V2X for transition of control in cooperative automated driving

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Outline

- TransAID scope
- TransAID V2X message set
- CAM, DENM and MCM extensions

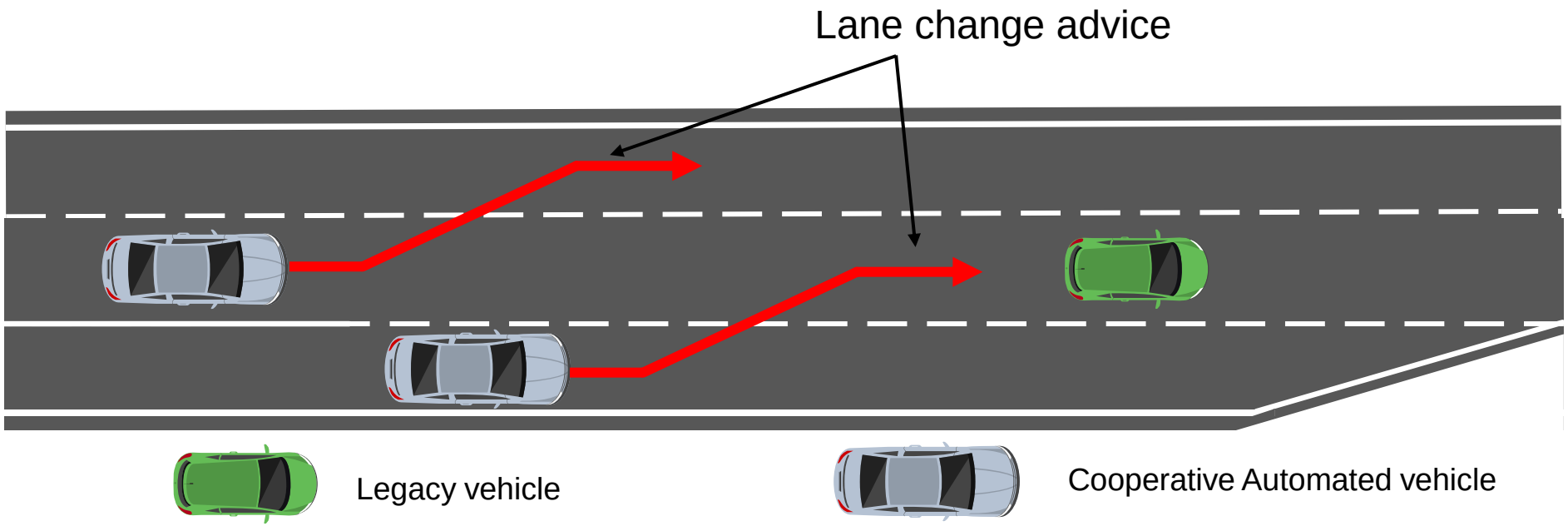
TransAID scope

- Transition area: area where multiple vehicles perform automation level transitions
  - If unmanaged transitions of control: potential traffic flow/safety issues

- V2X-based infrastructure-assisted traffic management procedures at transition areas:
  - Manage transition of vehicles
  - Distribute transitions of vehicles in time and space
  - Prevent transitions by providing additional information

TransAID scope

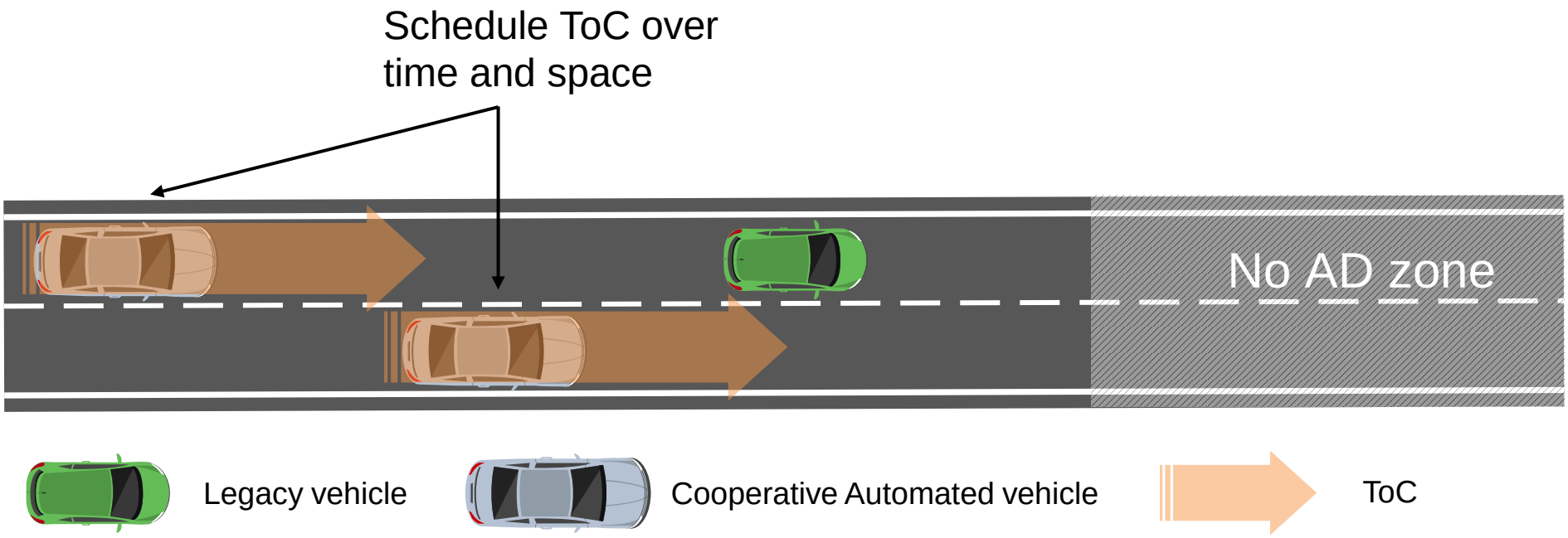
- Prevent ToC/MRM by providing speed, headway and/or lane advice:
  - Objective: Facilitate merging of on-ramp vehicles



TransAID deliverable 2.1: Link

TransAID scope

- Distribute ToC by scheduling ToC in time and space:
  - Objective: Avoid multiple ToC in the same area



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TransAID V2X message set

- The execution of the TransAID services requires the communication between vehicles or between vehicles and the infrastructure:
  - Messages employed: CAM, CPM, DENM, MAPEM, IVIM, MCM

