D2.1

PoDIUM use cases description and specifications

PoDIUM

PDI connectivity and cooperation enablers building trust and sustainability for CCAM

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List of abbreviations and acronyms

Abbreviation	Meaning
ADAS	Automated Driving Assistance System
API	Automated Programming Interface
CAV	Connected Automated Vehicle
CCAM	Cooperative, Connected and Automated Mobility
C-V2X	Cellular vehicle-to-everything (LTE-PC5)
CV	Connected Vehicle
CVM	Connected Vehicle Manager
DT	Digital Twin
EVM	Emergency Vehicle Manager
EV	Emergency Vehicle
LL	Living Lab
MEC	Multi-access Edge Computing
OBU	On-Board Unit
O-D	Origin-Destination
PDI	Physical and Digital Infrastructure
RSU	Road-Side Unit
SAE	Society of Automotive Engineers
TL	Traffic Light
TMC	Traffic Management Centre
TMS	Traffic Management System
UC	Use Case
VRU	Vulnerable Road User

Executive Summary

This deliverable provides a detailed specification of the PoDIUM project's five Use Cases (UCs) and their high-level requirements. The project aims to advance a set of key technologies both in the physical and digital part of the infrastructure to address the challenges in road automation and telecommunications linked with connectivity, cooperation, data management, interoperability and reliability in order to foster the development of advanced Connected, Cooperative and Automated Mobility (CCAM) solutions. The PoDIUM UCs presented in this deliverable will be demonstrated in three Living Labs located in Germany, Spain, and Italy, in urban, highway and cross-border environments.

The document presents an introduction to the project and its intended audience, followed by a general overview of the use cases and their strategic goals, needs, challenges, and constraints. The use cases cover a range of scenarios, including cooperative corridor management, user-centric traffic management, real-time responsive traffic management, trusted cooperative perception, and risk management in a highway tunnel.

The methodology for identifying and defining the high-level requirements is also presented, including the approach, requirement prioritization, and the use of the Volere tool for requirements definition, validation, and revision. The high-level requirements for each use case are presented, along with their validation and revision processes.

This deliverable is intended for stakeholders and experts involved in the development of cooperative, connected, and automated mobility systems. It provides valuable insights into the project's progress and helps ensure that the system meets the stakeholders' needs and requirements. The demonstration of the use cases in Living Labs will further validate the system's functionality and showcase its potential impact on improving CCAM.

1. Introduction

1.1. Project Introduction

PoDIUM aims to support advanced Use Cases (UC) of connected and cooperative automated mobility in real traffic conditions. Building urban and highway UCs on the facilities of 3 well-equipped Living Labs in Germany, Italy, and Spain, PoDIUM will tackle all the different requirements for the availability and performance of connectivity as well as the different cooperation enablers per UC. The proposed UCs aim to advance a set of key technologies both in the physical and digital parts of the infrastructure. In particular, the following non-exhaustive list of contributions will be pursued:

- A multi-connectivity approach to ensure reliability, availability, and redundancy of the PDI system.
- Advanced data fusion and integration of Multi-access Edge Computing (MEC) to the proposed hybrid data management environment to enable enhanced environment perception models towards digital twins.
- New C-ITS messages for enabling the specific advanced CCAM use cases.
- Ensure software integrity, trust, and truthfulness of CCAM data, their exchange, and their processing.
- Demonstration of urban and highway use cases in a diverse set of configurations with the integration of Vulnerable Road Users (VRU).

1.2. Purpose of the deliverable

The aim of PoDIUM is to enhance Connected Cooperative and Autonomous Mobility services in Europe. To reach this goal, the project focuses on the development and integration of the Physical and Digital Infrastructure needed to ensure the vehicle's connectivity via certain network technologies. A total of 5 PoDIUM Use Cases will be tested and validated under real-life conditions in the three Living Labs, located in Germany, Spain, and Italy. These Use Cases require advancing several technologies and elements that will be integrated under the common PoDIUM architecture. Thus, in order to define and develop this architecture, a set of requirements must be specified.

The objective of Deliverable 2.1 is to document the work carried out in task 2.1 (Use Cases refinement and specifications). It presents the PoDIUM Use Cases and their related scenarios, which will be validated and demonstrated within the project. This document also describes the high-level requirements of each of the Use Cases, which are needed to meet the project's objectives.

1.3. Intended audience.

This deliverable is classified as 'Public', therefore, it will be uploaded on the PoDIUM website, where it will be available for all project partners and external users. Nevertheless, the consortium members are the main intended audience of this document.

1.4. Structure of the deliverable and its relation with other work packages/deliverables

Deliverable 2.1 is structured as follows:

- Section 2 serves as an introduction and briefly describes the five Use Cases.
- Section 3 gives more detail about the Use Cases and their scenarios, considering the information provided by the partners through the Use Cases templates. This sectionaims to further elaborate on the technical details of the PoDIUM Use Cases.
- Section 4 focuses on high-level requirements and explains the approach used to identify and define these requirements using the Volere tool. The goal of this section is to provide insight into the methodology used for requirement identification and definition.
- Section 5 provides an overview of the requirements for each Use Case and the validation and iteration phases. The final list of Use Cases' requirements is also presented in this section.
- Section 6 serves as a conclusion, summarizing the key findings of the document.
- The Annex provides an overview of the requirements definition process and the use of the Volere tool.

Deliverable 2.1 interacts withseveral tasks of other Work Packages that are directly or indirectly related to T2.1. The inventory of high-level requirements contributes to the five Use Cases. In addition, T2.1 incorporates results from the requirements management tool Volere which is used by the project consortium for all Use Cases definition.

2. PoDIUM Use Cases general overview

2.1. Use Cases general overview

Use Case 1: Cooperative Corridor Management in City of Ulm

UC1 explores the benefit of a cooperative local environment model for managing complex urban traffic situations to support the ambitious EU safety and environmental targets by improving safety and efficiency in these situations. To improve availability and redundancy, different communication channels (5G mobile network with cm- and mm-wave; ITS-G5, 60GHz WiFi) will be realized and assessed.

UC1 will be implemented and evaluated at the Ulm-Lehr LL, which comprises a partly occluded T-junction with infrastructure sensor units at lamp posts: a side road merges into a priority road with right of way. Buildings occlude the line of sight between the side road and relevant areas of the priority road. The road users, e.g., connected vehicles (CV), connected automated vehicles (CAV) of various automation levels (L2-L4), and VRUs use the local environment of this T-junction in any direction.

Two different scenarios will be considered. In the first one, an obstacle (e.g. a parked truck) blocks one lane. Two CAVs, one from each direction, pass the obstacle with a cooperative manoeuvre.

This scenario is considered a) with dynamic traffic information only from the CAV (lightweight solution) and b) with supporting information from the infrastructure sensors (baseline solution).

In the second scenario, additionally, a VRU without cooperation capabilities passes the obstacle. This scenario will be only considered with infrastructure support.

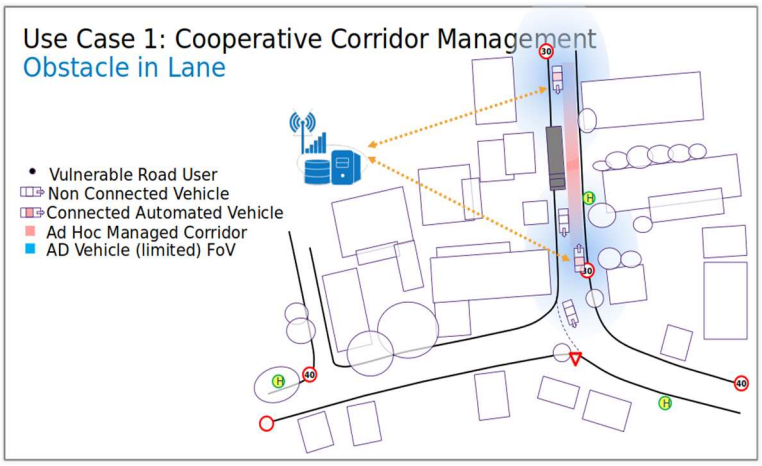


Figure 1. UC1 Overview

Use Case 2: PDI for User-Centric, CCAM-enabled Traffic Management in Urban Corridors with High Priority Vehicles and VRUs

PoDIUM UC2 aims to enhance urban control traffic by sharing with the infrastructure the information that can be provided by connected vehicles. UC2 is composed of three different scenarios that address different situations that will take place simultaneously in a firefighter's corridor in the city of Barcelona, Spain (see Figure 2).

Scenario 1 is focused on the management of high-priority vehicles, in this case, a firefighters' truck, which will need to indicate its route to the TMS, ask for priority at signalized crossings, and share its location at all times, whereas the infrastructure will send warnings to the rest of road users that an emergency vehicle is approaching.

Scenario 2 aims to optimize traffic management strategies by using the information provided by connected vehicles. Thus, all connected vehicles on the road will be sharing their speed, location, Origin, and Destination with the TMS. At the same time, the infrastructure will provide CVs with information on the traffic status and route options, while selecting the optimal traffic control strategies thanks to the O-D matrix and the route optimization algorithms.

Finally, in Scenario 3, "VRUs protection in an emergency event", the infrastructure detects the presence of VRUs and evaluates the potential risks. If a VRU is in a risk situation, the infrastructure sends warnings to the connected VRU about the presence of an emergency vehicle. At the same time, it sends warnings to the vehicles about the presence of VRUs.

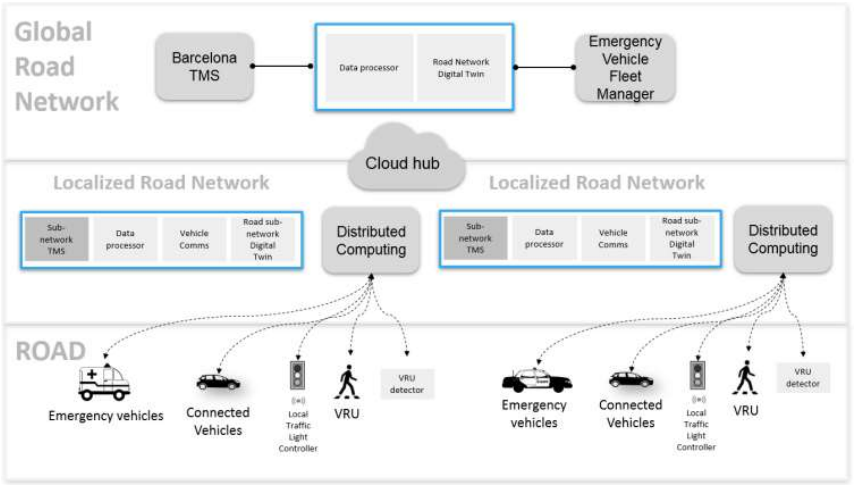


Figure 2. Barcelona urban LL

Use Case 3: Real-time responsive PDI for CCAM-enabled Traffic Management in the Mediterranean Cross-Border Corridor

UC3-MCBCB is introducing a new system to enable vehicles and road users to cooperate with the road operator and implement real-time traffic strategies for safe and smooth traffic. The demo will be carried out on a segment of the Figueres-Perpignan corridor across the French-Spanish border. The PDI system will incorporate internal and external data to generate a traffic status perception for each section of the road, and the system will calculate potential scenarios and traffic management strategies. In the event of an incident, the PDI will respond quickly by communicating with incoming vehicles and the vehicle involved.

The use case will explore two scenarios: daily commuting across borders and safety incidents across borders. The demonstration will also evaluate the implementation of direct-to-vehicle speed/maneuver commands coming from the PDI, as well as test the operation of tele-supervision via 5G.

Figure 3. Mediterranean Cross-border corridor illustration.

Use Case 4: Trusted Cooperative Perception for Intersection Manoeuvre Assistance

This use case demonstrates an infrastructure-based application for safe and efficient traffic management at an urban intersection, which assists connected automated vehicles at the crossroads and protects vulnerable road users. The application leverages on cooperative awareness of all connected road users, on collective perception by vehicles' and roadside infrastructure's sensing systems (to sense also non-equipped users) on signal phases and other digital information. These data are gathered via C-V2X at the Edge server, which implements a Digital Twin of the cross-roads. A "truthfulness module" provides a truth-index on the collected information. On top of it the core component, namely the VRU-aware Intersection Movement Assistant (VIMA) application, computes manoeuvres' suggestions for an oncoming vehicle. The use case uses a Trusted Platform Module (TPM -ISO/IEC 11889) approach to state the level of trust of the entities involved and the software running on MEC.

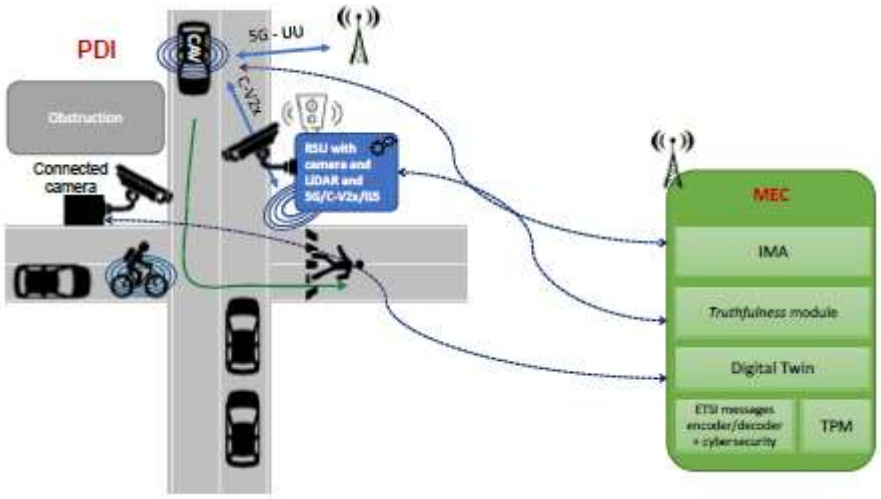


Figure 4. UC4 intersection illustration.

Use Case 5: Risk Management in a Highway Tunnel

Tunnels are crucial areas for road safety, as they are more subject to becoming traps in case of accidents. At the same time, tunnels represent a technical problem for cooperative ITS, due to the absence of open sky conditions, needed for ordinary GNSS services. Without GNSS, no cooperative awareness is possible (i.e., no common time-space reference). This highway UC addresses both issues with one service, which monitors traffic, assesses risk, and assists vehicles before and within the tunnel through C-ITS, despite the GNSS-denied environment. Roadside sensors count and classify vehicles at the tunnel entrance and exit. The information is collected by a Digital Twin and processed by an application that computes the real-time risk within the tunnel and sends a warning which is dispatched to the incoming connected and automated vehicle (CAV), outside and/or within the tunnel. Inside the tunnel, CAVs can obtain positioning information by using two alternative PDI services featuring indoor positioning: synthetic GPS received by a dedicated infrastructure running along the tunnel, or trilateration of V2X signals from the onboard unit and two roadside units placed at given points. Thanks to these positioning solutions, CAVs can effectively use the warning dispatched by the infrastructure asking e.g. for a lane change, speed change, or driver's intervention, but they can keep cooperative awareness thanks to V2V functionality which is still active.

