

TransAID

V2X communications and protocol solutions for cooperative automated driving

Dr. Miguel Sepulcre (msepulcre@umh.es)

Universidad Miguel Hernández de Elche

 www.transaid.eu
 [@transaid_h2020](https://twitter.com/transaid_h2020)
 www.linkedin.com/groups/13562830/
 www.facebook.com/transaidh2020/

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 723390

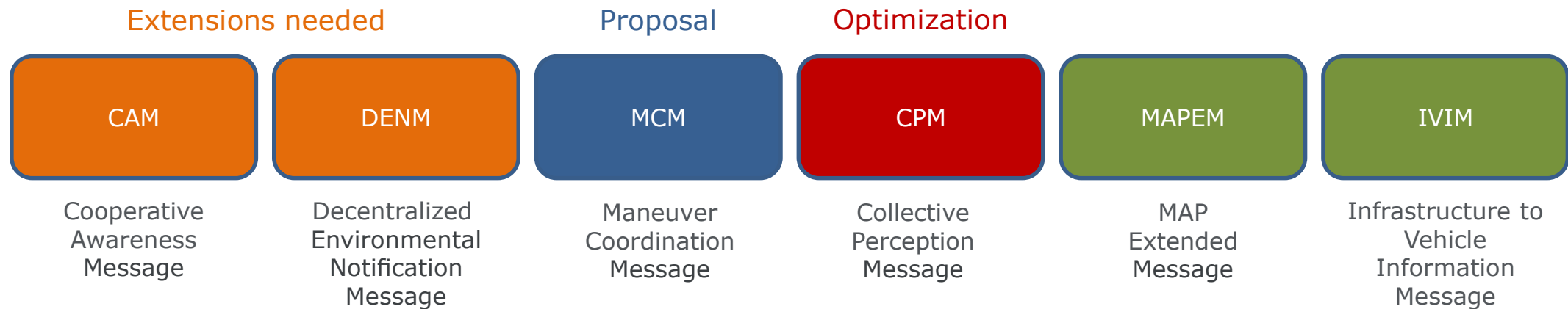


Agenda

- V2X message set definition
- Cooperative sensing
- Cooperative manoeuvring
- V2X communications reliability

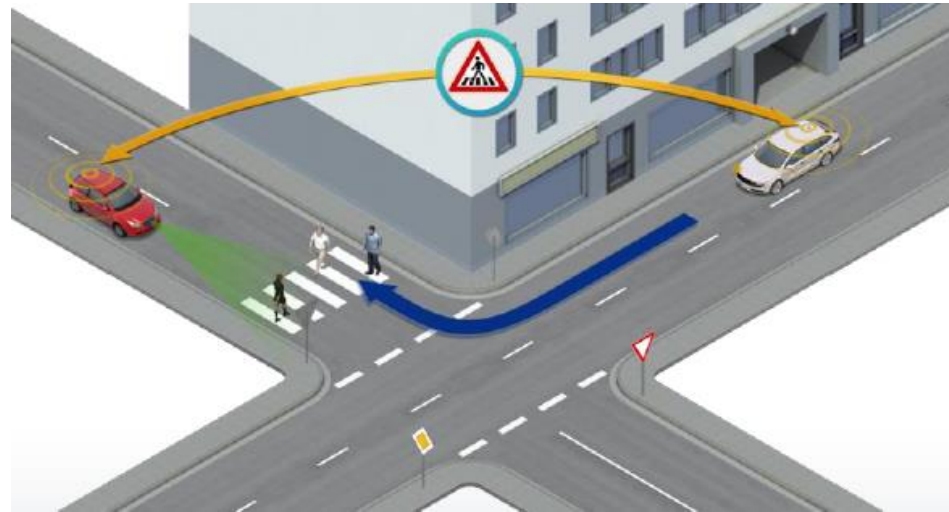
V2X message set definition

- Definition of V2X messages:
 - Support of TransAID Traffic Management Measures.
 - Cooperative sensing to improve detection.
 - Cooperative driving to coordinate manoeuvres.
- Approach: standard-compliant, backward compatibility and interoperability.



