



**Motorway merging assistant for
automated vehicles**

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Evoluon Congress Center
Helmond Automotive Campus

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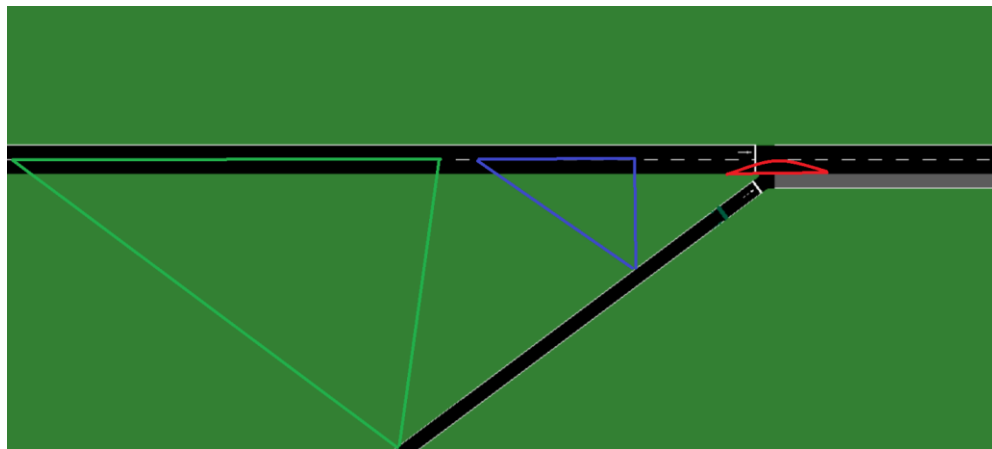
Acknowledgement:

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Problem definition

- Automated vehicles have limited sensory view:
- Transition of Control (ToC) required to guarantee safety
- With infrastructure guidance more information can be used than for human controlled vehicles

