Connected VRUs to enhance vehicle perception and safe interaction with connected automated vehicles in urban environments

[Arial 14, bold, centred, title case]

Abstract should be 3 pages max.

Stella Nikolaou, CERTH/HIT, Greece, snikol@certh.gr, **Ioannis Gragkopoulos,** CERTH/HIT, Greece, **Ioannis Tsetsinas,** CERTH/HIT, Greece, **Mary Panou,** CERTH/HIT, Greece

Keywords: collective perception, vulnerable road users, human-machine interaction, active safety systems, C-ITS communication, road safety.

OVERVIEW

The future transport and mobility environment will be disrupted by innovations in Connected and Automated Vehicles (CAVs), in which safety will be of the highest priority. SAFE-UP H2020 project aims to proactively address the upcoming safety challenges by developing innovative technologies, testing and assessment methods.

SAFE-UP EU project is based on four key pillars: i) future safety-critical scenarios, ii) new safety technologies, iii) novel safety assessment methodologies and iv) training activities and awareness creation on future traffic scenarios. Future safety-critical scenarios will be designed and analysed in a highly automated and mixed traffic environment in a traffic simulation platform. Based on these scenarios, new safety technologies for active and passive systems will be developed, resulting in 4 demo cases.

This paper presents the active safety system of Demo 4, which develops an enhanced communication system between all road actors (vehicles, infrastructure and VRUs) via C-ITS technology. The target is to develop Vehicle-to-Everything (V2X) communications-based safety applications, able to detect potential hazards between vehicles and VRUs and to warn both of them with proper messages on their HMI. Both connected and non-connected VRUs are considered

THE CONCEPT OF CONNECTED VRUs

This concept aims to enhance the safety and conspicuity of VRUs in future interaction scenarios with AVs, by implementing C-ITS services in smart devices and vehicles for providing warning messages.

Demo 4 develops a VRU safety system based on V2X technology that provides enhanced communication between vehicles, road infrastructure (RSU installed on traffic light) and VRUs (pedestrians and cyclists). The actual target is to provide additional environmental perception to vehicles regarding the presence of VRUs in critical situations, especially in cases where the vehicle sensors reach their limits (i.e. obstructed areas). Connected VRUs are able to directly exchange V2X

messages with both the equipped V2X vehicles and the infrastructure RSU, whereas the non-connected VRUs are monitored by the RSU that exchanges direct messages with the equipped V2X vehicles.

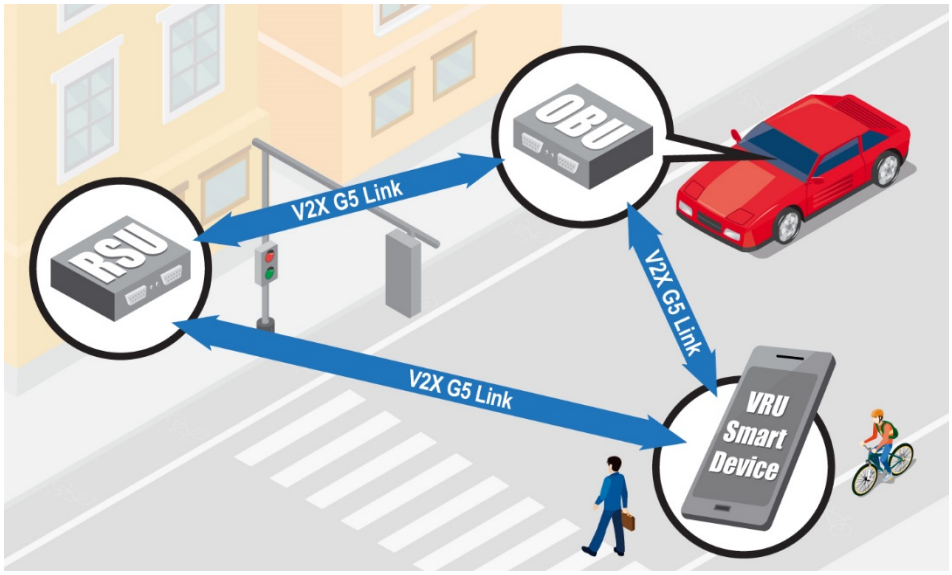

Figure 1: SAFE-UP Demo 4 overview.

The system deploys effective on-time warning messages on critical situations to both drivers and connected VRUs. For the drivers, the warning messages are delivered via in-vehicle display and audio elements, whereas for VRUs the warnings are delivered via a custom-developed C-ITS smart device. The vehicle is equipped with an AEB system based on perception sensors that may be engaged in cases where an immediate emergency stop is required. This AEB system will increase its efficiency in certain scenarios in combination with V2X technology, since perception sensors data and V2X information will feed the AEB system in order to be engaged on-time and to perform a smoother stopping manoeuvre in occlusion situations. The combination of higher speeds and obstruction could show potential for V2X compared to AEB scenarios.

