A simulation approach for increased safety in advanced C-ITS scenarios

Bruno Vieira

CISTER – Research Centre in
Real-Time & Embedded Computing Systems

Presentation Contents

- Introduction(Context, Objectives and Contributions)
- C-ITS Scenarios - Cooperative Platooning
- Vehicular Communications – ETSI ITS-G5
- COPADRIVe - A Realistic Simulation Framework for Cooperative Autonomous Driving Applications
- HiL simulation framework for Cooperative Platooning safety assurance
- Experimental Results
- Conclusions and Future Work

Introduction- Research Context

Safe Cooperating Cyber-Physical Systems using Wireless Communication | SafeCOP

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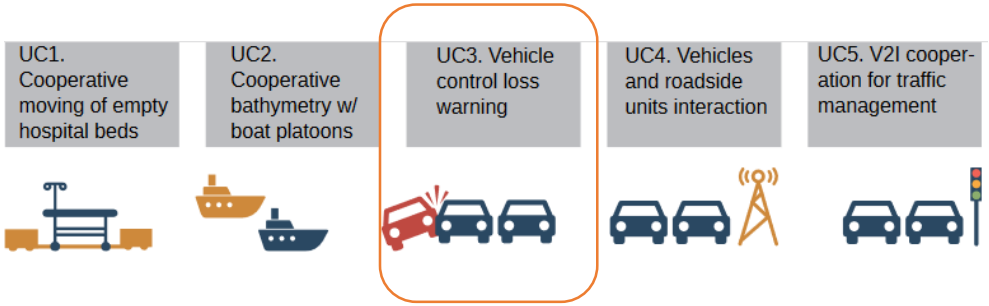
gmv INNOVATING SOLUTIONS



Development of simulation tools able to test and evaluate safety mechanisms in cooperative platooning systems

Introduction- Research Objectives and Contributions

- Implementation of a Platooning control model using only V2V communications;
- Overview of ETSI ITS-G5 and its adequancy to support Cooperative Platooning scenarios;

ETSI World Class Standards

- Development of the COPADRIVe tool, to enable analysis of C-ITS scenarios in a realistic simulation environment;
- Development of a Hardware-in-the-loop simulation framework to support testing of a CLW mechanism;

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- Results and Performance analysis gathered using both tools;
- Writing and publishing of two, already accepted, conference articles;

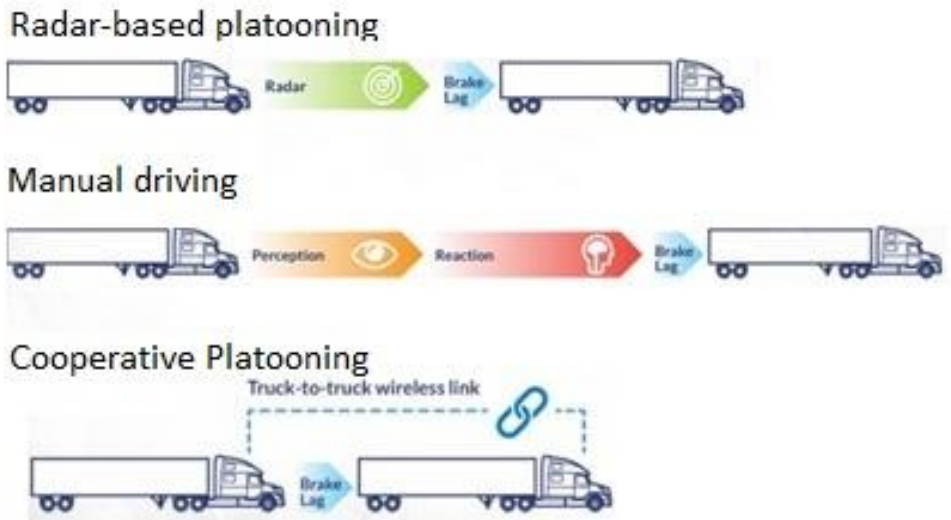
IEEE ISORC 2019

2019 IEEE ICCVE November 4-8, 2019

C-ITS Scenario – Cooperative Platooning

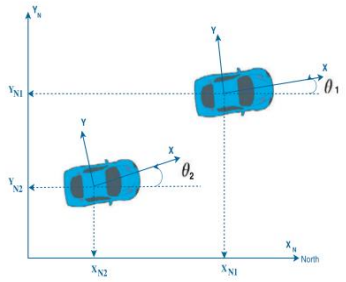
- What is Platooning?

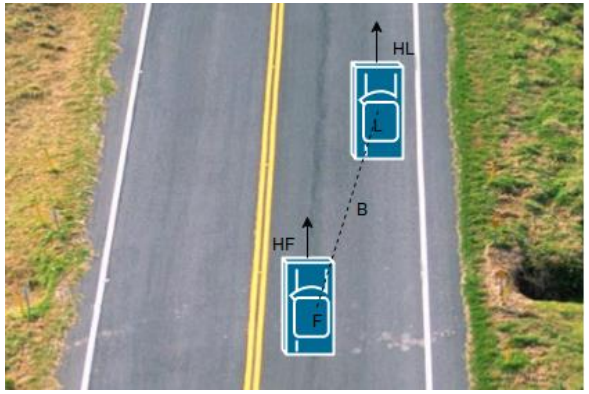
- Why Cooperative Platooning?