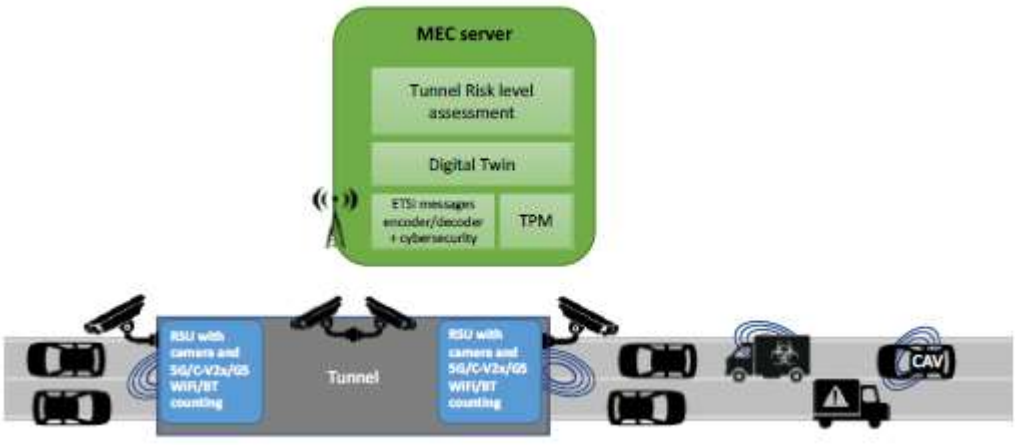


Figure 5. UC5 tunnel illustration.

2.2. PODIUM Use Cases strategic goals, needs, challenges, and constraints

Section 2.2 explores the strategic goals and potential needs, challenges, and constraints associated with the Use Cases of the PODIUM project.

Table 1: PODIUM Use Cases overview: Strategic goals

PODIUM Use Cases	Strategic Goals
UC1: Cooperative Corridor Management in City of Ulm	- Management of CAVs and other connected road users, especially VRUs. - Urban corridor management. - Extension of service availability in occluded areas. - Efficient decision-making based on cooperative local environment models. - VRUs protection. - Traffic efficiency improvement.
UC2: PDI for User-Centric, CCAM-enabled Traffic Management in Urban Corridors with High Priority Vehicles and VRUs	- Traffic Management optimization and efficient decision-making based on a Digital Twin on the Cloud. - Advanced VRUs detection and protection based on AI cameras and CCAM. - Priority at intersections for connected emergency vehicles. - Accidents minimization in complex urban conditions such as emergency situations. - Congestion reduction in complex urban conditions such as emergency situations.
UC3: Real-time responsive PDI for CCAM-enabled Traffic Management in the Mediterranean Cross-Border Corridor	- Advanced traffic strategies to ensure safe traffic conditions. - Local recommendations to vehicles to optimize traffic flow. - Enhancing cross-border cooperation between Spain and France. - To achieve a collaborative approach to improve traffic conditions across the border. - Make informed decisions on traffic control strategies. - Congestion reduction in highways.
UC4: Trusted Cooperative Perception for Intersection Manoeuvre Assistance	- Enable cooperative perception for CAVs. - Enhancing situational awareness and Operational Design Domains (ODDs) of CAVs via a Digital Twin service running on the Multi-access Edge Computing (MEC). - Enhancing trust in the information received from the Physical and Digital Infrastructure (PDI). - Compliance with hybrid communication approach: short-range ad-hoc communication and cellular communication. - Ensuring authenticity and integrity of C-ITS messages according to C-ROADS specifications.

UC5: Risk Management in a Highway Tunnel	- Enhancing Tunnel Safety on the trans-European transport network (TEN-T). - Quantifying the risk level and using it to adapt the automation level of upcoming CAVs. - Improving Risk Assessment by an innovative system that provides accurate and real-time information about the risk level inside the tunnel. - Enabling Trustworthy Communications among the infrastructure, vehicles, and RSUs, by leveraging the Trusted Platform Module (TPM) approach.

Table 2: PODIUM Use Cases overview: Potential needs

PODIUM Use Cases	Needs
UC1: Cooperative Corridor Management in City of Ulm	- To develop accurate local environment models of the intersection area in the Ulm-Lehr LL. - To rely on reliable connectivity and communication to allow real-time data exchange and cooperative decision-making. - Availability of vehicles and VRUs with advanced connectivity and automation capabilities for efficient operation. - To investigate potential disruptions of vehicle driving functions relying on MEC/cloud services.
UC2: PDI for User-Centric, CCAM-enabled Traffic Management in Urban Corridors with High Priority Vehicles and VRUs	- To set up a complex and realistic traffic environment for testing, with CVs, CAVs and VRUs. - To set up the Digital Twin that integrates the road network and its elements, connected vehicles, and VRUs. - To integrate and process data from multiple sources: HD cameras, vehicles, road users, and third-party services. - To adapt local recommendations for different types of vehicles and road users. - To modify the traffic plans according to the needs (i.e priority). - To exchange real-time information such as location, speed, and origin/destination with the Traffic Management System (TMS). - To comply with the ETSI C-ITS messages specification.
UC3: Real-time responsive PDI for CCAM-enabled Traffic Management in the Mediterranean Cross-Border Corridor	- To rely on Digital Twin Technology to establish a macroscopic global perception of traffic conditions. - To achieve data integration and processing from multiple sources: HD cameras, vehicles, road users, and 3rd party services. - To obtain accurate and real-time traffic information for decision-making. - To define real-time traffic control strategies based on macroscopic perception. - To adapt local recommendations for different types of vehicles and road users.

	- To optimally exchange ETSI C-ITS messages such as CAM, DENM, IVIM, VAM, CPM, and MCM using two radio communication technologies (cellular 5G and C-V2X).
UC4: Trusted Cooperative Perception for Intersection Manoeuvre Assistance	- To set up a complex and realistic traffic environment for testing, comprising a mix of vehicles with different connectivity levels, conventional vehicles, and VRUs - To achieve advanced levels of accuracy and reliability to comply with the close-to-market-ready objective. - To set up an edge server for deploying the Digital Twin, with the capability of processing large amounts of data in real time. - Availability of a commercial 5G network, to provide a realistic and reliable communication infrastructure. - To comply with the ETSI C-ITS messages specification.
UC5: Risk Management in a Highway Tunnel	- To accurately quantify the risk level inside the tunnel by considering various parameters to provide meaningful information for decision-making. - To collect real-time data from various sources such as sensors and vehicles to build a digital representation of the tunnel. - To achieve a reliable and accurate positioning technology inside the tunnel, to determine the absolute position of vehicles. - To be able to communicate triggered warnings or risk-mitigating maneuvers inside the tunnel. - To comply with the ETSI C-ITS messages specification.

Table 3: PODIUM Use Cases overview: Potential Challenges

PODIUM Use Cases	Challenges
UC1: Cooperative Corridor Management in City of Ulm	- Occlusion: The occluded areas at the Ulm-Lehr LL may pose challenges in obtaining accurate data for building local environment models, as line-of-sight between sensors and road users can be obstructed. - Data quality: The quality of transmitted data can vary, such that a respective trust building for data reliability has to be developed and established. - Environment model: Build an accurate model from road users' data only (without using infrastructure sensors) for a lightweight solution. - Cooperative planner: Develop a cooperative planner capable of solving sophisticated traffic situations with blockages and occlusions. - Heterogeneity of connected road users: The involvement of CAVs and VRUs. - Heterogeneity of communication channels: Achieve reliable end-to-end data transfer using heterogeneous communication technologies with dynamic and spatially local properties.

UC2: PDI for User-Centric, CCAM-enabled Traffic Management in Urban Corridors with High Priority Vehicles and VRUs	- Data accuracy and reliability: Ensuring that the information exchanged between vehicles and infrastructure is accurate and reliable. - Integration of diverse data sources: Integrating data from various sources, such as connected vehicles, infrastructure sensors, and the TMS, in real-time to enable effective decision-making. - Coordination among stakeholders: Coordinating communication and cooperation among multiple stakeholders, including emergency services, traffic management authorities, and road users, to ensure the smooth operation of the road network. - Privacy and security concerns: Sharing sensitive information about the location and route data of connected vehicles in a secure way, while ensuring compliance with data protection regulations.
UC3: Real-time responsive PDI for CCAM-enabled Traffic Management in the Mediterranean Cross-Border Corridor	- Data Quality and Accuracy: The accuracy and quality of data from multiple sources, such as high-definition cameras, vehicles, and third-party services. - Scalability and Granularity: Determining the appropriate deployment and granularity of roadside PDI's based on macroscopic perceptions of traffic from internal and external data may pose challenges in terms of scalability and accuracy of recommendations. - Cross-Border Coordination: Coordinating and aligning traffic control strategies across the Figueres-Perpignan corridor, which spans the border between France and Spain, may pose challenges in terms of regulatory, technical, and operational aspects. - Service availability: ensuring “always-on” connectivity between vehicles and PDI, either through 5G or PC5 C-V2X. - Low latency for safety-relevant situations
UC4: Trusted Cooperative Perception for Intersection Manoeuvre Assistance	- Ensuring trustworthiness and truthfulness of data: this involves implementing advanced concepts of trust, such as TPM, and requires fusing information from multiple and heterogeneous sources. - Compliance with hybrid communications, including short-range and cellular communication. - Ensuring seamless communication and interoperability between different communication technologies.
UC5: Risk Management in a Highway Tunnel	- Data Integration: Integrating data from multiple sources, such as sensors, vehicles, and RSUs, and processing it in real-time to build a digital representation of the tunnel and assess the risk level can be challenging. - Accuracy of Risk Assessment: Ensuring accurate risk assessment by considering various parameters and validating the trustworthiness of the data can be challenging, as the risk level

	inside the tunnel can change dynamically based on various factors. - Communication Reliability: Ensuring reliable communication between the infrastructure, vehicles, and RSUs, especially inside the tunnel where connectivity can be limited, can pose technical challenges.

Table 4: PODIUM Use Cases Overview: Potential Constraints

PODIUM Use Cases	Constraints
UC1: Cooperative Corridor Management in City of Ulm	- Regulatory and legal constraints: The implementation of the use case may be subject to regulatory and legal constraints, including data privacy regulations, traffic laws, and ethical considerations. Compliance throughout the implementation process will be pursued. - Scalability concerns: It is constrained to the Ulm-Lehr LL, which is a specific location. Generalizing the findings and insights from this specific location to other urban traffic situations may require further validation and customization.
UC2: PDI for User-Centric, CCAM-enabled Traffic Management in Urban Corridors with High Priority Vehicles and VRUs	- Infrastructure and technology availability (sensors, communication networks, level of automation of vehicles…) - Regulatory and legal constraints: Compliance with existing national or European regulations and standards related to information exchange, traffic management data privacy, and emergency services. - Scalability and interoperability constraints: Ensuring the system can accommodate future expansions, integration with other systems, and compatibility with different types of vehicles and infrastructure may pose constraints on the design and implementation of the solutions. - Realistic Traffic Environment Constraints: Testing and demonstrating the system in a complex and realistic traffic environment with connected and non-connected road users may pose constraints related to safety, logistics, and feasibility.
UC3: Real-time responsive PDI for CCAM-enabled Traffic Management in the Mediterranean Cross-Border Corridor	- Legal and Regulatory Constraints: Compliance with legal and regulatory requirements related to data privacy, data protection, and traffic management policies in both France and Spain. - Technological Constraints: The results may be constrained by the availability of appropriate technology infrastructure, such as advanced onboard units, high-definition cameras, communication networks, and processing capabilities. - Interoperability constraints: Ensuring the integration of different systems and communication networks in both Spain

	and France may pose constraints on the design and implementation of the solutions.
UC4: Trusted Cooperative Perception for Intersection Manoeuvre Assistance	- Technological Constraints: The implementation of the cooperative perception system may be constrained by the available technology, including the capabilities of the PDI and the communication networks. The availability and reliability of these technologies may impact the effectiveness and performance of the system. - Regulatory constraints: The system should comply with regulatory requirements and standards such as ISO/IEC and ETSI. These may impose limitations on the system design, functionality, and data exchange. - Data Privacy and Security Constraints: The cooperative perception system may need to adhere to strict data privacy and security requirements to protect sensitive information exchanged between the vehicles and the infrastructure. - Realistic Traffic Environment Constraints: Testing and demonstrating the system in a complex and realistic traffic environment with connected and non-connected road users may pose constraints related to safety, logistics, and feasibility.
UC5: Risk Management in a Highway Tunnel	- Regulatory Compliance: Compliance with Directive 2004/96/EC, which sets out minimum safety requirements for tunnels on the trans-European transport network (TEN-T). - Infrastructure Deployment: Deployment of dedicated C-V2X RSUs and other necessary infrastructure, such as cameras, LiDARs, and positioning technology, along the tunnel may require coordination with relevant authorities and stakeholders.

3. PODIUM Use Cases and Scenarios Specification

3.1. Use Case 1: Cooperative Corridor Management in City of Ulm

Table 5: Use Case 1: Cooperative Corridor Management in City of Ulm.

UC1-CCMU	Cooperative Corridor Management in City of Ulm	
Scope	This use case considers two scenarios, which have in common that on a road with one lane per direction, one lane is blocked, e.g., by a truck, which additionally limits the field of view of onboard sensors in the vehicles. Cooperative services, namely an environment model (digital twin) and a cooperative planner in the infrastructure, will support connected automated vehicles and/or connected VRUs to handle this situation with a limited ego view.	
Demo site	Area of the intersection of Mähringer Straße and Loherstraße in Ulm-Lehr, City of Ulm, Germany	
Triggering Event	Lane blockage is detected and a connected and automated vehicle or a connected VRU needs to pass this blockage.	
Pre-condition	The traffic is flowing normally on both lanes, corridor management is monitoring the corridor but is not active.	
Post-condition	The connected and automated vehicle/connected VRU has successfully passed the blockage.	
Physical and Digital Infrastructure (PDI) required	Infrastructure sensors. 5G network (mm and cm wave) Ad hoc networks (ITS G5 / 60Ghz) MEC server Roadside unit(s) Exclusive optical fiber connection between the pilot site and the Nokia site Two connected and automated vehicles incl. relevant connectivity devices and sensors VRUs incl. connected nomadic devices Digital twin and vehicle planning SW services HD Map	
Actors involved		
No.	Name	Role/Responsibility
1	Connected and Automated Vehicles (CAVs)	Want a) to pass blockage on the road or b) to support a vehicle or VRU from the opposite direction passing this blockage Serve as Sensor Platform for digital twin (for lightweight: those are the only sensors available) Receive manoeuvre information and potentially further supporting information from the MEC server. Plan their own trajectories, where necessary limited by manoeuvres given by cooperative corridor planners.
	VRUs	Want to either pass blockage (bicyclist) or (potentially) give way for a passing vehicle.