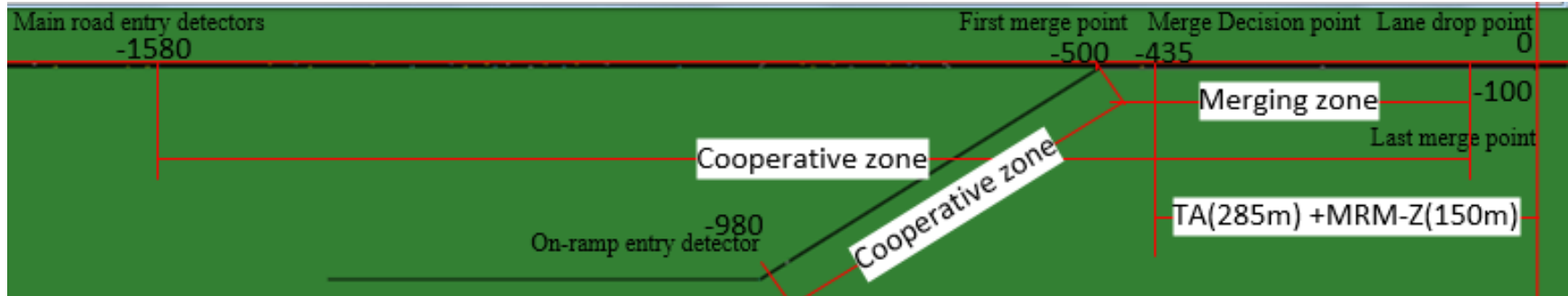


Literature solutions

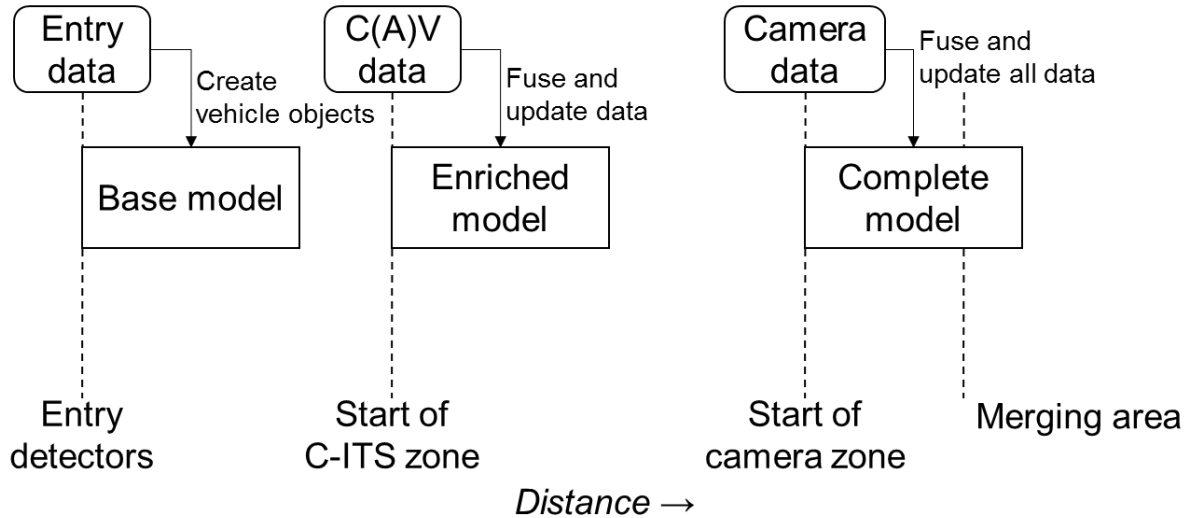
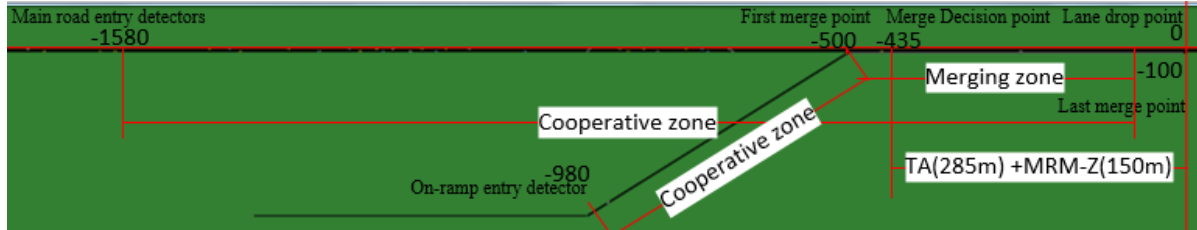
- Ramp meters like ALINEA control on a macro level:
 - $r(k) = r(k - 1) + K_R[\hat{o} - o_{out(k)}]$
 - Volume as a function of occupancy
- Lots of work requiring 100% equipment rate:
 - 1960s work on linear optimal regulator problem
 - Decentralized approach
 - Slot based approach
 - First In First Out (FIFO) principle
- Other work on lane change behaviour
 - Only for imminent lane changes

