Assessment of automated driving to design infrastructure-assisted driving at transition areas

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Impact Assessment

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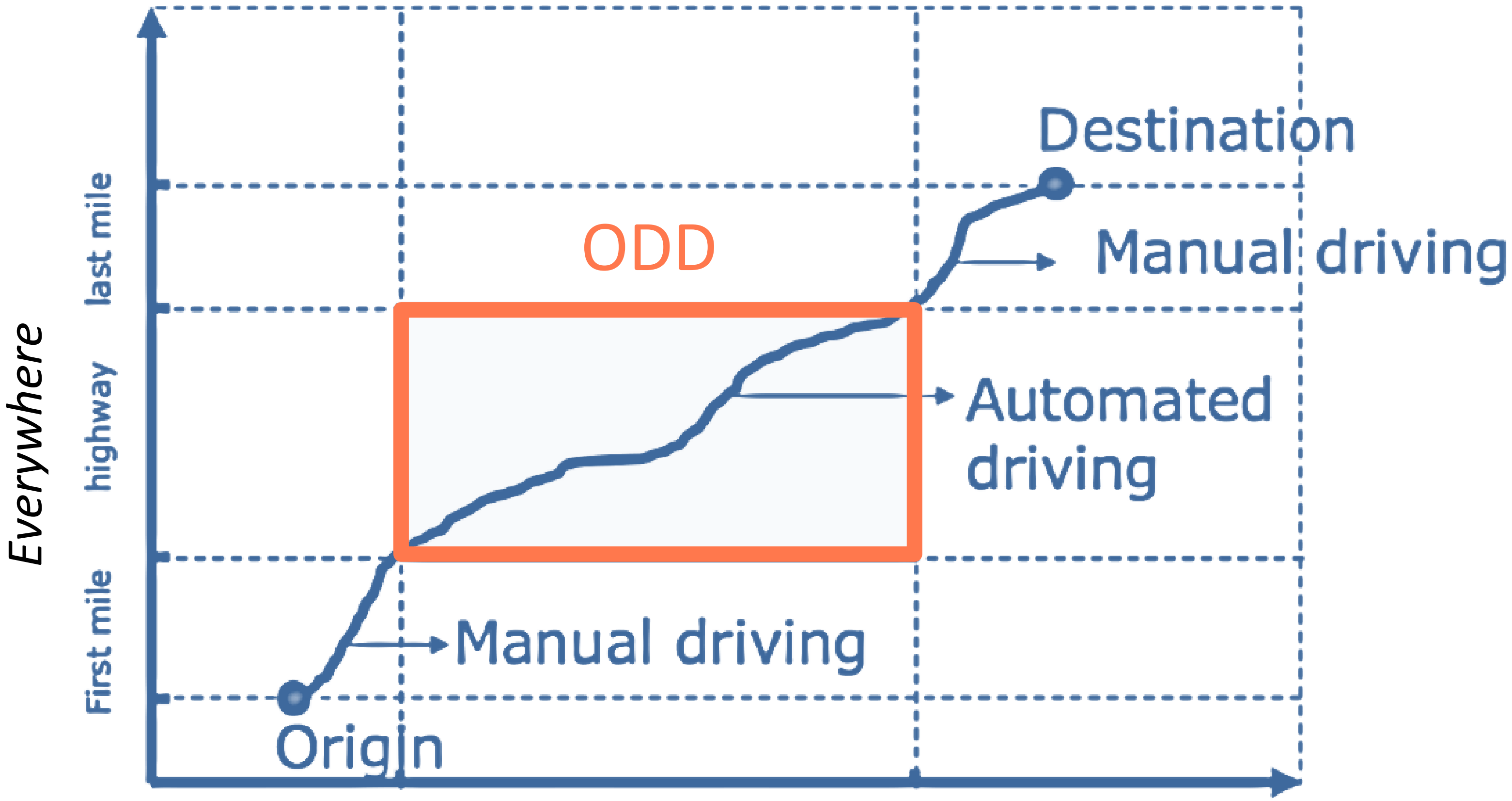
Operational Design Domain (ODD)