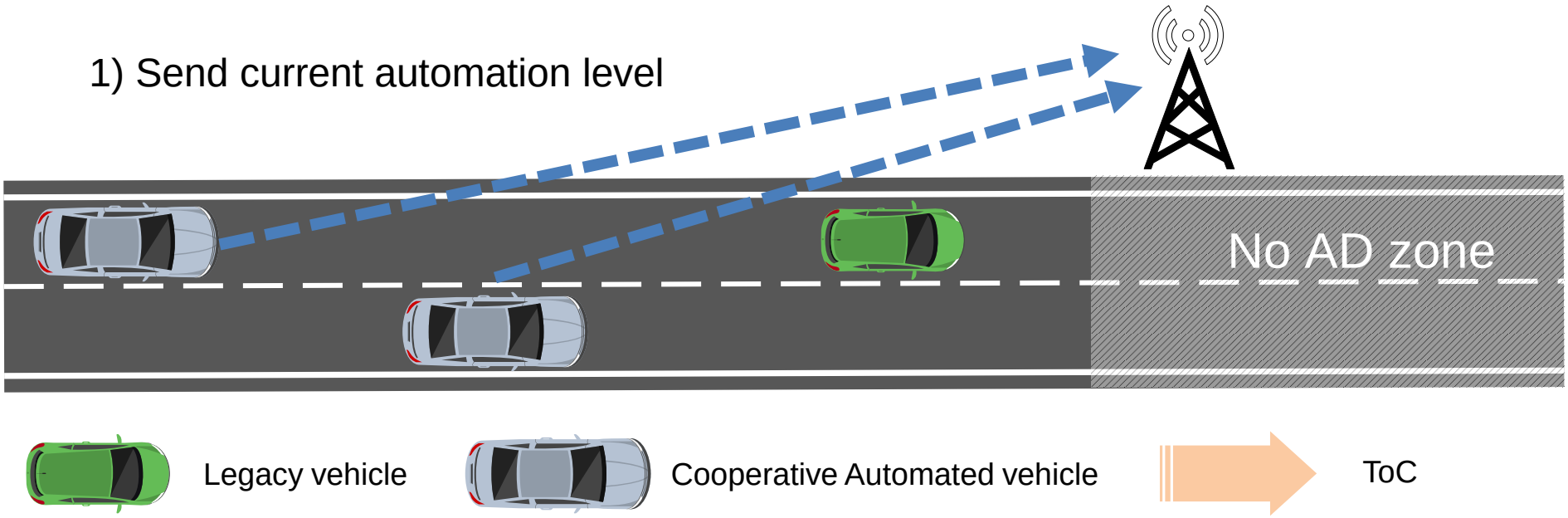
- We should extend current version of V2X message standards in order to manage transitions of control:
  - Messages extended: CAM, DENM, MCM

CAM: Extensions

- Additional information needed:
  - Current automation level

Distribute ToC by scheduling ToC in time and space

CAVs need to execute a ToC before entering the no AD Zone



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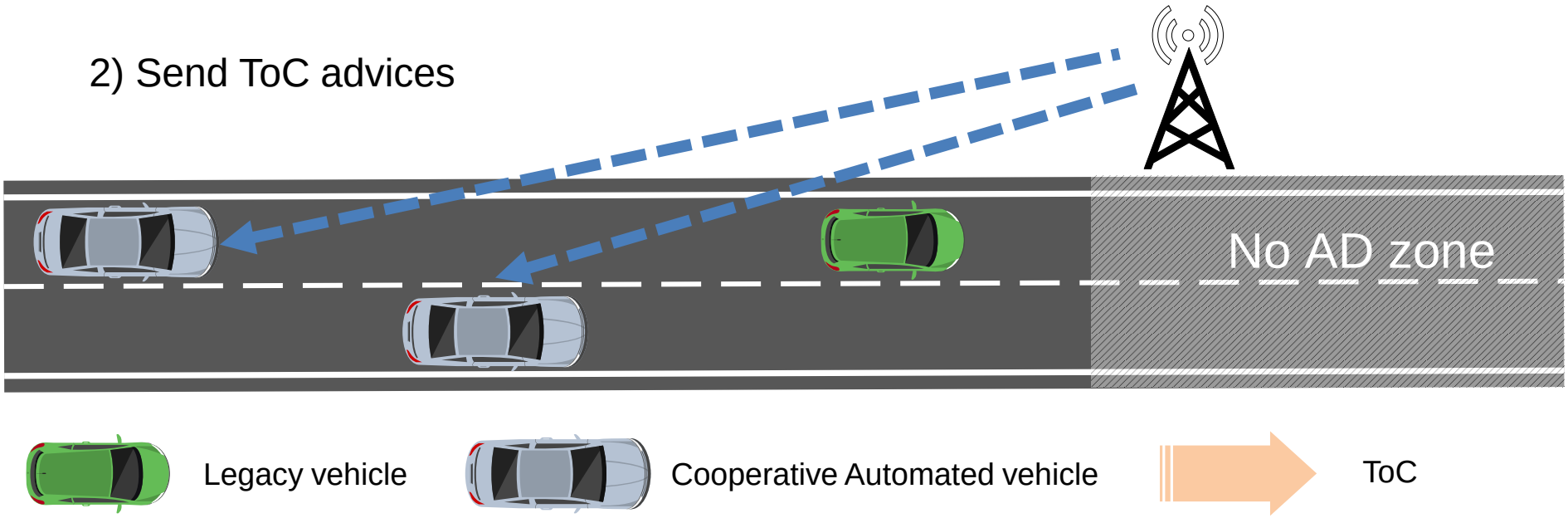

