# Traffic Management and Automated Driving

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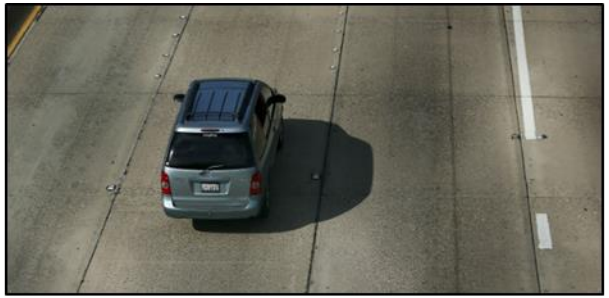
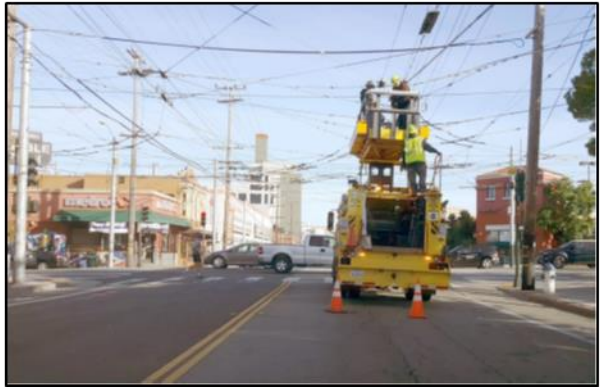
# Background

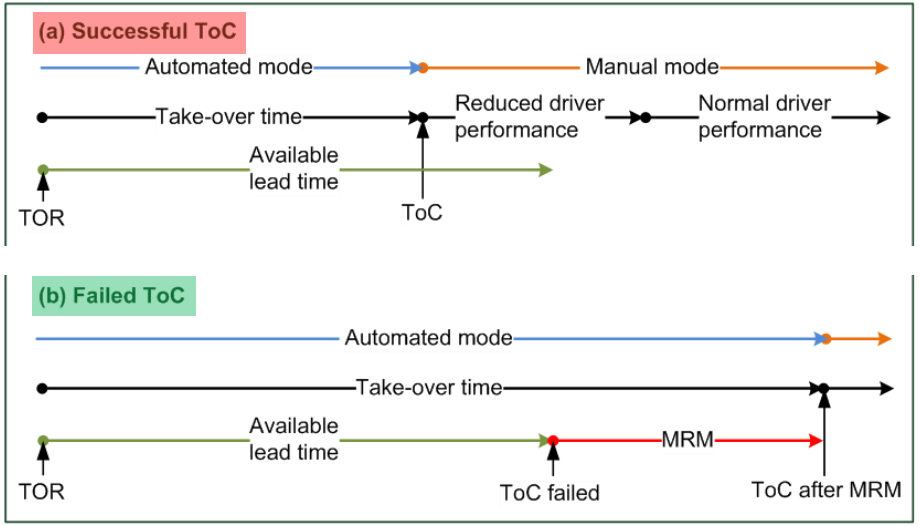
# Situations in which (C)AVs may struggle



# Sequence of events when AD disengages

- Take-over request (**TOR**) issued by the car
- Transition of Control (**ToC**) from car to driver
- Minimum-Risk Maneuver (**MRM**) by the car



# Cooperative management as a solution

- Different SAE levels, (C)AVs, legacy vehicles, … share the road
- Missing sensor inputs, highly complex situations, adverse weather conditions, …
  - Current limitations of automated driving may require a change of level

  ➡ **Transition Areas**
- The EC's Horizon 2020 TransAID project ('18-'20) focuses on:
  - Realistic driver/vehicle behaviour and V2X communications
  - Hierarchical traffic management procedures for transition areas
  - Field tests in The Netherlands and Germany
  - Guidelines and roadmap for stakeholders (OEMs, authorities, cities, …)