Tom Alkim, Rijkswaterstaat, 2017

Always & All conditions

Vehicle capabilities

x

Geographical domain

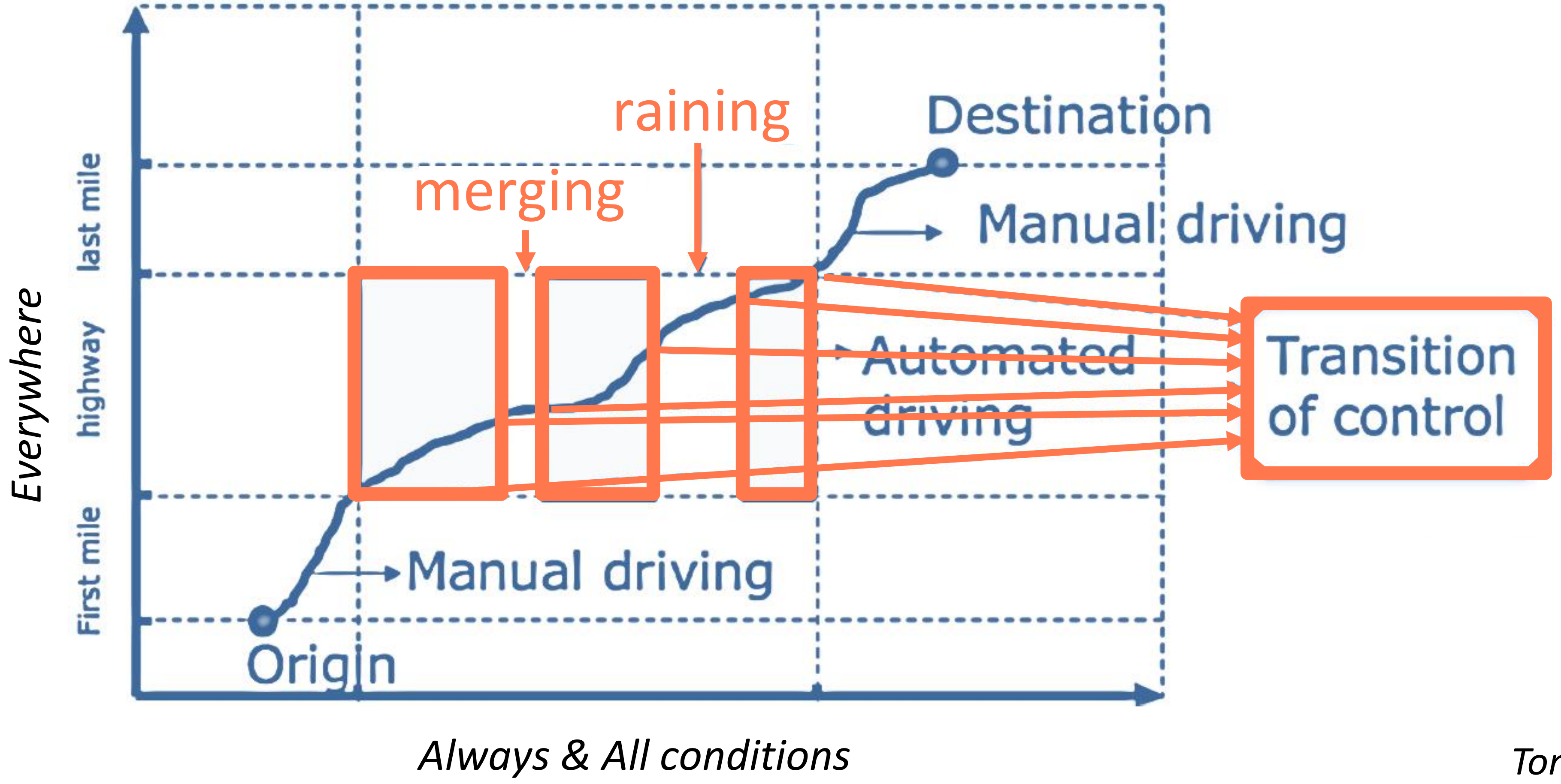
x

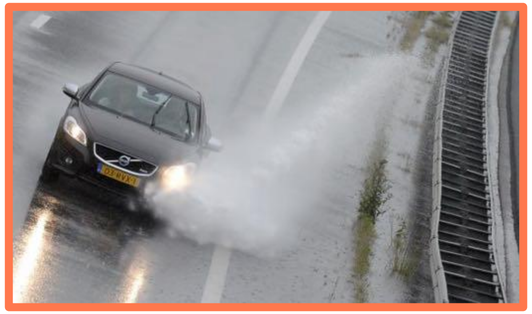
Traffic & situational environment

=

ODD

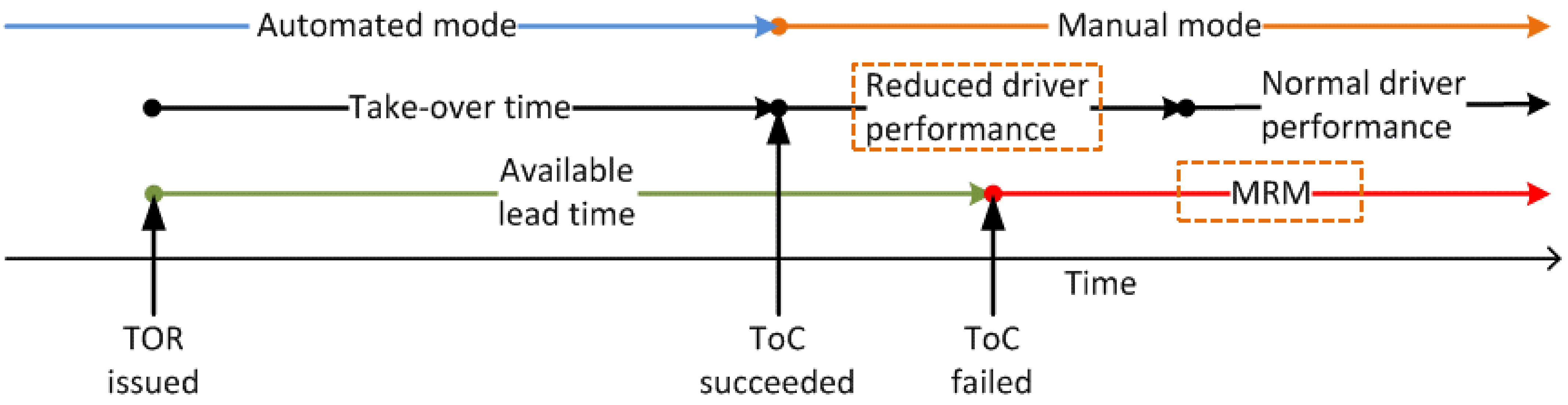
ODD >> ToC / MRM >> Transition areas (TAs)