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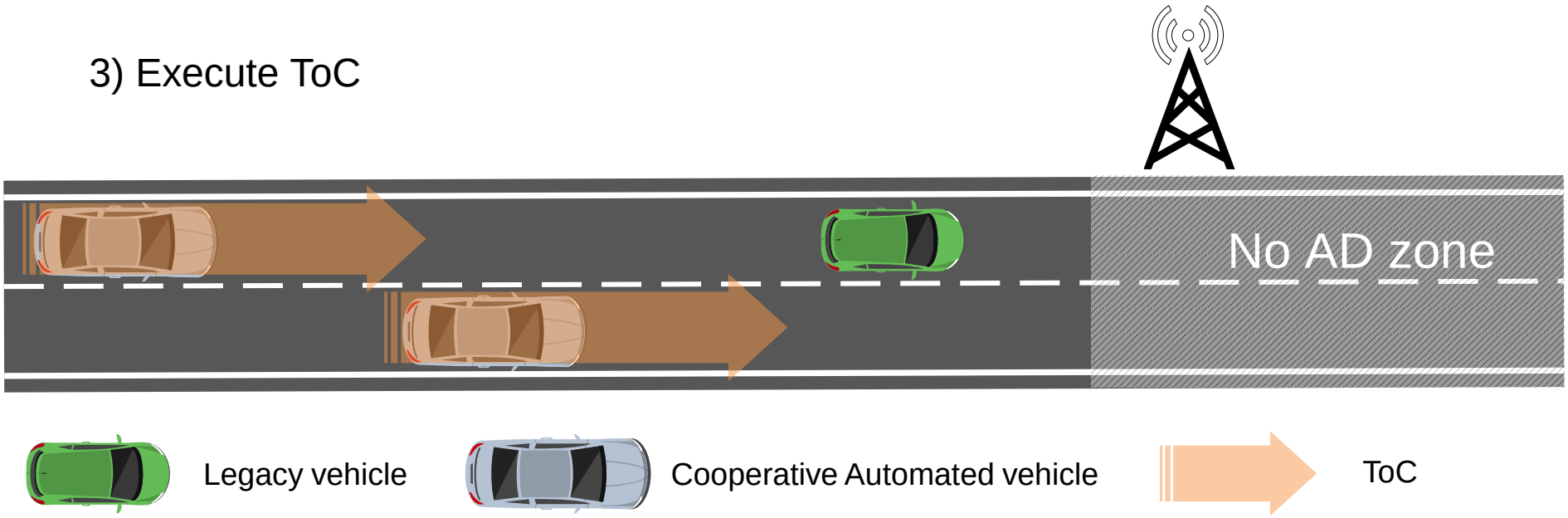
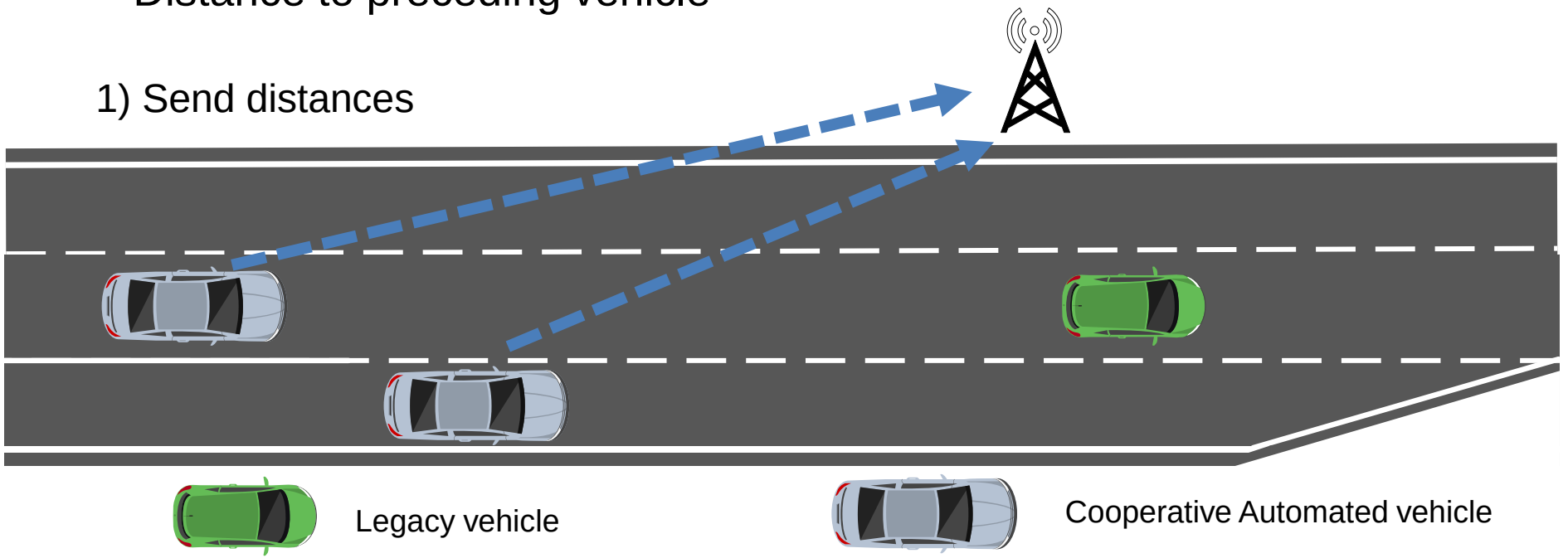


CAM: Extensions

- Additional information needed:
  - Current automation level
  - Distance to following vehicle
  - Distance to preceding vehicle

Prevent ToC/MRM by providing speed, headway and/or lane advice

CAVs on the on-ramp needs to merge to the main road



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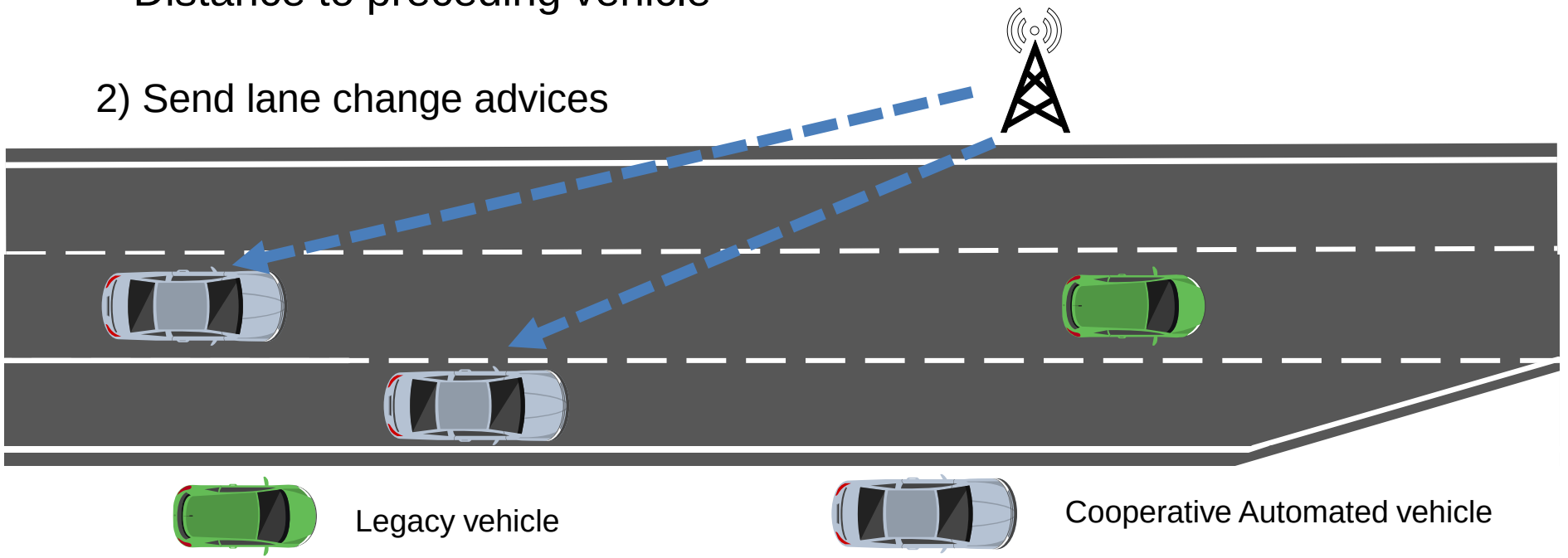