Algorithm development

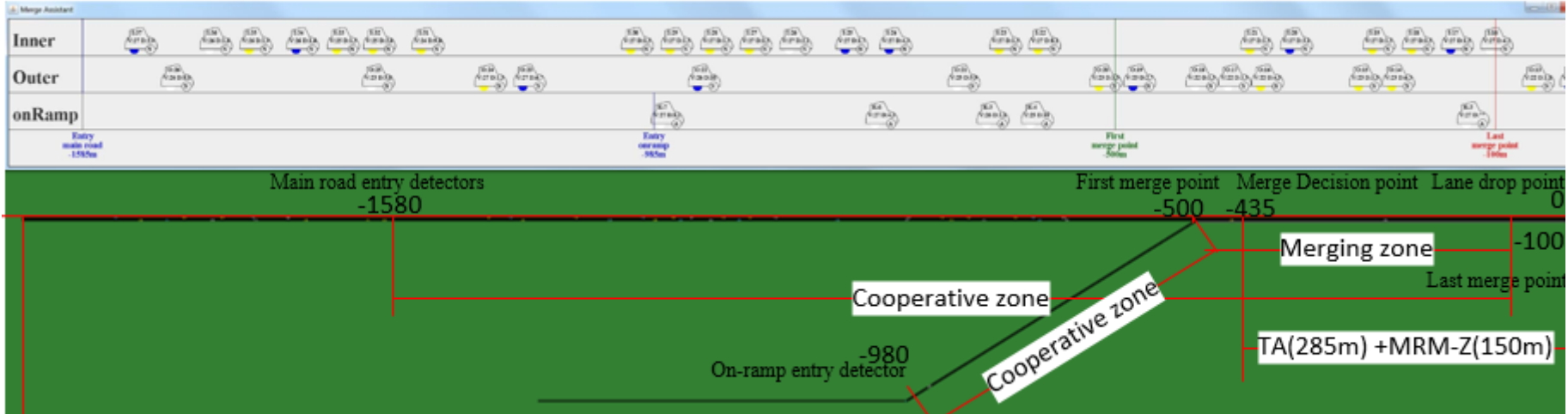
- Clear need for new micro-model based algorithm for on-ramp guidance
- Backbone of the solution is an approach model
- Based on model status advice is calculated
- C(A)V follow advice and are guided to optimal area to merge



Approach model



Approach model



Solutions

1. ToC and MRM fail-safe
2. Merging guidance - onramp
3. Lane advice on the mainline left lane
4. Cooperative speed advice for gap creation
5. Cooperative lane advice for gap creation
6. Intelligent ramp metering