		Provide information on their position and receive manoeuvre information to/from the MEC server
	Digital Twin	Collects and fuses information from different sources and tracks different dynamic objects. Provides information on available dynamic objects in a defined area Runs on MEC server and/or road- side unit
	Cooperative Corridor planner	Plans cooperative maneuvers for connected vehicles / VRUs with the goal to manage corridors with potential conflicts. Based on digital twin Runs on MEC server and/or road- side unit
	Infrastructure Sensors	Provide detection of dynamic objects inside their field of view to the Digital Twin

Scenarios			
No.	Name	Description	Primary actor
1	CAV vehicle passing obstacle	A CAV approaches a blockage on its own lane and needs to use the lane in the opposite direction to pass this blockage. Based on the information from connected road users (lightweight solution) and infrastructure sensors (baseline solution), an environment model (digital twin) is built on the MEC server or an RSU, which is used by a cooperative planer to manage the traffic on the remaining lane next to the blockage. This can include, if necessary, asking an on-coming CAV to slow down or stop to let the other CAV pass the blockage.	CAVs
2	VRU passing obstacle	A CAV approaches a blockage on its own lane, while a VRU (e.g. bicyclist) approaches on the other lane. Based on the digital twin, the cooperative planner indicates to the CAV if/when it is safe to pass the blockage on the opposite lane.	VRU & CAV

Realization	
Main responsible partners	UULM, BOSCH, UDE, NOKIA
Contributing partners	UULM, BOSCH, UDE, NOKIA

Use Case Diagram (UML diagram)

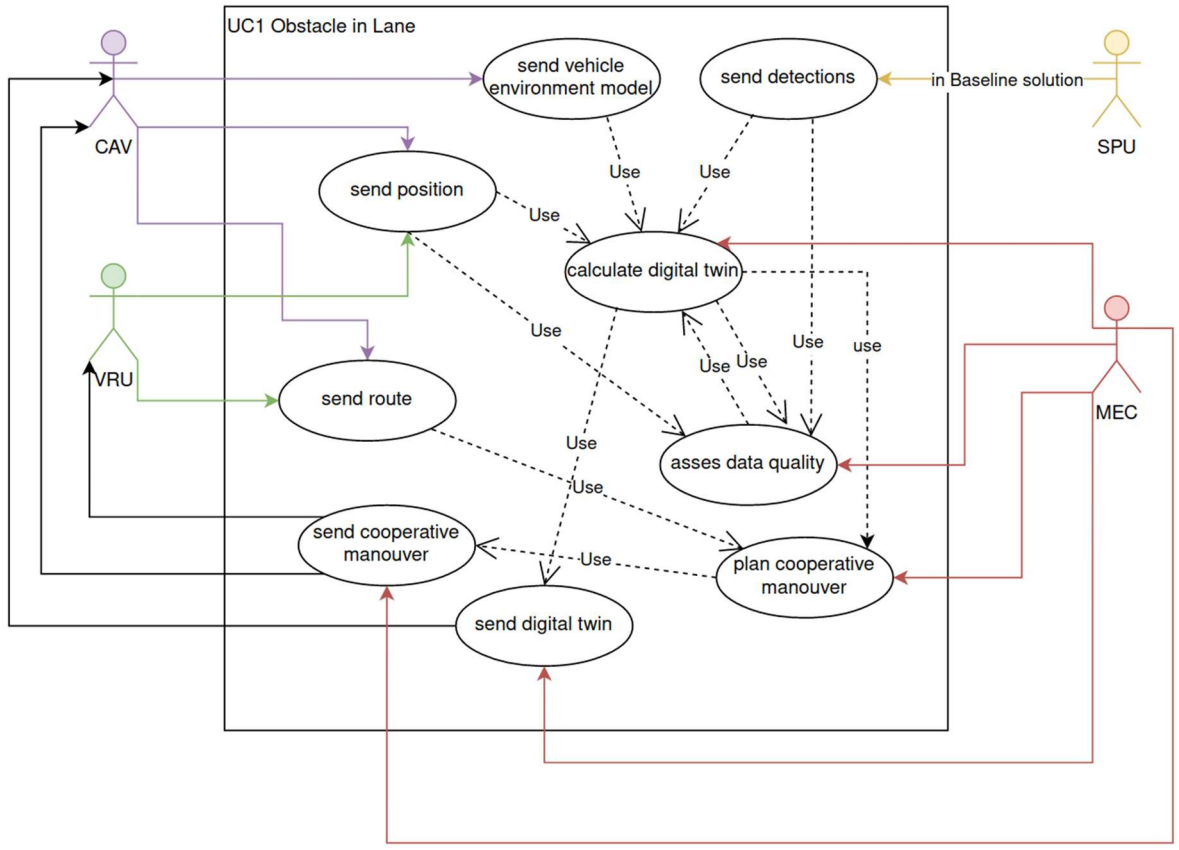


Figure 6. Use Case 1 UML Diagram. SPU is the Sensor Processing Unit available in baseline scenario only.

3.2. Use Case 2: PDI for User-Centric, CCAM-enabled Traffic Management in Urban Corridors with High Priority Vehicles and VRUs.

Table 6: Use Case 2: PDI for User-Centric, CCAM-enabled Traffic Management in Urban Corridors with High Priority Vehicles and VRUs

UC2-CTMUB	**PDI for a User-Centric, CCAM-enabled Traffic Management in Urban Corridors with High Priority Vehicles and VRUs (UC2-CTMUB)**
Scope	UC2-CTMUB considers three scenarios that will be running simultaneously in a specific traffic event when a high-priority vehicle is going through a corridor in a real urban traffic environment. The action will take place in a firefighting corridor in the city of Barcelona that connects two points (covering a distance of around 2 km) which will be also connected by, at least, two alternative routes.
Demo site	Paralel Avenue and Gran Via de les Corts Catalanes, Barcelona (Spain).
Triggering Event	The emergency vehicle receives an emergency warning.
Pre-condition	The Traffic Management Centre is operating under usual conditions when the Emergency Vehicle Manager receives an emergency warning.
Post-condition	The emergency vehicle has arrived at its final destination and the Traffic Management Centre returns to its normal operation.
Physical and Digital Infrastructure (PDI) required	Devices for VRU detection and communication. Traffic lights controllers. Traffic regulator. Traffic Management System. Firefighters' corridors. Emergency Vehicle Manager. Firefighters' Manager (Mycellium). VRU Manager. Connected Vehicle Manager. MISTRAL Smart Mobility Platform. AURORA Cooperative Server. 5G network infrastructure. MEC server. Optical fibre infrastructure. Updated HD Maps. Digital Twin. Short-range communications. Long-range communications.

Actors involved		
No.	Name	Role/Responsibility
1	High-Priority Vehicle	The high-priority vehicle will be a firefighter's truck that will run through a determined corridor. When the Scenario starts, it will receive the emergency's location and the selected corridor for the route. During the Use Case execution, it will be constantly sending updated information on

		positioning, speed, etc. to the Traffic Management System. The Use Case ends when the High-Priority Vehicle gets to its final destination.
2	Conventional connected vehicles	Conventional connected vehicles will share information on positioning, speed, and O-D with the Connected Vehicle Manager. At the same time, if an emergency occurs, they will receive notifications on Emergency Vehicles approaching and on risky situations involving VRUs.
3	Autonomous Connected Vehicles	Autonomous connected vehicles will share information on positioning, speed, and O-D with the Connected Vehicle Manager. At the same time, if an emergency occurs, they will receive notifications on Emergency Vehicles approaching and on risky situations involving VRUs.
4	VRUs	VRUs will be detected on the streets and, if they get involved in a risky situation, they will receive warnings, either via APP or through the road infrastructure.
5	Digital Twin	The representation of the road network and all the road users will be available in real time in the Digital Twin. It will provide information to the Strategy Manager, to avoid congestion and accidents while optimising all vehicles' routes. On the other hand, it will also feed the Collision Risk Estimator.
6	MISTRAL	MISTRAL is the Smart Mobility Platform developed by ETRA I+D that will get upgraded for the realisation of the Use Case. Its functions will differ depending on the performed scenario. In Scenario 1 it will execute the corridor management and the priority requests to the Traffic Regulators. In Scenario 2 it will receive the proper information from AURORA and analyse it through the Digital Twin and the embedded Strategy Manager. Finally, it will communicate the Traffic Management Plan to the Traffic Regulator. On the other hand, if an Emergency happens, MISTRAL will send suitable information to the Connected Vehicle Manager. Finally, in Scenario 3, MISTRAL will get the risk information from AURORA and examine it via the Collision Risk Estimator. Then, it will provide feedback on the vehicles and the VRUs affected to AURORA.
7	AURORA	AURORA is the Cooperative Server developed by ETRA I+D. It will get upgraded for the execution of the Use Case. Although it will have slightly different functions depending on the Use Case, its main purpose is to exchange the needed information between MISTRAL and the different developed Managers (Emergency, Connected Vehicles and VRUs). Currently, it just exchanges MAPEM and SPATEM messages, its evolution considers including additional messages such as warnings and the position of CVs and VRUs.
8	Traffic Management System	The Traffic Management System is essential for the development of the Use Case, it will perform the analysis of the data provided by AURORA and indicate the optimal traffic management strategies to avoid congestion, accidents, and any risk situation. It will be embedded in MISTRAL.
9	Traffic Regulator	Traffic regulators will perform the Traffic Management Plans indicated by MISTRAL. They will receive the priority requests and execute them.

10	VRU Manager	The VRU Manager will get all the information treated by the cameras and the VRU's location obtained by the VRU APP. It will filter this data and communicate the essential information to AURORA in a proper format.
11	Emergency Vehicle Manager	The Emergency Vehicle Manager will get all the information and communicate with the Emergency Vehicle and MISTRAL. It will share the opened corridor with the Emergency Vehicle, which will be always broadcasting its location. The Emergency Vehicle Manager will share this location with AURORA. Apart from that, the EVM will send warnings about the presence of VRUs to the Emergency Vehicle.
12	Connected Vehicle Manager	The Connected Vehicle Manager will take the information on the location, speed and Origin-Destination of all the connected vehicles in the road network, the conventional and the autonomous ones, and it will send this data to AURORA. At the same time, it will receive from MISTRAL information on the route network status, route options and warnings on the approach of Emergency Vehicles and the presence of VRUs.
13	Collision Risk Estimator	The Collision Risk Estimation will receive information about the location and speed of Connected Vehicles (autonomous or not) and VRUs, from the Connected Vehicle Manager and VRU Manager through AURORA, and will generate a prediction of their trajectories, estimate the risk of collision and inform the Connected Vehicle Manager and the VRU Manager about the high risk events. The latter two will send warnings to vehicles and VRUs, respectively.
14	Mycellium	Mycellium is the firefighters' platform. It will receive the emergency alert and ask MISTRAL for the corridor opening. MISTRAL will send Mycellium its validation for crossing the different intersections.

Scenarios			
No.	Name	Description	Primary actor
1	Management of high-priority vehicles	The high-priority vehicle (firefighters) will indicate to the Traffic Management System that it must initiate the route. At the same time, the high-priority vehicle will be sending its location to the Emergency Vehicle Manager, who will send it to AURORA (Cooperative server). AURORA will broadcast it to MISTRAL (Smart Mobility Platform). On the other hand, MISTRAL will receive from Mycellium the corridor opening request and will send back its validation, so the high-priority vehicle can start its route. MISTRAL will ask the traffic lights controllers for signal priority along the corridor. Each time a high-priority vehicle approaches a critical intersection. MISTRAL will send warnings of the high-priority vehicle approaching to the Connected Vehicle Manager, informing the affected connected vehicles and including some recommendations for security and cooperative behavior.	High-priority vehicle

2	Advanced Traffic Management based on real-time response	All connected vehicles in the road network will be sharing information with the Connected Vehicle Manager (location, speed, Origin-Destination…). The manager will transmit this data to AURORA, which will send it to MISTRAL. MISTRAL will do the proper analysis of all the data through the Traffic Management System and the real-time Digital Twin and will select the most suitable strategy in order to avoid congestion and accidents. Finally, MISTRAL will communicate the Traffic Management Plan to the Traffic Regulators.	CAVs / Traffic Management System
3	VRUs protection in an emergency event	VRUs will be detected through Artificial Intelligence devices (cameras) and, potentially, a VRU APP. Their location and the info treated by the cameras will be sent to the VRU Manager, who will communicate it to AURORA. Then, the risk information will be shared with MISTRAL, which will perform the Collision Risk Estimation through the Digital Twin and the Collision Risk Estimator. After, MISTRAL will inform AURORA of the affected vehicles and VRUs; AURORA will communicate it to the VRU and the Connected Vehicle Managers, which will display the proper warnings to their respective APPs. It will also instruct the Traffic Management System to request Traffic Controller to display the warning through some device in the infrastructure.	VRUs
Realization			
Main responsible partners		ETRA, IDIADA	
Contributing partners		ETRA, IDIADA, MILLA, ISFM, RETE, BCN, IMI	
Use Case Diagram (UML diagram)			