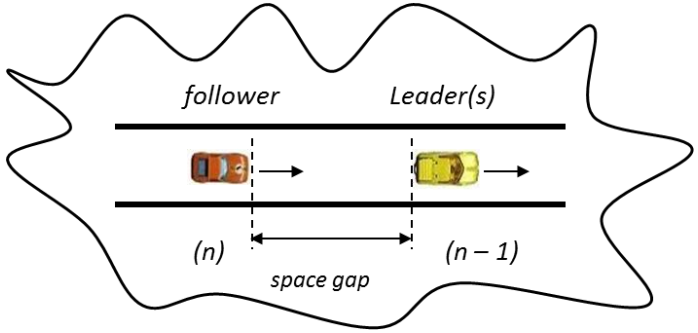
# Modelling Automated Driving

# Microscopic traffic flow modelling

- Describe explicitly the interactions of vehicles in a traffic stream (seems more realistic)
- Low aggregation, high level of detail

**Car-following model**

- Stimulus-response
- Optimal velocity
- Psycho-physical distance
- Cellular automata
- Queueing theory




**Lane-choice model**

- Gap-acceptance
- Mandatory versus discretionary lane change

- Submicroscopic flow models encompass physical characteristics such as engine performance, gear shifting, ... and human decisions (non-strategic)

# When SimCity is made by traffic engineers

*Source: Pixabay*
*(Cities: Skylines, 2019)μμ*

# Cooperative adaptive cruise-control and lane-changing

Speed Control Mode


Gap-closing Control Mode

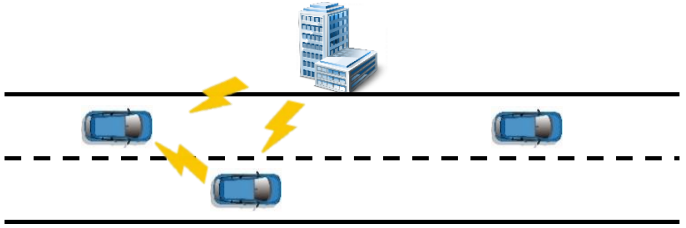

Gap Control Mode


Collision Avoidance Control Mode

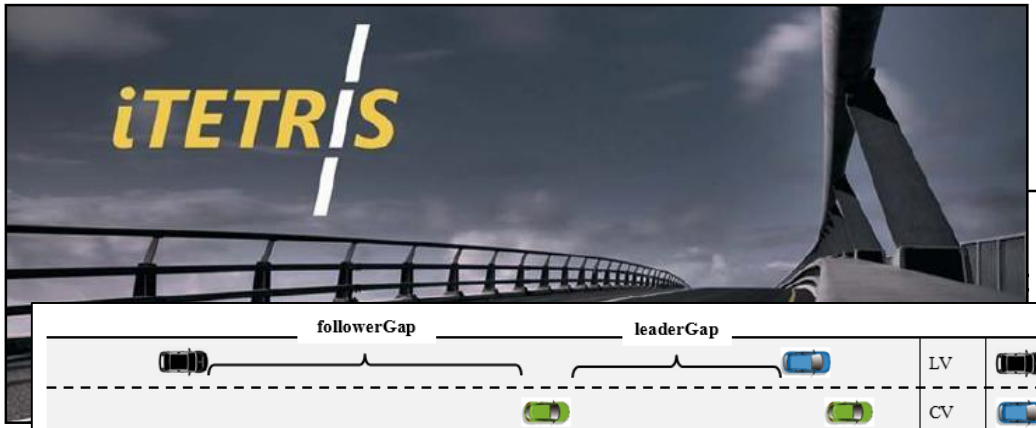

*Difference between platooning and clustering!*

## Centralized Approach

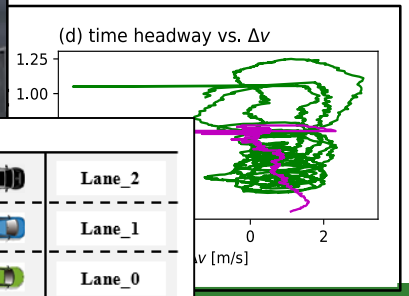
- Enhanced Perception
- Global Coordination
- Optimal Performance
- V2X Communication

