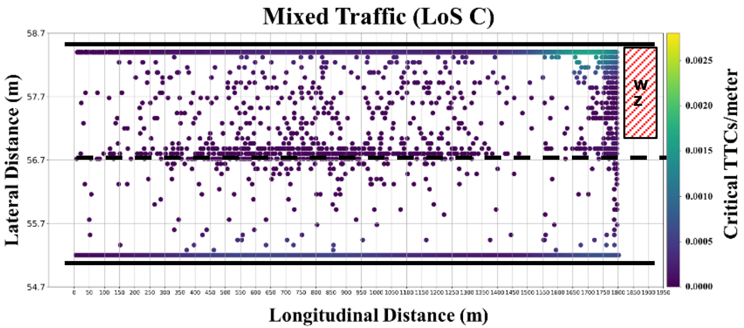


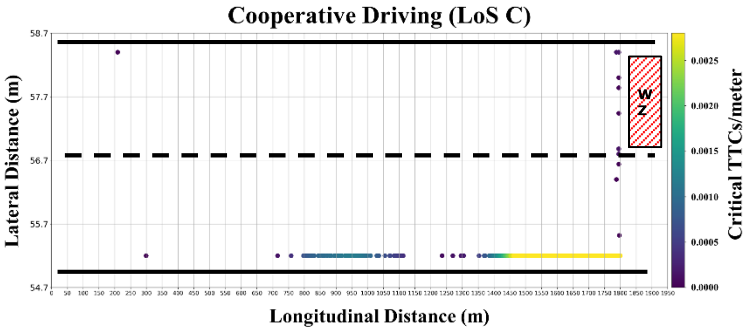


Results (cont'd)

- **Impacts of vehicle disengagements on** **Conflict Risk** → Critical Events: Time-to-Collision ≤ 1.5 sec







Conclusions / Research Outlook

- **Mixed Traffic Conditions → Congestion/High Conflict Risk**
  - ➢ when multiple ToCs/MRMs take place and traffic management measures are not deployed (even for low demand scenarios)
  - ➢ higher traffic disruption and conflict risk compared to manual driving
- **Cooperative Driving + Infra-assisted Management**
  - ➢ prevention of traffic breakdown
  - ➢ Low Conflict Risk
- **Mixed Traffic + Day 1 C-ITS Applications**
- **Guidance of MRMs to safe spots**
- **Heavy/Light Goods Vehicles in the fleet mix**

Thank you for your kind attention!

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