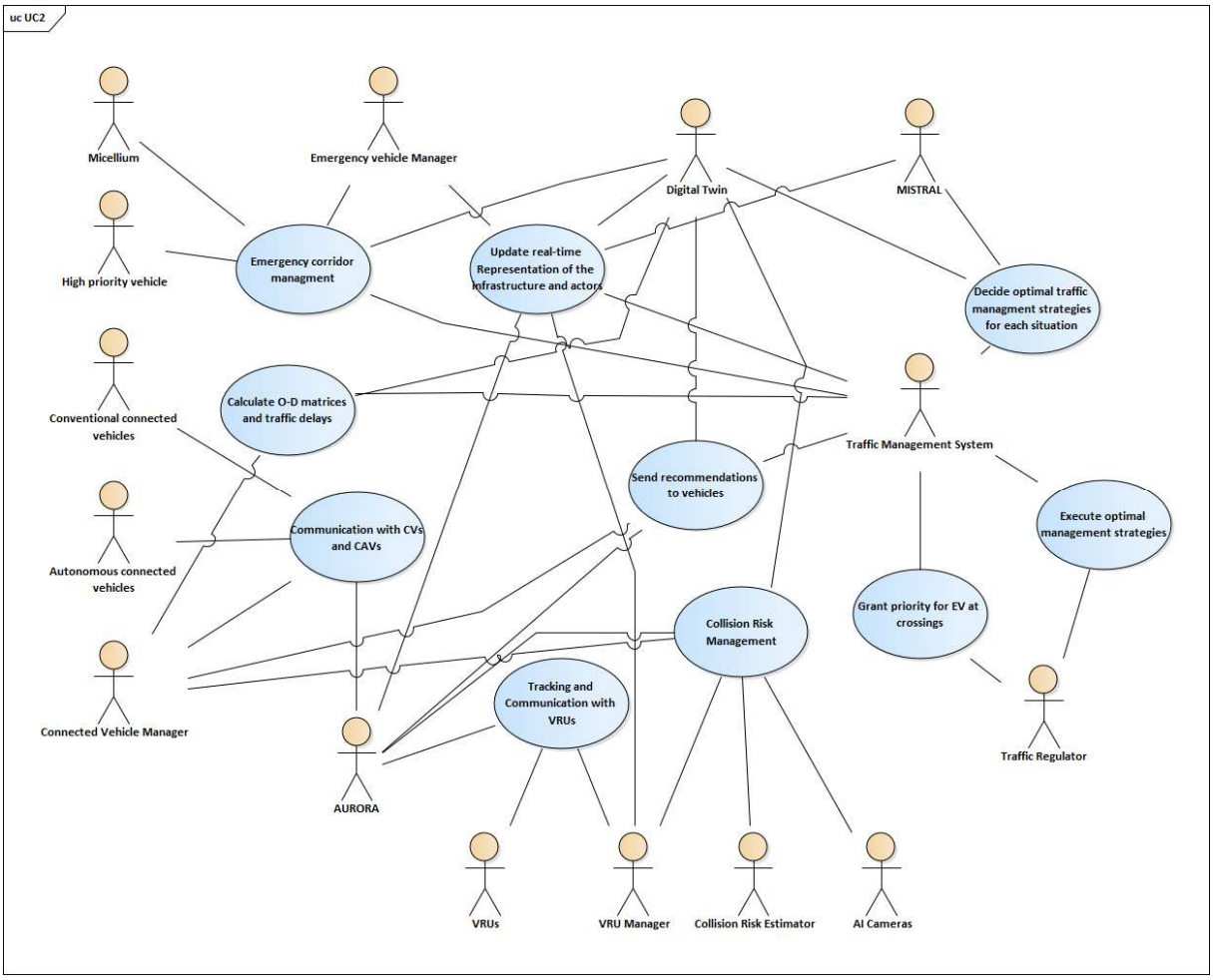


Figure 7. Use Case 2 UML Diagram

3.3. Use Case 3: Real-time responsive PDI for CCAM-enabled Traffic Management in the Mediterranean Cross-Border Corridor.

Table 7. Use Case 3: Real-time responsive PDI for CCAM-enabled Traffic Management in the Mediterranean Cross-Border Corridor.

UC3-MCBCB	Real-time responsive PDI for CCAM-enabled Traffic Management in the Mediterranean Cross-Border Corridor
Scope	Geographical scope for demonstration: A segment of the "Figueres - Perpignan" corridor, including border crossing between France and Spain. Mobility hub – Spain: Gran Junquera Outlet & Shopping Mobility hub – France: Le Boulou The existing EV charging station will be needed at/around Gran Junquera (Trusted Computing Bases-TBC), for charging the electric shuttle of MILLA. The scope of the business case can be extended, e.g., from Figueres to Perpignan. Possibility to connect Port Bou and Cervera. Criteria to be considered for the business case definition include: routes with people and goods traffic flows between origin and destination, nearby multi-modal mobility hubs connected with public transport.
Demo site	The Mediterranean (Spanish-France) CBC LL – ODD.

	The Spain-France cross-border corridor is located in the cross-border region between Le Boulou (France) and Figueres (Spain). It is a portion of the "Barcelona - Perpignan" section of the Mediterranean corridor (E15 highway). The LL itself is composed of 2 sections or test sites: 1) La Jonquera - a 6km, 2 lane highway connecting the AP-7 (Spain) & A-9 (France) in the cross-border region between Le Perthus (France) and La Jonquera (Spain), and 2) Figueres - a section of around 20 km of the E-15 highway (near Girona, Spain). Both sites are integrated with Autopistas Hub (AAE consortium member), Autopistas' traffic data management testing platform, enabling real-time data acquisition, and processing for dynamic traffic management scenarios.
Triggering Event	The shuttle receives a user petition for a ride. AND/OR The PDI receives detects a road incident.
Pre-condition	The shuttle is waiting at the origin stop. The Traffic Management Centre is operating under usual traffic conditions.
Post-condition	The shuttle arrives safely at the destination (or at the emergency area if needed).
Physical and Digital Infrastructure (PDI) required	**Physical infrastructure:** • Connected automated shuttle including connected OBUs (LTE and 5G connectivity). • MEC servers on both sides of the borders. (2 in Spain, 1 in France) • 5G network infrastructure on the LL. • Mobile devices for VRUs (smartphones or similar). • Infrastructure sensors & cameras. **Digital infrastructure:** • 5G/LTE and C-V2X LL coverage. • Local TMCs and Global TMC. • Support of CAM, CPM, VAM, MCM, DENM. • Services running on local MEC. • Shuttle Supervision Centre. • Up to date HD-Maps, GNSS, RTK.

Actors involved		
No.	Name	Role/Responsibility
1	Autonomous Connected Shuttle (MILLA)	The shuttle vehicle will be provided by MILLA. It will pick up passengers from the origin "station" and drive autonomously on the highway with a max speed of 80 km/h (Optional: it will be explored if it is feasible to increase to 90 km/h , not to disrupt any trucks that move along the right lane; Main technical concerns is passenger comfort e.g. due to braking). The Use Case ends when the shuttle gets to its final destination. During the Use Case operation, it will be sending continuous information on its positioning, speed, O-D, etc. to the Traffic Management Centre via the gateways, and receiving "commands" from it, which it will implement as part of its driving objectives. It will also share information on the

		vehicles and obstacles that it detects in its surroundings. At the same time, it will receive notifications on incidents on its path.
2	Autonomous Connected Vehicle (IDIADA)	An autonomous connected vehicle will be provided by IDIADA. It will share information with the TMC via the gateways. It will also share information on the vehicles and obstacles that it detects in its surroundings. At the same time, it will receive notifications on incidents on its path and risky situations involving VRUs.
3	Conventional connected vehicles (RETE)	Conventional connected vehicles will exchange information with the TMC via the gateways, through the use of OBUs (On-Board Units) and HMIs (Human-Machine Interface) such as a tablet. The OBUs have to be compatible with both technologies: 5G stand-alone, and V2X (LTE-PC5).
4	VRUs (I2CAT)	VRUs will be detected on the road or near the shuttle stops, through messages transmitted by the VRU's mobile app (containing geolocation). When the shuttle is approaching a stop, any present VRUs (shuttle users) will receive an alert of "incoming shuttle" via the APP or through the road infrastructure. The CAVs will also receive a timely alert of potentially dangerous situations involving VRUs.
5	Digital Twin (I2CAT, ETRA, AAE)	The representation of the road network and all the road users will be available in real time in the Digital Twin. It will represent a local and global perception of the traffic state, based on the fusion of the data input coming from the traffic cameras and the connected vehicles. It will be able to evaluate different traffic strategies. It will interact with the Traffic Management Centre (TMC). It will include a Local Dynamic Map (LDM), which is a dynamically updated database of vehicles on each road section.
6	Traffic Management Centre (AAE)	The Traffic Management Centre is provided by AAE, it will perform the analysis of current road conditions (via the Digital Twin) and any incidents detected, and test and select the optimal traffic management strategies in real-time, in order to avoid congestion, minimising journey times and hard braking, and maximise overall safety. **Local TMC:** MECs (Multi-purpose Edge Computers) are installed along the corridor of the highway, in set intervals. Their purpose is to rapidly analyse the vehicle data captured by the cameras and received by the connected vehicles in real-time and with low latency, as well as detect and recognise any incidents happening in their area of coverage. A **Global TMC** is set up in the cloud by AAE. Its role is to supervise the entire highway corridor (all intervals) and ensure that high-level traffic management strategies are implemented.
7	V2X-GW, RSUs, Traffic cameras, Antennas (RETE, I2CAT, IDIADA)	Roadside infrastructure and traffic cameras are installed along the corridor of the highway, at specific intervals. This fixed infrastructure includes 5G base stations, C-V2X RSUs, and Multipurpose Edge Computers (MECs) that execute the V2X gateways (V2X-GW) to provide interoperability among vehicles connected through different radio technologies.
8	Tele-supervision system & human	The shuttle has a remote human supervisor who monitors the status of the shuttle. If there is an issue, the supervisor is able to safely guide the shuttle in real-time via 5G low-latency communications and the tele-supervision system of MILLA.

	supervisor (MILLA)	
9	Shuttle user (passenger) & mobile app (ENIDE)	The passengers of the shuttle will use a mobile app to request the shuttle (and pay for a ticket). The app will also allow users to see where the shuttle is at the moment, the estimated journey time, the estimated time of arrival at the destination, the time of the next departure, as well as other infotainment options.

Scenarios

No.	Name	Description	Primary actor
1	**Daily commuting across borders**	The objective of this scenario is to evaluate the new functionalities developed in the project for a commuting service where an automated shuttle transports road users from a mobility hub on one side of the borders to a mobility hub on the other side. This scenario will demonstrate an on-demand sustainable multimodal transport service. The goal is to maximise the use of the shuttle and minimise their presence on the road without passengers onboard or without goods loaded. For example, in the morning and late afternoon, the shuttle is on continuous service (peak hours) where there might be a constant need. During the day and night (off-peak hours), the shuttle is on demand. It can be called by a dedicated app to pick up a passenger or transport and deliver packages. **Storyboard:** 1. The road users leave their vehicles in a parking lot (or arrive by public transport if around a multi-modal mobility hub) and switch to the shuttle. They go to the shuttle stop and request a shuttle ride via the mobile app. The users are informed of the forecasted arrival time of the next shuttle. 2. Just before arriving at the stop, the shuttle alerts the users' (VRU) phones of its arrival, to avoid any inattentive walker/bystander. The shuttle slows down / stops if a VRU might be in danger. 3. The shuttle arrives at the meeting point to pick up its passengers. The passengers aboard the shuttle. They are informed of the estimated time of departure, and time of arrival at the destination (monitoring traffic conditions and comparing with forecasted demand to select the optimal time to wait/leave). The shuttle service provides information/infotainment service via mobile app to shuttle users while waiting/travelling. 4. The shuttle leaves the starting point and travels along the route. During travel, the shuttle is continuously supervised by the monitoring centre and the	Shuttle passengers, VRUs, MILLA shuttle, CAV, CCVs, TMCs, Digital twin, RSUs

		responsive PDI. It communicates its position and trajectory with the PDI via CAM, MCM messages, or others. 5. At the same time, other connected vehicles (non-autonomous) travelling on the same trajectory also send their positions to the PDI via CAM messages. The PDI also monitors traffic status via the traffic cameras. 6. The Digital Twin continuously updates the traffic status, and the TMC generates optimised traffic strategies if needed (e.g. in case of disruption, e.g. incident, congestion, rain, etc.) 7. The road infrastructure, using the 5G network, the RSUs, and V2X Gateway, sends information to connected vehicles about other vehicles on the road, independently on the radio technology they are using. 8. If road traffic conditions allow it, the shuttle increases speed up to 80-90km/h (depending on technical feasibility and local legislation of the border side). 9. The shuttle arrives at its designated destination on the other side. Passengers leave the shuttle and use the multi-modal mobility hub for further travel. The shuttle takes new passengers for the return trip.	

2	Safety incidents across borders - continuous, efficient and resilient service	The objective of this scenario is to demonstrate potential solutions to mitigate possible risks of the new CCAM service and the potential solutions to mitigate these risks.
		From the point of view of the road operation (AAE), the safe and timely response and mitigation of risky scenarios (including cross-border) is important, based on robust and low latency communications (taking advantage of the Edge).
		The long-term goal for MILLA is to safely take out the security operator from inside the shuttle and deploy fully autonomous shuttles. Therefore, the shuttle must be fully supervised and driven in real-time (hence the importance of 5G low latency and ultra-reliable connectivity).
		
		Storyboard:
		• Incident on the road is detected by PDI (e.g., stopped car, congestion, accident, work zone), either in one country or the other.
		  • An incident is detected by the traffic cameras (or by the CAVs). It is communicated to the PDI.
		  • The Digital Twin (edge) is instantly updated and communicates with the TMC. The TMC then generates an immediate-response strategy and sends a series of traffic recommendations (speed and safety distance adaptation...) to the approaching connected vehicles,
			Local TMC, MILLA Shuttle, Tele-supervisor

also the ones that are still across the border, e.g., via IVIM message or other.
    - The corresponding PDI alerts vehicles (automated shuttle and other CAVs) of the incident, e.g., via DENM message, and recommends manoeuvres (speed limit, lane change, etc.), e.g., via MCM, IVIM message, or other.
    - The shuttle CAV receives commands ("behaviour targets" for autonomous driving) to slow down, and change lane (TBC by Milla) if needed and responds safely to them. This can be done via MCM, IVIM, or other types of messages.
    - The shuttle passenger app is updated (incident alert, new arrival time)
    - Connected vehicles' HMI (e.g., tablet) receives alert and speed/manoeuvre recommendations. The drivers respond accordingly.
- When approaching the area of the incident, if the road is blocked and an overtaking is necessary:
    - The shuttle slows down / stops.
    - The supervision platform alerts the security operator (SAE L4 CAV) or the supervisor (SAE L5 CAV) of its partial or full delegation need. The tele-supervisor evaluates the situation.
    - If needed, the tele-supervisor may take control of the shuttle from a supervision dashboard and perform manoeuvres to avoid the incident area and continue the journey.
- The shuttle exits the area of the incident and continues its journey as normal.
    - The delegation from tele-supervisor back to fully autonomous driving. Recovers normal speed.
    - Passenger's app updated (new arrival time)
- The shuttle's ADAS detects any problem that may endanger autonomous driving.
    - The shuttle notifies the tele-supervisor and the PDI of the issue.
    - The PDI is notified, and nearby vehicles are alerted to pay attention to the incident (via DENM messages).
    - The Digital Twin (on the edge) is instantly updated and communicates with the TMC. The TMC generates an immediate response strategy and sends a series of traffic recommendations (speed and safety distance adaptation...) to the surrounding connected vehicles. (e.g., via IVIM, MCM, etc.)