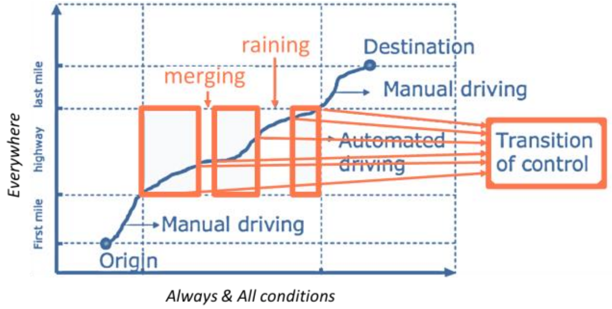
Tom Alkim, Rijkswaterstaat, 2017

ToC and MRM process (deactivations)



MRM minimum risk condition = stop or park safely

ODD >> ToC / MRM >> TAs >> capacity & flow problems



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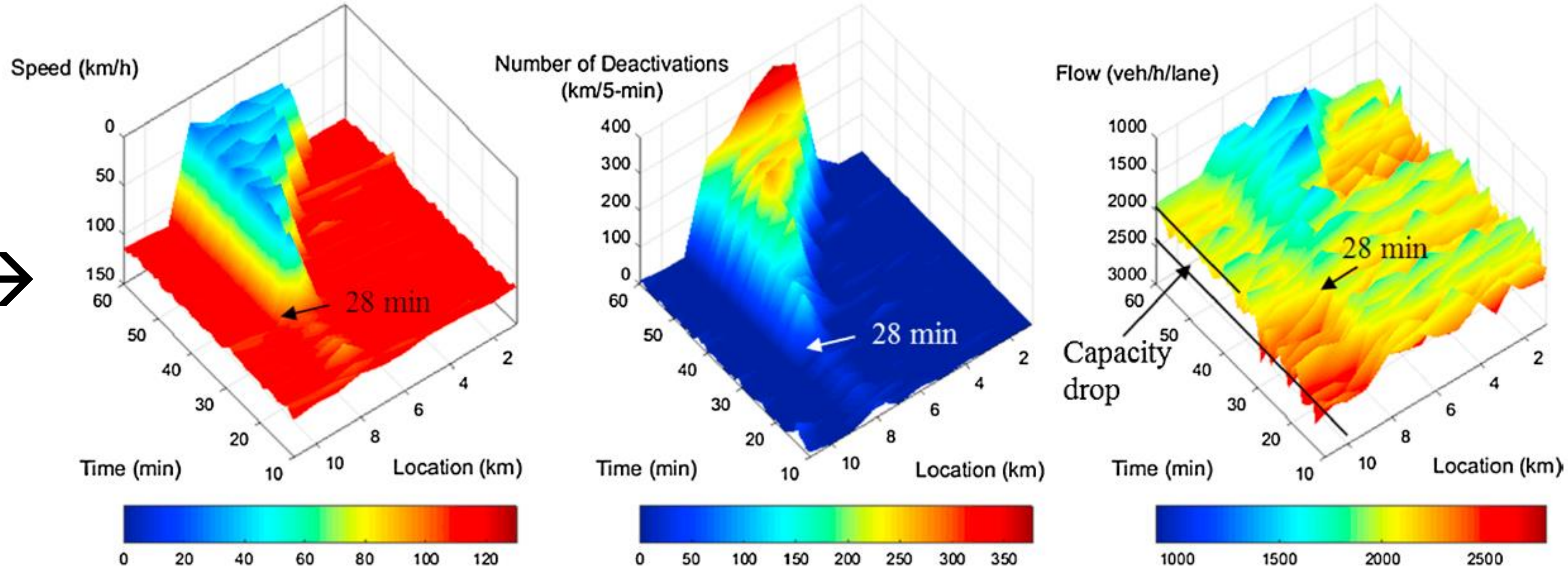
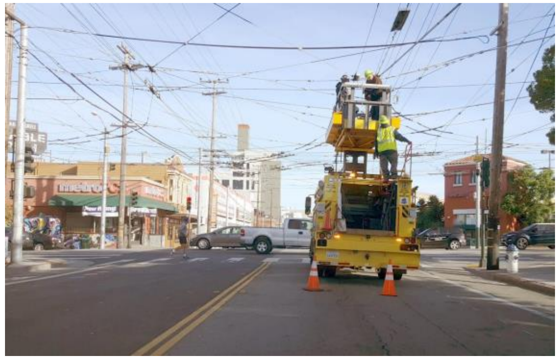