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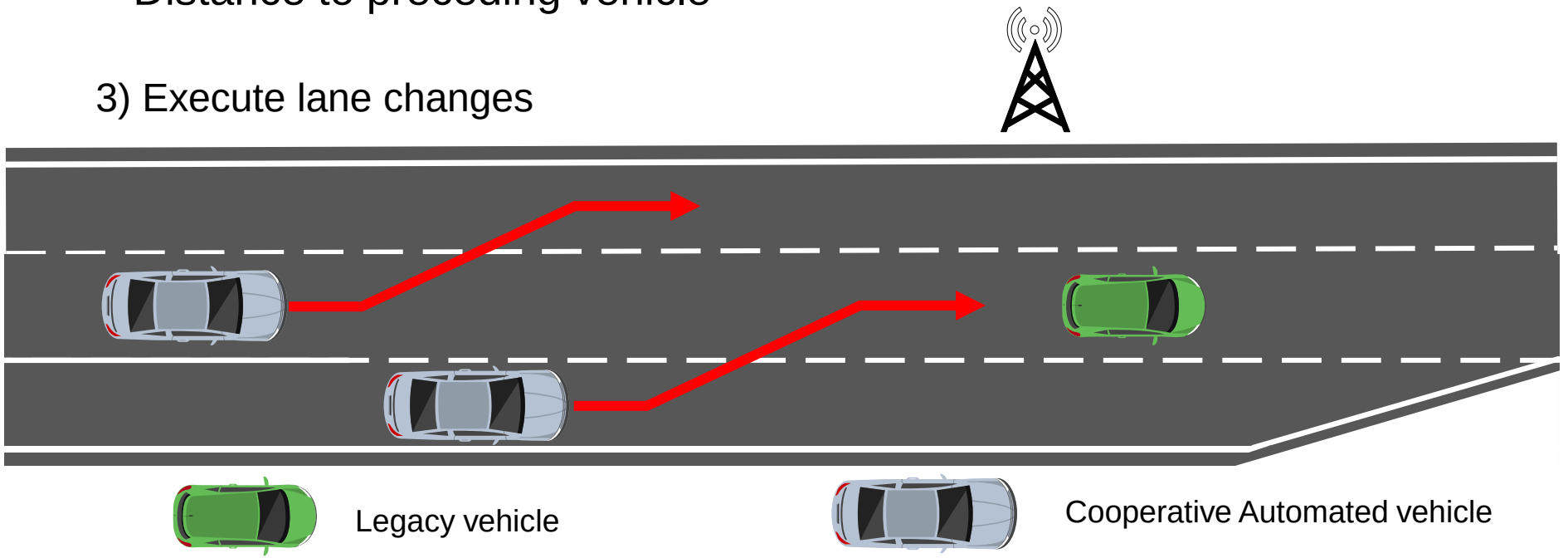
Prevent ToC/MRM by providing speed, headway and/or lane advice

CAVs on the on-ramp needs to merge to the main road

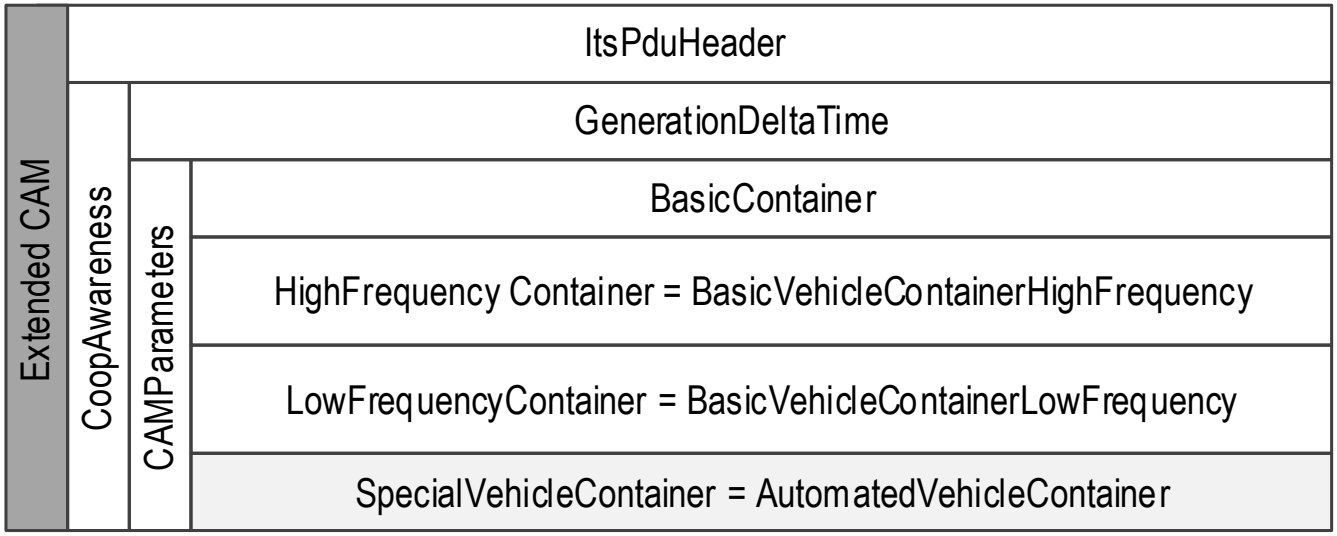
3) Execute lane changes



CAM: Extensions

- Additional information needed:
  - Current automation level
  - Distance to following vehicle
  - Distance to preceding vehicle