Cooperative sensing

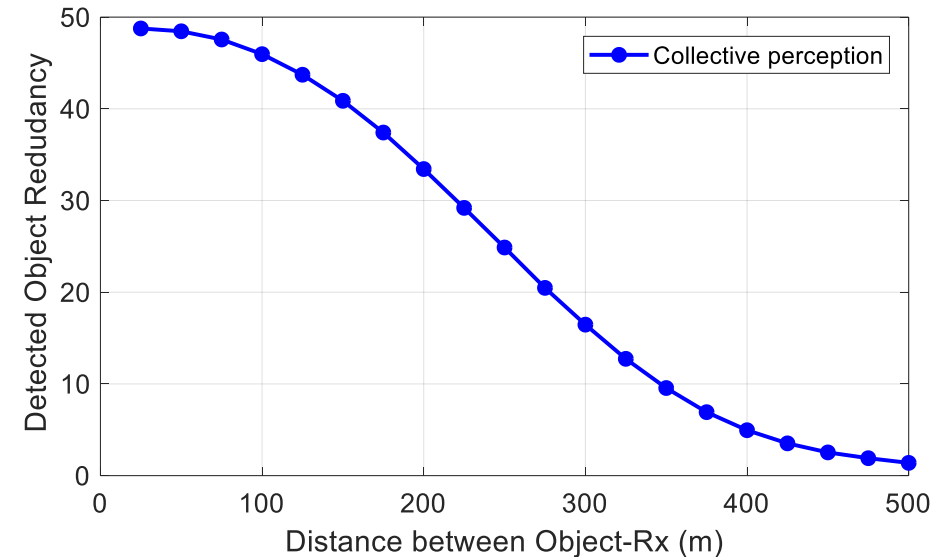
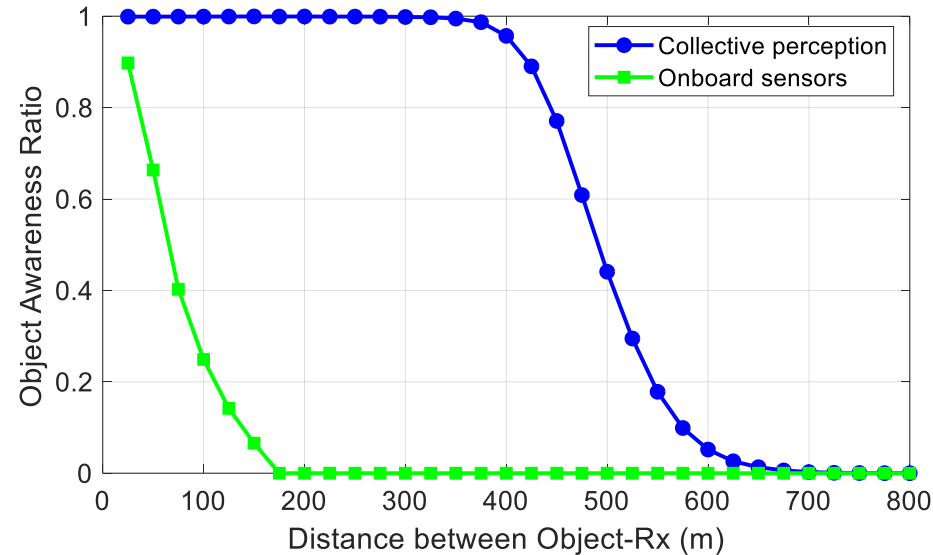
- Cooperative Sensing (also known as Collective Perception):
 - Information exchange about perceived environment.
 - Expand onboard sensors capabilities.



- ETSI is defining the Collective Perception Service (CPS):
 - Tx/Rx CPM messages: position, speed and other info about detected objects.
 - CPM size and rate could impact the V2X network stability and performance.

Cooperative sensing

- Study the impact of CPM generation rules on V2X network stability:
 - In-depth evaluation considering forward and 360° sensors, and different penetration rates.
 - Analysis of CPM rate & size, comms performance, awareness and redundancy.
 - Improved perception capabilities with CPM, but high level of redundancy.