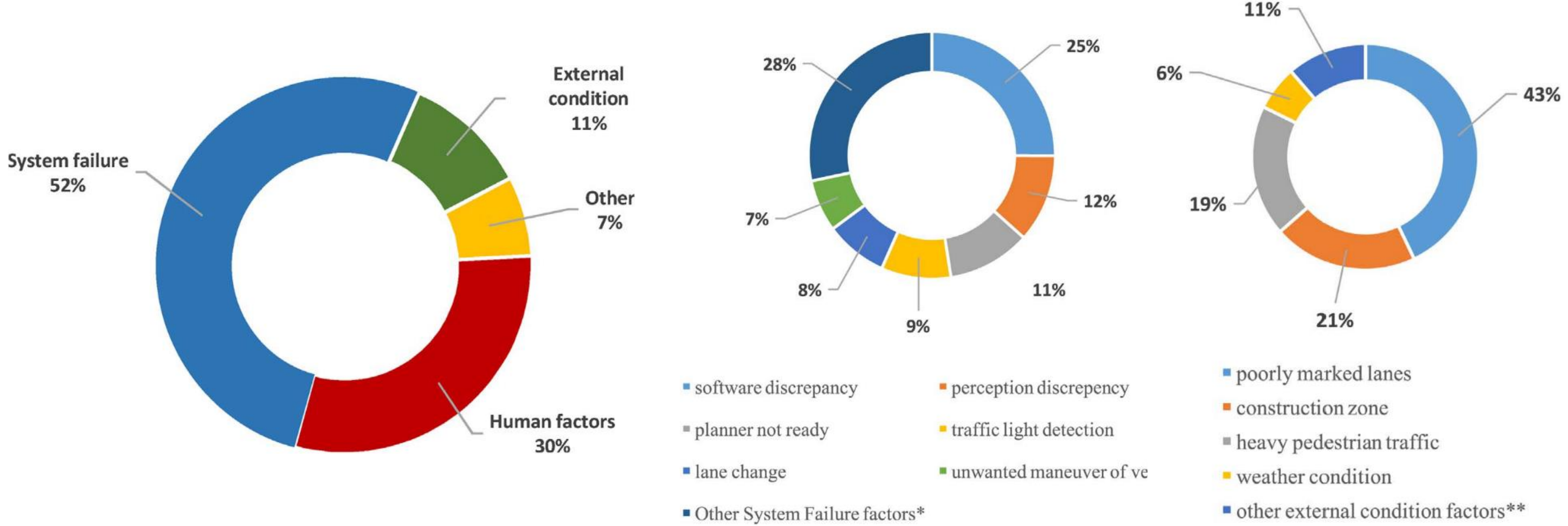
Xiao, L., Wang, M., Schakel, W., & van Arem, B. (2018). Unravelling effects of cooperative adaptive cruise control deactivation on traffic flow characteristics at merging bottlenecks. Transportation Research Part C: Emerging Technologies, 96, 380-397.

When, where, why?

permanent - transient static/dynamic - highly dynamic



What we know from the field



Favaro et al. (2017), Autonomous vehicles' disengagements: Trends, triggers, and regulatory limitations, Accident Analysis & Prevention, Vol. 110, pp. 136-148

I2V infrastructure support

Vehicle capabilities (A)
x
Geographical domain (B)
x
Traffic & situational environment (C)
=
ODD

- B + C = A ODD: OK
- B + C ≠ A ODD: NOK
- B + C = A + ? ODD: OK?

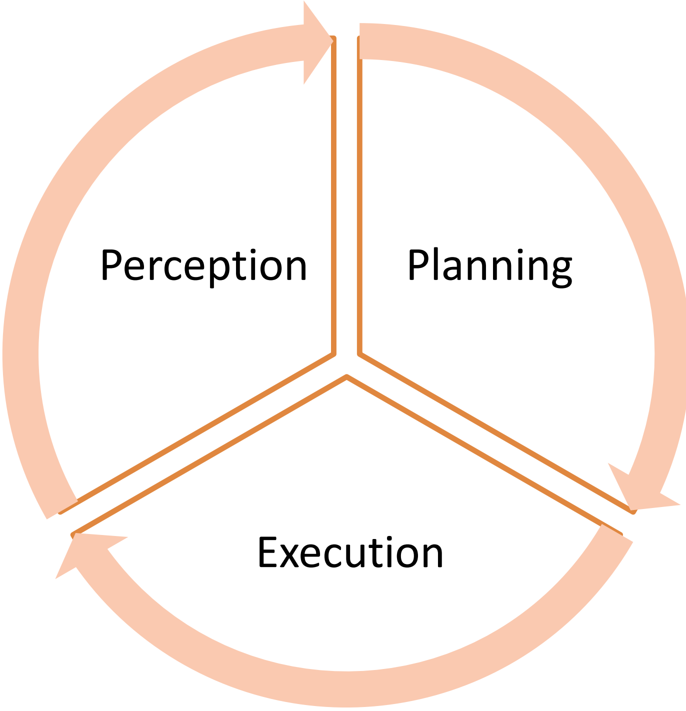
➢ ? = digital connected traffic management

Project overview

- TransAID (ART-05)
- Transition Areas for Infrastructure-Assisted Driving
- 01-09-2017 ~ 31-08-2020
- Budget: EUR 3.836.353,75
- Seven partners from 6 countries: DE, UK, BE, NL, EL, ES
- Website: www.transaid.eu

Identifying needs

- Vehicle logic:
  - Sense and build environmental awareness
  - Ability to determine action(s)
  - Ability to perform action(s)