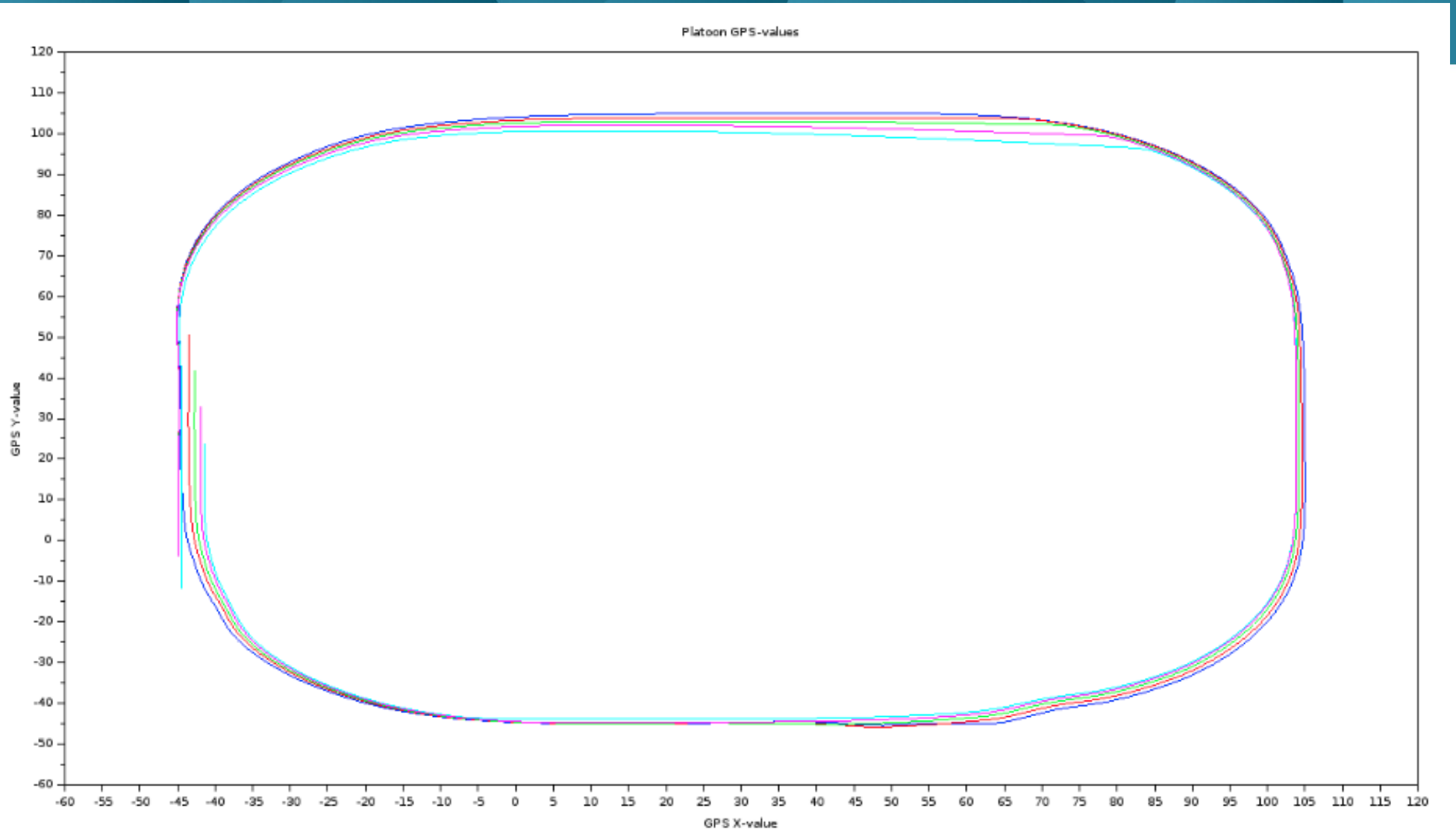
Cooperative Platooning Control Model

- V2V communications **only** based platooning control model.
- **PID** control for both **lateral** and **longitudinal** control.
- Control Inputs:
  - GPS coordinates
  - Heading
  - Speed
- **Bearing** angle contribution for **steer** control.
- **Webots** simulation

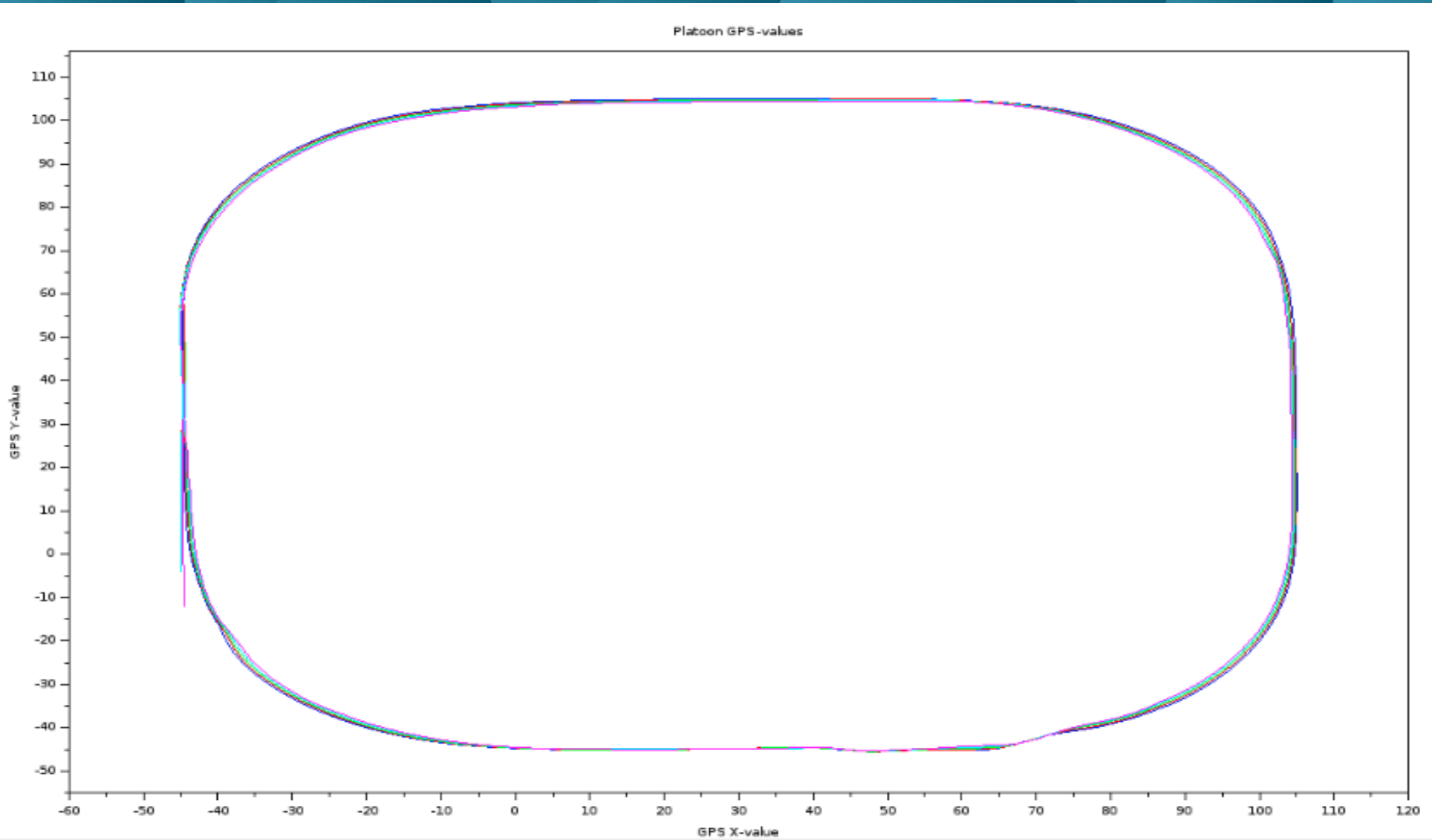




Cooperative Platooning Control Model

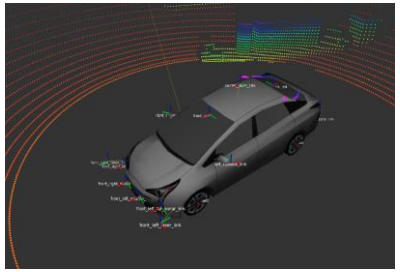


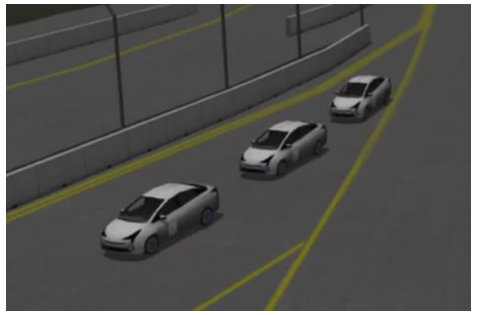
Cooperative Platooning Control Model



COPADRIVe - A Realistic Simulation Framework for COOPerative Autonomous DRIVing Applications

