



# Infrastructure Support for Cooperative Maneuvers in Connected and Automated Driving

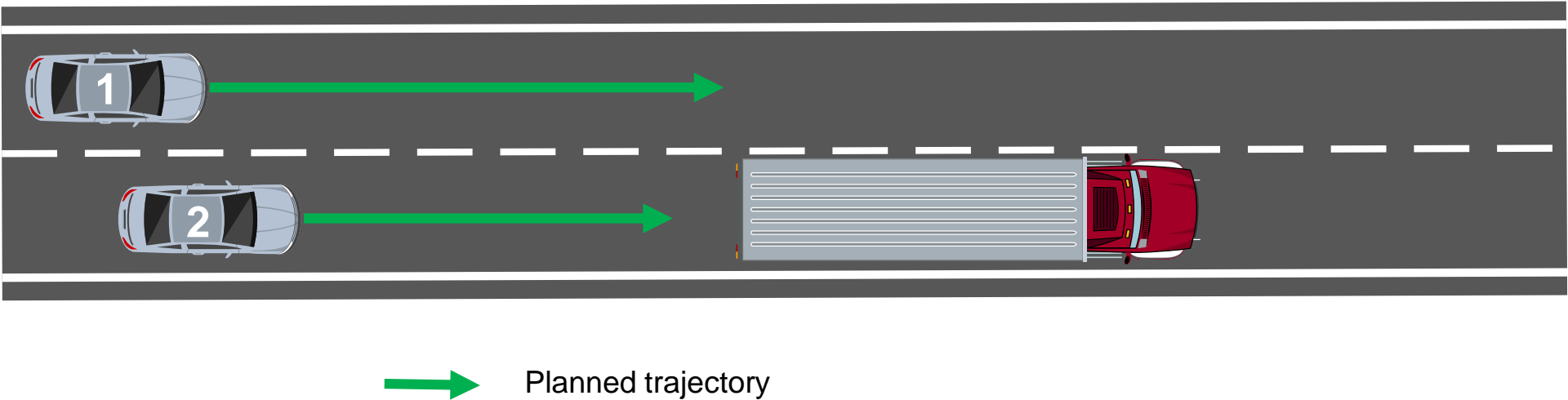
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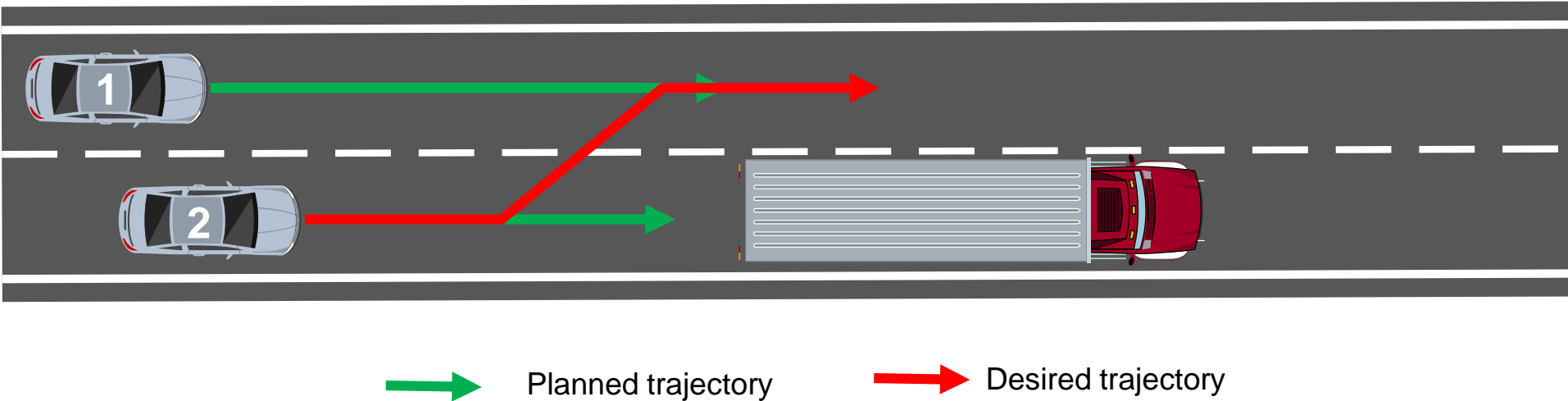