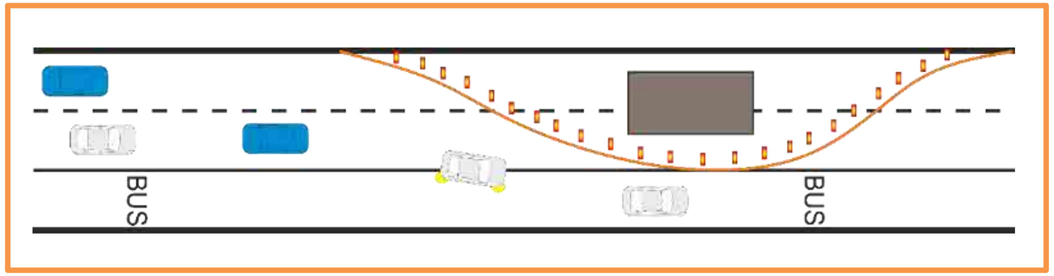


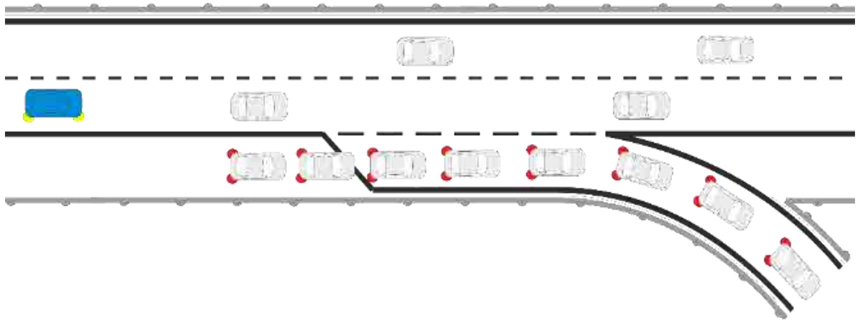
Identifying I2V / TM support measures

- Vehicle logic:
  - Sense and build environmental awareness
    - Situational support: provide information
  - Ability to determine action(s)
    - Operational support: provide an (alternative) action
  - Ability to perform action(s)
    - Tactical support: arrange favourable conditions

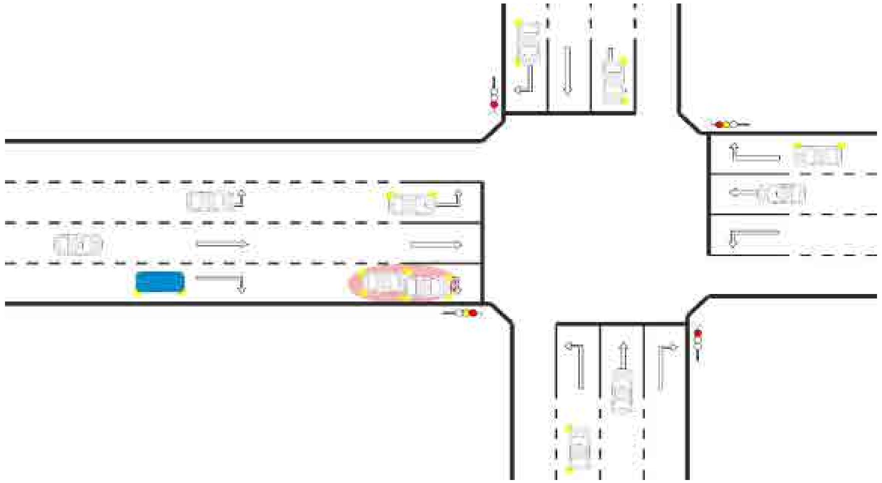
Used in simulation study (upcoming slides)

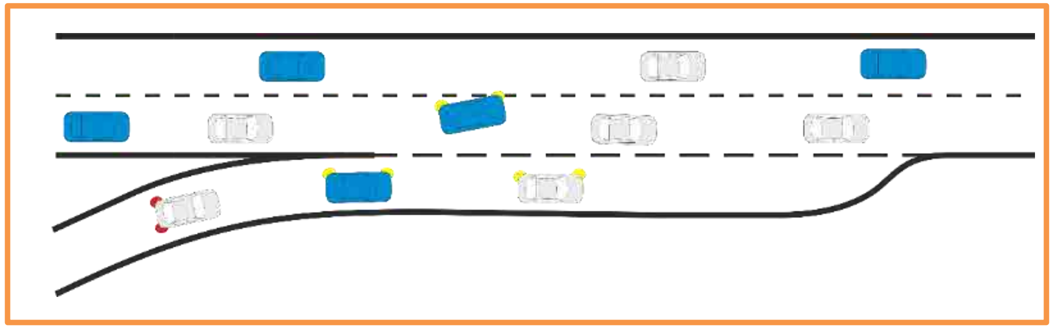
- Service 1: Prevent ToC/MRM by **providing vehicle path information**





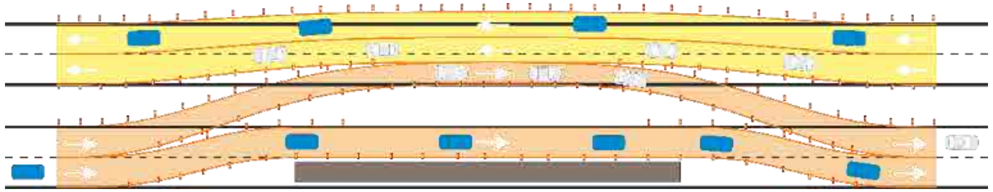
- Service 2: Prevent ToC/MRM by **providing speed, headway and/or lane advice**

