Research and innovation perspectives on CCAM

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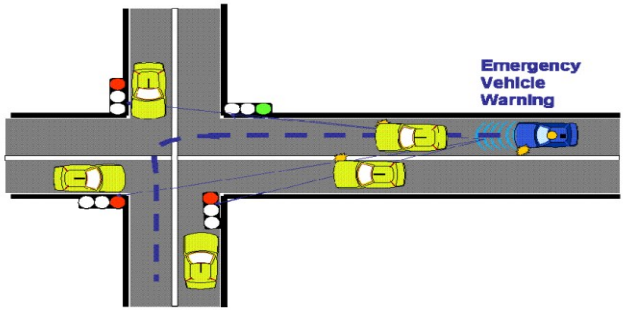
An EU agenda for safe, clean, and connected mobility

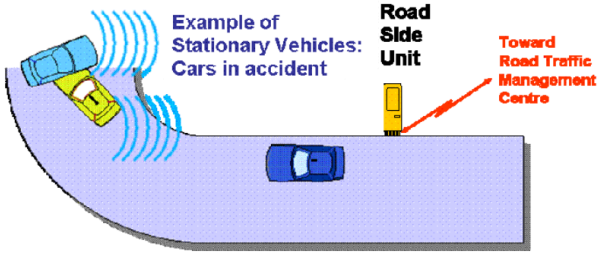
- **OBJECTIVE: triple zero → emissions, congestion, accidents**
- To this end, three issues are addressed:
  1. an integrated **policy for road safety**;
  2. **CO2 standards** for heavy-duty vehicles;
  3. a strategy for **connected and automated mobility**
- The Vehicle General Safety Regulation (EU 2019/2144) that starts its application in July 2022, addresses the Advanced Emergency Braking Systems, Intelligent Speed Assistance and Emergency Lane-keeping Systems as mandatory advanced driver assistance systems to improve road safety
- All new vehicles will be connected to the Internet with many of them communicating directly vehicle-to-vehicle (V2V) while supported by free high-precision digital mapping thanks to satellite data from **Galileo services**.
- To achieve this, the commission will adopt rules to ensure:
  - secured communications,
  - data protection,
  - interoperability,
  - **a recommendation on the use of spectrum for fifth generation (5G) large-scale testing.**

Examples of cooperative road safety

E-call + emergency vehicle warning



Stationary vehicle warning



Levels of automation by SAE (US Soc. of Automotive Engineers)

SAE level	Name	Narrative Definition	Execution of Steering and Acceleration/ Deceleration	*Monitoring* of Driving Environment	Fallback Performance of *Dynamic Driving Task*	System Capability *(Driving Modes)*
***Human driver* monitors the driving environment**						
0	**No Automation**	the full-time performance by the *human driver* of all aspects of the *dynamic driving task*, even when enhanced by warning or intervention systems	Human driver	Human driver	Human driver	n/a
1	**Driver Assistance**	the *driving mode*-specific execution by a driver assistance system of either steering or acceleration/deceleration using information about the driving environment and with the expectation that the *human driver* perform all remaining aspects of the *dynamic driving task*	Human driver and system	Human driver	Human driver	Some driving modes
2	**Partial Automation**	the *driving mode*-specific execution by one or more driver assistance systems of both steering and acceleration/ deceleration using information about the driving environment and with the expectation that the *human driver* perform all remaining aspects of the *dynamic driving task*	**System**	Human driver	Human driver	Some driving modes
***Automated driving system* ("system") monitors the driving environment**						
3	**Conditional Automation**	the *driving mode*-specific performance by an *automated driving system* of all aspects of the dynamic driving task with the expectation that the *human driver* will respond appropriately to a *request to intervene*	System	**System**	Human driver	Some driving modes
4	**High Automation**	the *driving mode*-specific performance by an automated driving system of all aspects of the *dynamic driving task*, even if a *human driver* does not respond appropriately to a *request to intervene*	System	System	**System**	Some driving modes
5	**Full Automation**	the full-time performance by an *automated driving system* of all aspects of the *dynamic driving task* under all roadway and environmental conditions that can be managed by a *human driver*	System	System	System	**All driving modes**