- Automated vehicles are equipped with multiple sensors
  - Difficult to infer driving intentions of other vehicles
- Connected and Automated vehicles exchange driving intentions
  - ETSI draft standard for maneuver coordination based only on V2V
- Proposal: road infrastructure to support maneuver coordination
  - Extension based on V2I communications
  - Message format definition
  - Preliminary analysis of message generation rules

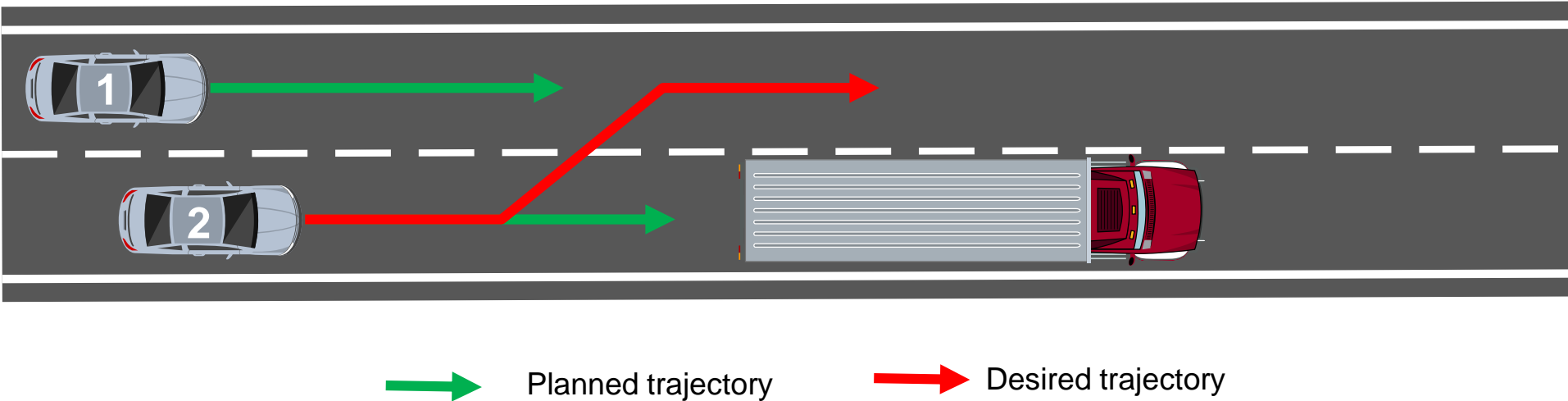
- Based on periodic V2V exchange of planned/desired trajectories
  - Coordination governed by right of way rules.
  - Generic approach valid for *all* scenarios.
- Example: Step 1 - CAVs exchange planned trajectory



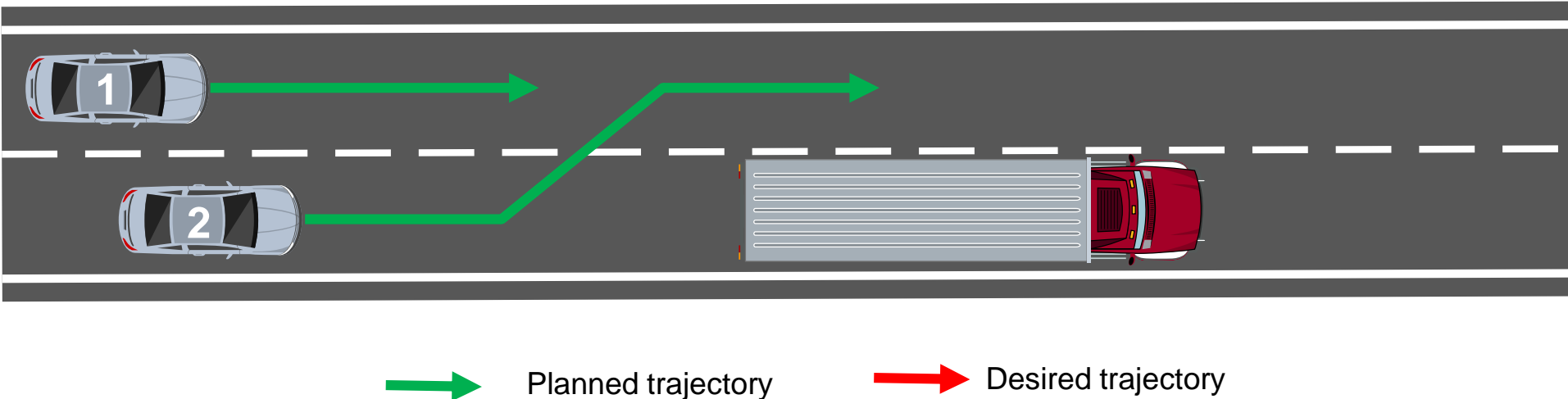
- Based on periodic V2V exchange of planned/desired trajectories
  - Coordination governed by right of way rules.
  - Generic approach valid for *all* scenarios.
- Example: Step 2 - CAV2 sends desired trajectory to change lane