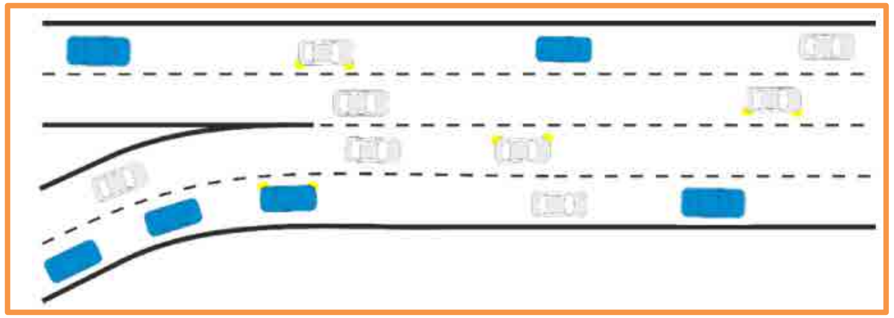




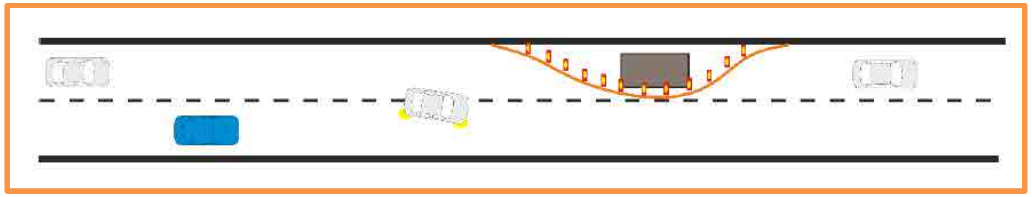
Used in simulation study (upcoming slides)

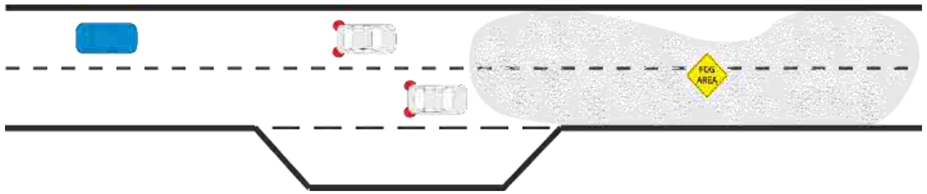
- Service 3: Prevent ToC/MRM by **traffic separation**



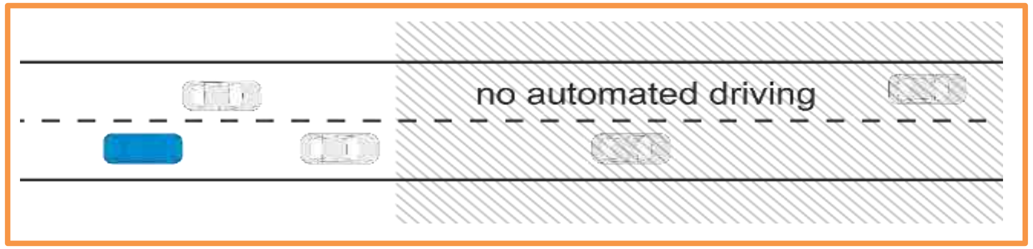


- Service 4: Manage MRM by **guidance to safe spot**





- Service 5: Distribute ToC/MRM by **scheduling ToCs**



Simulation task

- Step 1: determine baseline situation.
- *What is the impact of ToC / MRM without traffic management measures?*

- SUMO simulation software (which includes PHEMlite emission model).
- ACC model adopted from previous studies[1,2], with few modifications.
- Parametrised SUMO's default lane change model.

1. Xiao, L., Wang, M., & van Arem, B. (2017). Realistic Car-Following Models for Microscopic Simulation of Adaptive and Cooperative Adaptive Cruise Control Vehicles. Transportation Research Record: Journal of the Transportation Research Board, 2623, 1–9. https://doi.org/10.3141/2623-01

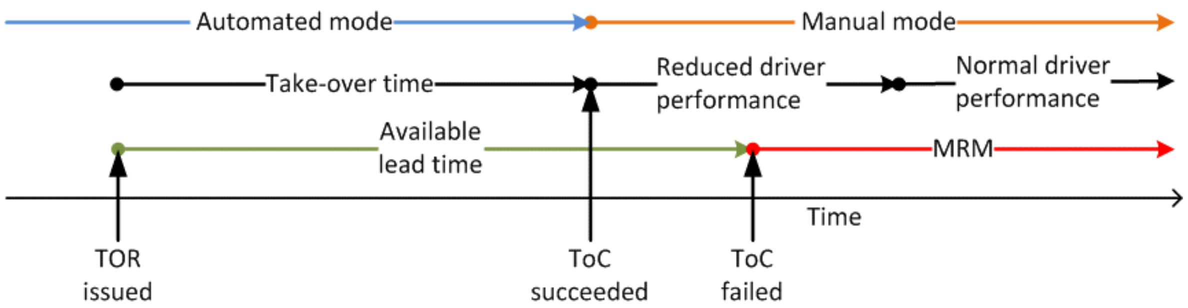
2. Liu, H., Kan, X., Wei, D., Chou, F.-C., Shladover, S. E., & Lu, X.-Y. (2018). Using Cooperative Adaptive Cruise Control (CACC) to Form High-Performance Vehicle Streams - Microscopic Traffic Modeling (FHWA Exploratory Advanced Research Program No. Cooperative Agreement No. DTFH61-13-H-00013). University of California, Berkeley: California PATH Program.