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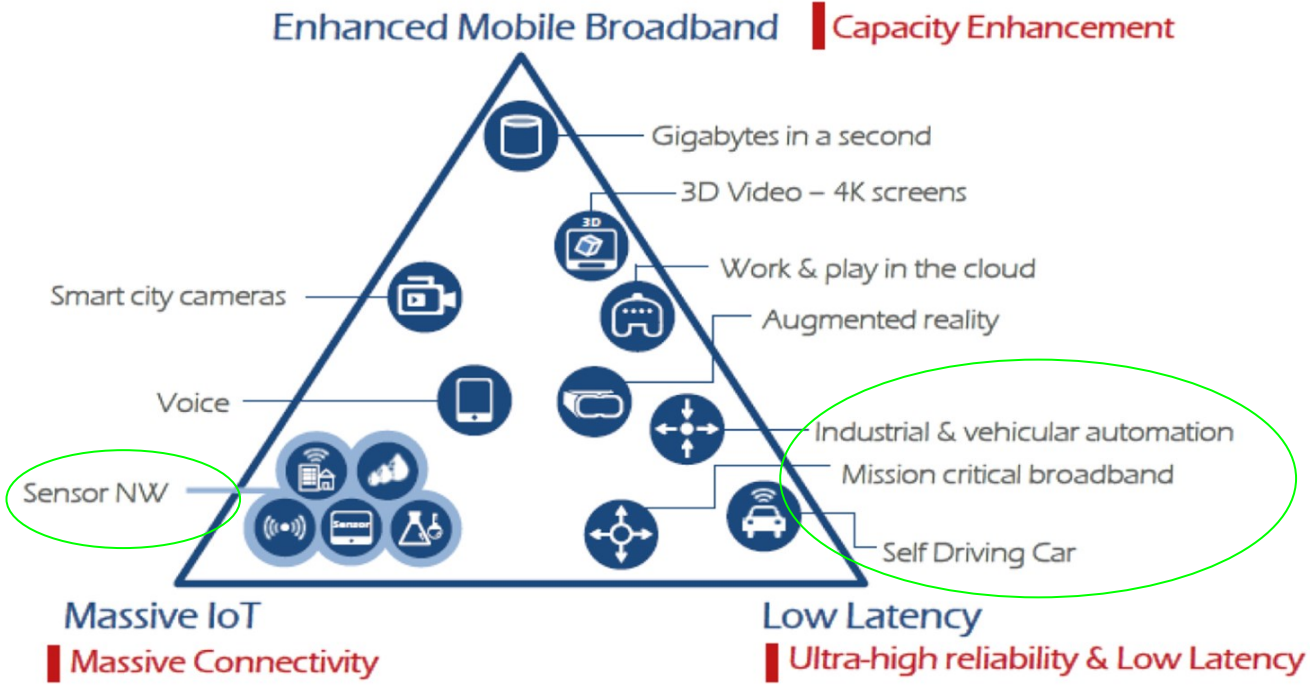
Overview of classes of use cases that explicitly rely on V2X communications

3GPP	ETSI	5GAA	5GCAR	5GPPP
Advanced Driving	Cooperative road safety	Safety	Cooperative Safety	Traffic Safety
		Society and Community		
	Cooperative Traffic Efficiency	Traffic Efficiency and Environmental friendliness	Cooperative Maneuver	Cooperative Sensing
Extended Sensors			Cooperative Perception	Traffic Efficiency
Remote Driving	-	-	Remote Driving	-
-	Cooperative local services	Convenience	-	Infotainment Services
	Global Internet services			

Several organizations and companies are involved in the C-ITSs field and many contributions are available. However **there isn't a common agreement to describe use cases nor service level requirements**