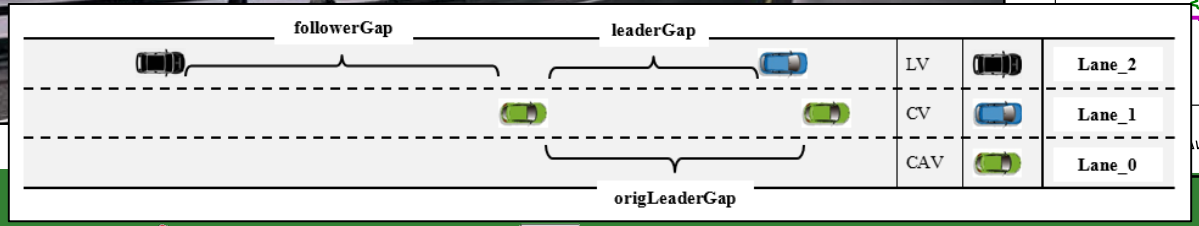


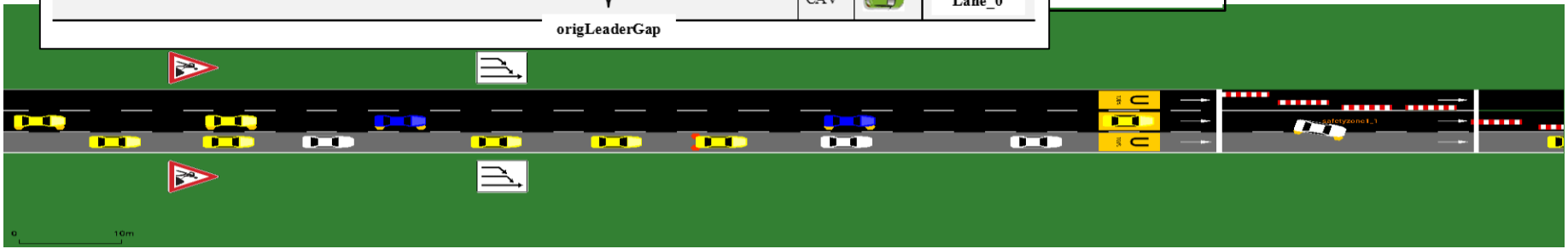
# TransAID's simulation environment




SUMO
Simulation of Urban MObility



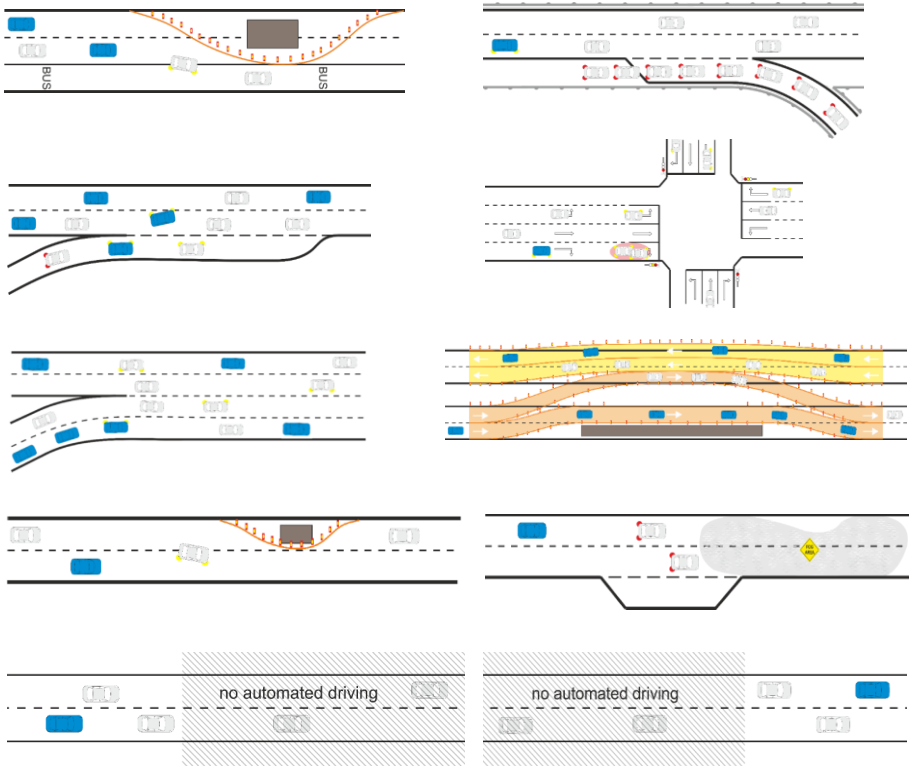



# Traffic Management in Transition Areas

# Initial selection of services / use cases

1. Prevent ToC/MRM by providing vehicle path information
2. Prevent ToC/MRM by providing speed, headway and/or lane advice
3. Prevent ToC/MRM by traffic separation
4. Manage MRM by guidance to safe spot
5. Distribute ToC/MRM by scheduling ToCs



# Main observations about state-of-the-art

- General approaches
  - Coordinated network-wide traffic management
  - Using KPIs, hierarchical controls via layered architectures, TMaaS
- Cooperative systems
  - V2X / VANETs / C-ITS
- Machine learning techniques (AI)
  - Traffic light control and congestion / queue length predictions

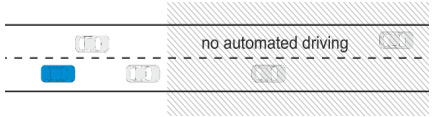