		• Passengers are notified. Users waiting at shuttle stops are notified of breakdowns and delays.
		• Following the human tele-supervisor's decision, two scenarios exist:
		  ○ If the issue is minor, and safe to drive (e.g., one camera is obstructed), the tele-supervisor leads the shuttle to the final destination.
		  ○ If the issue is major, and not safe to continue the journey (e.g., RTK does not offer the correct location), the TMC offers the nearest safe area to the vehicle and starts the assistance protocol (warnings and recommendations to the rest of the road users) to the difficult teleoperation. The tele-supervisor accompanies remotely the vehicle to a safe area and adjusts the parameters of the autonomous behaviour depending on external and internal vehicle factors.

Realization		
Main responsible partners	AAE, I2CAT, MILLA	
Contributing partners	MILLA, I2CAT, IDIADA, RETE, ENIDE, TENAL	
Use Case Diagram (UML diagram)		

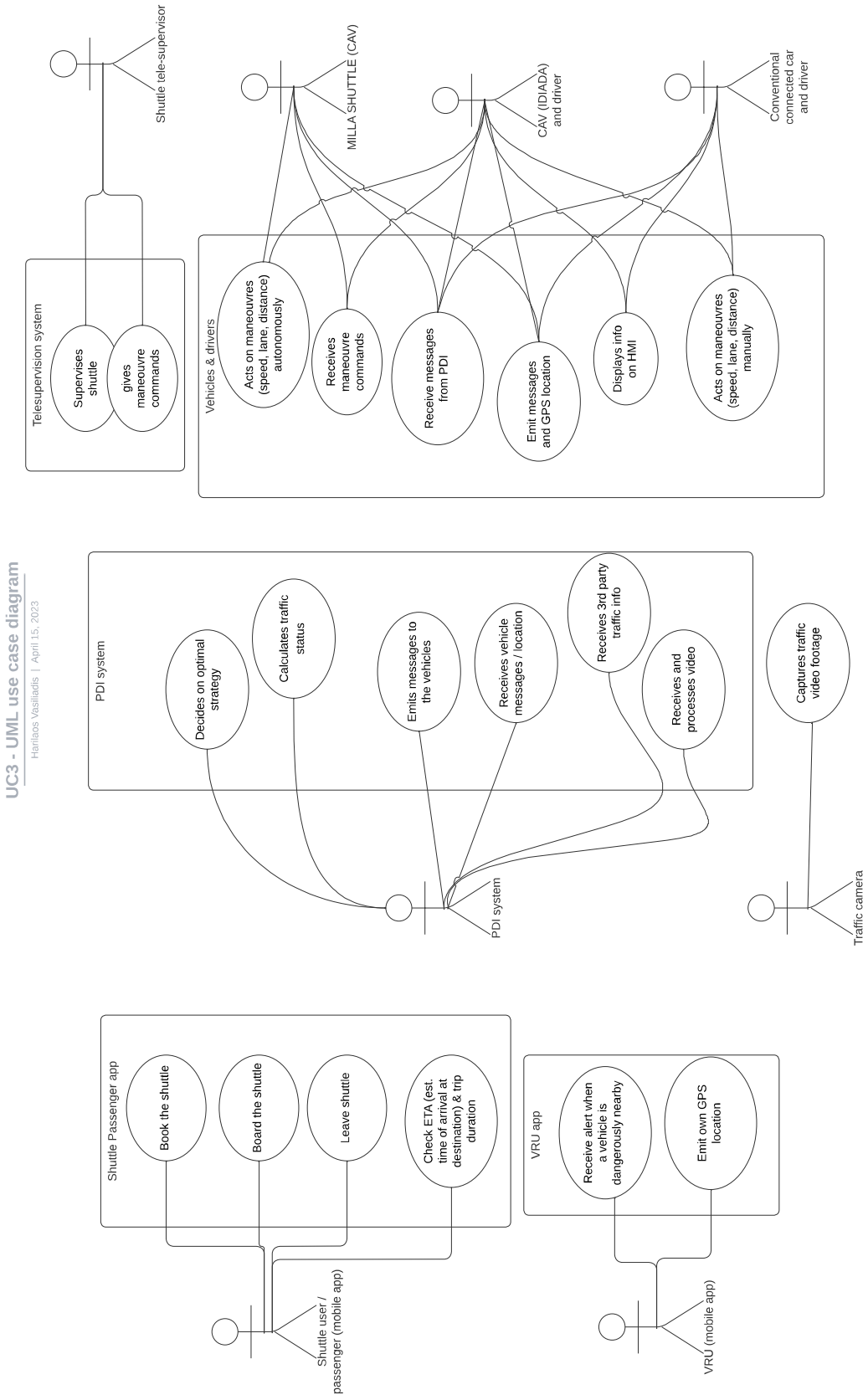


Figure 8. Use Case 3 UML Diagram

3.4. Use Case 4: Trusted Cooperative Perception for Intersection Manoeuvre Assistance

Table 8. Use Case 4: Trusted Cooperative Perception for Intersection Manoeuvre Assistance

UC4-TCP4IMA	Trusted Cooperative Perception for Intersection Manoeuvre Assistance.
Scope	The Use case demonstrates the feasibility of a highly-trusted PDI-based VIMA for CAVs under different conditions. The traffic conditions will be real traffic, and the CAV actions will be displayed in CAV's HMI.
Demo site	Italian LL in Turin, plus technical tests in Trento (to be confirmed)
Triggering Event	The service is continuously provided and VIMA is activated once a CAV arrives at the cross point.
Pre-condition	The system is acquiring data from the sources without emitting IMA indications
Post-condition	The system sends Intersection Movement Assistant (IMA) indications while the vehicles perform the manoeuvres.
Physical and Digital Infrastructure (PDI) required	Crosspoint Traffic lights RSU with camera sensors CAV VRU, VRU with smartphone APP 5G network and Edge infrastructure

Actors involved		
No.	Name	Role/Responsibility
1	CAV	CAVs are the main users of the UC; they communicate their presence via broadcast messages, and they consume the indication messages produced by the PDI.
2	VRU	Contribute to the traffic status of the cross point via the camera sensors and/or travel App.
3	RSU	Detect CAV presence and other connected/non-connected road users to contribute to cross-point data. They are attestors for CVs using the PDI services.
4	TL	Traffic lights give information in real time. Phase and timing are provided via a local broker
5	TM	Truthfulness module: a functional component that fuses redundant incoming information in order to assign truth-index to objects detected.
6	AE	Attestation entities: are software modules that allow the attestation of the trustworthiness of the OBUs and RSUs present in the system. AEs are present in MEC and RSUs.
7	DT	Crossroads Digital Twin: A software service that maintains a real-time picture of the status data produced by the tunnel. It keeps an updated version of measurements of the cross point, such as TL phases, road users' position types, and kinematic information. Queries may be done by VIMA service in order to compute suggested manoeuvres.
8	VIMA service	Software service that uses the DT real-time information

Scenarios:The scenarios will be built based on the following basic routines			
No.	Name	Description	Primary actor
1	Give way	The vehicle arrives, breaks, and gives way to VRU	CAV
2	Stop and wait	The vehicle arrives, breaks, and comes to a stop for a certain time window.	CAV
3	Pass through	The vehicle arrives and passes within a time window to quickly clear the way, as VRUs intend to cross next.	CAV
4	Prevented start	The vehicle previously stopped is about to cross, but does not pass due to VRU crossing	CAV
5	Collision avoidance	The vehicle is warned about a sudden VRU red violation	CAV
6	Attestation	A vehicle is authorized or deauthorized by the attestor due to an OBU tampering	AE
Realization			
Main responsible partners		CRF	
Contributing partners		CRF, LINKS, TIM, SWM	
Use Case Diagram (UML diagram)			

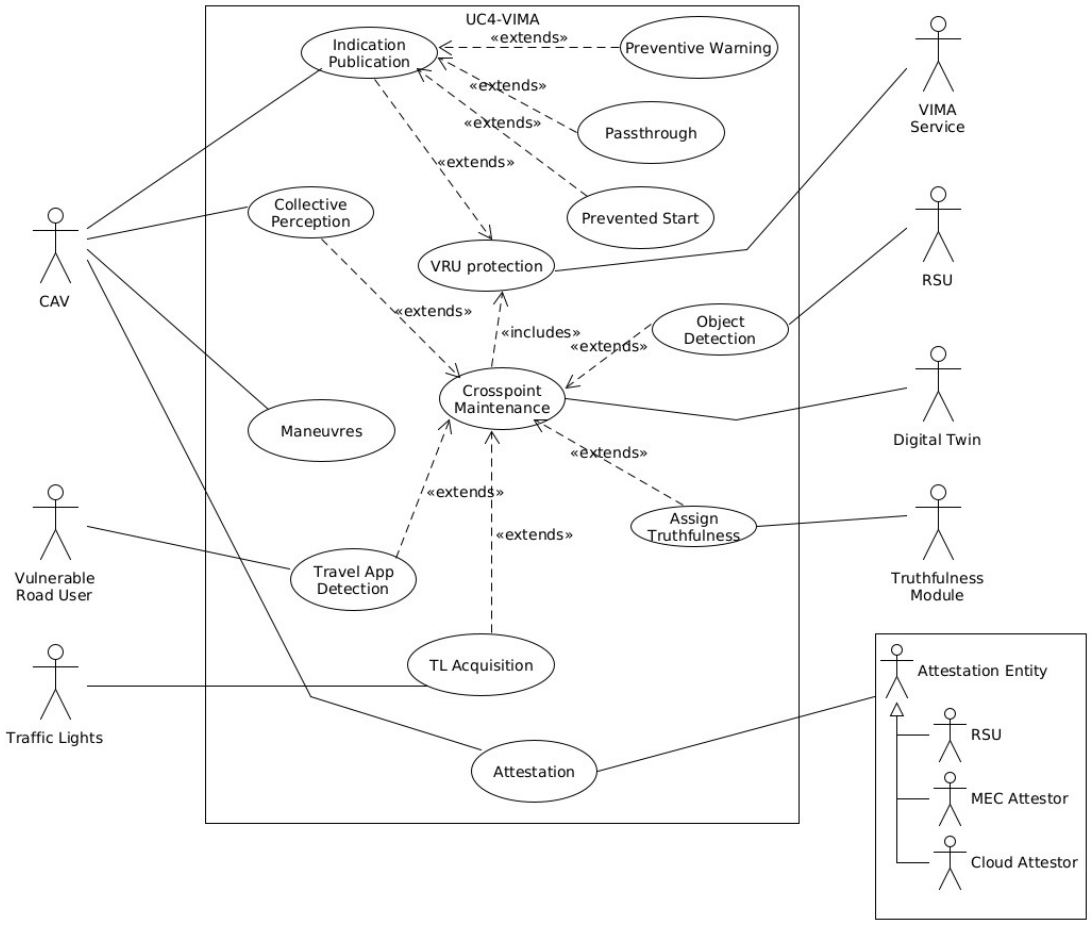


Figure 9. Use Case 4 UML Diagram

3.5. Use Case 5: Risk Management in a Highway Tunnel.

Table 9. Use Case 5: Risk Management in a Highway Tunnel

UC5-RMT	Risk Management in a Highway Tunnel	
Scope	Compute and maintain a risk index of the current status of the tunnel with real traffic and send feedback to CAVs to help them taking a safer decision. Deploy two V2x-based alternative solutions to locate vehicles inside the tunnel and help maintain a certain ODD level	
Demo site	A22 Trento Highway Tunnel, south direction	
Triggering Event	The service is continuously provided, but the triggering event is any road event that raises the risk level above a threshold.	
Pre-condition	The ego-CAV runs along the highway with the planned cruise and SAE level, relying primarily on its own sensors, but also on V2X, for perception for motion control. Most likely in the public road trials, only up to L2 (but perception and decision-making can be emulated up to higher levels).	
Post-condition	The ego-CAV, having received and processed a warning message before or within the tunnel, proceeds either (1) at SAE L1 with a lower target speed, e.g. if a new lower speed limit is included in the C-ITS message, or on (2) a new lane (e.g. if lane closure message has been received) (3) with L0 manual driving (for any other cases). It should be noted that L1 can be kept only if the risk is kept at a minimum by lowering speed or changing lanes.	
Physical and Digital Infrastructure (PDI) required	Tunnel RSU with/without camera sensors CAVs CNAVs (Connected non-automated vehicles) NCVs (Non-connected vehicles) Digital Twin 5G network Cloud infrastructure	
Actors involved		
No.	Name	Role/Responsibility
1	CAV	CAVs with high automation capabilities and HMI. CAVs are the main users of the UC; they communicate their presence via broadcast messages and via Camera sensors. CAVs belong to CRF. Their OBUs are equipped with 5G/C-V2X/ITS-G5 communication modules.
2	NCV	Non-connected vehicles. They contribute to tunnel data passively via camera sensors and interact physically with the other road users
3	CNAV	Connected non-automated vehicles: vehicles that can consume the information provided by the PDI but do not apply indications. They are instead visualized in the driver's HMI (when present). CNAVs contribute to tunnel data via ITS messages and camera sensors.
4	RSU	Two RSUs with cameras, LiDARs, and hybrid connectivity (5G/C-V2X/ITS-G5). RSUs detect CAV presence and other connected/non-connected road users to contribute to tunnel data.

5	Traffic Control Center	Existing management infrastructure belonging to BRE and connected to tunnel infrastructure.
6	DT	Digital Twin: software service that maintains a real-time picture of the data produced by the tunnel. Queries may be done by other services in order to perform computations, such as the risk level.
7	TRLA	Tunnel Risk Level Assessment: access DT data in real-time to calculate the risk level status of the tunnel.