The "connected vehicle" in the 5G framework

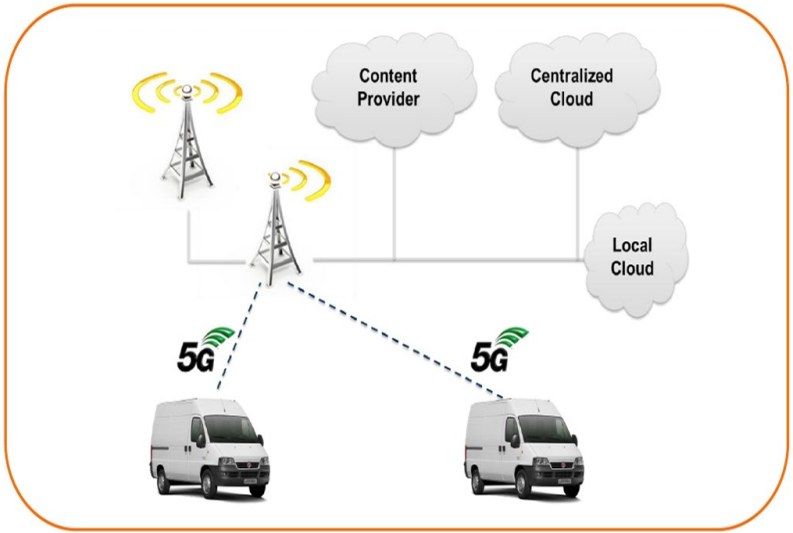


(Source: ETRI graphic, from ITU-R IMT 2020 requirements)

UC6 use case in 5G pre-commercial trials in L'Aquila

Advanced solutions for Intelligent Transport Systems based on **5G connected vehicles**.

- **Road safety**
- Better comfort and driving experience
- **Traffic management and pollution monitoring**



Use Case LEADER

WIND

Partner coinvolti

Università degli Studi dell'Aquila

CRF

Università degli Studi Firenze

IPZS Istituto Poligrafico e Zecca dello Stato

cellnex

ZTE Leading 5G Innovations

Alma Mater Studiorum Università di Bologna

Aziende/Enti Coinvolti

GSSI Gran Sasso Science Institute

INFN Center for Advanced Studies

Qualcomm

EMERGE ecosystem

The EMERGE project is the center of gravity of several mutually coordinated synergistic initiatives such as the Ex-EMERGE Center of Excellence, SCALA, STEV and P-CAR.

- Agreement signed in March 2018 - Project started in mid 2018
- Project started in January 2020 - Centre started in Dec. 2019

2+. SCALA	2. EMERGE Navigation	1. Centre Ex-EMERGE	3. STEV (Satellite Testbed for GNSS Vehicle Validation)
FCA-CRF/STELLANTIS	Radiolabs	UnivAQ	Radiolabs
in sinergy with EMERGE Navigation	with Elital, Leonardo, Telespazio, UnivAQ	University research centre with international connections (GSA, ESA, ASI, ...)	with Polo Automotive Abruzzo and UnivAQ
Advanced applications for connected, geo-localized and cybersecure vehicles	Technological platforms and applications • *Geo-localization* • *Connectivity* • *Cyber-security* • *Cloud and edge computing* • *Navigation* Prototyping on light commercial vehicles (DUCATO)	Advanced research on connected vehicles • *Research* • *Higher education* • *Development of labs* • *City-wide test bed:* • *→ GALILEO* • *→ 5G*	Feasibility and development of experimental infrastructure for testing muti-sensor positioning systems for automotive applications
Industrial innovation and development program FCA/STELLANTIS - MiSE	R&D Industrial project Agreements for innovation	Specific action of Italian Government (RESTART)	ESA-GSTP initiative
MiSE & Abruzzo Region		- 1 National Competence Centre - 2 European Digital Innovation Hub	- 5G for L'ART (ESA) - P-CAR in NAVISP3 - Mention from GSA