- **Conclusion**
  - No (readily available) implementations of more advanced TM schemes
  - Focus on solving partial problems with specific measures

# Traffic management by TransAID's services

- Solutions take the form of these actions:
  - **Prevent** ToC/MRM
  - **Manage** or support ToC/MRM
  - **Distribute** (in time and space) ToC/MRM

- Assess solutions based on impacts measured by **KPIs**:
  - **Traffic efficiency**
    - Network-wide: average speeds and throughput
    - Local: tempo-spatial diagrams
  - **Traffic safety**
    - Number of events with time-to-collision < 3 sec
  - **Environmental impact**
    - $CO_2$ emissions

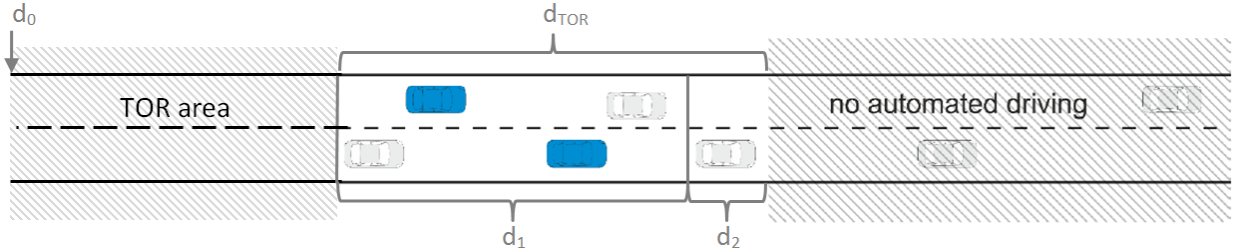
# Example service: TOR distribution




- When?

| Vehicle mix | LOS A | LOS B | LOS C |
|---|---|---|---|
| 1 | | | |
| 2 | | | |
| 3 | | | |

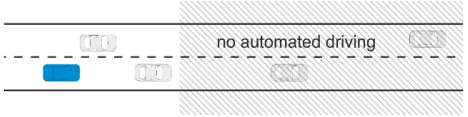
- Where?