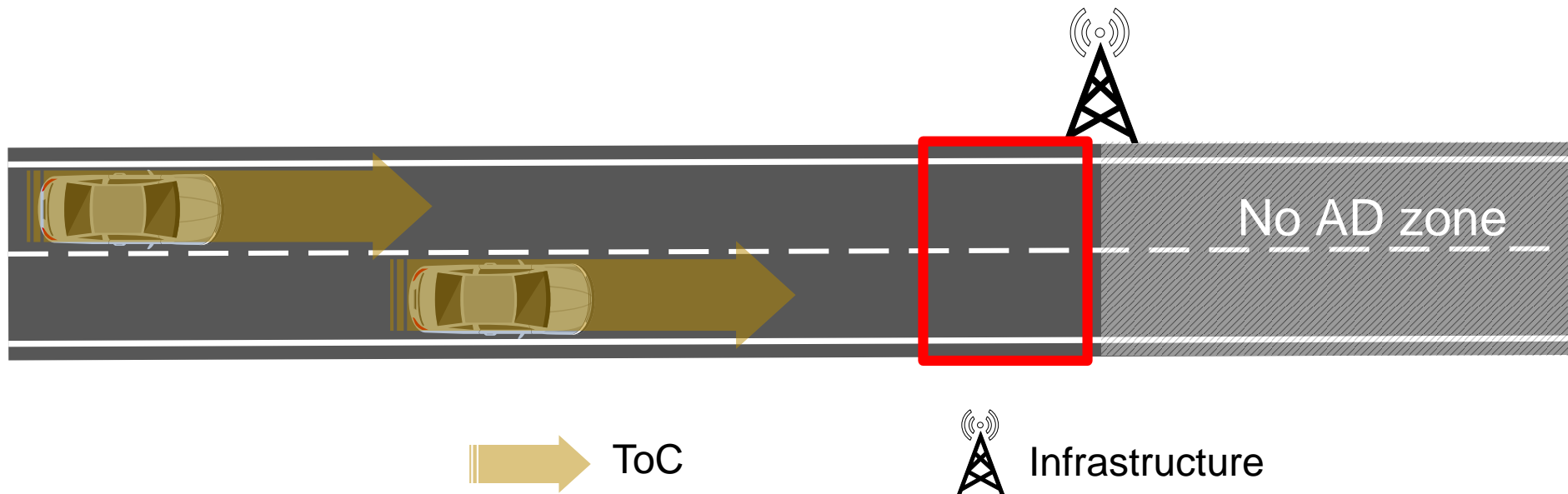
- Based on periodic V2V exchange of planned/desired trajectories
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  - Generic approach valid for *all* scenarios.
- Example: Step 3 - CAV1 updates its planned trajectory



- Based on periodic V2V exchange of planned/desired trajectories
  - Coordination governed by right of way rules.
  - Generic approach valid for *all* scenarios.
- Example: Step 4 - CAV2 updates trajectories & changes lane



- Use case example: no automated driving zone
  - Automated vehicles need to perform Transition of Control (ToC)
  - TOC: handing over control to driver
- Baseline: multiple Toc in same area (before No AD zone)
- Proposal: infrastructure support to distribute ToC by time and space



