Management of Transitions of Control in Mixed Traffic with Automated Vehicles

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- Background
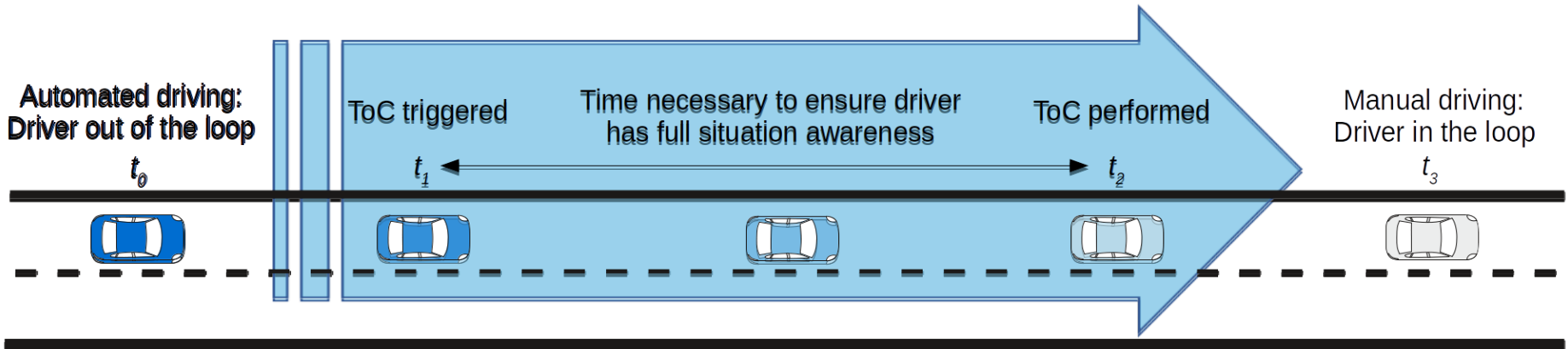- Transition of Control
- TransAID traffic management measures
- Conclusions and future lines of work

- Automated driving will not be possible everywhere

- A Transition of Control (ToC) is required

- Downward ToC: automated → manual
  - Automated mode reaches its functional system limits

- Upward ToC: manual → automated
  - Human driver is not able to respond or avoid an accident

- A ToC is the process of changing from one static state of driving to another static state

- Example of downward ToC:

- Negative impacts of Transitions of Control in traffic

- Example with automated vehicles with traffic management measures:
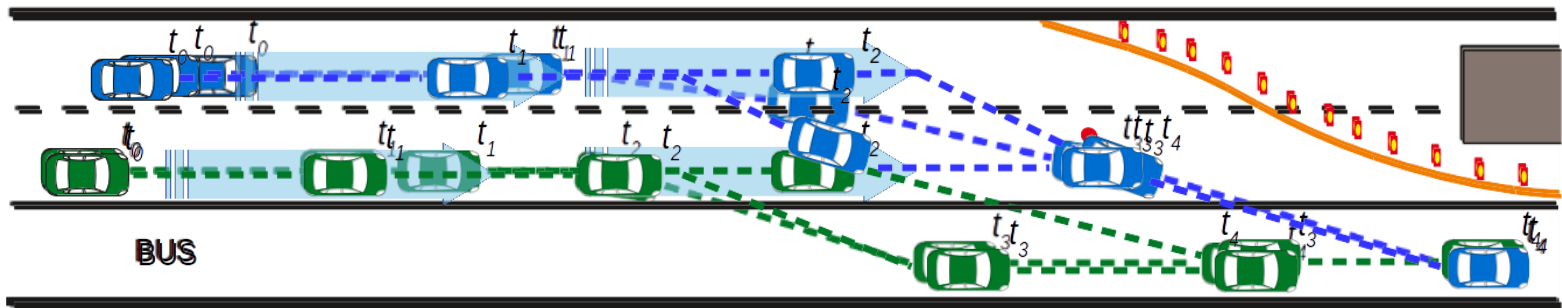
- A ToC negatively affects the traffic flow and safety
  - A ToC failure triggers a Minimum Risk Maneuver