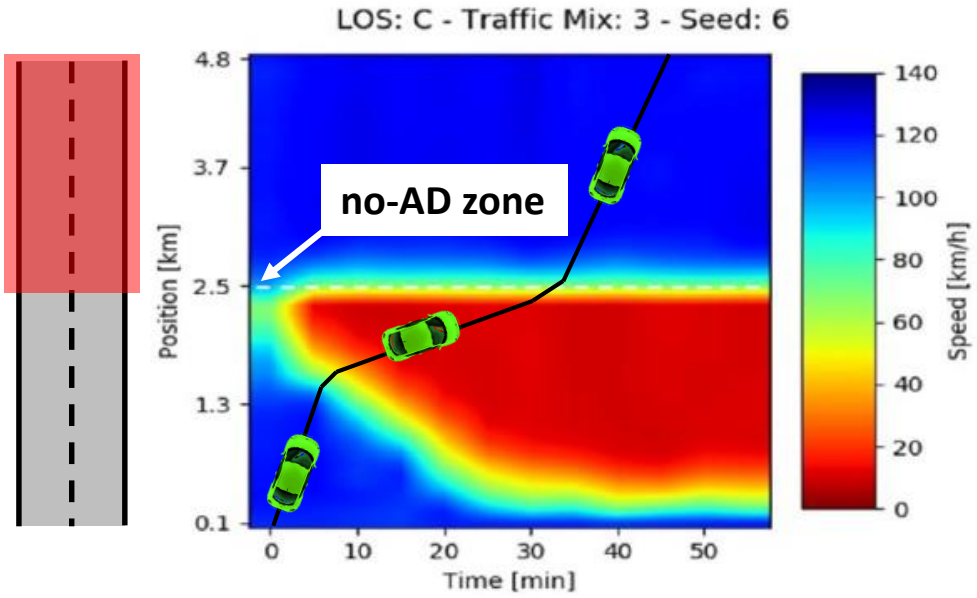

- How?
  - **Distribute the TORs** within a dedicated TOR area ranging from $d_{TOR}$ farther upstream to a distance of $d_0 > d_{TOR}$

# Example use case 5.1 (local speeds)

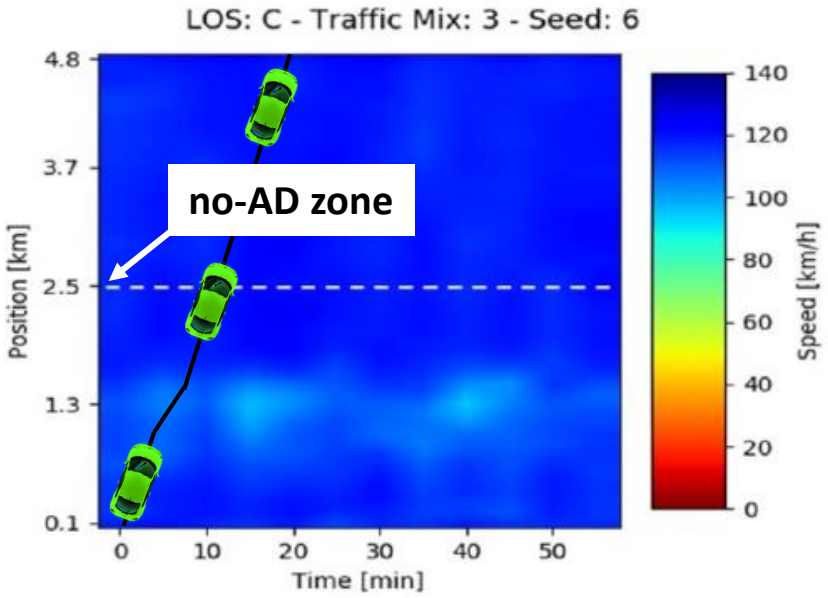
*Distribute the TORs within a dedicated TOR area*