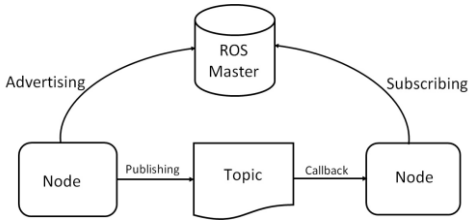
GAZEBO





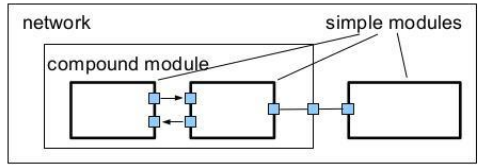
ROS

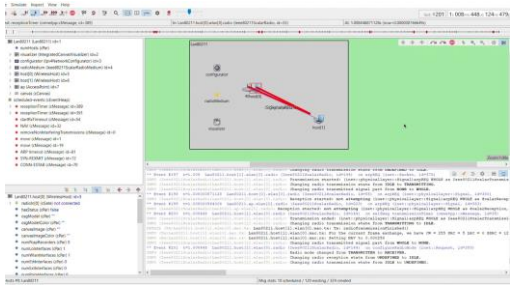
Open Source Robotics Foundation



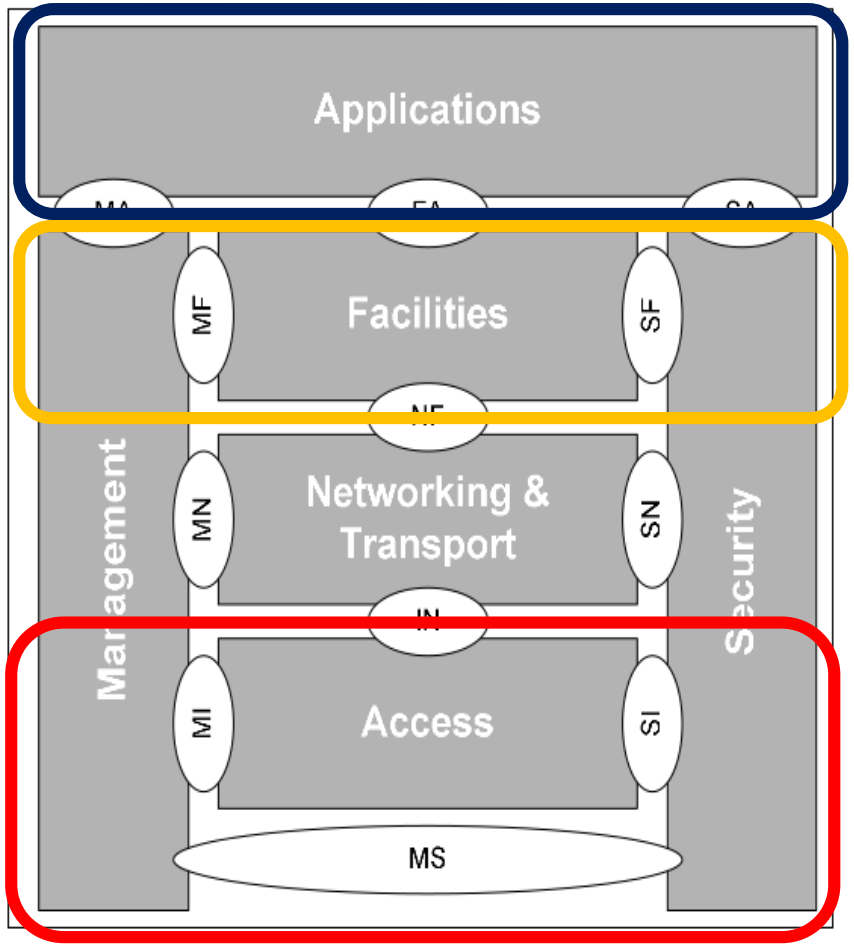
OMNeT++

Discrete Event Simulator

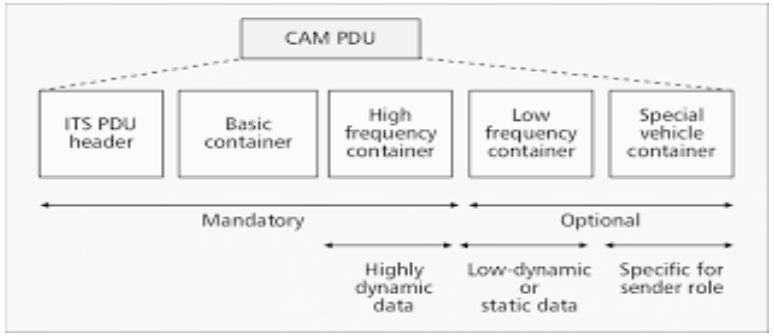




Vehicular Communications – ETSI ITS-G5



Cooperative Awareness Message (**CAM**)



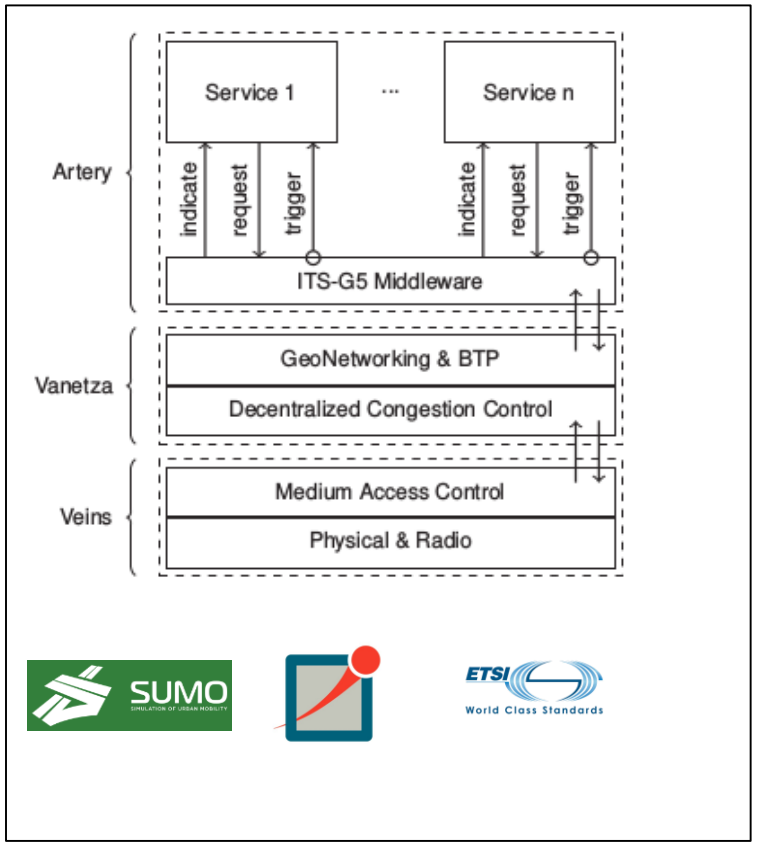
Cooperative Awareness Service (**CaService**)

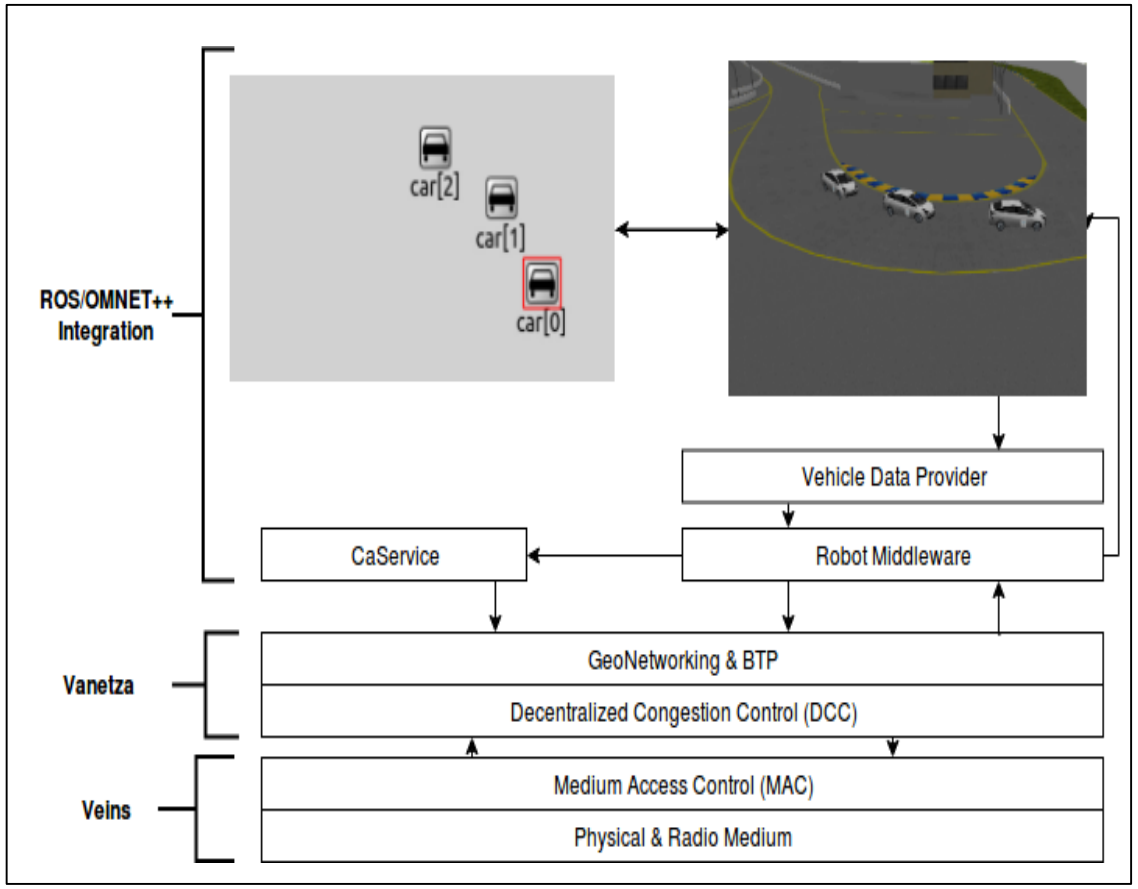
Physical and MAC layers - **IEEE 802.11p**