- Transition Area: area where multiple ToCs occur
  - Negative effects of ToCs magnified at Transition Areas

- V2X communications can help managing ToC:
  - Enhanced perception of the environment
  - Coordination of vehicle maneuvers

- Design traffic management measures to reduce the negative impacts of ToCs at Transition Areas

- Three different approaches defined:
  - Prevent Transitions of Control:
    - Maintain current automation level
  - Distribute Transitions of Control:
    - Schedule ToC over time and space
  - Manage Transitions of Control:
   - Support the execution of ToC

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

- Challenges for CAVs:
  – Define the alternative route to overpass road works
 – Temporary use of an area designated for other uses
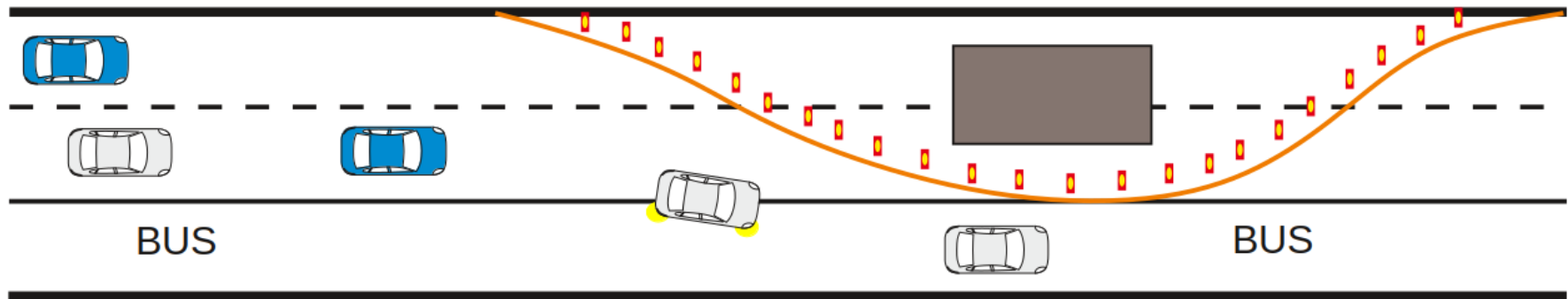
- Define a path to overpass road works area
  - Path definition based on traffic conditions

- Communication requirements:
  - Collective perception of the environment → CPM
  - Alert about road works
  - Information about closed lanes ⎤ DENM
  - Share path to overpass road works
  - Bus lane allowed for driving ⎤ MAPEM
  - Cooperative lane changes → MCM

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

- Challenges for CAVs:
  - Elevate number of interactions with legacy vehicles
  - Traffic turbulence, shockwaves
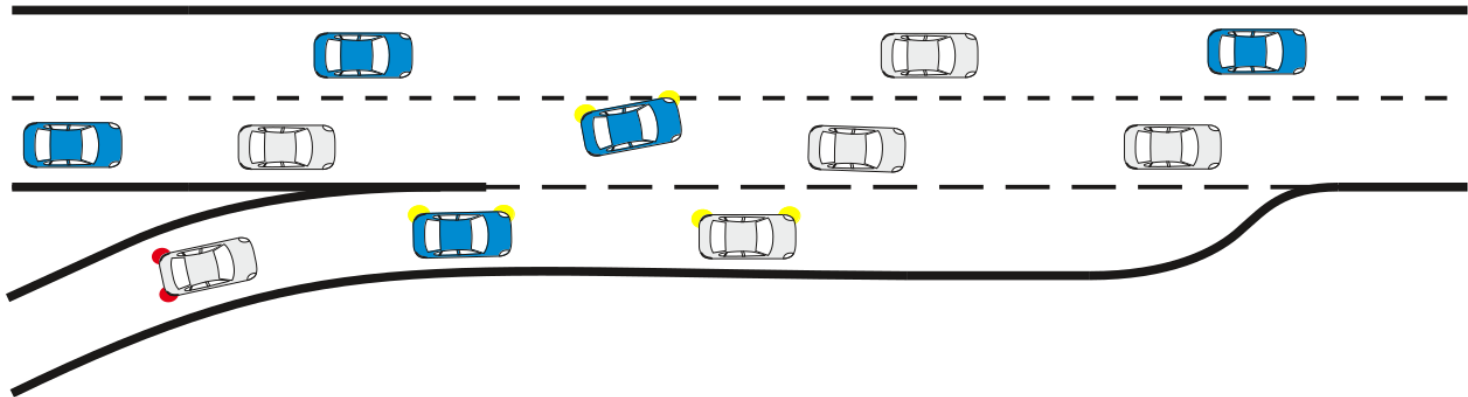
- ## Define speed and lane advices:
    - Create gaps for on-ramp merging vehicles