Scenarios			
No.	Name	Description	Primary actor
1	Risk maintenance	PDI receives data from RSUs and camera sensors; based on this information computes a risk level of the tunnel periodically, emitting alerts to vehicles when necessary	DT, RSU, TRLA
2	Precise positioning	Vehicles travelling the tunnel use the PDI services to know their location. Location sources are V2X and SDR	CAVs
3	Manual driving	The vehicle is operated manually and received warnings are displayed in its HMI.	CAVs, CNAVs
4	ACC	Vehicle following Adaptive Cruise Control (ACC): longitudinal control kept through forward-looking sensors and a target speed, the latter may be changed by V2I.	CAVs
5	CACC	Cooperative ACC: longitudinal control kept with standard sensors and CAM; target speed may be changed by V2I.	CAVs, CNAV

Realization	
Main responsible partners	CRF
Contributing partners	BRE, LINKS, TIM

Use Case Diagram (UML diagram)

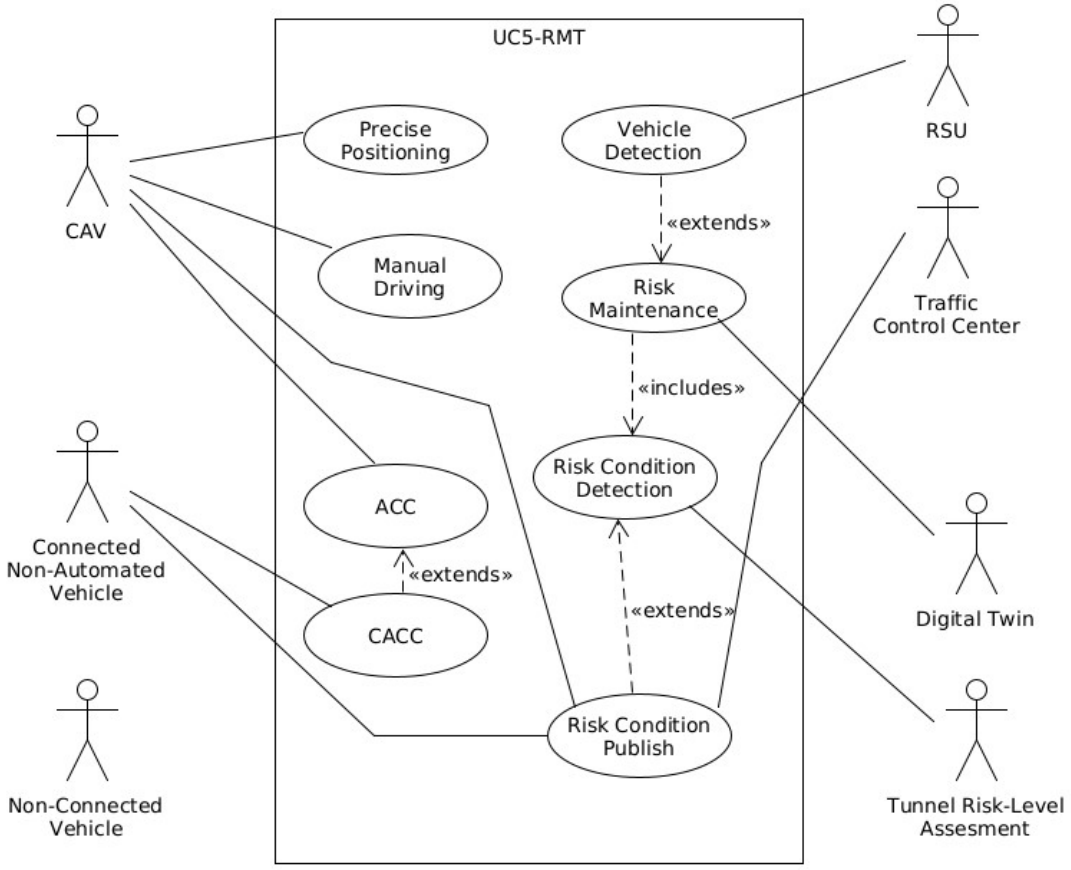


Figure 10. Use Case 5 UML Diagram

4. High-level Requirements - Methodology.

4.1. Approach.

The methodology is characterised by an integrated approach (Figure 11): high-level requirements obtained from the technical experts and pilot sites of the consortium through the Volere tool may be implemented.

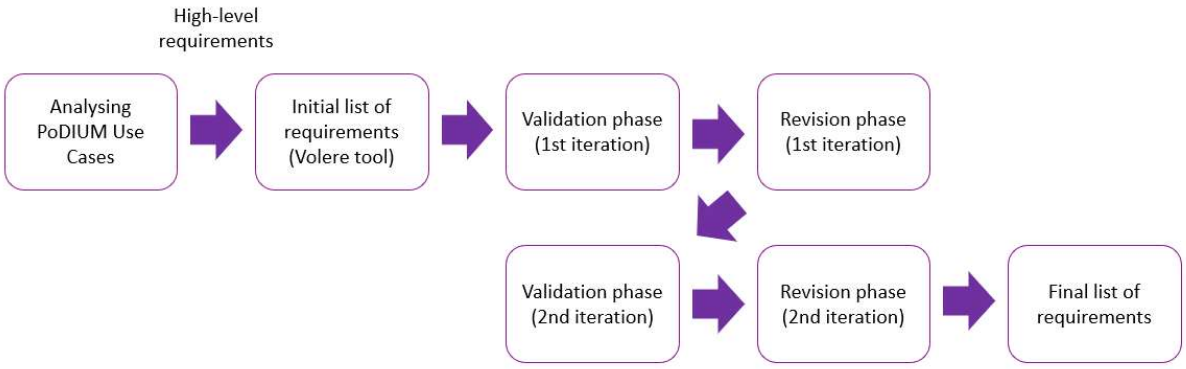


Figure 11. Methodological approach

The identification of the high-level requirements comprises a broader set of requirements to be considered within the development process of the PoDIUM Use Cases. For coordinating the definition of requirements by the partners from the PoDIUM consortium, the Volere methodology has been used. Volere provides a conceptual framework for organizing and structuring the definition of requirements, as well as some templates for their formalization and some procedural rules and pattern for the work.

The following subsections provide a detailed overview of the applied approach.

4.2. Identification and Definition of High-Level Requirements.

To define the high-level requirements necessary for the development of each of the PoDIUM Use Cases and based on the information from the questionnaires carried out to the experts, explained in the previous sections, the Volere methodology has been followed.

This methodology has been proven successful in previous H2020 projects such as DORA, MEISTER, X-FLEX, NOBEL GRID, WISEGRID, USER-CHI, or CROSSBOW, where it was used mainly because of its simplicity. It helped project partners to describe, discuss, formalise, and track the project requirements explicitly and collaboratively. Besides being successfully realised in the above-mentioned previous projects, the Volere methodology was selected for the following reasons:

1. It requires simple steps to identify and formalise the requirements unambiguously.
2. It provides an easy process to track and evaluate the progress of the project.

The application of the Volere methodology is not only useful in the initial phases of the project for specifying requirements, but it is also helpful in specifying a reference point for the later stages. For example, it is useful for use case analysis to ensure that all important aspects of the requirements are covered by the different defined use cases. But also, during the implementation and management, it can be used to track and evaluate the progress of the individual work packages and the overall project. Besides being efficient and easy to use, the Volere methodology provides a mechanism for all partners to specify the requirements in a standard format. Thereby, specifying the additional context of a

requirement such as the rationale and the acceptance criteria for every requirement helps to build a common understanding of the overall system. Furthermore, defining priorities helps to clarify the focus of the project.

4.2.1. Requirement prioritization.

In order to prioritize requirements, the project consortium has introduced five different classes of priorities. These classes range from one (lowest priority) to five (highest priority) and the consortium has defined them as follows:

- **5 - High**: Requirements in this class are either realizing a key innovation of the project or they are needed to realize it. These requirements are necessary to achieve the goals of the project.
- **4 - 3 Medium**: Requirements in this class are not necessary to realize a key innovation but they are necessary or very helpful to realize the application prototypes. These requirements are important to the application developer.
- **2 - 1 Low**: Requirements in this class are necessary neither for realizing a key innovation nor for the application of the prototypes. However, in a broader context possibly beyond the scope of the project, they may be important.

Therefore, for the success of the project, it is essential to fulfilling the requirements with high priority. Concerning providing thorough support for product developers, it is important to realize the requirements with medium priority as well. The requirements with low priority, however, do not have immediate relevance to the project. However, if they are taken into account may provide additional features or benefits for applications or users.

4.2.2. Volere tool.

Aiming at defining an optimum and complete list of requirements, a web-based application based on the Volere methodology has been used for gathering the requirements in PoDIUM. This web tool incorporates the concepts in the data model, the templates within its user interface, and the procedural patterns in the application business rules. The Volere tool facilitates collaborative and interactive work between partners iteratively and progressively.

For the PoDIUM requirements gathering, WP2 partners agreed to classify the requirements, based on a hardware/software separation. In general, there were created six groups of requirements. Each requirement is therefore associated with the Use Cases that must accomplish the proposed structure, as it is shown in Figure 12.

Figure 12. Groups of requirements defined for PoDIUM Use Cases

For each group of requirements, all partners from the different Use Cases were involved as collaborators. Therefore, multidisciplinary groups were created formed by technical experts and pilot site leaders responsible to define, discuss and agree on the requirements for each group. The overall process of Volere as supported by the web tool is specified, revised, and solved by the original author of the requirement. Iteratively, this process is repeated for each set of new requirements that are

included in the tool. Once all issues are closed and no more requirements are expected, the result constitutes the final list of requirements.

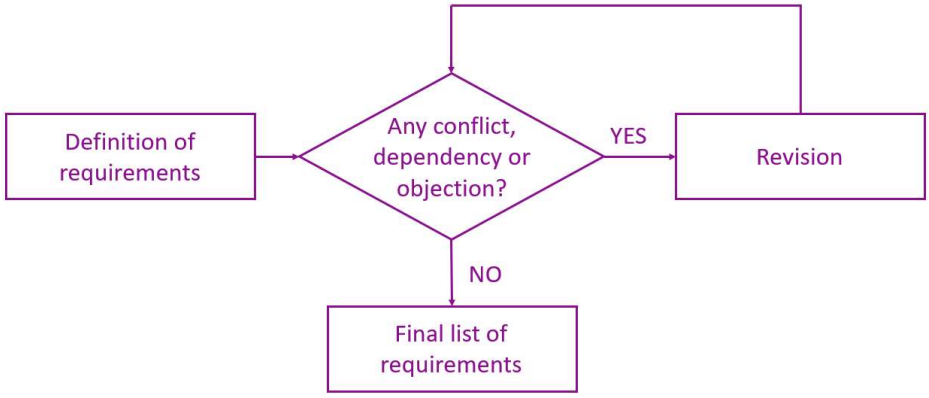


Figure 13. Requirements specification process diagram

4.2.2.1. Requirements definition.

In this first stage, a complete list of the requirements of the PoDIUM Use Cases that are needed to accomplish the project objectives should be defined.

This initial list of requirements will be refined and expanded in future iterations. In this stage, 199 requirements were initially included in the Volere web tool throughout 2 and a half weeks, from the beginning of February to mid-February 2023.

The most useful information and the main functionalities of this stage are available on the main page, which could be seen in Figure 14:

- **List of requirements:** The list of requirements with some additional options.
  - Filtering options: The list of requirements filtered per id., type, and/or filtered per author.
  - Expand table: Show/hide some columns, displaying more or less information about the requirement.
- **Requirements management:** Modification options for requirements.
  - View a requirement.
  - Edit a requirement (only available for the author).
  - Delete a requirement (only available for the author).
- **Requirements tracing:** After the first validation, a new service is made available for keeping track of all requirements history.

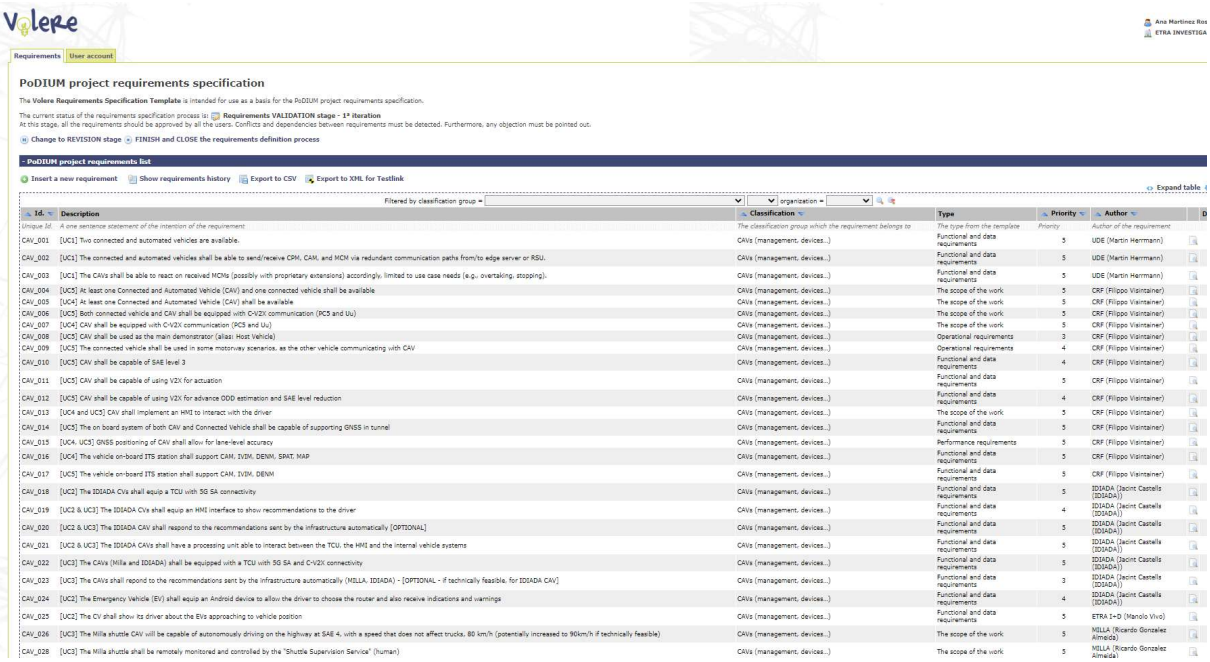


Figure 14. Volere main page

- **Insert a new requirement**: Opens a new window **¡Error! No se encuentra el origen de la referencia.**(Figure 15) to allow adding a new requirement. All the fields are required except for the "Comments" field which is optional. The required fields are:
    - ID: The scope of this requirement. Appended by an automatically generated sequential number, this ID uniquely identifies each requirement. This ID will be generated after the requirement has been added. (See Figure 16).
    - Classification: The group of requirements to which the requirement belongs.
    - Description: A one-sentence statement which describes the intention of the requirement.
    - Type: The type of requirement as defined by Volere.
    - Rationale: A justification of the requirement.
    - Acceptance criteria: A measurement of the requirement for further verification that the solution matches the original requirement.
    - Priority: The importance for the customer of successfully implementing the requirement