ToC model implementation

- Definition reduced driver performance: random decline in awareness causing ‘perception errors’ (mainly speed and headway) with certain awareness recovery rate. MRM full stop not included in this project iteration cycle.

- Assumption ToC frequency: 75% at predefined locations in each scenario.

- http://sumo.dlr.de/wiki/ToC_Device



Simulation setup

- Traffic demand: LoS A, B & C
- Vehicle Mix :
  - 70% manual, 15% partial AD, 15% high AD
  - 50% manual, 25% partial AD, 25% high AD
  - 20% manual, 40% partial AD, 40% high AD
- Light vehicles only and no connectivity.

Driver model parameters

Driver Model	Parameter Name	SUMO Parameter
ACC (Longitudinal Motion)	Desired time headway	tau
Sub-lane (Lateral Motion)	Desired longitudinal gaps	$lcAssertive$
	Driver response time	$responseTime$
ToC/MRM	Post ToC driver performance	$initialAwareness$
	ToC likelihood (internal and external factors)	$responseTime$ $timeTillMRM$

- For each parameter, classification:
  - Value = high, moderate, low
  - With behaviour = conservative, moderate, aggressive
  - And effect on safety and efficiency: negative, neutral, positive

Five schemes to test a range of behaviours

Parametrization Scheme	ACC Desired time headway	Lane Change Desired longitudinal gaps	ToC/MRM Driver response time	ToC/MRM Post ToC driver performance	ToC/MRM MRM likelihood
Pessimistic Efficiency (PE)	Large	Large	Long	Low	High
Pessimistic Safety (PS)	Small	Short	Long	Low	High
Moderate Safety and Efficiency (MSE)	Moderate	Moderate	Moderate	Moderate	Moderate
Optimistic Efficiency (OE)	Small	Short	Short	High	Low
Optimistic Safety (OS)	Large	Large	Short	High	Low

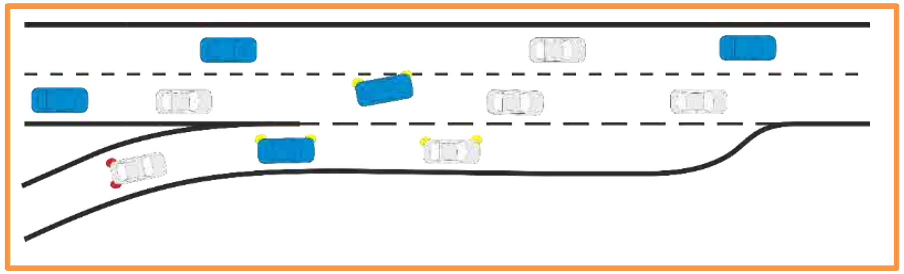
Simulation setup summary

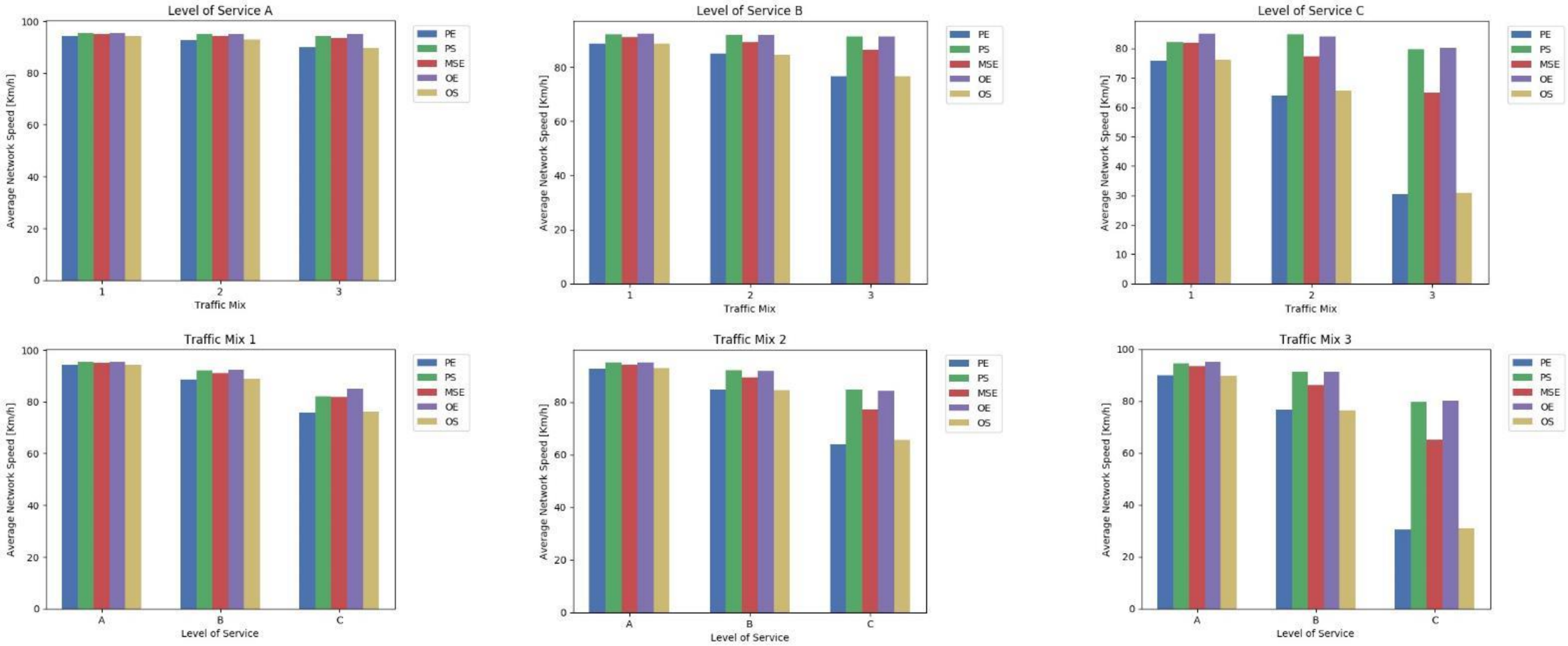
- 3 demand levels
- 3 vehicle mixes
- 5 parameter schemes
- 5 networks