Create a new type of Special Vehicle Container to assure backwards compatibility



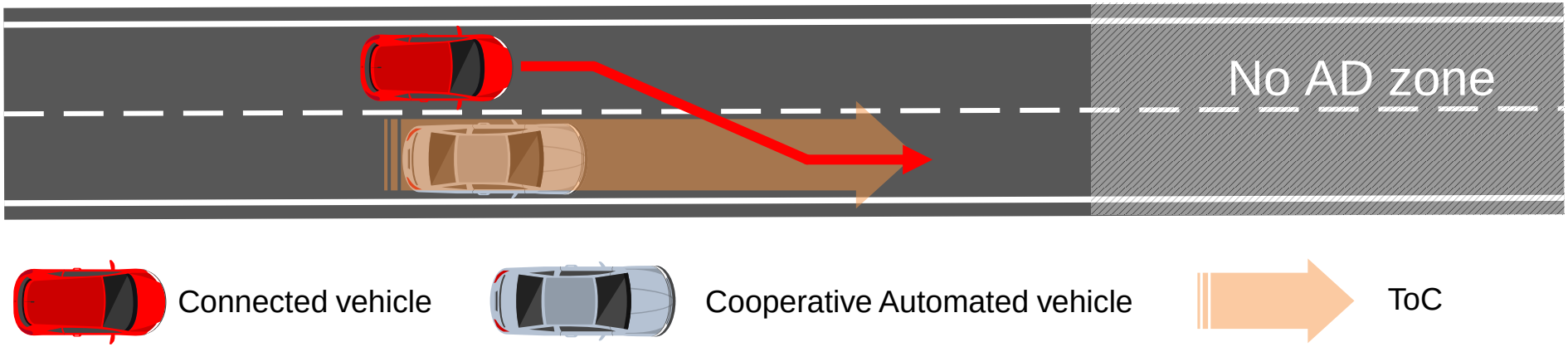
TransAID deliverable 5 .1: Link

DENM: Extensions

- Additional Information:
  - ToC alert
  - MRM alert

Distribute ToC by scheduling ToC in time and space

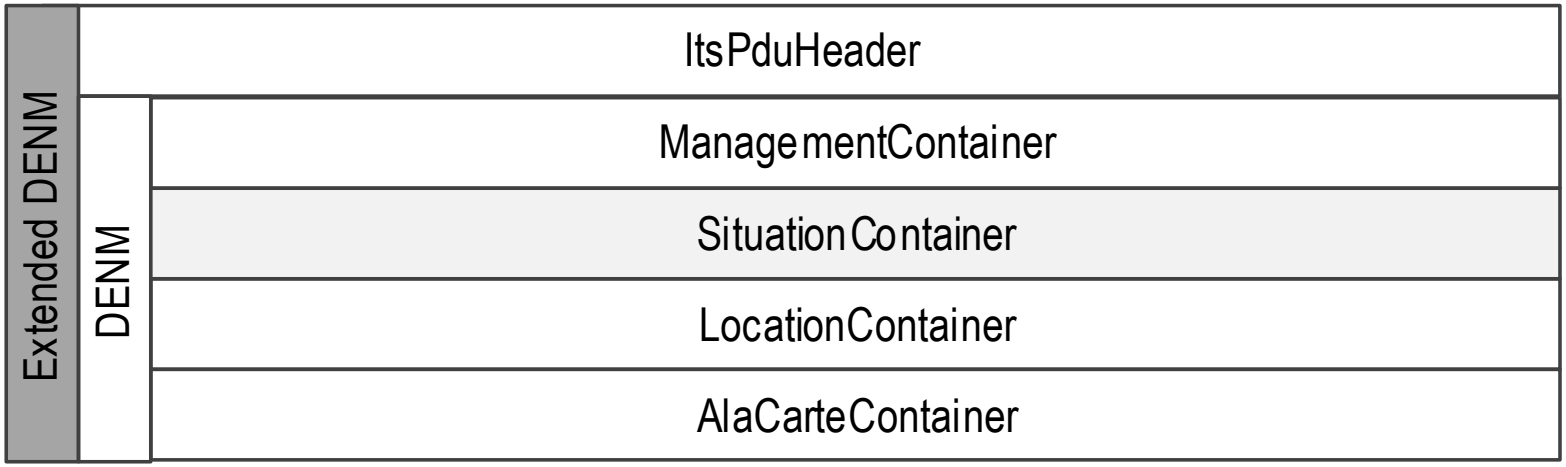
Problematic situation due to CAV executing ToC while a CV is executing a lane change