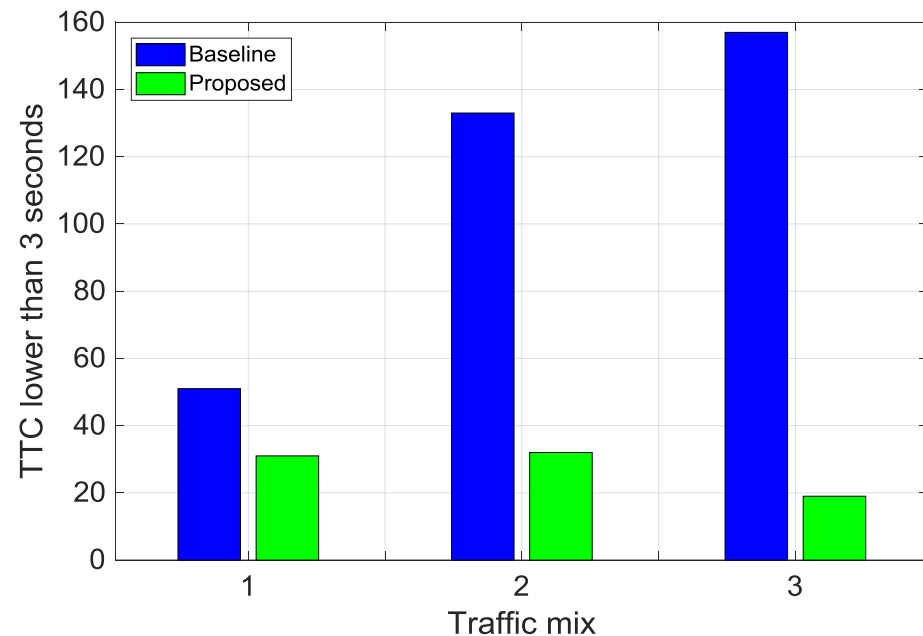
- Proposal: road infrastructure to support maneuver coordination
  - Infrastructure acquires traffic/vehicle info
  - Sends speed and gap, lane change and ToC advices
- Identified benefits
  - Neutral coordination: coordinate multiple maneuvers
  - Enhanced perception: extended range & fusion
  - Coordination of multiple vehicles: common coordinating entity
  - Complements current ETSI approach



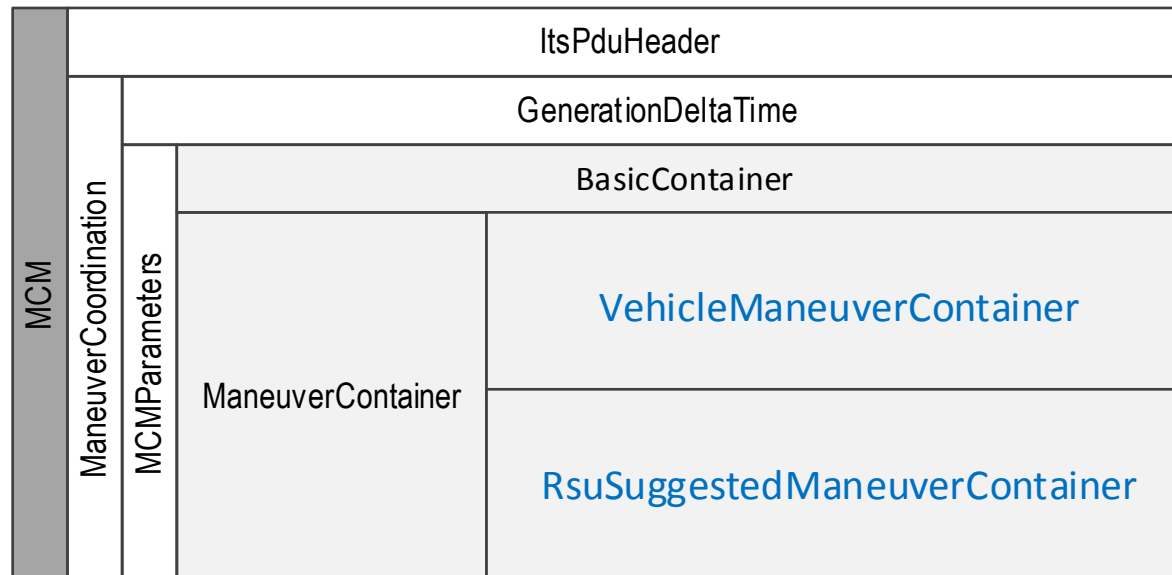
- Use case example: no automated driving zone
  - Evaluated in SUMO with 3 different traffic mixes
  - Safety metric: Avg no. of times Time to Collision < 3 seconds
  - Proposed solution improves safety compared to baseline

|      | Mix 1 | Mix 2 | Mix 3 |
|------|-------|-------|-------|
| CAVs | 15%   | 25%   | 40%   |
| CVs  | 25%   | 35%   | 50%   |
| LVs  | 60%   | 40%   | 10%   |

Level of service C (1617 veh/hour/lane)