COPADRIVe - A Realistic Simulation Framework for COOPerative Autonomous DRIVing Applications

Artery Integration

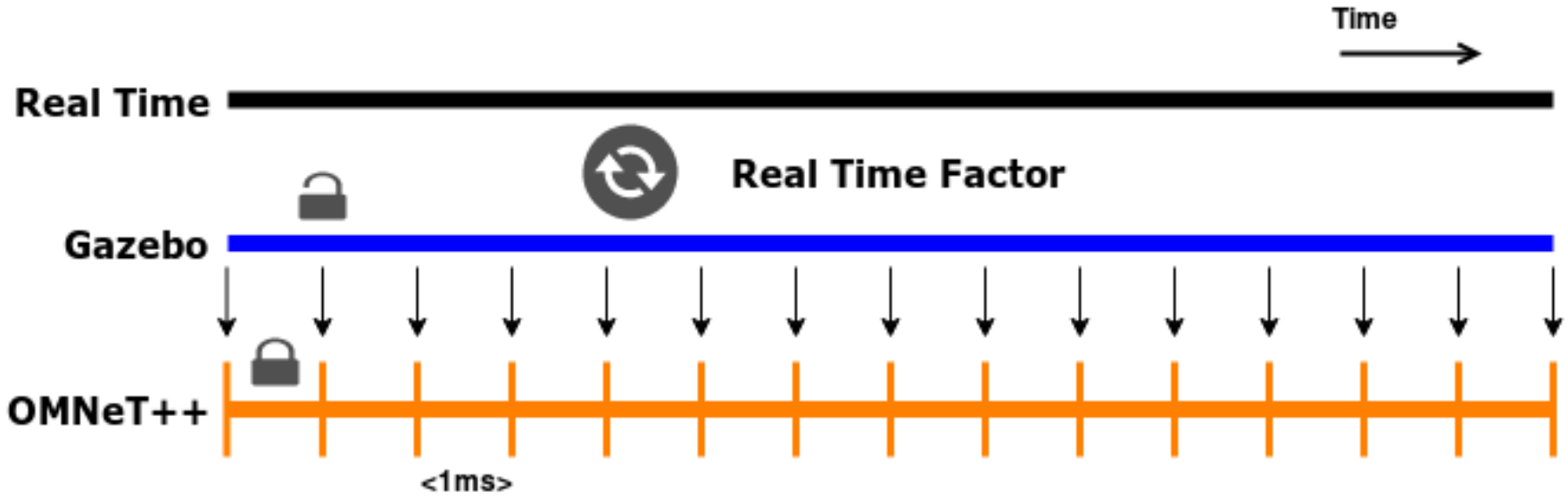
https://github.com/riebl/artery





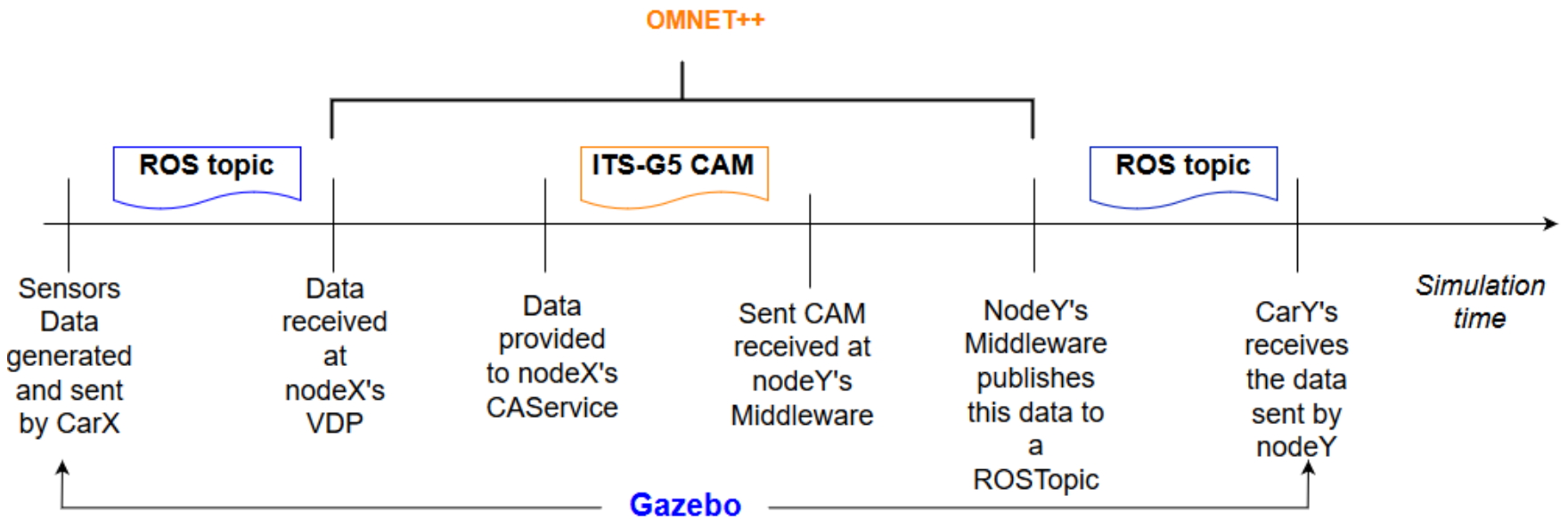
COPADRIVe - A Realistic Simulation Framework for COOPerative Autonomous DRIVing Applications

- Simulation time synchronization



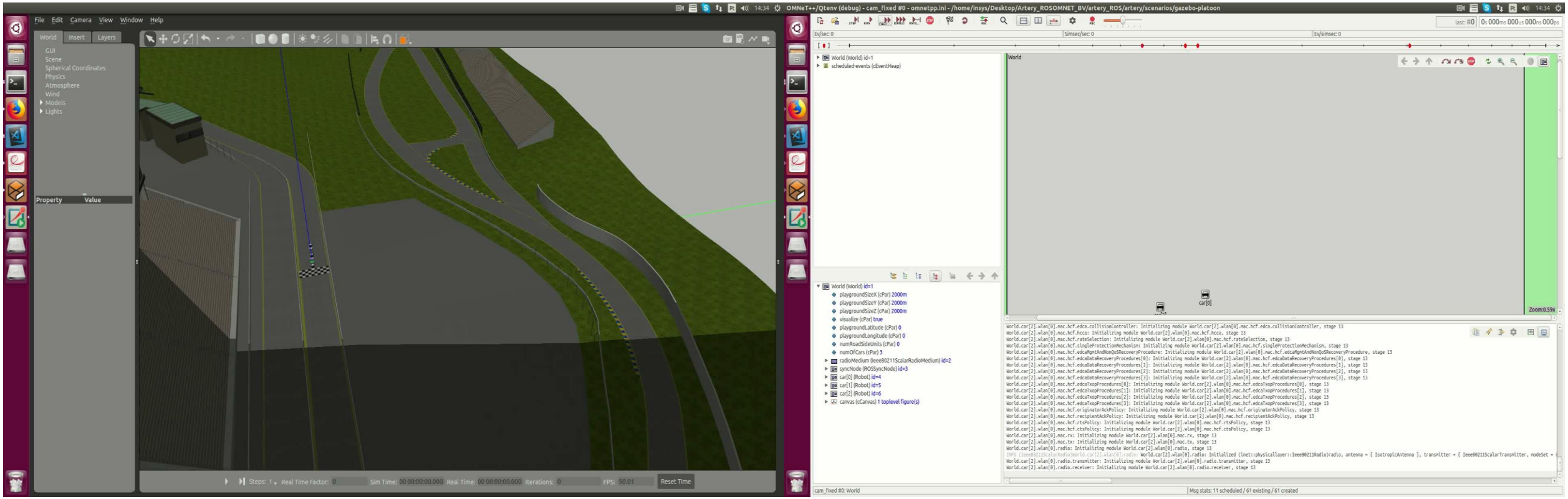
COPADRIVe - A Realistic Simulation Framework for COOPerative Autonomous DRIVing Applications