DENM: Extensions

- Additional Information:
  - ToC alert
  - MRM alert

Extend Event Type field in the Situation Container

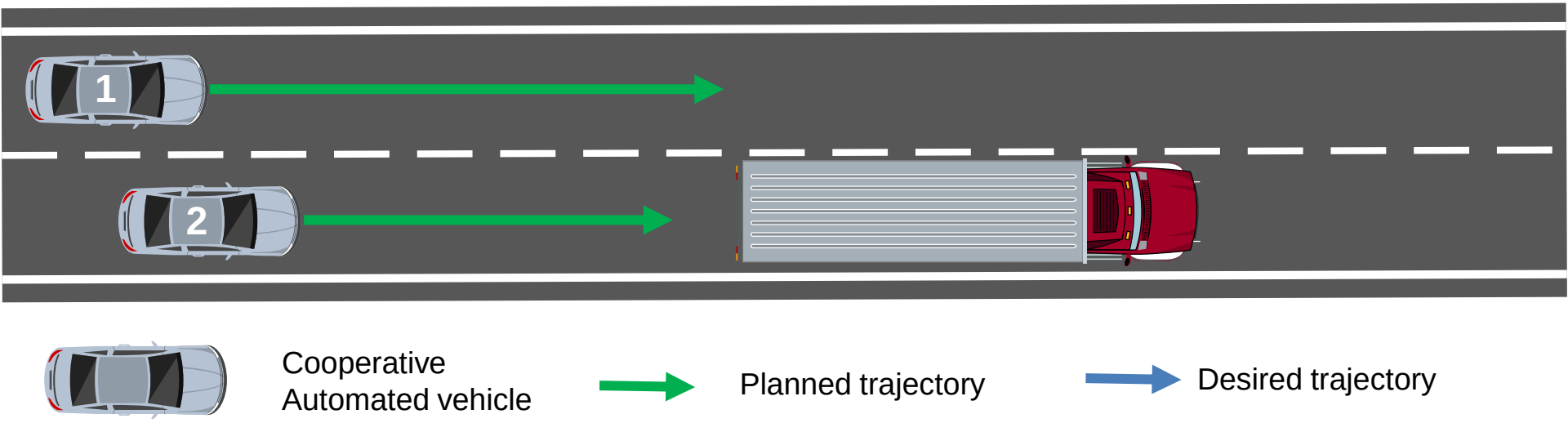


TransAID deliverable 5 .1: Link

Maneuver Coordination Service

- Current ETSI proposal:
  - Based on the exchange of trajectories

1) CAVs exchange planned trajectory



Cooperative Automated vehicle

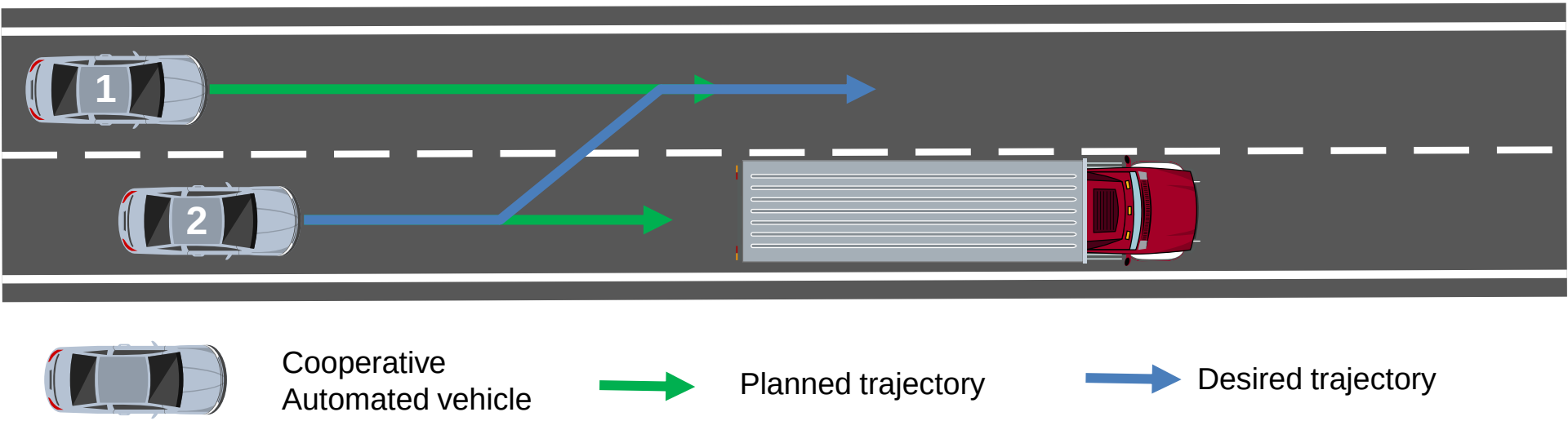
Planned trajectory

Desired trajectory

Maneuver Coordination Service

- Current ETSI proposal:
  - Based on the exchange of trajectories

2) CAV-2 wants to start cooperative maneuver and sends its desired trajectory



Cooperative Automated vehicle

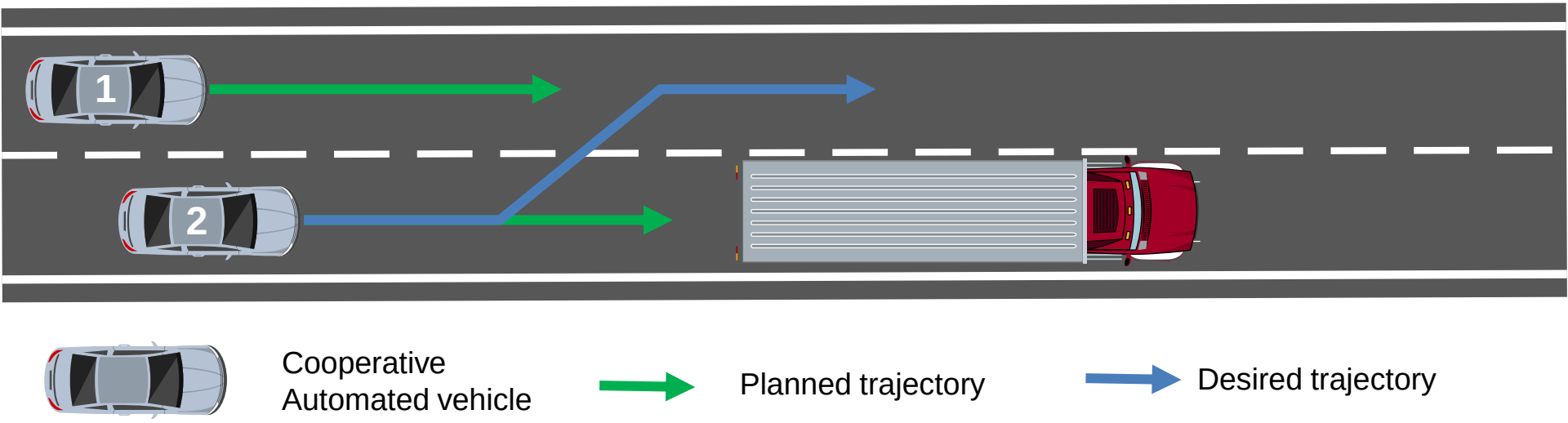
Planned trajectory

Desired trajectory

Maneuver Coordination Service

- Current ETSI proposal:
  - Based on the exchange of trajectories

3) CAV-1 accepts cooperative maneuver and updates its planned trajectory