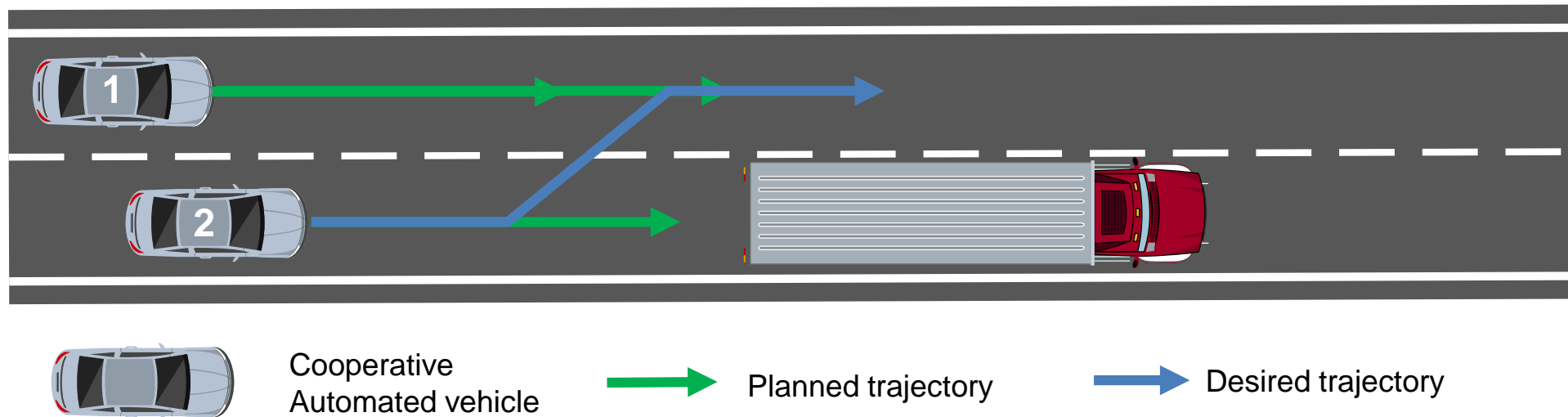
- Results included in [ETSI TR 103 562](#).

Cooperative sensing

- Evolution of CPM generation rules: look-ahead mechanism ([ETSI TR 103 562](#)):
 - Group detected objects to avoid transmission of high number of small CPMs.
 - Transmit in current CPM objects that will need to be transmitted in the near future.
 - Reduce number of messages: reduce headers and info about ego vehicle.
 - Proposal reduces the channel load (15%-25%) and improves the object perception.
- Evolution of CPM generation rules: redundancy mitigation ([ETSI TR 103 562](#)):
 - Avoid transmission of unnecessary info (e.g. too frequent updates about each object).
 - If info about an object has been recently received ⇒ don't transmit it.
 - Proposal reduces the load up to -68% info while maintaining perception at critical distances.
- Look-ahead + redundancy mitigation
 - Combination of standalone algorithms increases performance: lower load and better awareness.