Data Lifetime



COPADRIVe - A Realistic Simulation Framework for COOPerative Autonomous DRIVing Applications

https://youtu.be/BgSCGZBTa-w



Experimental Results - COPADRIVe

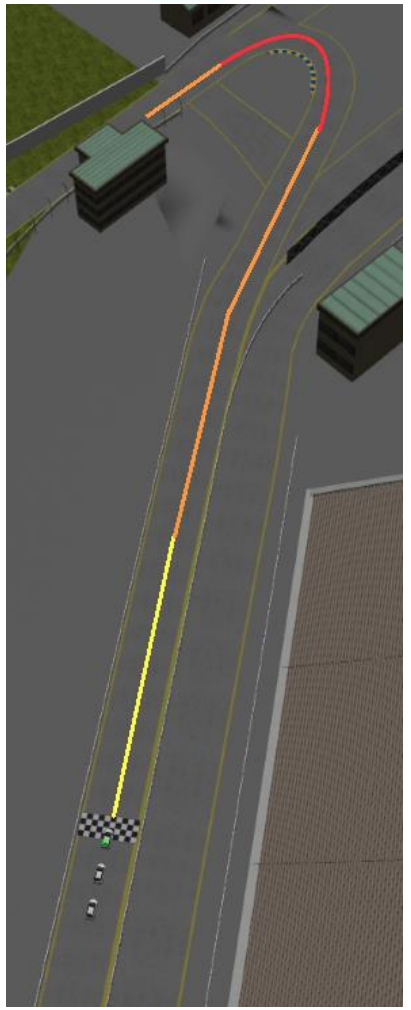
Four scenarios regarding **CAM exchanging** frequency:

Scenario A - Fixed Frequencies (10, 5, 3.3 and 2.5 Hz)

Scenario B - Basic System Profile (BSP) from ETSI

Scenario C - BSP with platooning-defined specifications

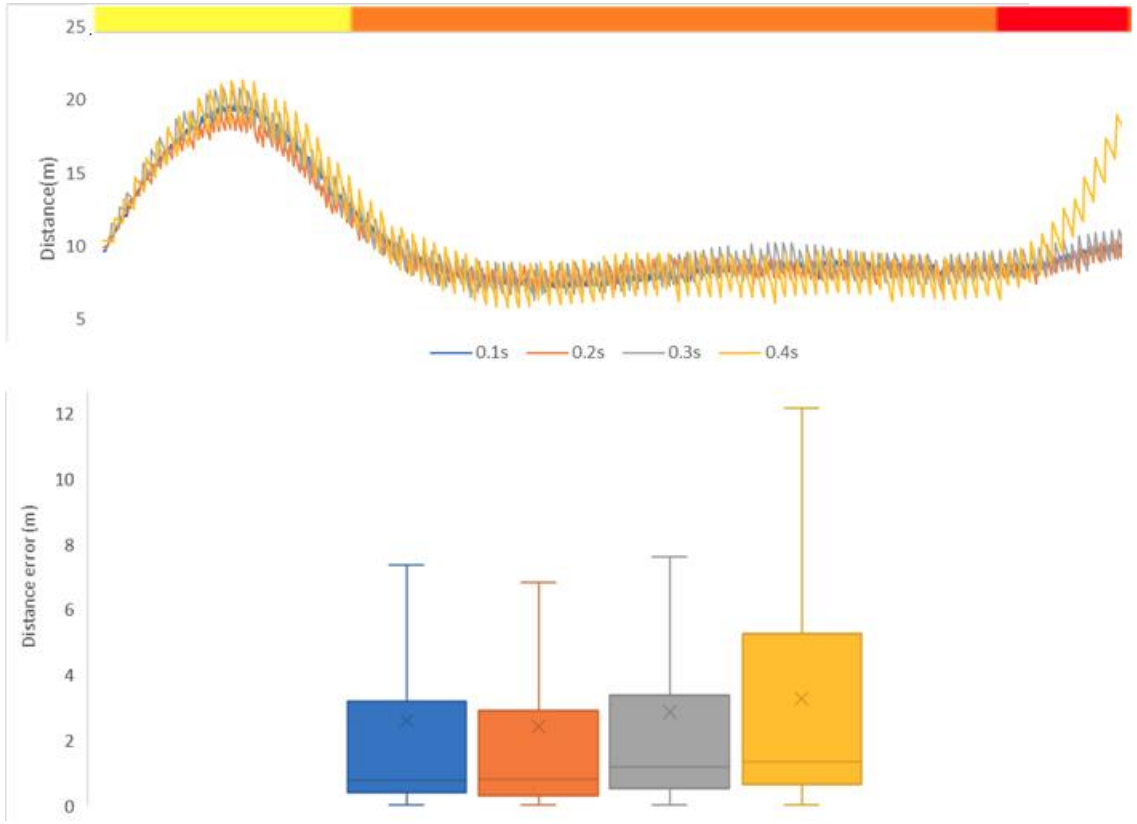
Scenario D - A custom profile defined following the analysis previously done

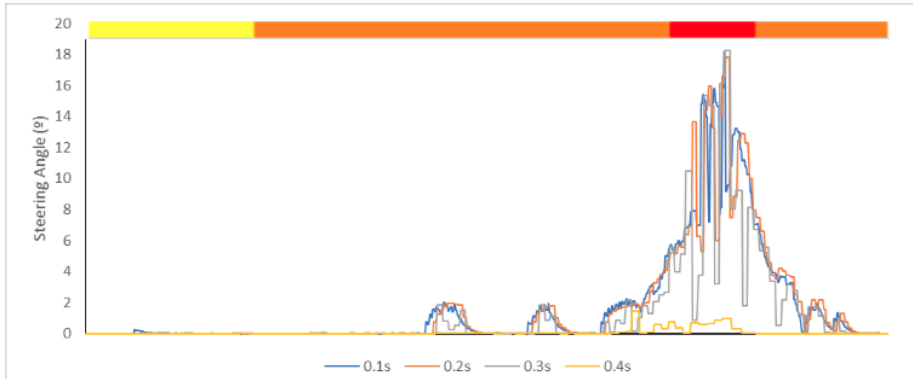


Experimental Results – COPADRIVe – Scenario A

Fixed frequencies:

- 10 Hz (0.1s)
- 5 Hz (0.2s)
- 3.3 Hz (0.3s)
- 2.5 Hz (0.4s)