- ## Communication requirements:
    - Collective perception of the environment → CPM
    - Lane and speed advice for connected vehicles → IVIM
    - Lane and speed advice for CAVs
   - Cooperative lane changes

MCM

- Service 3: Prevent ToC/MRM by traffic separation

- Challenges for CAVs:
  - Elevate number of interactions with manually driven vehicles
  - Human-initiated maneuvers (e.g. sudden merging)
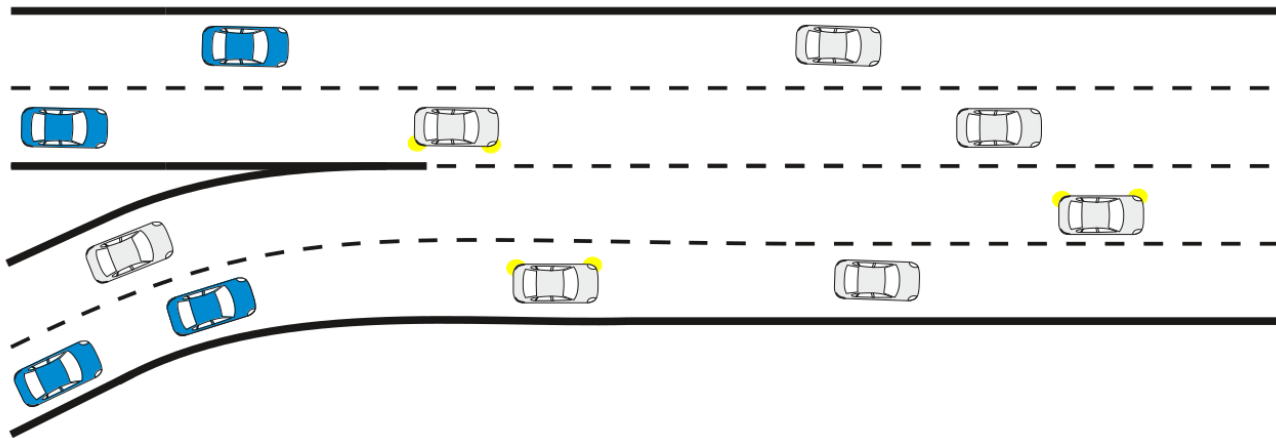
- Define traffic separation policy:
  - Minimize interactions in middle lanes where dangerous human-initiated maneuvers can take place
  - Estimate traffic stream composition

- Communication requirements:
  - Collective perception of the environment → CPM
  - Current automation level → CAM
  - Target lane for connected vehicles → IVIM
  - Target lane for CAVs
 - Cooperative lane changes } MCM