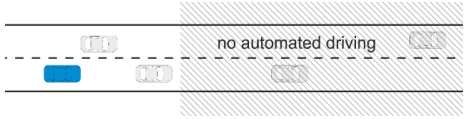

**Without traffic management**




**With traffic management**

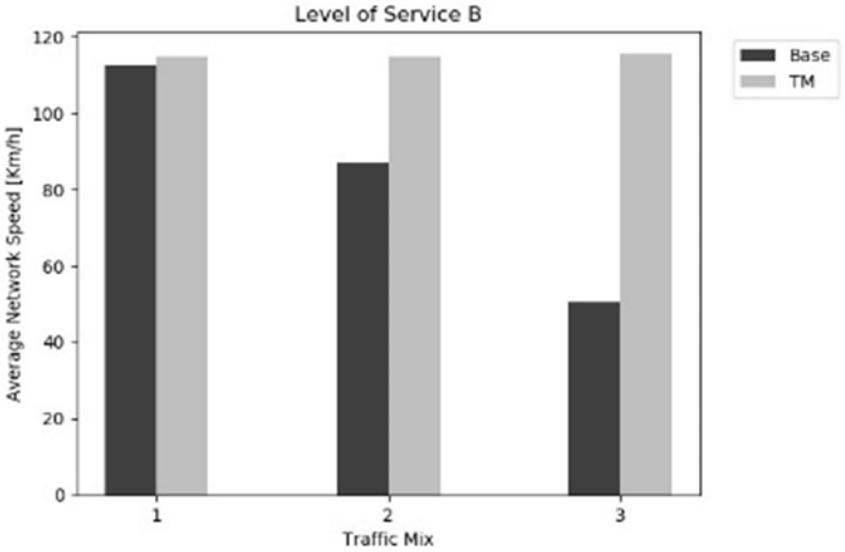


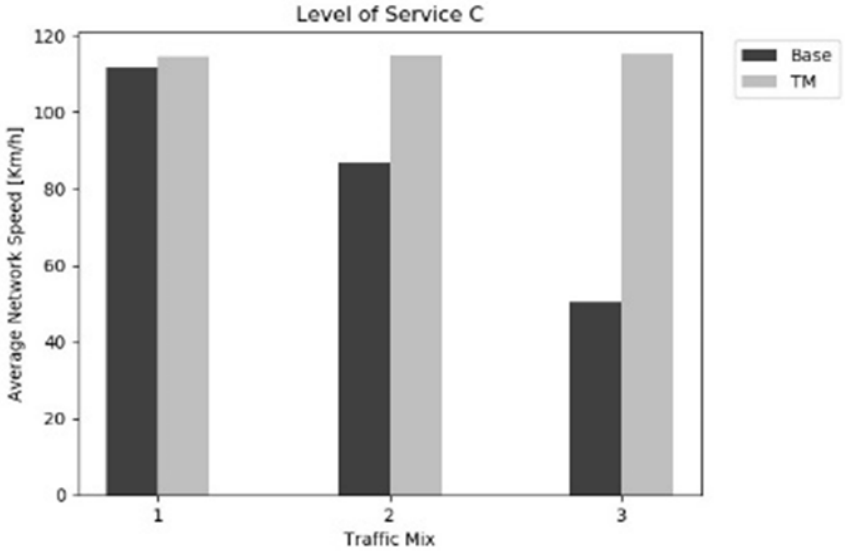
# Example use case 5.1 (network speeds)