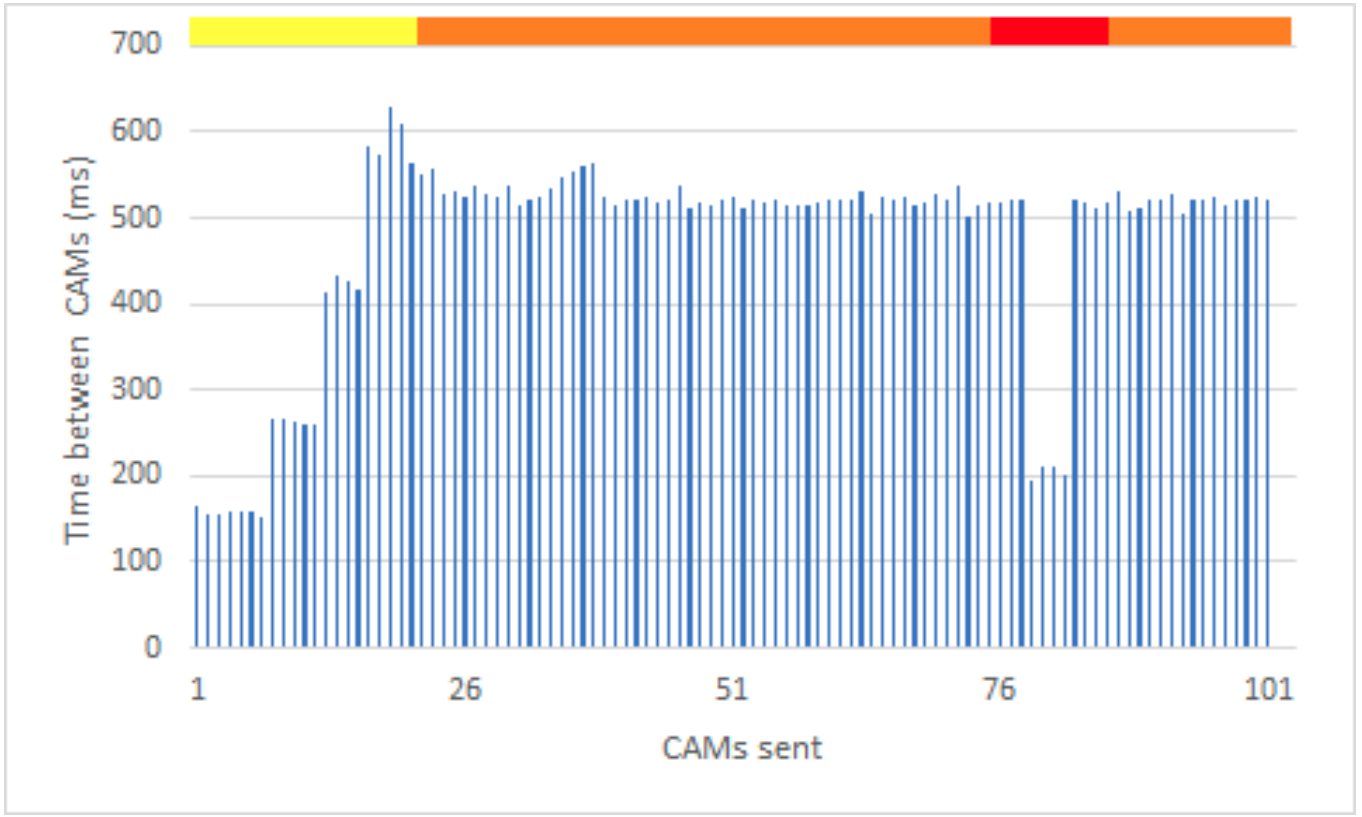




Experimental Results – COPADRIVe – Scenario B

Basic Service Profile:

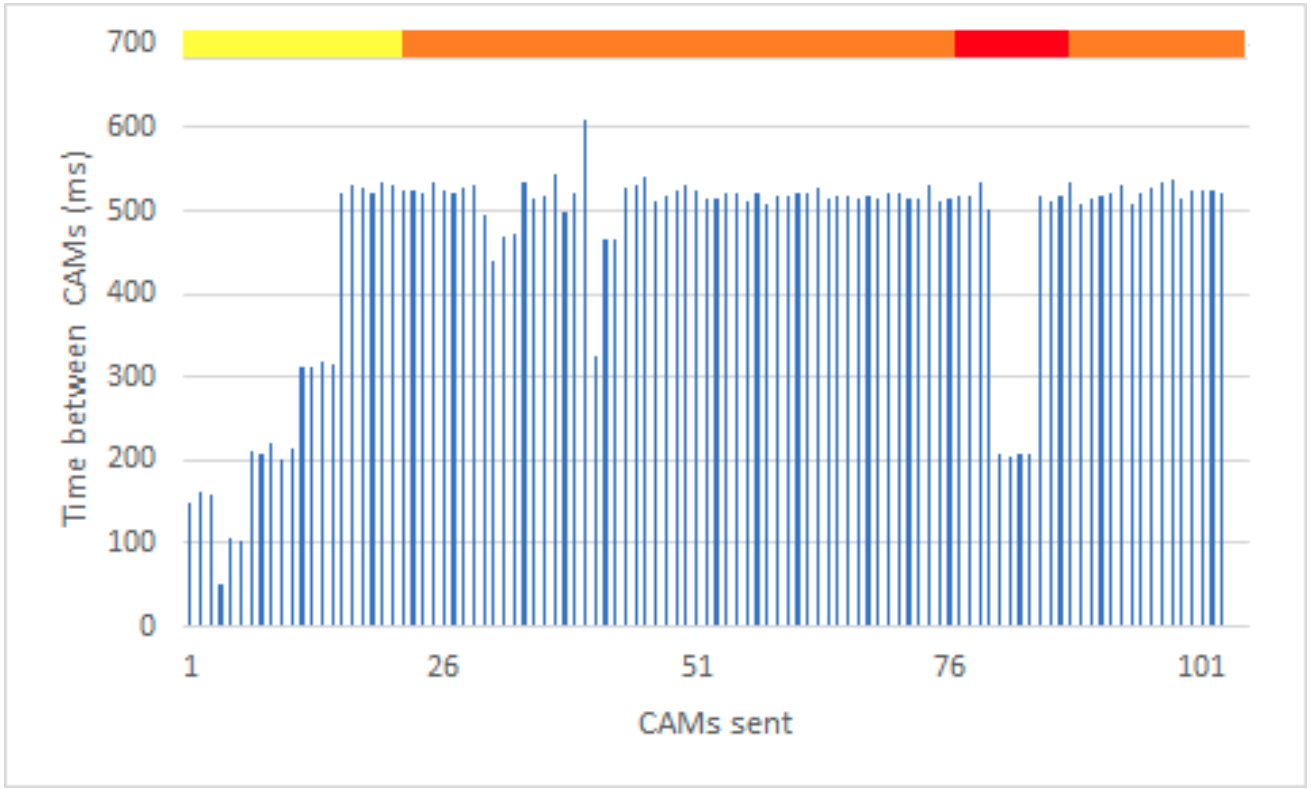
- Time interval between CAM generations: 0.1s - 1 s;
- Absolute difference between headings > 4º ;
- Absolute difference between positions > 4m ;
- Absolute difference between speeds > 1m/s ;
- Rules checked every 100ms .



Experimental Results – COPADRIVe – Scenario C

Basic Service Profile (platoon):

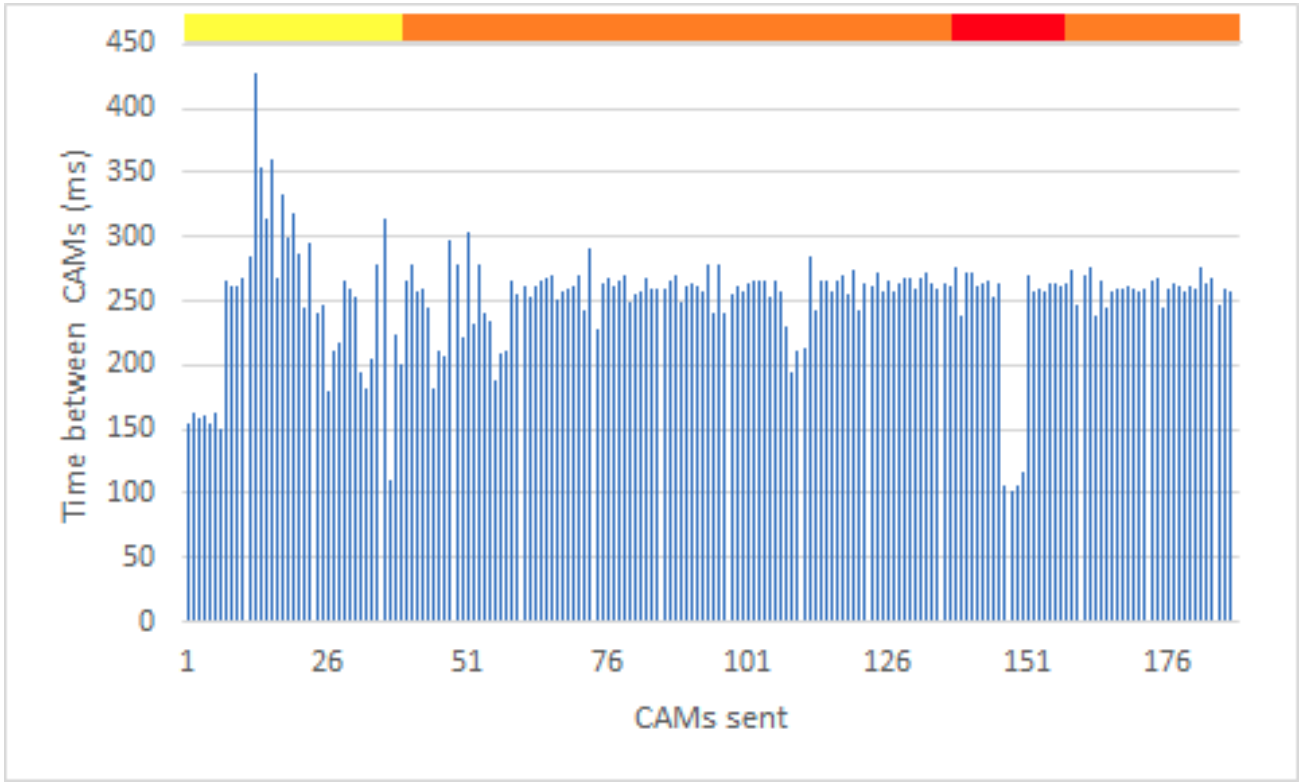
- Time interval between CAM generations: 0.1s - 0.5s;
- Absolute difference between headings > 4° ;
- Absolute difference between positions > 4m ;
- Absolute difference between speeds > 1m/s ;
- Rules checked every 100ms .