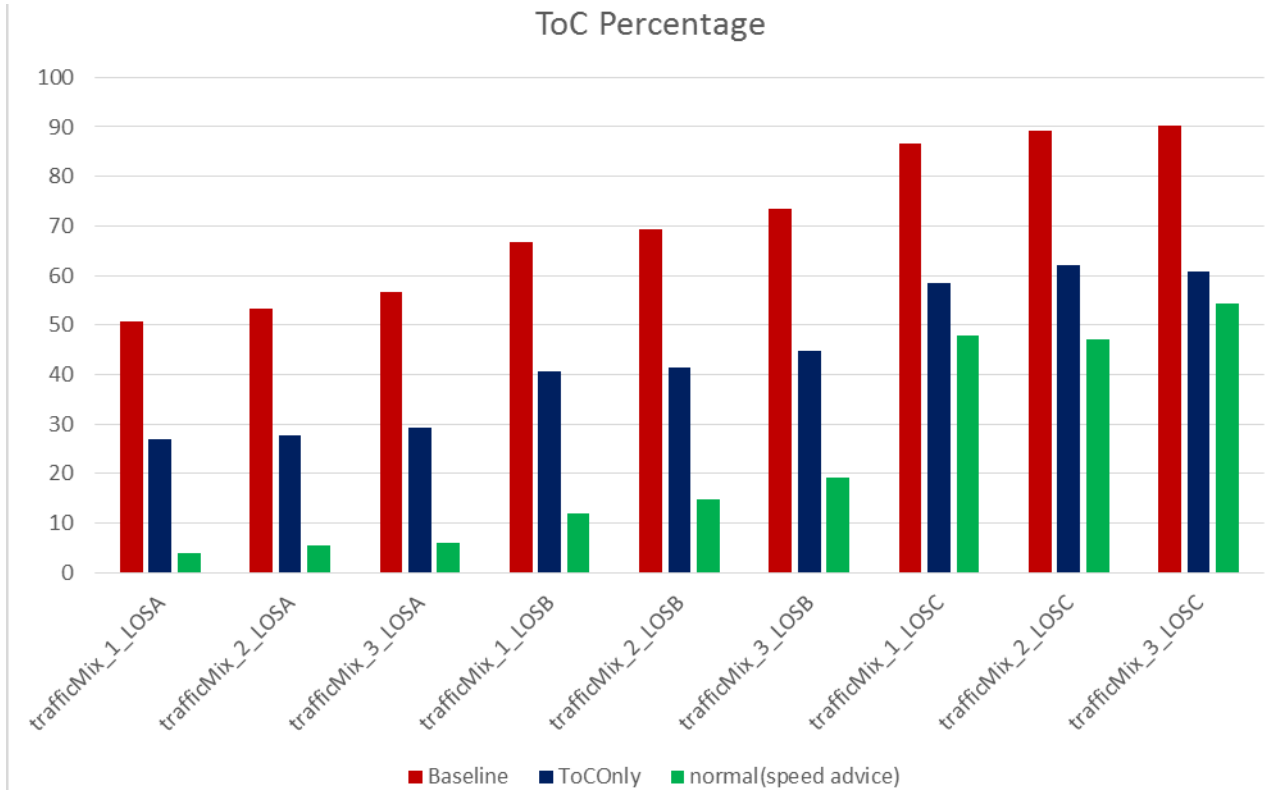
Simulation scenarios

Facility Type	Capacity (veh/h/l)	Level of Service (LOS)		
		A	B	C
On-ramp (100km/h)	1650 veh/h/l	462	726	1056
	Capacity (IC or VC) ratio	0.28	0.44	0.64
Motorway (100 km/h)	2000 veh/h/l	600	960	1400
	Capacity (IC or VC) ratio	0.3	0.48	0.7

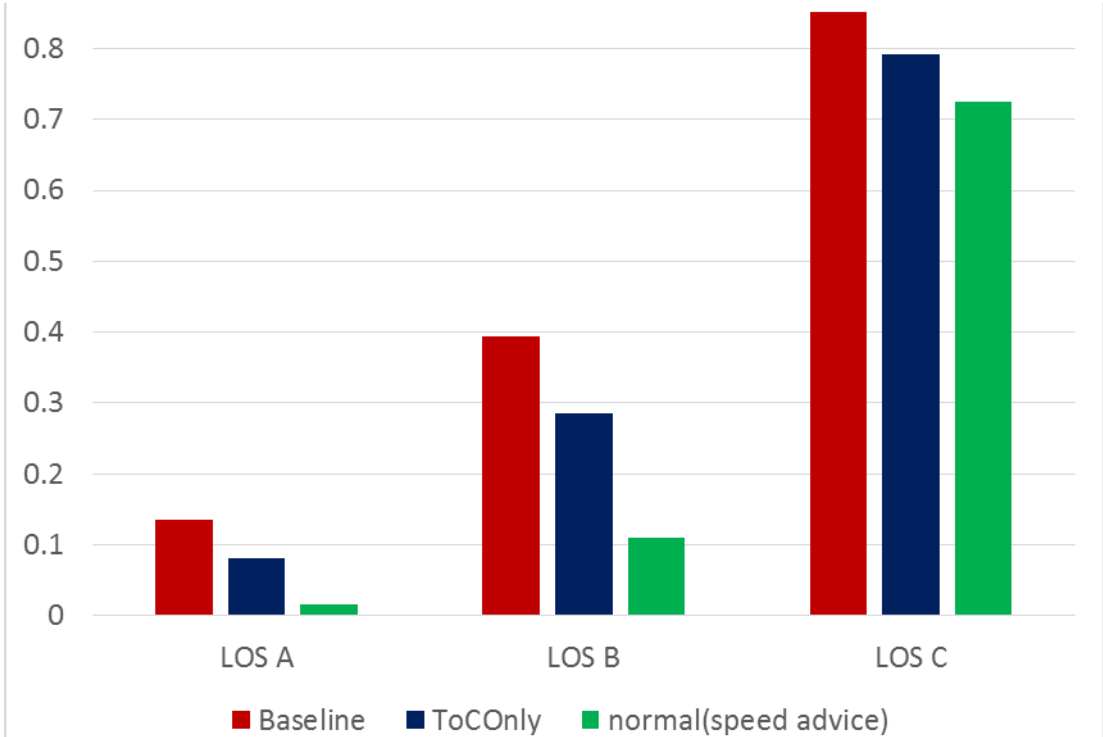
Fleet mix	Legacy Vehicle	Cooperative	Automated
1	70	15	15
2	50	25	25
3	20	40	40