Cooperative Automated vehicle

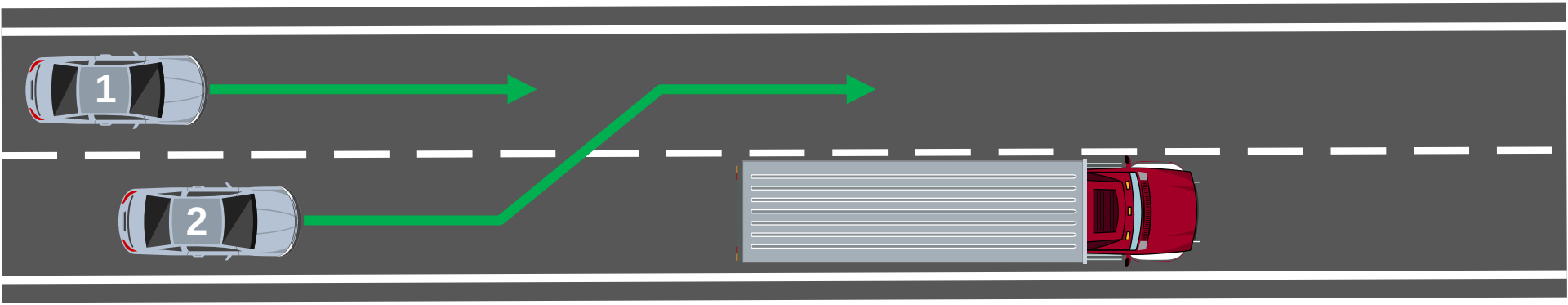
Planned trajectory

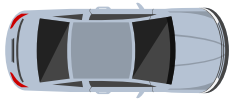
Desired trajectory

Maneuver Coordination Service

- Current ETSI proposal:
  - Based on the exchange of trajectories

4) CAV-2 can now employ its desired trajectory as a planned trajectory





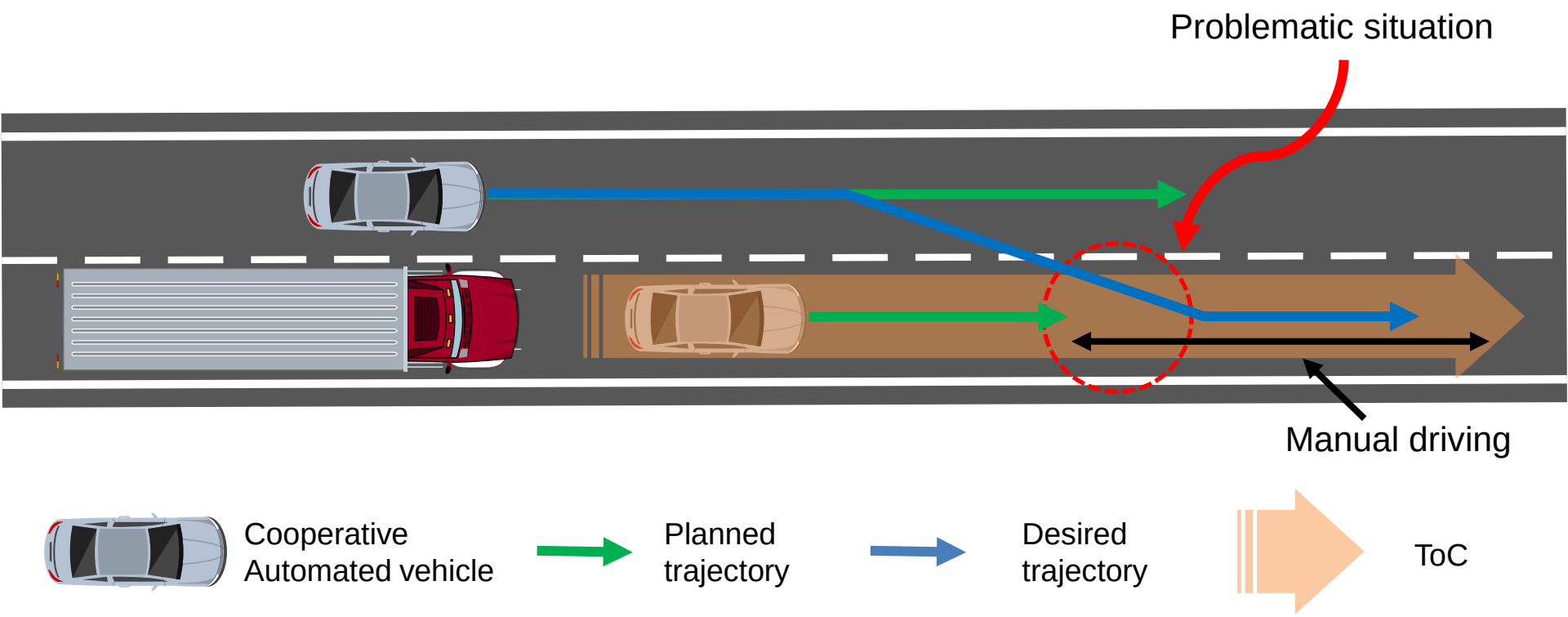
Cooperative
Automated vehicle

Planned trajectory

Desired trajectory

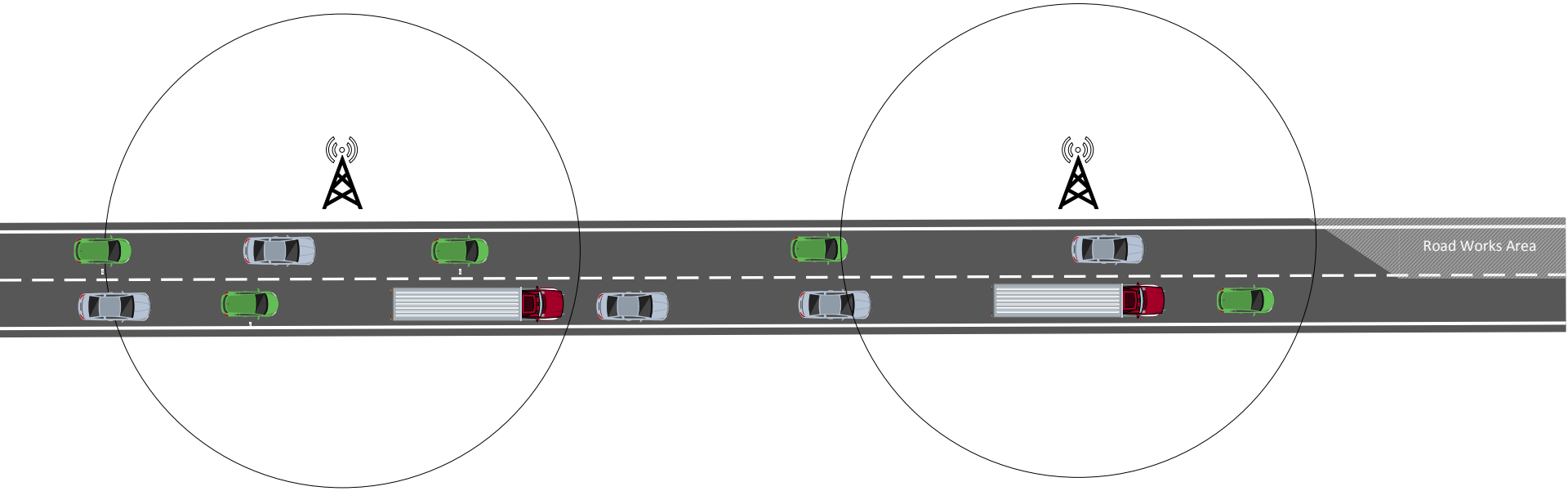
MCS Challenges

- Uncertainties during Transition of Control:
  - When the human driver will take control of the vehicle?



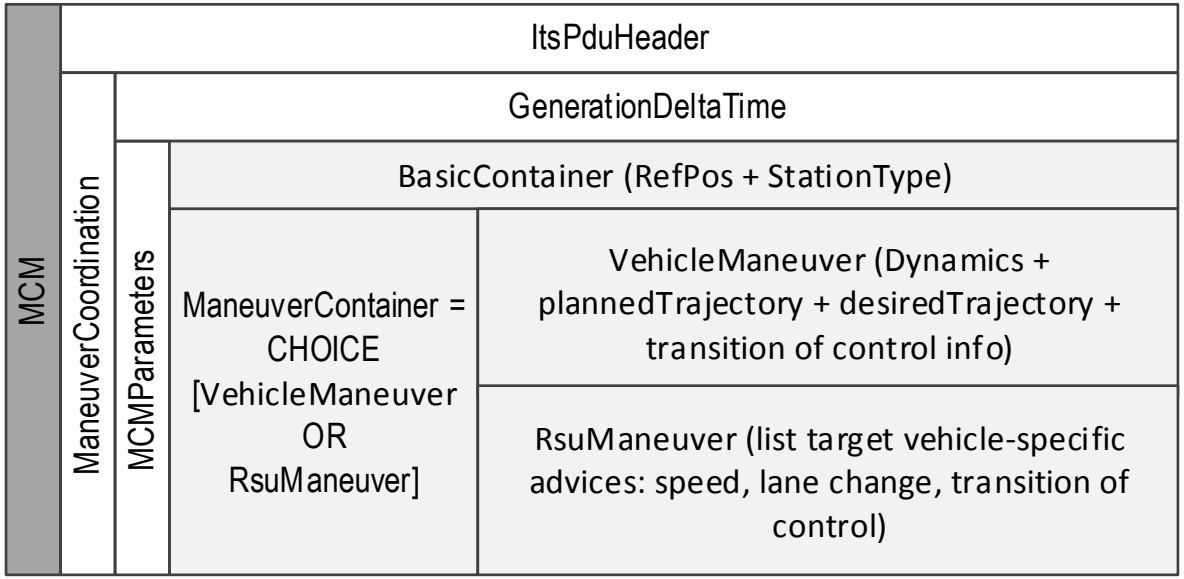
MCS Challenges

- Perception capabilities of CAVs:
  - Challenges increase when cooperative maneuvers imply vehicles at more than one hop communications distance
  - How to increase the overall traffic flow/safety?