Experimental Results – COPADRIVe – Scenario D

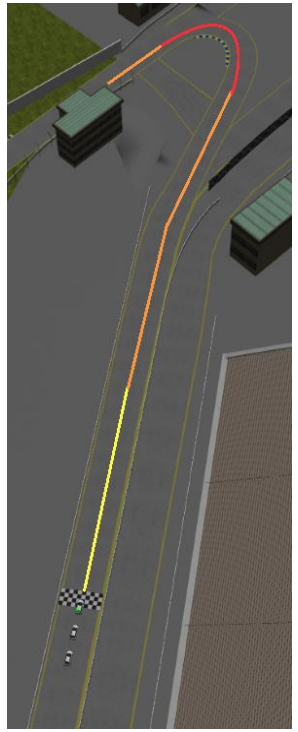
Custom Service Profile:

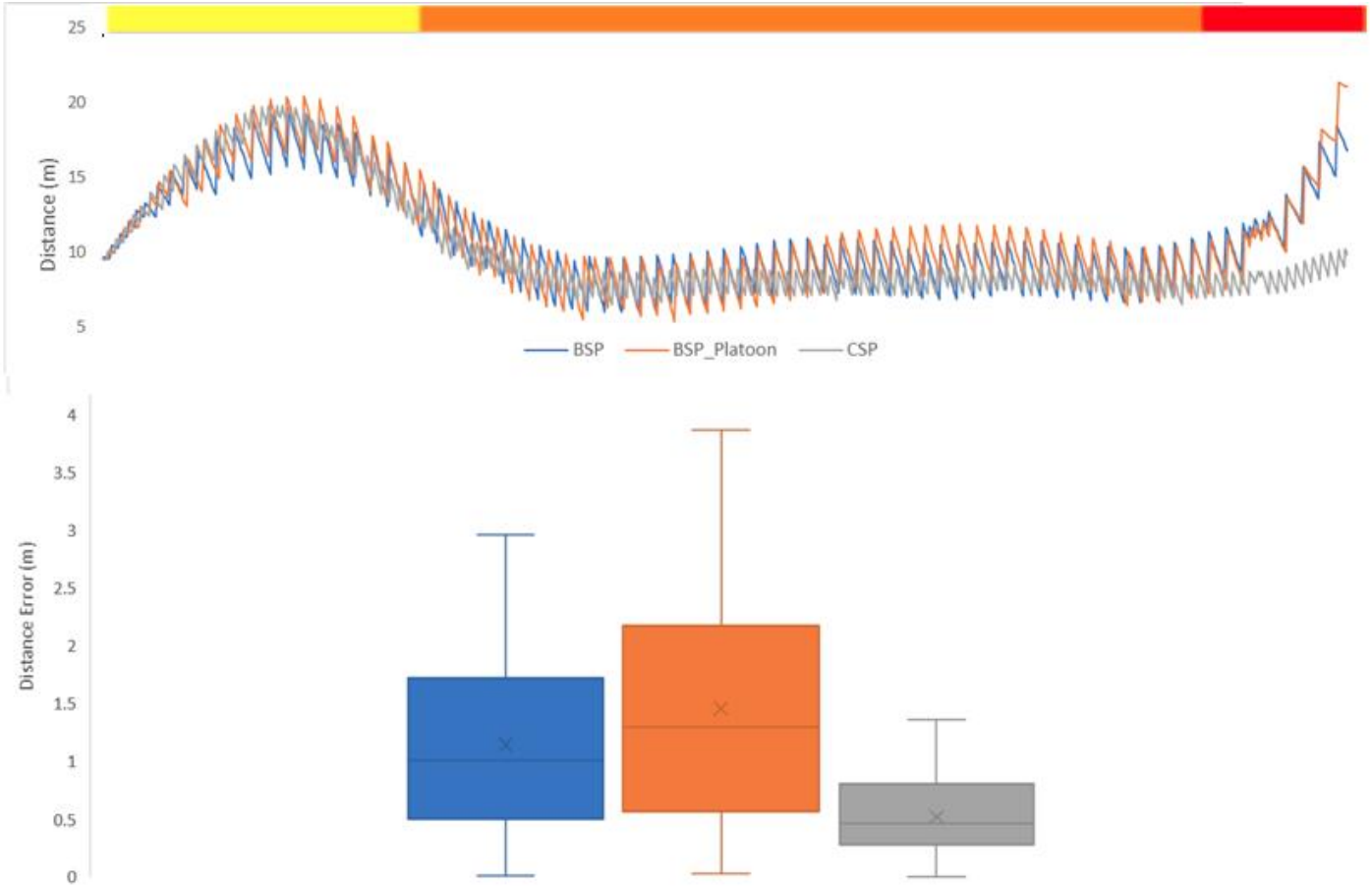
- Time interval between CAM generations: 0.1s - 0.5s;
- Absolute difference between headings > 4° ;
- Absolute difference between positions > 4m ;
- Absolute difference between speeds > 1m/s ;
- Rules checked every 100ms .



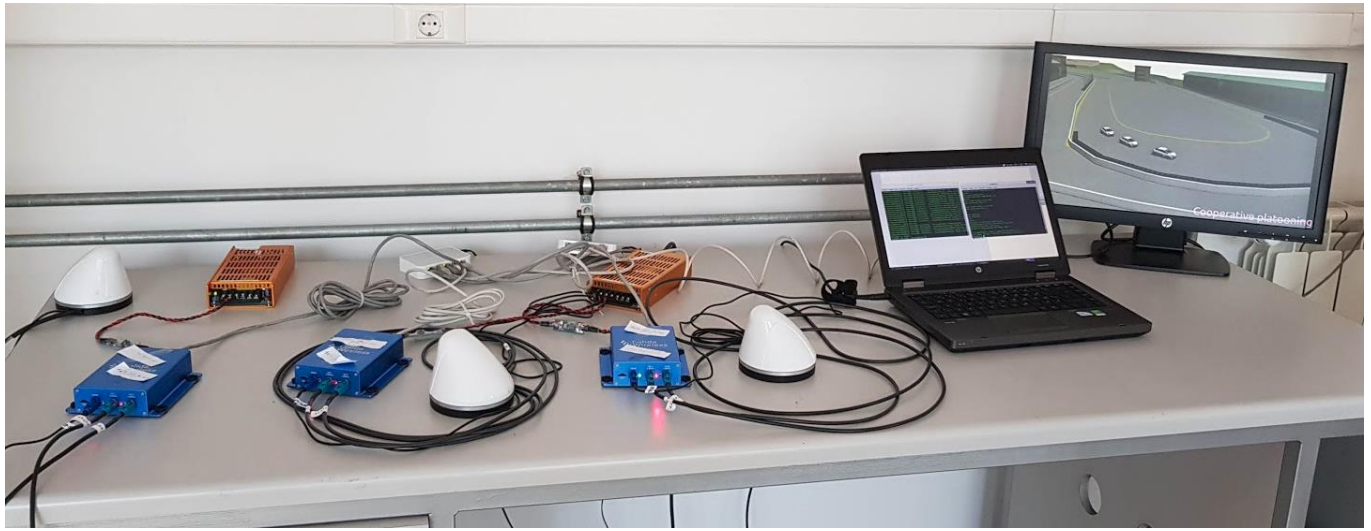
Experimental Results – COPADRIVe – Scenario B/C/D