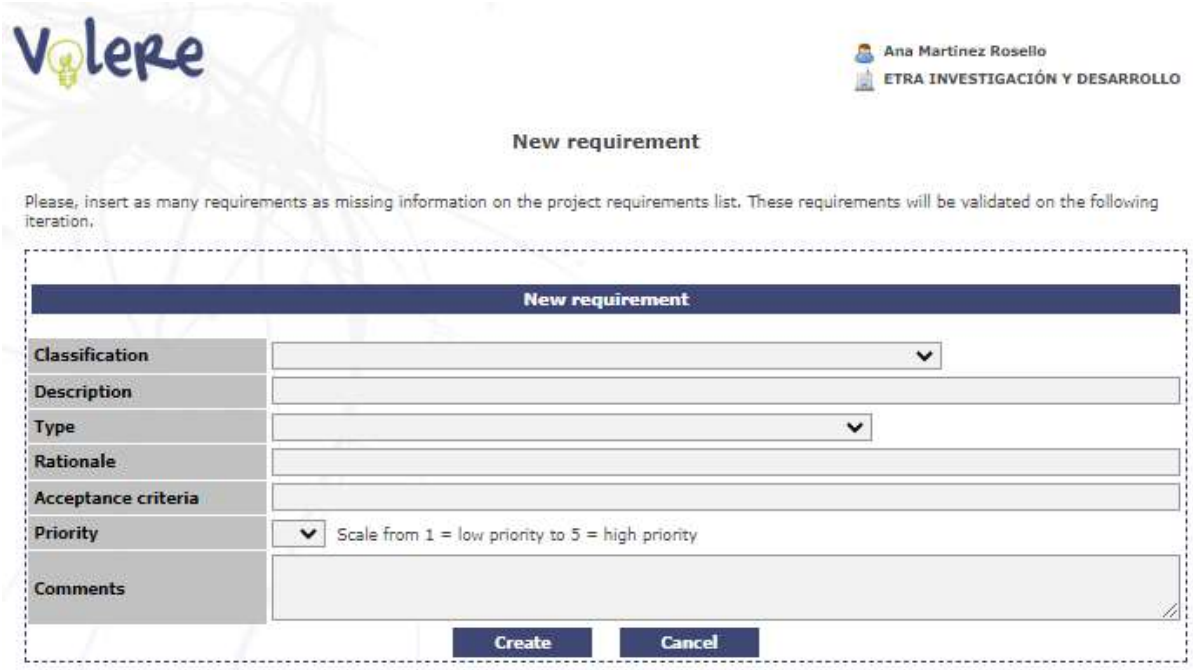


Figure 15. Window to insert a new requirement

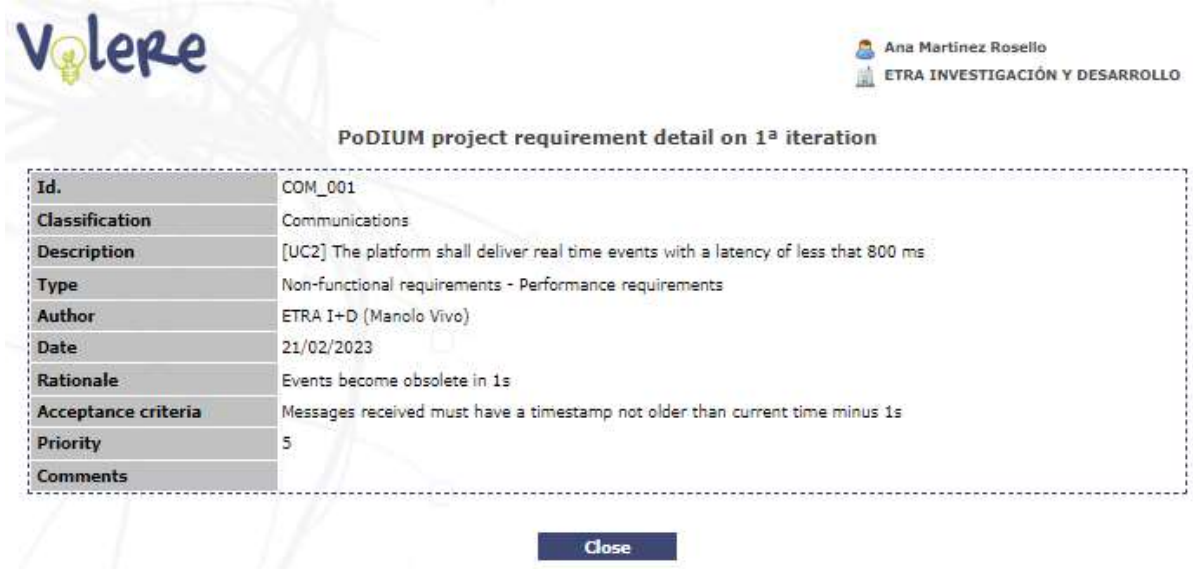


Figure 16. PoDIUM project requirement details

4.2.2.2. Requirement Validation.

After the initial definition of requirements, the validation process begins. All the requirements should be approved by all the users. At this stage, conflicts and dependencies between requirements must be detected. Furthermore, any objection must be pointed out:

Objection: A reason or argument due to disagreement, opposition, refusal, or disapproval of the requirement.

Dependency: Requirements that have some dependency on other requirements.

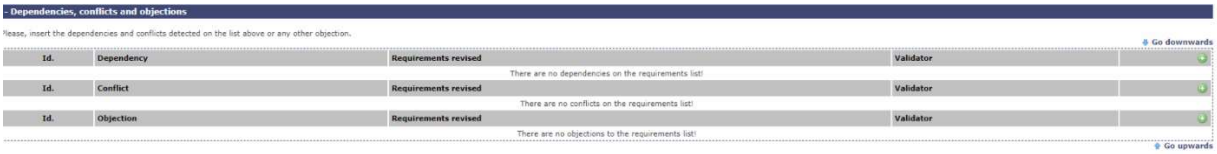
Conflict: Requirements that cannot be implemented if another requirement is implemented or there is a conflict due to an insufficient definition of the requirement.

How to insert an objection

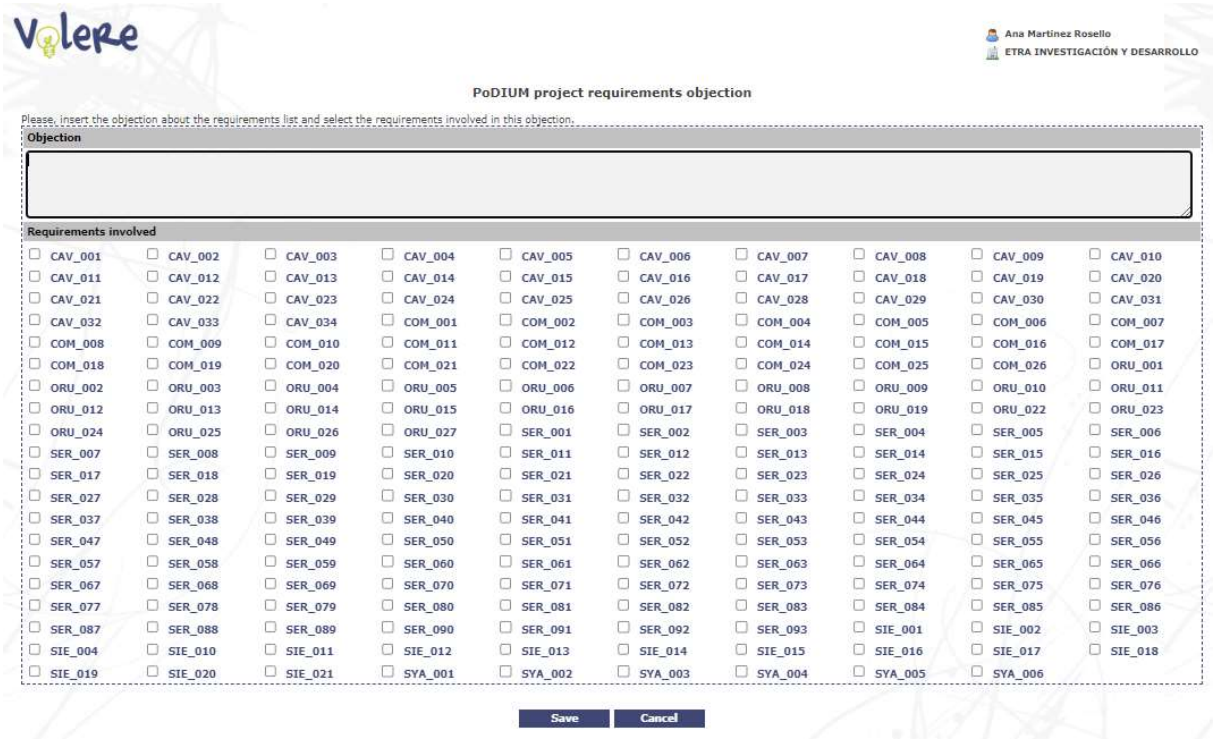
An **Objection** is a reason or argument offered in disagreement, opposition, refusal, or disapproval of the requirement. To introduce an objection in VOLERE, the procedure is as follows:

- Identify the Requirement number to which we want to object.

- Press  icon to add a new Objection.



- Select the requirement number on which we want to make the objection and write the description of the Objection.



- The new objection has been created and the Validator and Revisor for that requirement have been assigned. The Validator is the person who has introduced the objection and the Revisor is the person who generated the requirement.

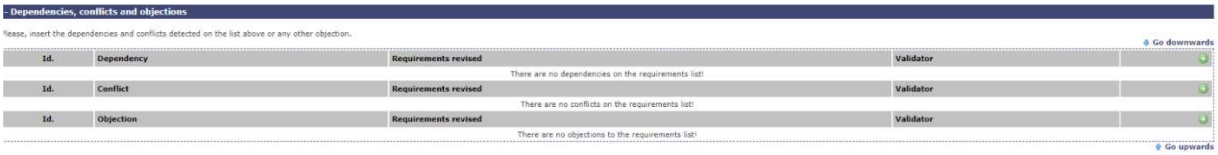
- *How to insert a conflict*

- Two or more requirements are in Conflict if those requirements cannot be implemented if another requirement is implemented. To introduce a conflict in Volere, the procedure is as follows:

- Identify the Requirements number on which we want to make the conflict.

CAV_018	[UC2] The IDIADA CVs shall equip a TCU with 5G SA connectivity	CAVs (management, devices...)
CAV_019	[UC2 & UC3] The IDIADA CVs shall equip an HMI interface to show recommendations to the driver	CAVs (management, devices...)
CAV_020	[UC2 & UC3] The IDIADA CAV shall respond to the recommendations sent by the infrastructure automatically [OPTIONAL]	CAVs (management, devices...)
CAV_021	[UC2 & UC3] The IDIADA CAVs shall have a processing unit able to interact between the TCU, the HMI and the internal vehicle systems	CAVs (management, devices...)
CAV_022	[UC3] The CAVs (Milla and IDIADA) shall be equipped with a TCU with 5G SA and C-V2X connectivity	CAVs (management, devices...)

- Press  icon to add a new Conflict.



- Dependencies, conflicts and objections

Please, insert the dependencies and conflicts detected on the list above or any other objection.

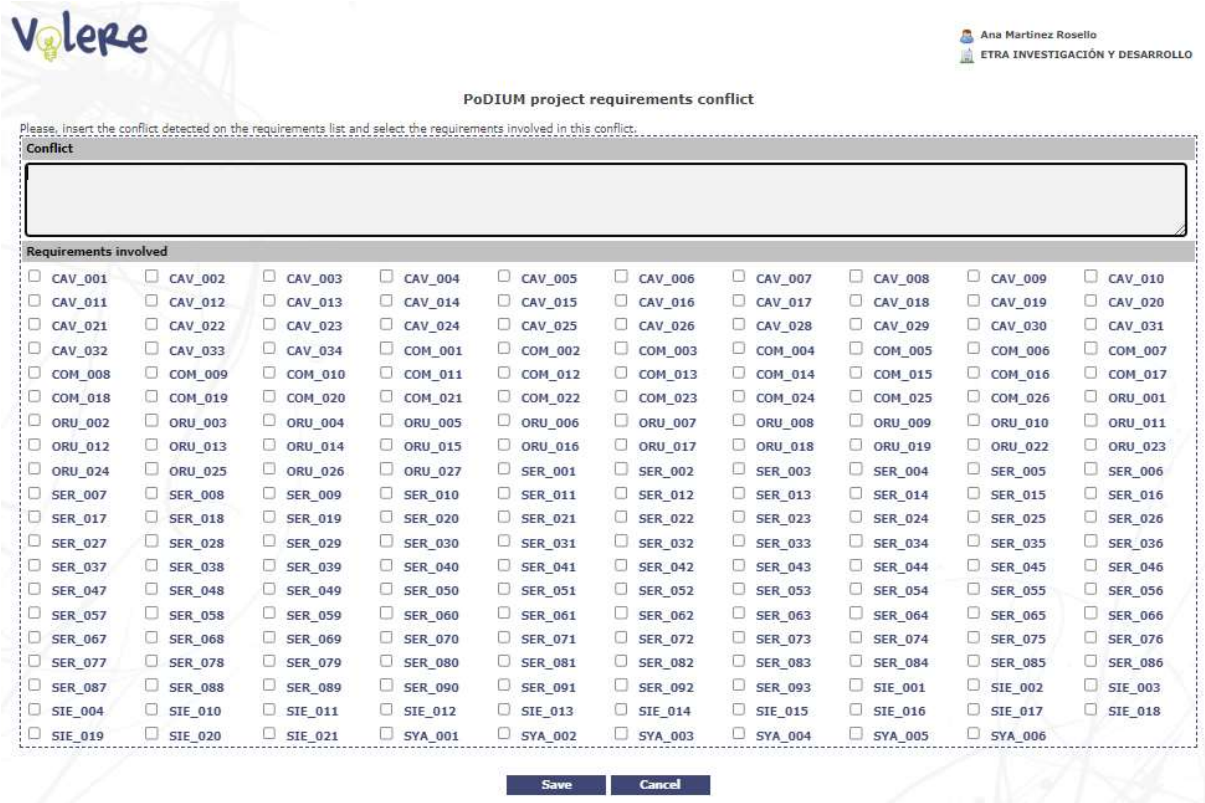
Go downwards

Id.	Dependency	Requirements revised	Validator
		There are no dependencies on the requirements list!	
Id.	Conflict	Requirements revised	Validator
		There are no conflicts on the requirements list!	
Id.	Objection	Requirements revised	Validator
		There are no objections to the requirements list!	

Go upwards

Id.	Objection	Requirements revised	Validator
OBJ_1392	The requirement description should specify the Use Case to which it is adressed. It shall follow the following structure: [UCx] + textual description	• SWM (Albert Bellini) - ORU_027 - SER_074 - SER_075 - SER_076 - SER_077 - SER_078	ETRA I+D (Ana Martinez Rosello)

- Select the requirement numbers on which we want to make the objection and write the description of the Conflict.