EMERGE ecosystem

The Centre of Excellence Ex-EMERGE @ UnivAQ
http://exemerge.disim.univaq.it

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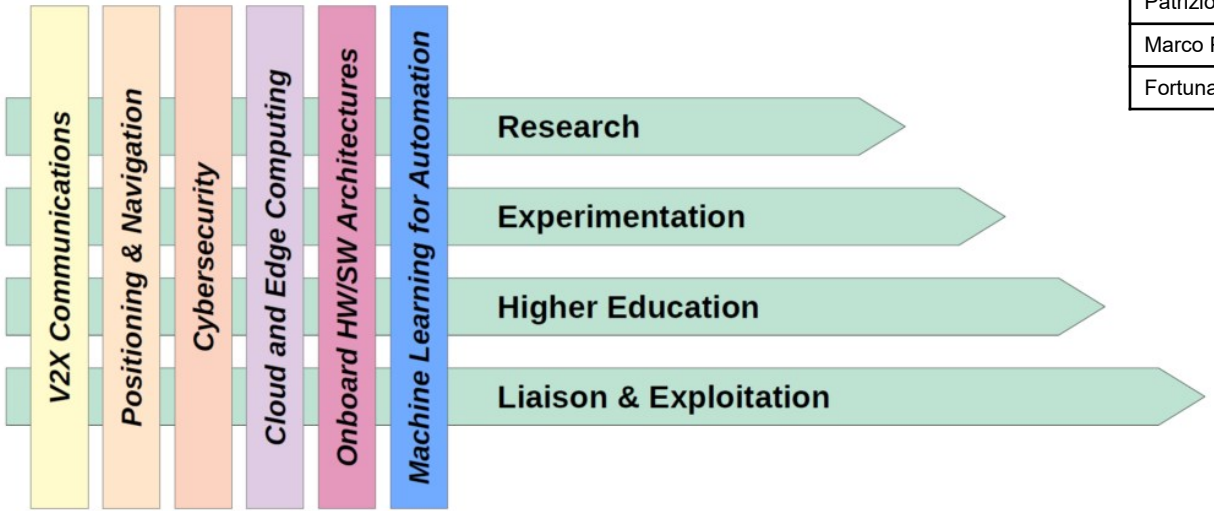
Centre of EXcellence (EX) on Connected, Geolocalized and Cybersecure vehicles (*EX-EMERGE*)



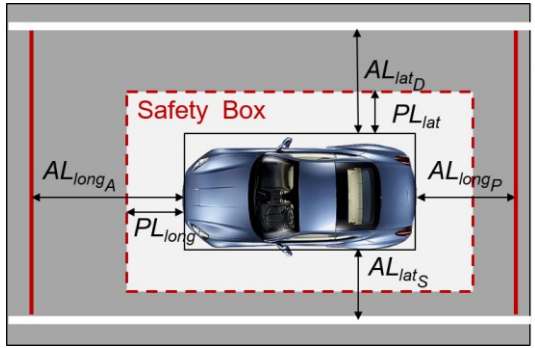
KPIs for V2X communications

V2X application area	Name	Comm. Type	V2V Datarate [Mbps]	V2I Datarate [Mbps]	Latency [ms]	Tx Rate [msg/s]	Position Accuracy lat[m]/lon[m]	Vehicles Density
Platooning	Information sharing for SAE Level 2/3 platooning	V2V/V2I	2.75	2.5	20	50	0.1/0.5	High
	Information sharing for SAE Level 4/5 platooning	V2V/V2I	65	50	20	50	0.1/0.5	High
Advanced Driving	Information sharing for SAE Level 2/3 autom. diriving	V2V/V2I	0.55	0.5	100	10	0.1/-	High
	Information sharing for SAE Level 4/5 autom. diriving	V2V/V2I	53	50	100	10	0.1/-	High
	Intersection safety info provisioning for urban driving	V2I	-	DL:0.5 / UL:50	-	50	-	Medium
Extended Sensors	Automotive: sensor and state map sharing	V2V	25	-	10	-	-	High
	Collective perception of environment in case of imminent collision	V2V	1000*	-	3*	10	-	High
Remote Driving	Information exchange between a UE supporting V2X application and a V2X Application Server	V2I/V2N	-	DL:1 / UL:25	5	-	-	-

*Only one of the requirements need to be fulfilled at the same time

KPIs for autonomous driving

Driving context	Accuracy (2*sigma)	Alert Limit (AL)	Time to Alert (TTA)	Availability
Highway; Max speed 130 Km/h	0.25 m (Lat); 1 m (Long)	0.75 m (Lat); 3 m (Long)	<1 s	HIGH
Secondary suburban road; Max speed 90 Km/h	0.15 m (Lat); 0.5 m (Long)	0.45 m (Lat); 1.5 m (Long)	<1 s	HIGH
Urban road; Max speed 50 Km/h	0.13 m (Lat); 0.35 m (Long)	0.40 m (Lat); 1 m (Long)	<2 s	HIGH
Rural road (narrow and winding); Max speed 60 Km/h	0.06 m (Lat); 0.15 m (Long)	0.20 m (Lat); 0.45 m (Long)	<1 s / < 2 s	HIGH