Scenario	Fixed Frequencies				BSP	BSP Plat.	CSP
	10	5	3.3	2.5			
Message	441	227	151	113	101	101	181
Safety	OK	OK	OK	NOK	NOK	NOK	OK

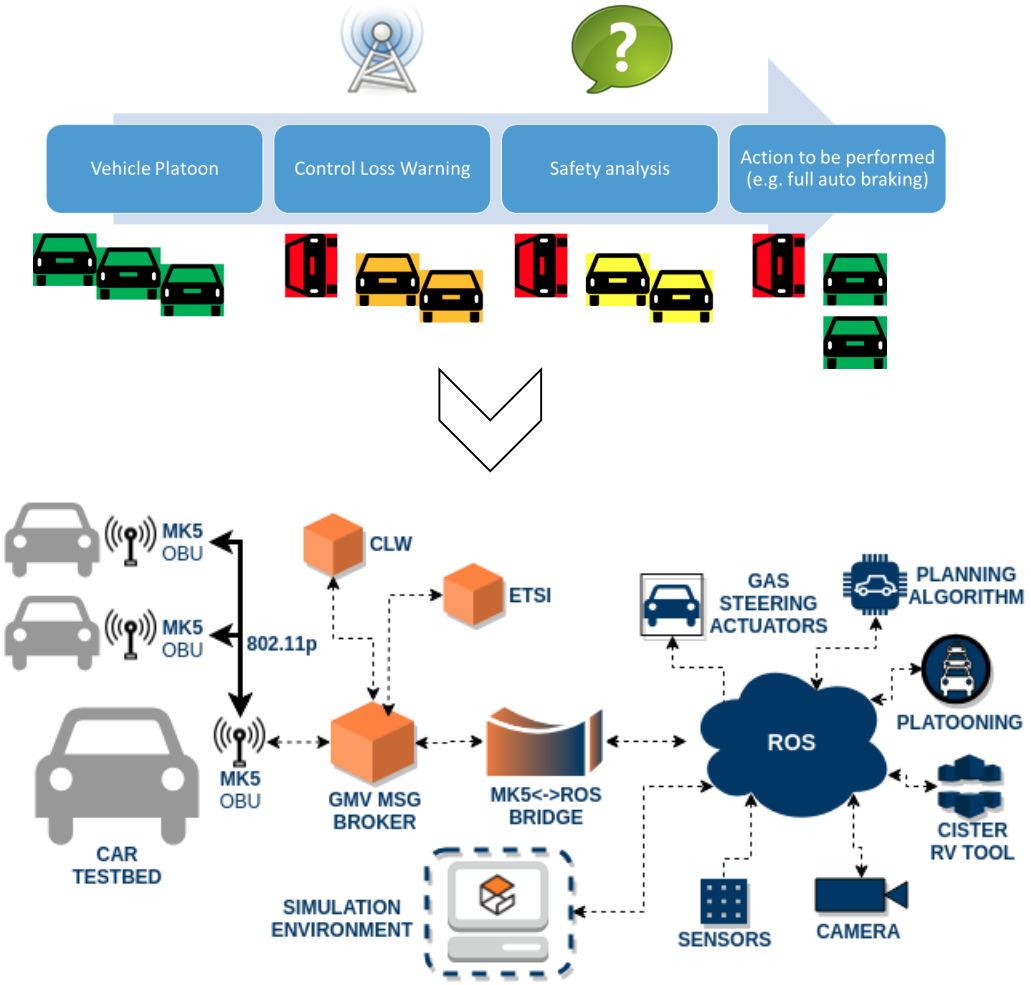




HiL simulation framework for Cooperative Platooning safety assurance



HiL simulation framework for Cooperative Platooning safety assurance

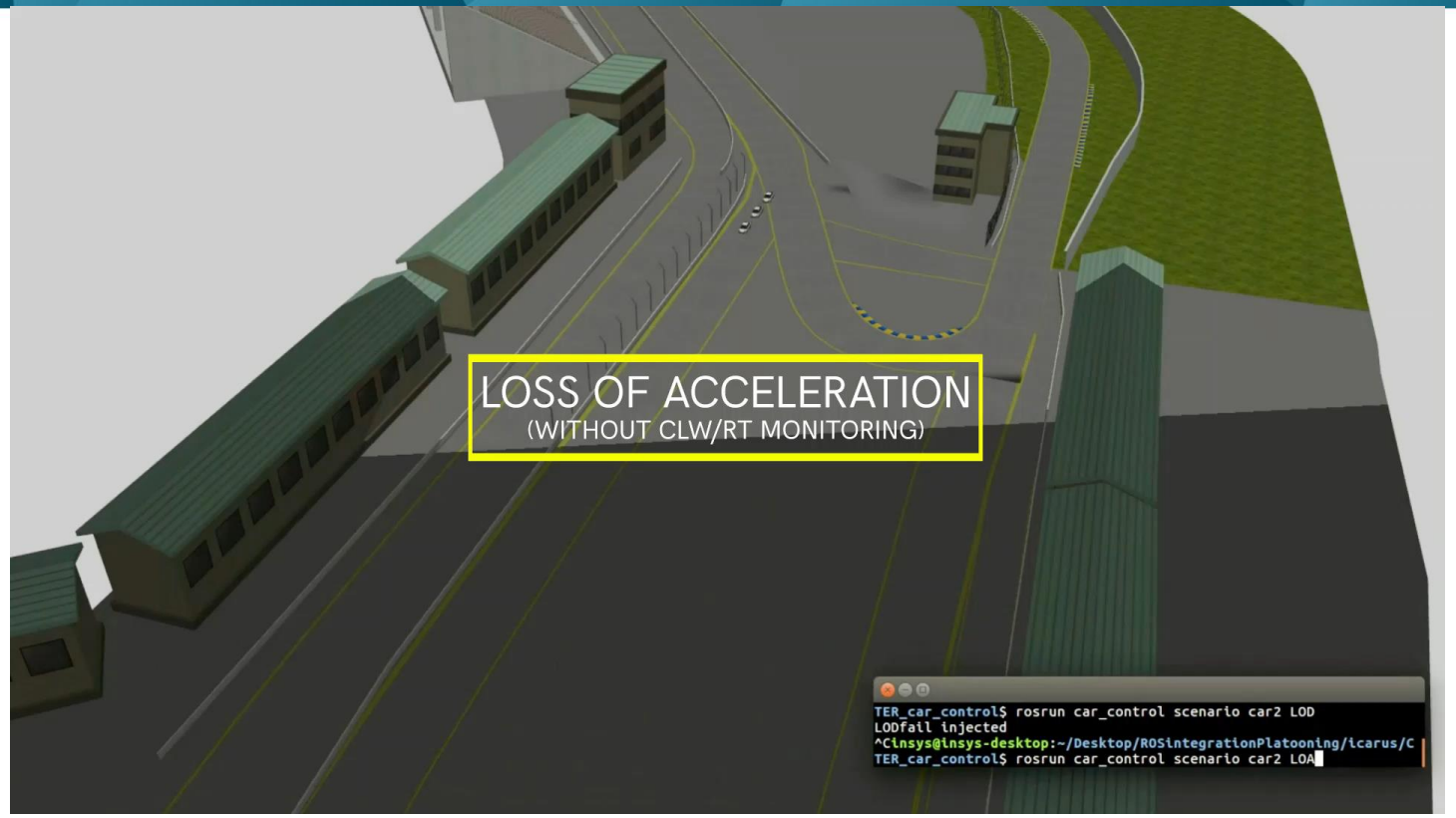


What is a Control Loss Warning (**CLW**) module? Runtime Monitor?

Control Loss scenarios :

- **LOA** – Loss of acceleration
- **LOB** – Loss of brakes
- **LOD** – Loss of direction

HiL Simulation – Loss warning scenarios



https://youtu.be/oWmyI6yCot8

Conclusions and Future Work

- Both tools proven to be able to analyse Cooperative Platooning scenarios.

- Extending COPADRIVe – different scenarios, change communications stack.

- Test out new safety mechanisms under the HiL environment.

- More scientific contributions to be done.


Questions?
Discussion