Figure 2 below presents the high level architecture of the VRU system, one of the three main components in Demo 4, the other two being the RSU and the vehicle components respectively. This device will be developed as a prototype for the purposes of Demo 4, in order to be used by the connected VRUs (pedestrians and cyclists) and exchange direct C-ITS G5 messages with the vehicle and the RSU, as well as provide warnings to the VRUs in critical situations. This prototype development is essential as current market smart phones do not integrate V2X technology.

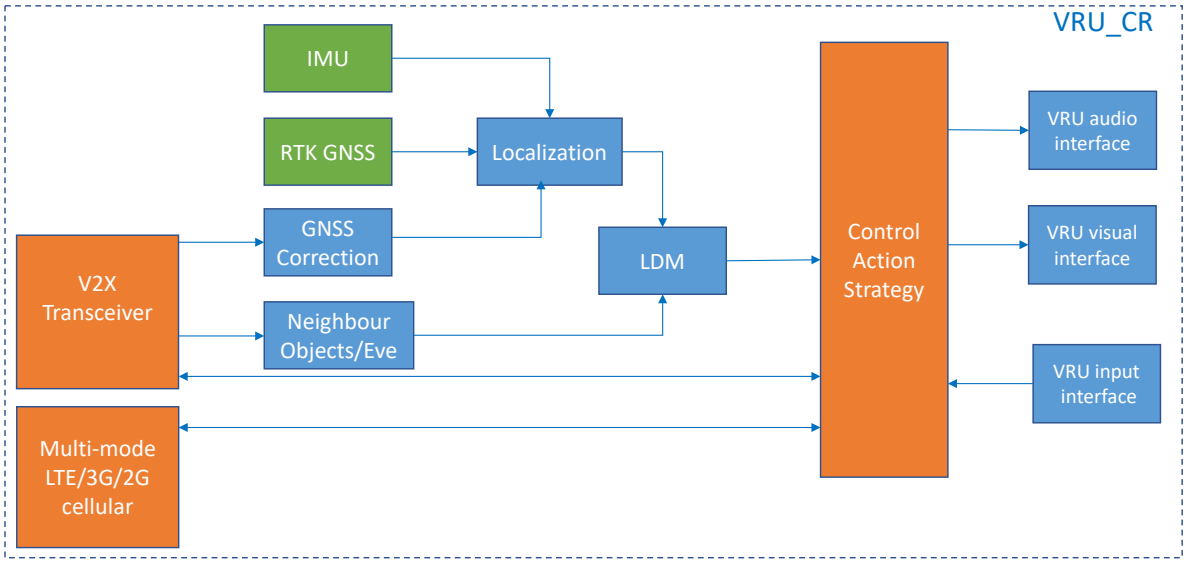

Figure 2: Demo 4 VRU core physical architecture diagram.

The VRU device will operate as any conventional V2X device and will transmit its own awareness information (CAM messages). Based on the reception of common awareness and notification messages transmitted by the other actors of Demo 4, a Local Dynamic Map will be sustained keeping track of the incoming objects and events in the neighbourhood area. Visual and acoustic interfaces will be used to warn the VRUs (pedestrians and cyclists) via their smart device, whereas haptic warnings will be also explored via Bluetooth connection with a smartwatch haptic interface.

SCENARIOS SELECTION

Initial findings from the accidentology work of the SAFE-UP project, have identified that this system may prevent ~28% of fatal pedestrian accidents with vehicles crossing from the left with sight obstruction and ~20% of fatal pedestrian accidents with vehicles crossing from the right with sight obstruction. For cyclists the prevention percentages are estimated to ~25% for bicycles crossing from the left while passenger car is moving forward and ~38% for cyclists crossing from the right, while passenger car is moving forward.

The relevant scenarios will be verified in simulation and will feed the development phase of the project that has started in June 2020. The first version of the system will be available in November 2020 and will focus mainly on the testing and verification of the communication system between all actors. The final demo is expected to be available in September 2021 and will include also the HMI of the warnings that will be provided both to the drivers and to the VRUs in their smart devices.

ACKNOWLEDGEMENT

The SAFE-UP project (proactive SAFEty systems and tools for a constantly UPgrading road

environment) has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement 861570. The sole responsibility of this publication lies with the author. The European Union is not responsible for any use that may be made of the information contained therein.

REFERENCES

Nikolaou Stella, Infrastructure-based communication and interaction of the autonomous vehicle with VRU, Summer school for professionals "Human Factor issues for the future car autonomous experience", HUMANIST VCE, Lyon, France, July 2019.

SAFE-UP EU Project Grant Agreement (861570), May, 2020.