EMERGE use cases

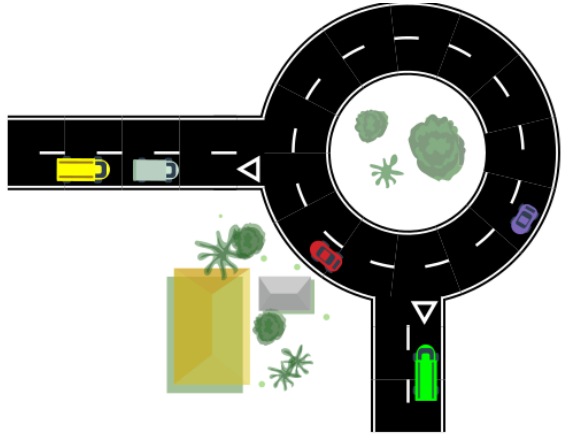
SCENARIO	CLASS	USE CASE
Daily	COOPER. DRIVING AND PERCEPTION	**UC_D1: Virtual electronic horizon**
		UC_D2: AI techniques for traffic efficiency
	COOPER. SAFETY	UC_D3: Left Turn Assist
		UC_D4: Intersection Safety Information Provisioning
		UC_D5: Vulnerable Road Users (VRU) detection
Emergency	COOPER. DRIVING AND PERCEPTION	**UC_E1: Critical events detection and monitoring**
	CONVENIENCE	UC_E2: Pervasive connectivity for emergency management
	COOPER. SAFETY	**UC_E3: Special vehicle warning for a dynamic emergency corridor**

Daily use cases

UC_D1: Virtual electronic horizon

Objective: provide a dynamic map to the ground service center of the region of interest and enable vehicle to setup the virtual electronic horizon

Requirements: V2X connectivity and high-accuracy localization.



UC_D2: AI techniques for traffic efficiency

Objective: congestion events detection and/or prediction through **AI/estimation algorithms** to provide an alternative route to the drivers by balancing the traffic in a given area.

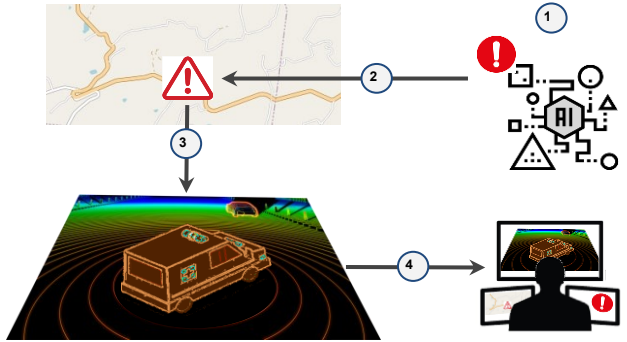
Requirements: V2X connectivity and communications towards the ground service center. The service center has to be enabled for AI/estimation algorithms computation.

Emergency use cases

UC_E1: Critical events detection and monitoring

Objective: (1) detect the critical event and (2) make the ground service center aware of the road condition.

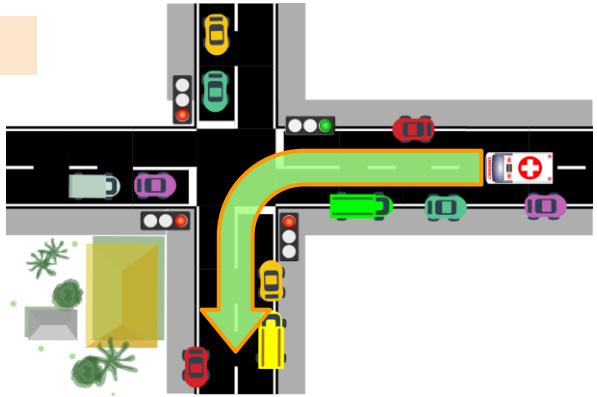
Requirements: high-reliable communication; satellite communication; high-integrity navigation system; on-board camera and other perception system. The ground service center is enabled to compute AI/estimation algorithms.