- Service 4: Manage ToC/MRM by guidance to safe spot

- Challenges for CAVs:
  - Determine path to overpass road works
  - Possible MRM blocking free lane
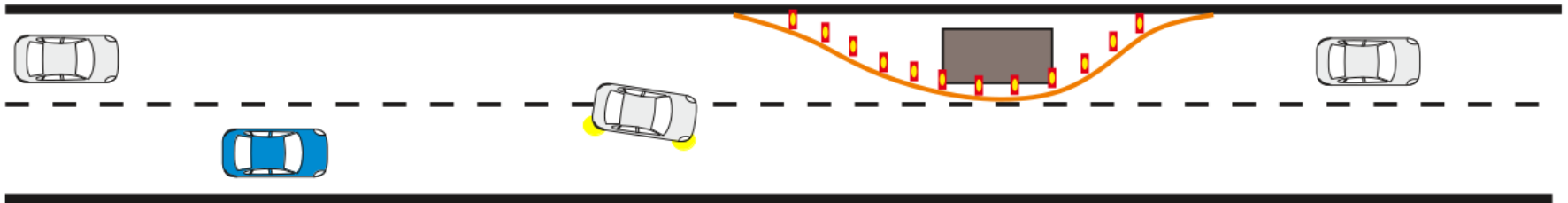
- Provide safe spots where MRM can be done without negatively affecting the traffic flow and safety

- Communication requirements:
  - Collective perception of the environment → CPM
  - Alert about road works
  - Information about closed lanes } DENM
  - Dissemination of safe spots → MAPEM

- Service 5: Distribute ToC/MRM by scheduling ToC

- Challenges for CAVs:
  - Multiple simultaneous ToC at the same area

No automated driving
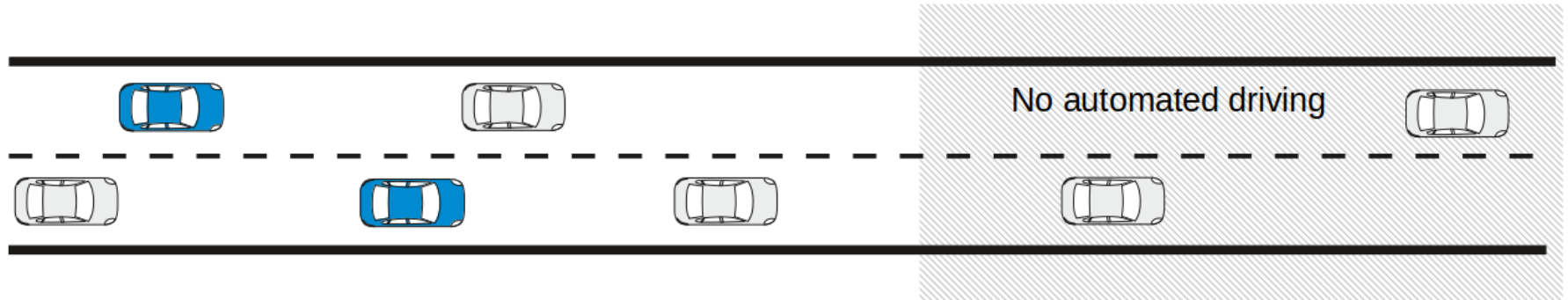
- Schedule ToCs over time and space to avoid multiple simultaneous ToCs at the same area

- Communication requirements:
  - Alert about no automated driving zone → DENM
  - Collective perception of the environment → CPM
  - Current automation level → CAM
  - Distribute time and place of ToCs → MCM

- First set of cooperative traffic management measures for managing transitions of control

- Minimize negative effects of ToCs at Transition areas

- Three different approaches for the design of traffic management measures:
  – Prevent ToCs
  – Distribute ToCs
  – Manage ToCs

- Five different traffic management measures designed for five different identified Transition Areas

- Design realistic models of vehicle behavior during ToC

- Extension of available ETSI V2X messages:
  - Triggering conditions of the CPM and MCM
  - MCM: infrastructure support for cooperative maneuvers

- Identify new Transition Areas and the appropriate traffic management measures

Thank you for your attention

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