**Without traffic management**

**With traffic management**



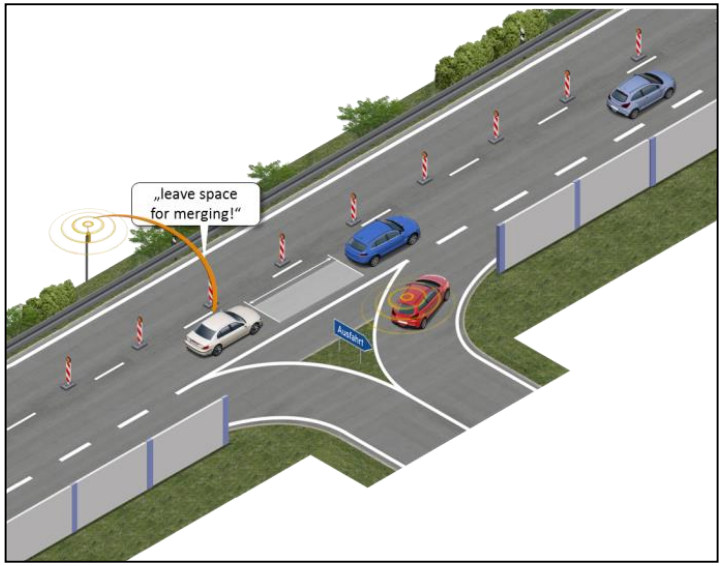

*(varying the LOS and vehicle mixes)*

# Suitable V2X Communications

# Designing suitable V2X message sets

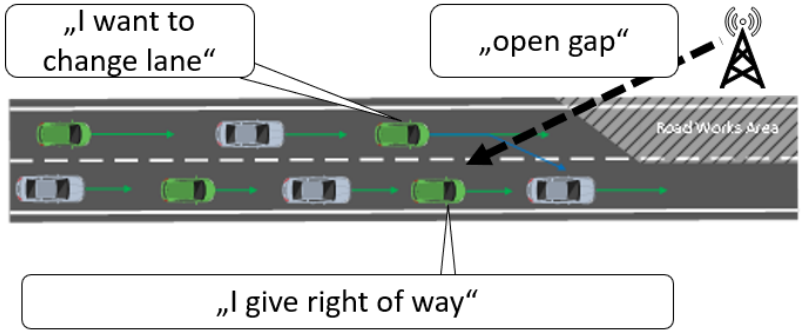
- Cornerstone for I2V-assisted traffic management

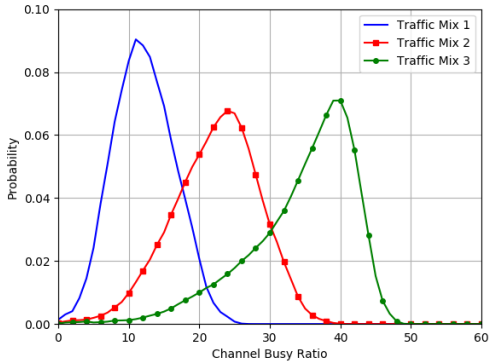
- Suitability strongly depends on:
  - Reuse of existing standards (interoperability)
  - Backwards compatibility
  - Reasonable use of radio resources (QoS)

# V2X message sets to facilitate TM for automated driving

- Contributed to the standardisation of:
  - ETSI V2X messages / IEEE 802.11bd / ETSI Technical Report 103 562
- Evaluation and evolution of ETSI collective perception
- TransAID services have been validated with realistic modelling of communications (ns-3)



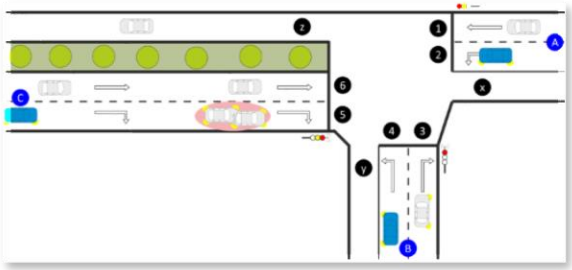



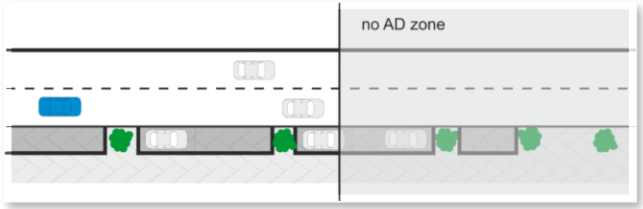
# Real-World Testing

# Real world integration: First iteration testing (07/2019)




# Real world integration
# Planned public road tests (07/2020)




# Let’s stay in touch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