Results ToC

ToC Percentage

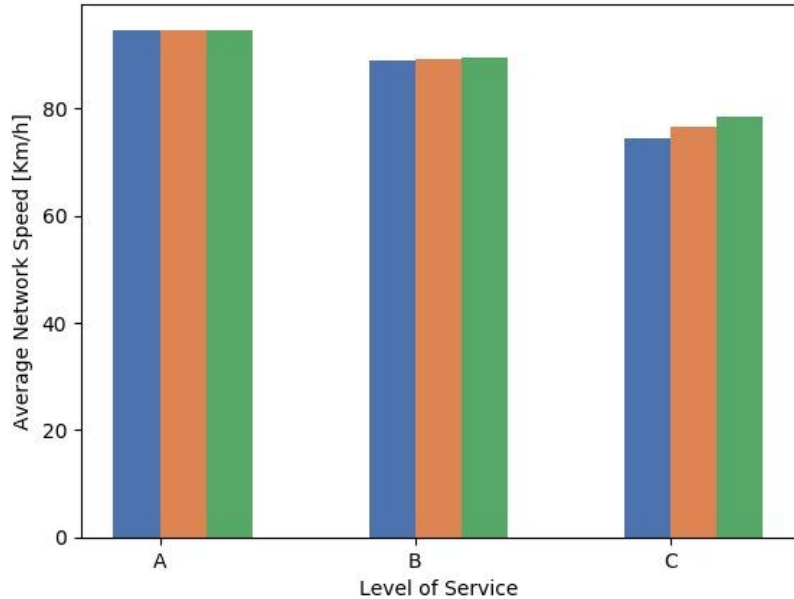


Results Stops (mix 1)

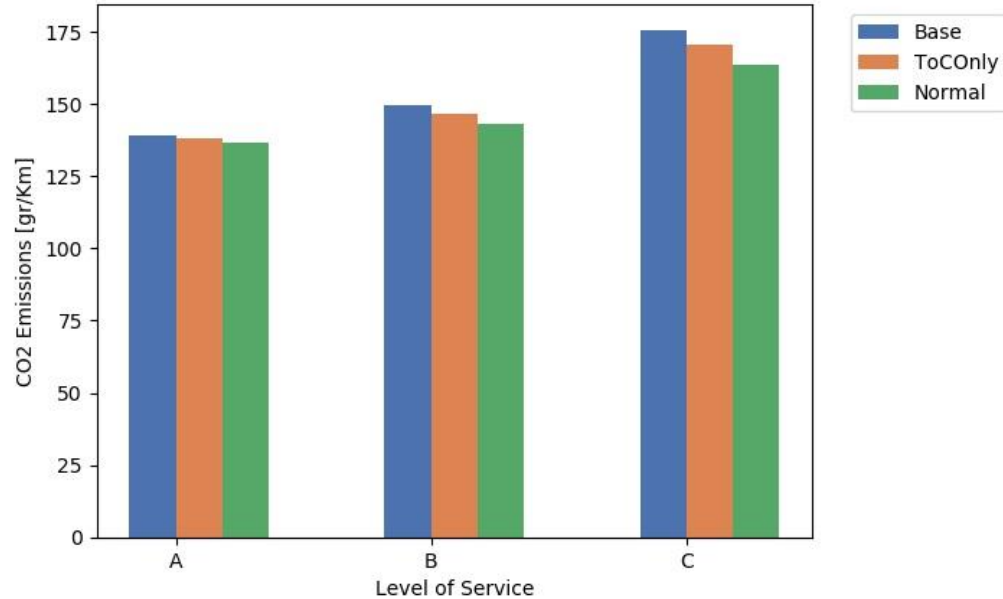


Results speed and CO₂ (mix 1)

Traffic Mix 1



Traffic Mix 1



Conclusion

- System can handle any degree of penetration
- 92% ToC reduction
- 87% stops reduction
- 7.3% CO₂ reduction

- Future work to add main road guidance and ramp metering