= 225 scenarios

KPI Name
Average network speed
Space-mean speed
Total Number of Lane Changes
Time-to-collision (TTC)
CO_2 emissions (gr)/km

Results (example)





https://www.transaid.eu/wp-content/uploads/2017/Deliverables/WP3/TransAID_D3.1_Modelling-simulation-and-assessment-of-vehicle-automations.pdf

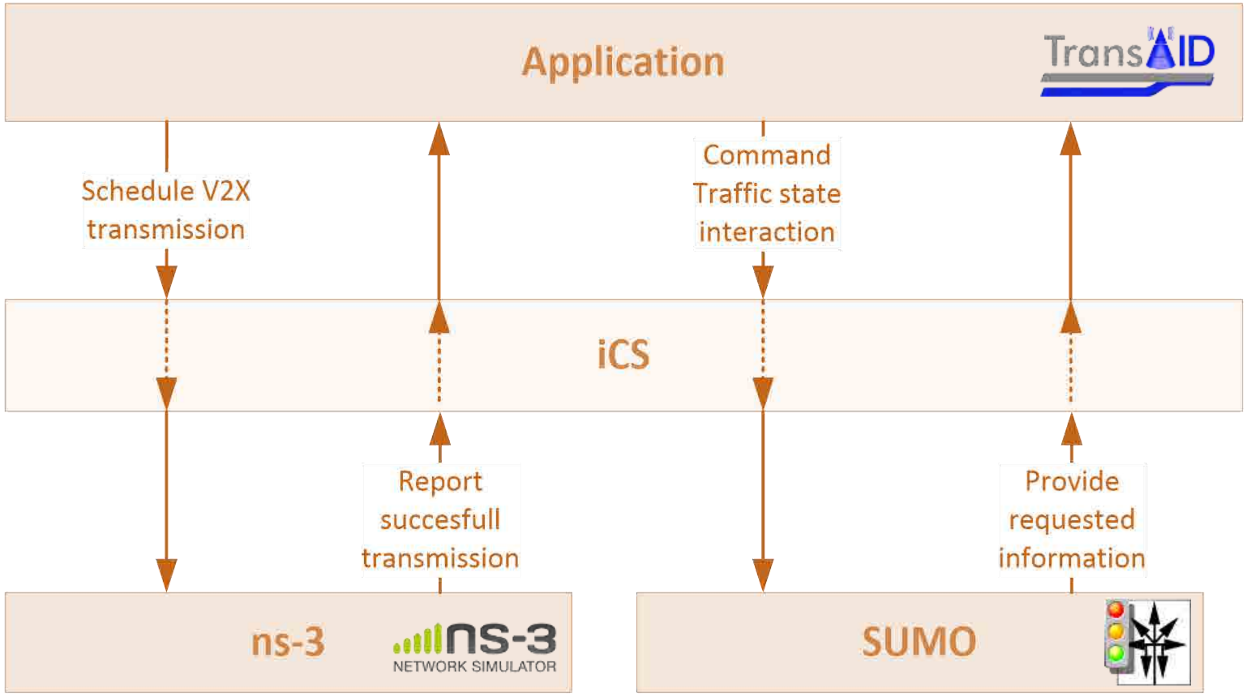
Main findings

- Work provided first theoretical understanding, especially of the spectrum.
- By comparison of schemes, lane change behaviour is the dominant factor.
- Decrease of safety with increase of AD (conservative driving causes inability to merge, thereby sudden braking).
- Impact of ToC/MRM most disadvantageous at lane drop scenario, therefore merge and/or lane advice measures seem to be promising.
- Schemes with similar results are those with similar driver model settings.
- As such, ToC/MRM in current form has little impact on traffic operations.

- (C)ACC and LC models require further calibration (esp. for selected situations).
- ToC model needs to be more situational aware, thereby more realistic.

Future work

- Driver model calibration.
- Study time-space diagrams.
- ToC model enhancement: dynamic rules for ToC activation.
- Add effects of connectivity.
- Add other networks.
- Configure traffic management measures.
- Include simulation of wireless communication.



- Last but not least: data from AD field observations and tests is needed.

EU collaboration - challenges

INFRAMIX

Road infrastructure support levels

TransAID

I2V TM at Transition Areas

I2V services for automated driving

MAVEN

Traffic control and I2V negotiation

CoEXist

Automation-readiness of infrastructure

Mutual work items

- Role of traffic management
- I2V communication
- City authority involvement
- Modelling and simulation

Harmonise simulation activities?

- Driver model parameters
- Vehicle types & mix
- Networks
- KPI's

Thank you for listening! Are there any questions?

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