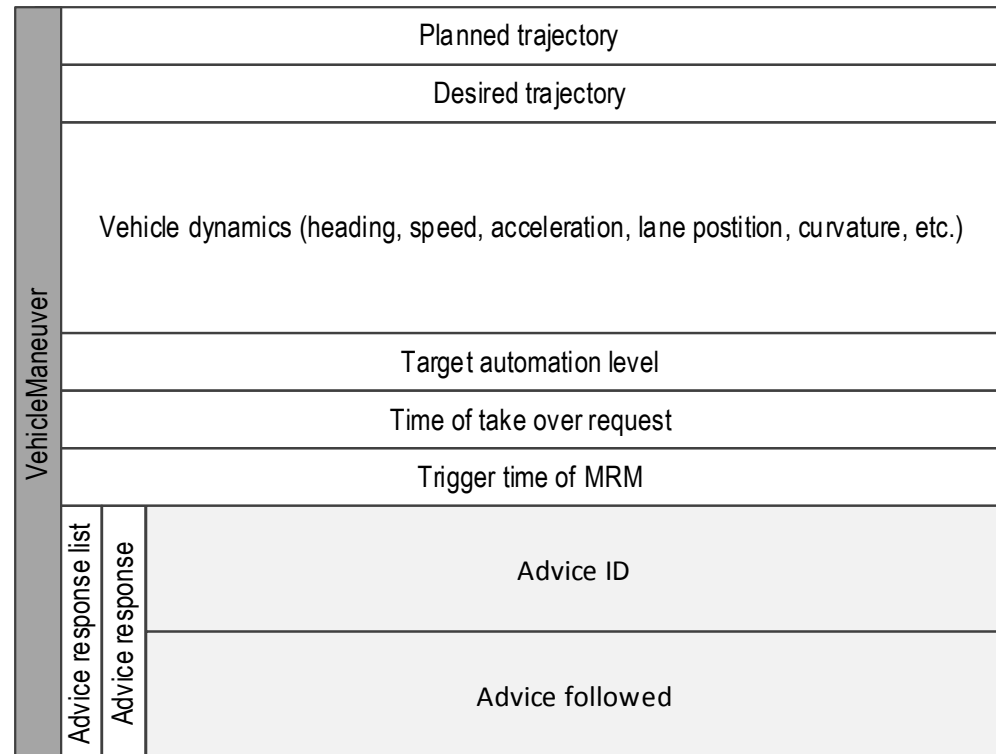


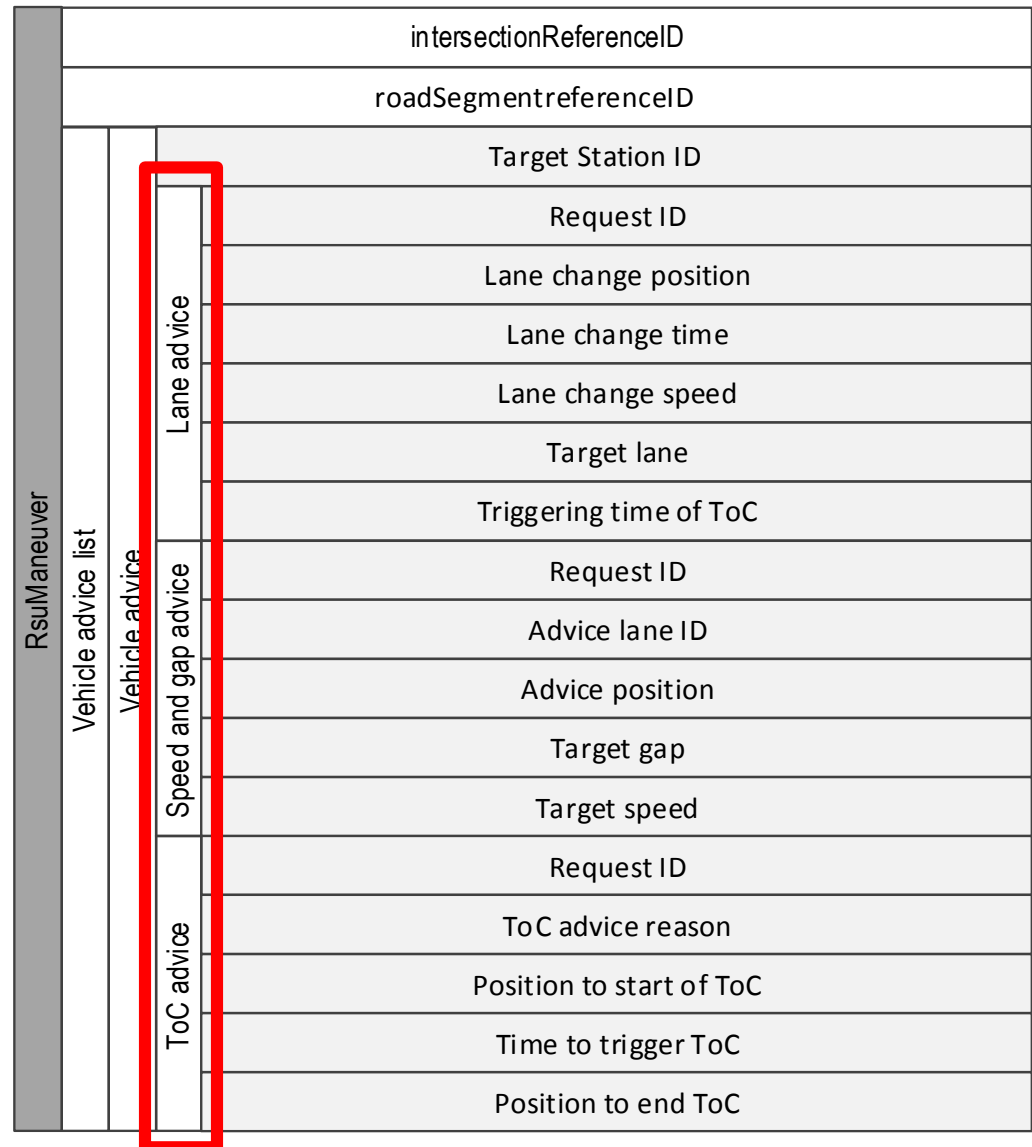
- Proposed format for the MCM:
  - Different containers for CAV and RSU
  - CAVs can locally execute cooperative maneuvers
  - RSU provides advices to increase overall traffic flow/safety