UC_E3: Special vehicle warning for a dynamic emergency corridor

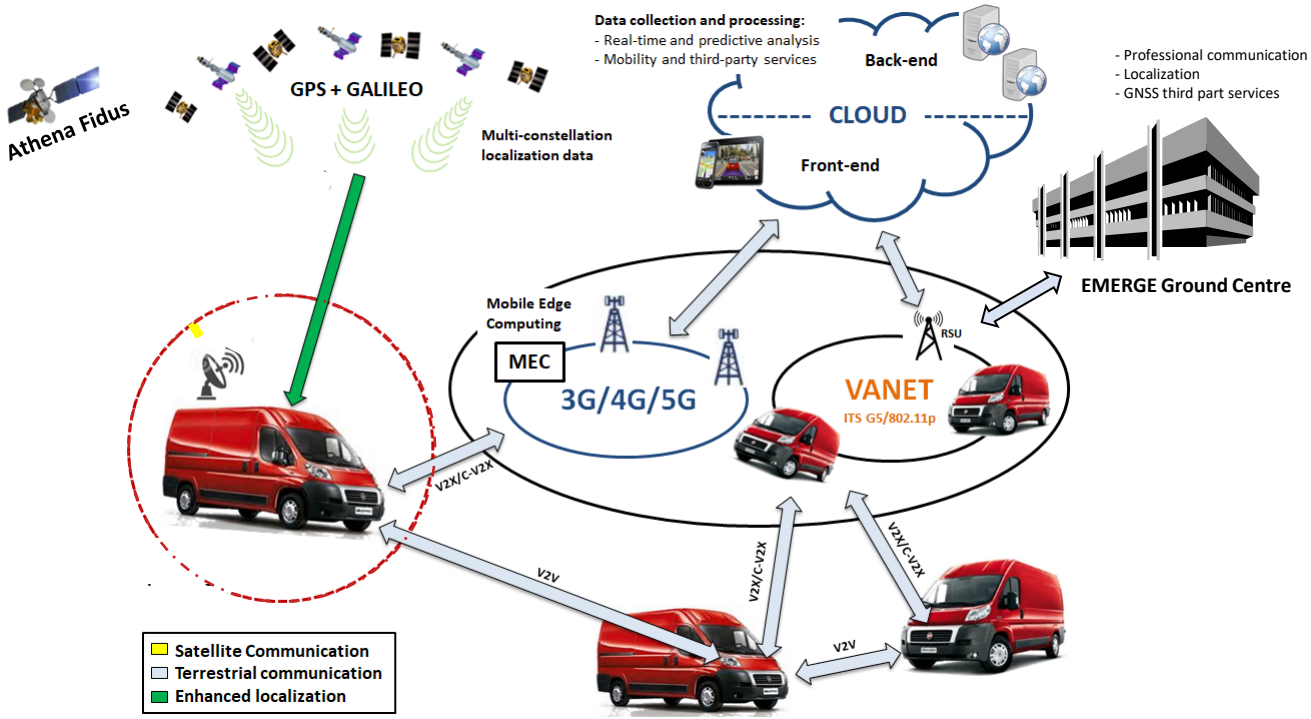
Objective: the special vehicle signals its presence and provides the required information to make the other vehicles able to give-way and free an emergency corridor

Requirements: V2X communications/smart road infrastructure. High-reliable communication for the special vehicle.



EMERGE ecosystem

Application scenario and architecture



The P-CAR project

The objective of P-CAR project (*PNT Center for Automated Road-Transport*) is to realize a **PNT laboratory focused on safety and performance evaluation of GNSS-based positioning systems** for CAD.

Funded under the ESA NAVISP Element 3 program, that aims on supporting Member States' navigation priorities.

Classified as a **strategic infrastructure** for Italy, it will also exploit the new satellite constellations (e.g., GALILEO) for CCAM vehicles' positioning.

A look ahead

Main objectives: i) development of next generations of ICT enablers for on-board units; ii) design and deployment of smart infrastructures

- Innovation on mobile cellular technologies for vehicular communications with "ubiquitous" connectivity through effective satellite coverage: 5G (*3GPP Rel 17*) and 6G for improved reliability and lower latencies; continuity of coverage also in rural and remote areas through integrated terrestrial-satellite networks;
- *High performance computing and AI*: edge computing and artificial intelligence for more advanced levels of automation (e.g. SAE 4);
- Design and deployment of smart infrastructures for both road and rail: 'smart roads' is a prospective action of road operators and FRMCS is the state-of-the-art solution for connected and automated railways; security-by-design is to be guaranteed and multi-modal mobility is a perspective;
- Other issues: electric motors, machine ethics, legal concerns about responsibilities on automated operations and management of large amounts of data coming from the field.

Many thanks!