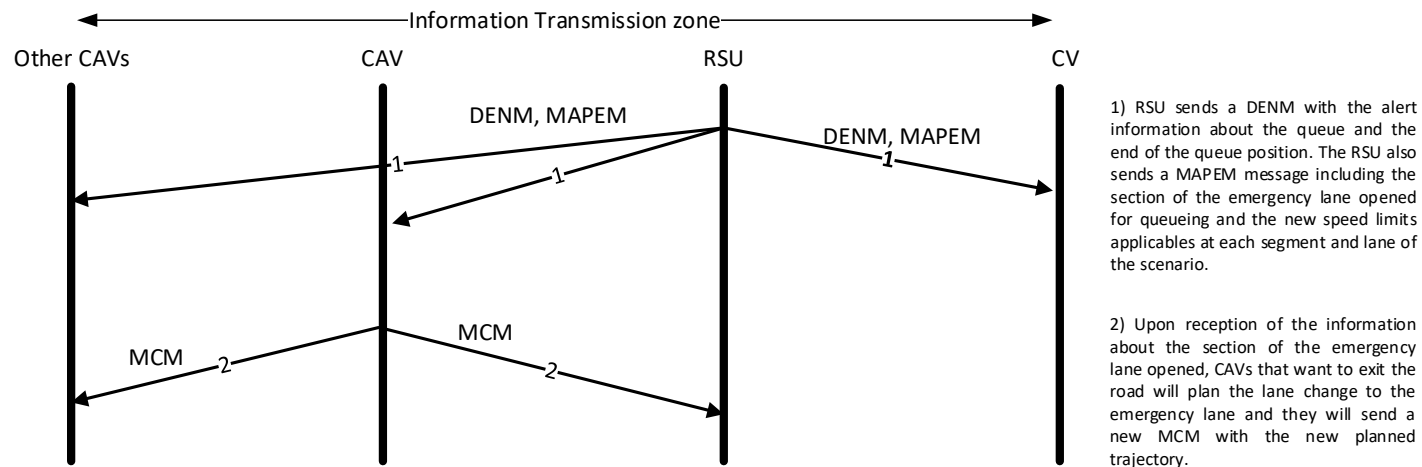
Cooperative manoeuvring

- V2V decentralized maneuver coordination concept (under discussion at ETSI):
 - Vehicles periodically broadcast MCM (Maneuver Coordination Message).
 - Planned trajectory: current planned trajectory for the next 5-10 seconds.
 - Desired trajectory: trajectory that vehicles want to follow but cannot due to right of way.
 - Implicit coordination via exchange of trajectories.



Cooperative manoeuvring

- Proposal of a novel V2I-aided maneuver coordination approach:
 - Enables the road infrastructure to support maneuver coordination.
 - Allows the execution of Traffic Management measures at transition areas.
 - Presented to ETSI and currently under discussion.
 - Included in ETSI TR 103 578 (Informative Report for Manoeuvre Coordination Service).
- Definition of V2X message flows for all the TransAID use cases.



Cooperative manoeuvring

- Proposal of different V2V MCM generation rules:
 - *Risk*: a new MCM is generated if time to risk of collision $<$ threshold.
 - *Risk & Dynamics*: a new MCM is generated if *Risk* and vehicle has moved more than 4m.
 - *Tracking Trajectories*: a new MCM is generated if distance between trajectories $>$ threshold.
- Evaluation of MCM generation rules:
 - Tradeoff between update frequency and channel load.
 - *Risk* generates MCM at high frequency to maintain updated all vehicles in risk.
 - *Tracking Trajectories* transmits small updates assuming that trajectories are reliable.
 - *Risk & Dynamics*: reasonable balance between awareness and load.

V2X communications reliability

V2X message compression to reduce interference and improve reliability

- Identification and implementation of multiple compression techniques:
 - Entropy based (Shannon-Fano) and adaptive (Gzip and Compress).
- CAM, CPM and MCM compression analysis conducted:
 - Standard-compliant messages extracted from real-world experiments.
 - Message size can be compressed up to -40%.
- Impact on V2X reliability:
 - Analytical compression models to integrate compression algorithms in network simulator ns3.
 - Channel load reduced between -18% and -26%.
 - Significant increase of awareness range (up to 200% increase of distance for PDR=0.7).