- **Vehicle Maneuver Container:**

- Planned/ Desired trajectory
- Vehicle dynamics
- Information about future ToC
- Acknowledgement of advice

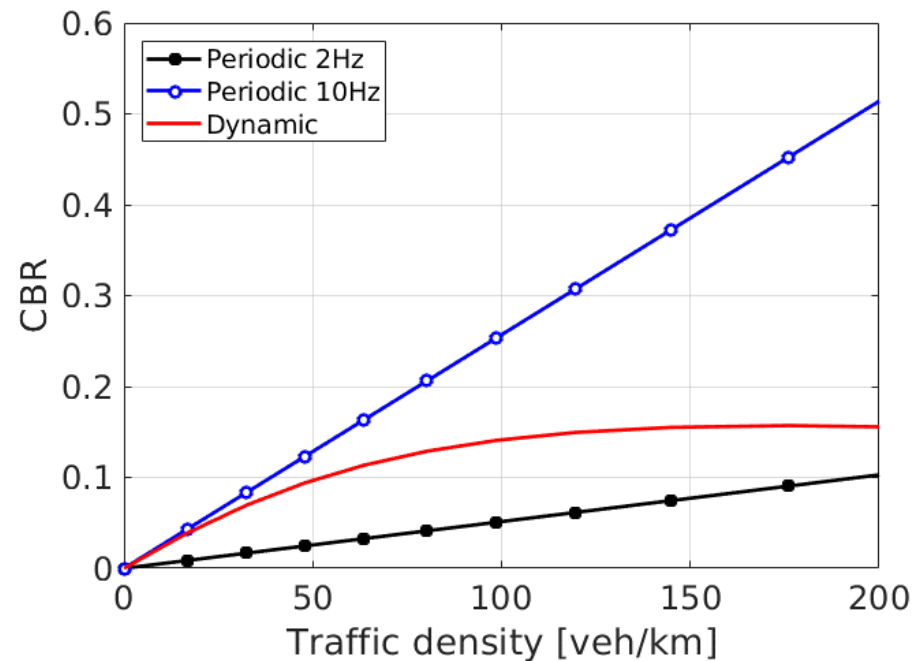




- RSU Maneuver container:

- Lane advice
- Speed and gap advice
- ToC advice

- Comparison of periodic and dynamic generation rules:
  - Periodic: 2 Hz and 10 Hz
  - Dynamic: every 4 meters
- CBR increases with density
- Dynamic policy adapts better to the increase of traffic



Highway 4 lanes, speed 130 Km/h, 300 Bytes

- Maneuver coordination needed to improve safety and efficiency
  - ETSI maneuver coordination approach based on V2V
- Novel proposal of infrastructure aided maneuver coordination
  - Road infrastructure participates by sending individual advices
  - Message format defined for vehicles and RSUs
  - Analysed the load generated by different message generation rules

# Thank you for your attention



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