MCM: Message Format

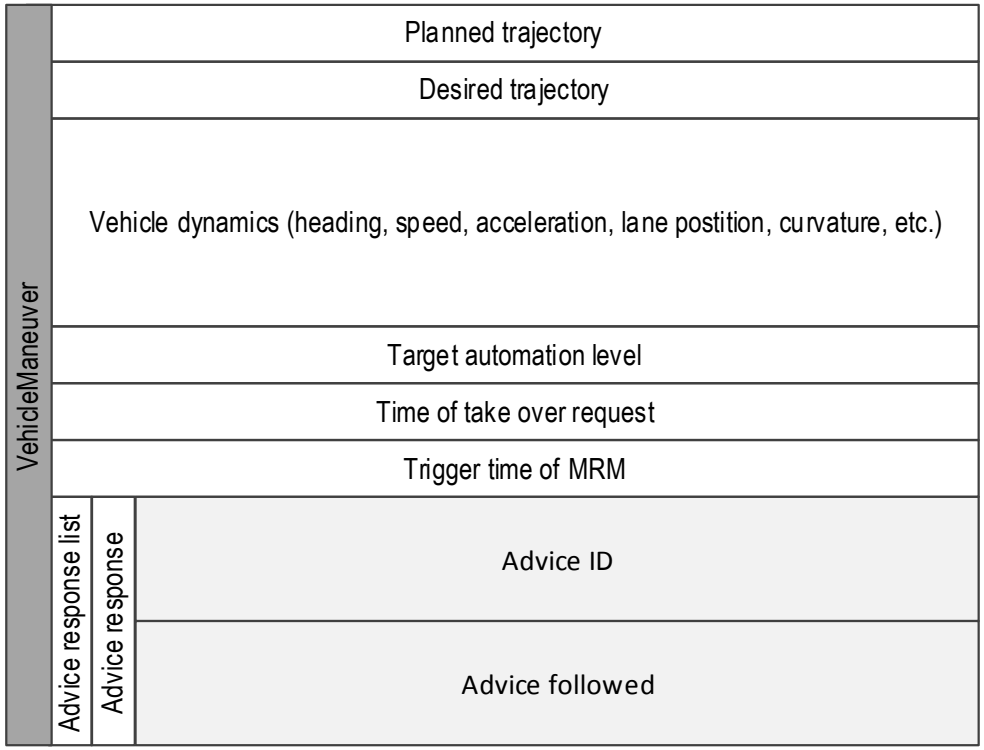
- Proposal format for the MCM:
  - Specific containers for different ITS-S: CAV and RSU
  - Vehicles can locally execute cooperative maneuvers
  - RSU provide advices to increase overall traffic flow/safety



TransAID deliverable 5 .1: Link

MCM: CAV

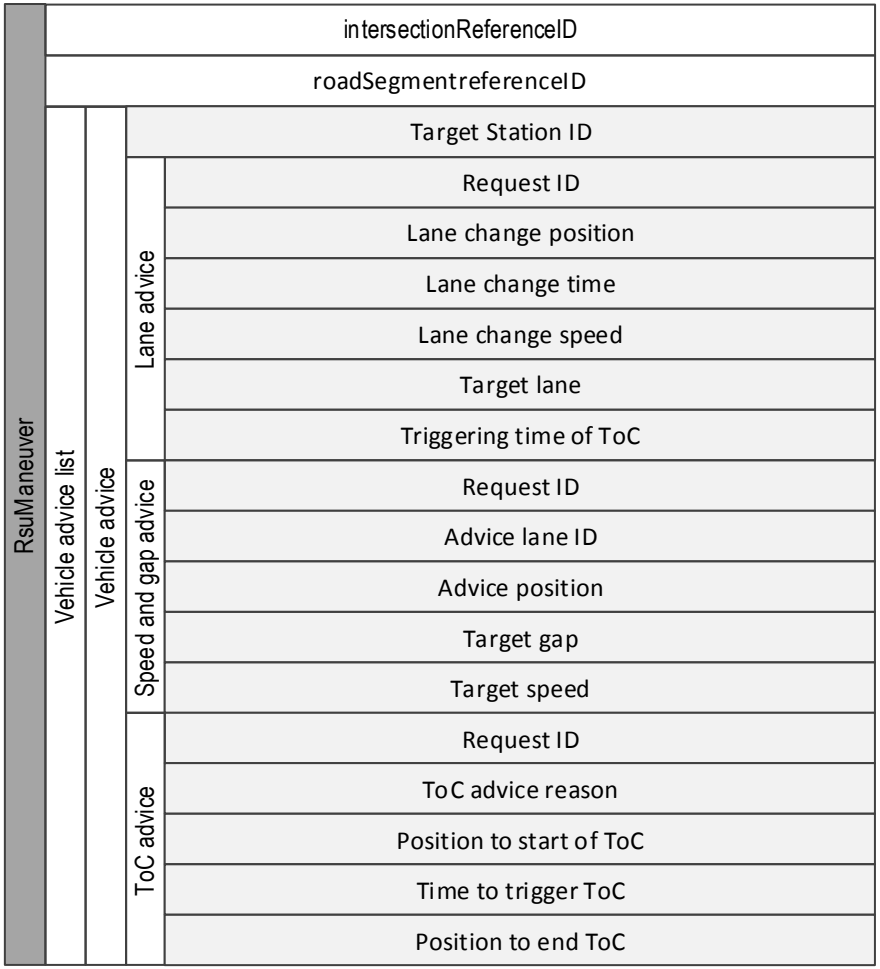
- Vehicle Maneuver Container:
  - Sent by CAV
  - Planned trajectory
  - Desired trajectory
  - Vehicle dynamics
  - Information about future ToC
  - Acknowledgement of advice acceptance
- ToC information is included to increase safety during ToC
- Surrounding vehicles can plan its manuevers accordingly



TransAID deliverable 5 .1: Link

MCM: RSU

- RSU Maneuver container:
  - Sent by RSU
  - Vehicle advice list
  - Lane advice
  - Speed and gap advice
  - ToC advice
- Infrastructure can provide multiple advices to multiple vehicles
- Vehicle decides if the advice will be followed



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Conclusions

- Need to manage transitions of control
- Extensions of CAM, DENM, MCM needed
- Infrastructure can support managing multiple transitions of control

Thanks for your attention!

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