V2X communications reliability

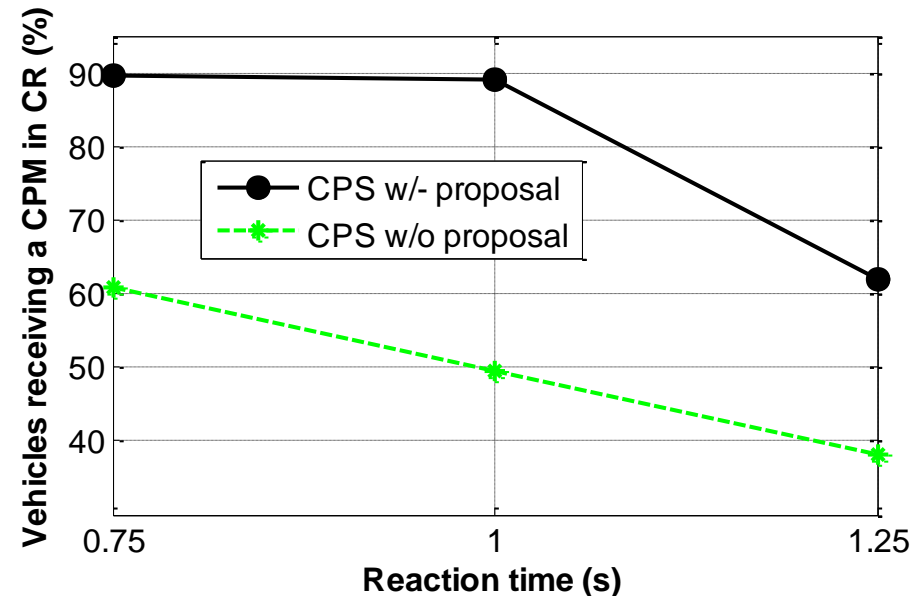
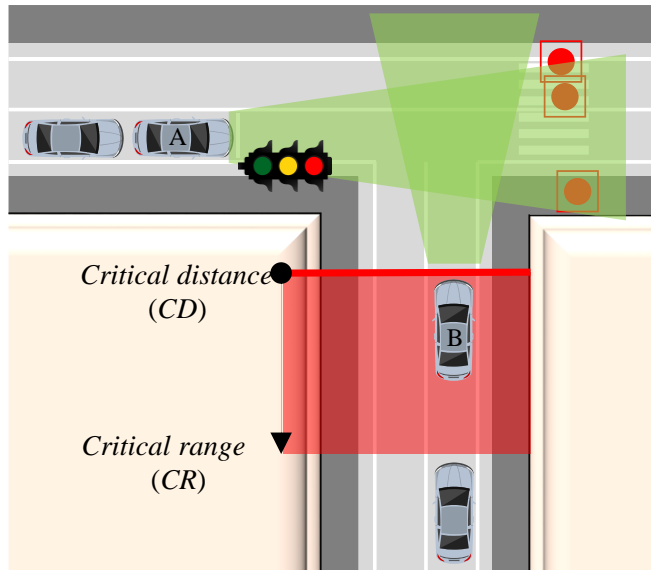
Congestion Control for enhanced reliability

- ETSI DCC (Decentralized Congestion Control):
 - DCC Access: maintain the channel load under control based on message flow control.
 - DCC Facilities: share the available resources among different applications (or messages).
- Study of the impact of DCC on reliability:
 - DCC can maintain the load under control: improve reliability at radio level.
 - Packets can be internally dropped: degradation at the application level.
 - Packet transmissions can be delayed due to DCC: increase of information age.
- Comparison between DCC and proposed CPM generation rules:
 - Our proposal can improve awareness and reduce the channel load.

V2X communications reliability

Context-based broadcast acknowledgement

- Proposal: selective request of acknowledgment of specific/critical broadcast messages.
 - Increased reliability: retransmissions triggered if needed.
 - Scalability: tx vehicles select the vehicle/s that has/have to report the ACK packet.
 - Under discussion in IEEE 802.11bd (Next Generation V2X, ~IEEE 802.11p v2).
- Evaluation in ns3 for Collective Perception Service: crossing pedestrian awareness.



Summary

- V2X message set definition:
 - Traffic Management measures, cooperative sensing and manoeuvring.
 - More info at: [TransAID D5.1](#)
- Cooperative sensing:
 - Study and evolution of CPM generation rules.
 - More info at: [TransAID D5.2](#)
- Cooperative manoeuvring:
 - Definition of V2I-aided approach, message flows and V2X MCM generation rules.
 - More info at: [TransAID D5.2](#)
- V2X communications reliability:
 - V2X message compression, DCC reliability analysis, broadcast acknowledgement.
 - More info at: [TransAID D5.3](#)

Discussion topics

- V2X standardization activities on cooperative sensing or manoeuvring.
- Current V2X technology trends in Japan: DSRC vs LTE-V2X.
- Relevant future 5G V2X use cases in Japan.
- Interest in future ICT EU-Japan Joint calls.

TransAID

Thank you for your attention!

Miguel Sepulcre (msepulcre@umh.es)

Universidad Miguel Hernández de Elche

 www.transaid.eu
 [@transaid_h2020](https://twitter.com/transaid_h2020)
 www.linkedin.com/groups/13562830/
 www.facebook.com/transaidh2020/

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 723390