- A new conflict has been created and the Validator and Revisor for that requirement has been assigned. The Validator is the person who has introduced the objection and the Revisors are the people who generated the requirement.

Id.	Conflict	Requirements revised	Validator
CONF_135	CAV_019 does not apply to UC3 because CAV_034 already does	• IDIADA (Jacint Castells (IDIADA)) - CAV_019 • RETE (Manu Cañete) - CAV_034	IDIADA (Jacint Castells (IDIADA))

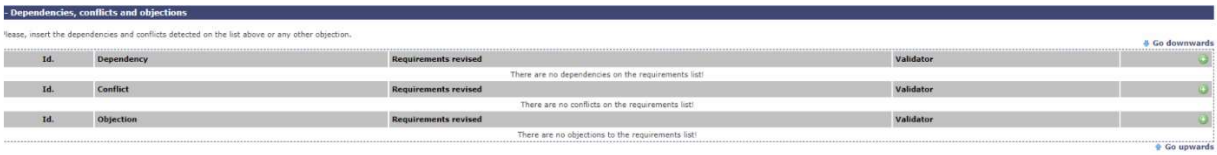
How to insert a dependency

Two or more requirements are **Dependent** if their fulfillment depends on the partial or total implementation of other requirements. To introduce a dependency on VOLERE, the procedure is as follows:

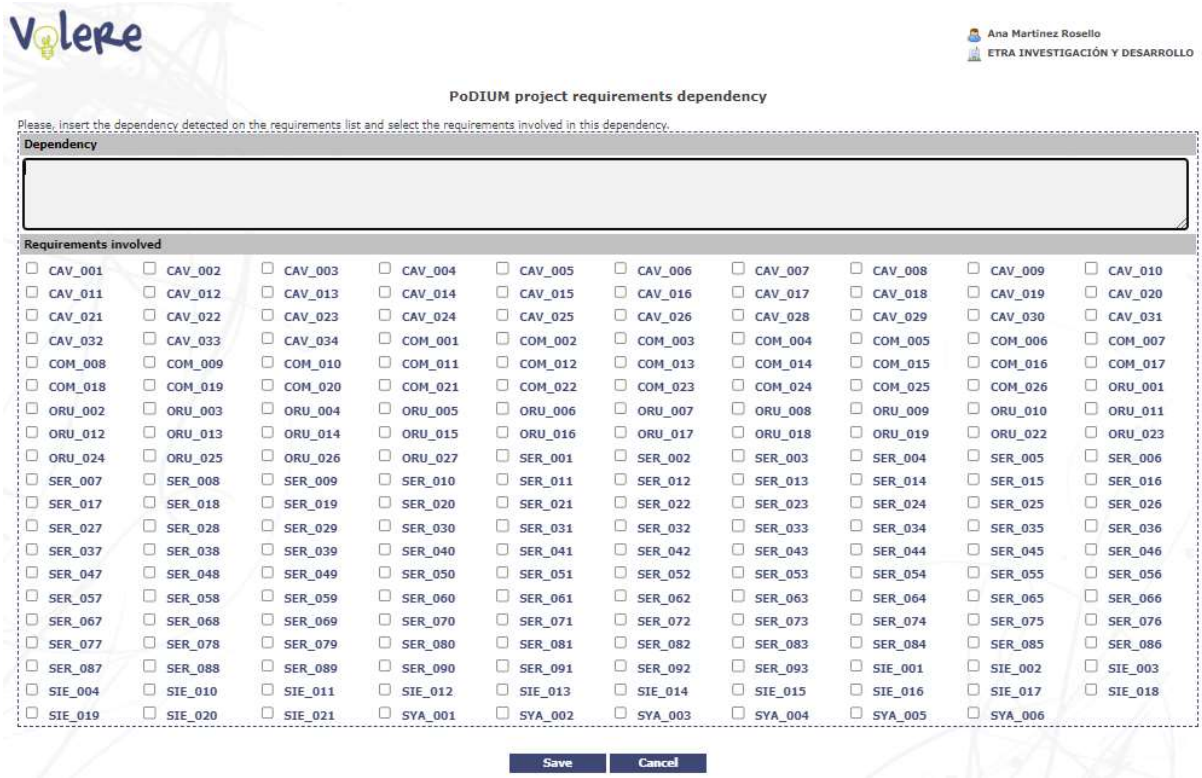
- Identify the Requirements number on which we want to make the dependency.

ORU_027	The infrastructure could manage SPATEM and MAPEM for traffic light intersections	Other Road Users: VRUs/Passengers (users, management, devices...)
SER_001	[UC1] The infrastructure shall provide an AMQP broker to collect and distribute relevant messages like ETSI CAM, CPM, MCM, VAM (potentially with proprietary extensions).	Service Layer at Server side (Traffic Management System, Digital Twins...)
SER_002	[UC1] Digital twin on edge server or RSU is able to fuse and track data from infrastructure sensors and CAM/CPM/VAM from connected users and create a joint CPM with at least 1 Hz.	Service Layer at Server side (Traffic Management System, Digital Twins...)
CAV_001	[UC1] Two connected and automated vehicles are available.	CAVs (management, devices...)
CAV_002	[UC1] The connected and automated vehicles shall be able to send/receive CPM, CAM, and MCM via redundant communication paths from/to edge server or RSU.	CAVs (management, devices...)
CAV_003	[UC1] The CAVs shall be able to react on received MCMs (possibly with proprietary extensions) accordingly, limited to use case needs (e.g., overtaking, stopping).	CAVs (management, devices...)

- Press  icon to add a new Dependency.



- Select the requirement numbers on which we want to make the objection and write the description of the Dependency.



- The new dependency has been created and the Validator and Revisor for that requirement has been assigned. The Validator is the person who has introduced the objection and the Revisors are the people who generated the requirement.

4.2.2.3. Requirement Revision.

After the validation, the revision process begins. The dependencies, conflicts, and objections highlighted by the experts during the Validation stage must be revised and solved by the requirement's author. However, if the authors do not agree with the validator's comments, they can include their viewpoint in the "Revisor's comments" section for explanations and requirement clarifications. In this stage, the authors of the requirements pointed to be revised are able to add comments to the dependency, conflict, or objection.

Step 1: Check the requirements with issues

Each partner should **identify** each one of the requirements that have been **impacted by an objection, conflict, or dependency,** by checking the Requirement revised column in the Dependencies, Conflicts, and Objections section.

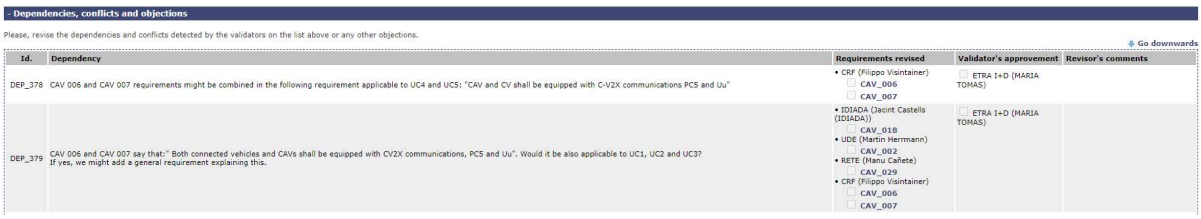


Figure 17: Dependencies, Conflicts, and Objections section

Step 2: Add comments on the issues

The requirements impacted with an objection, conflict, or dependency have the "Add comment" button enabled. The revisor(s) (the partner who introduced the requirement) are the people in charge to start writing comments (see Figure 18)

The comments could be oriented to explain the requirement:

- Is **confirmed as described** (could be a misunderstanding or maybe the requirement description was confusing).
- The revisor noticed that the requirement should be **edited.**

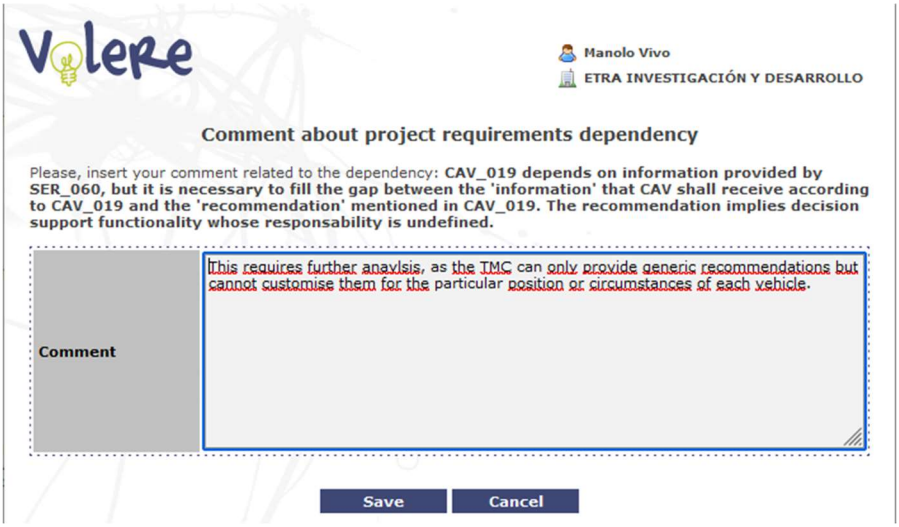


Figure 18. Example of a comment of a project objection (1).

After saving the comment introduced, the comment appears in the mentioned objection, as it is shown in Figure 19.

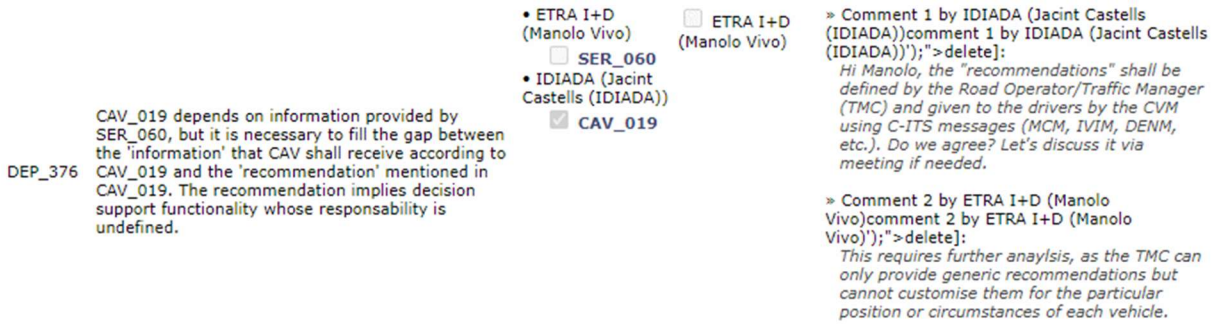


Figure 19. Example of a comment on a project requirement dependency.

In this case, the revisor has detected that the Requirement needs extra information. Therefore, after writing the comment, the requirement should be edited, as it is shown in Figure 20 and Figure 21.

Figure 20. Editing a requirement during the revision phase (1)

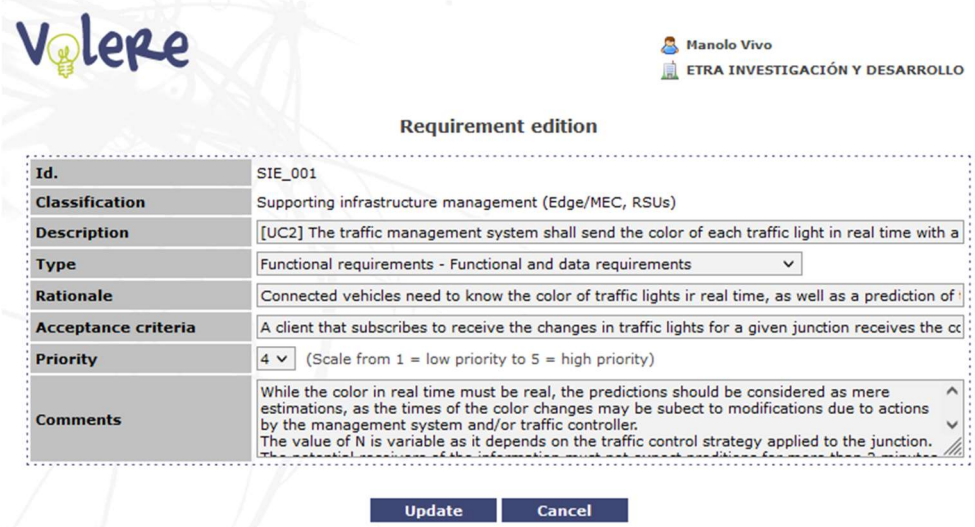


Figure 21. Editing a requirement during the revision phase (2)

Step 3: Mark the objection, conflict or dependency as revised

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The person who wrote the requirement should **mark the issue as revised** they have written the comments and edited the requirement (if necessary). (Figure 22)

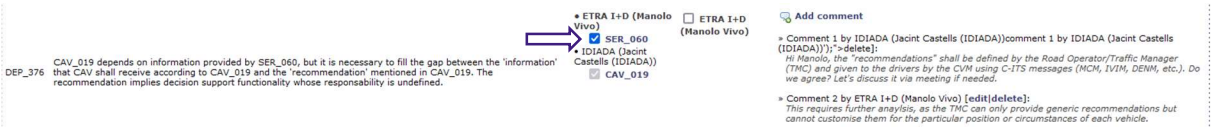

Figure 22. Mark the requirement objection as revised.

Step 4: Mark the objection, conflict or dependency as validated

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The person who detected the conflict/dependency/objection should check the changes and comments made. If agrees, should mark the requirement as **validated**. If not, he or she should **argue the reason why.** (Figure 23).

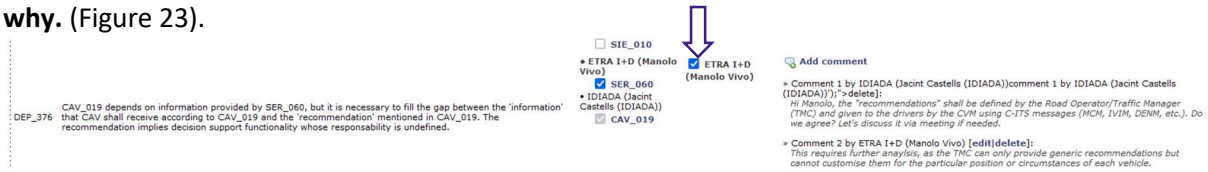


Figure 23. Mark the requirement objection as validated.

4.2.2.4. Iterations and final results.

The previously explained process is repeated several times in order to include newly defined requirements, as shown in Figure 24.

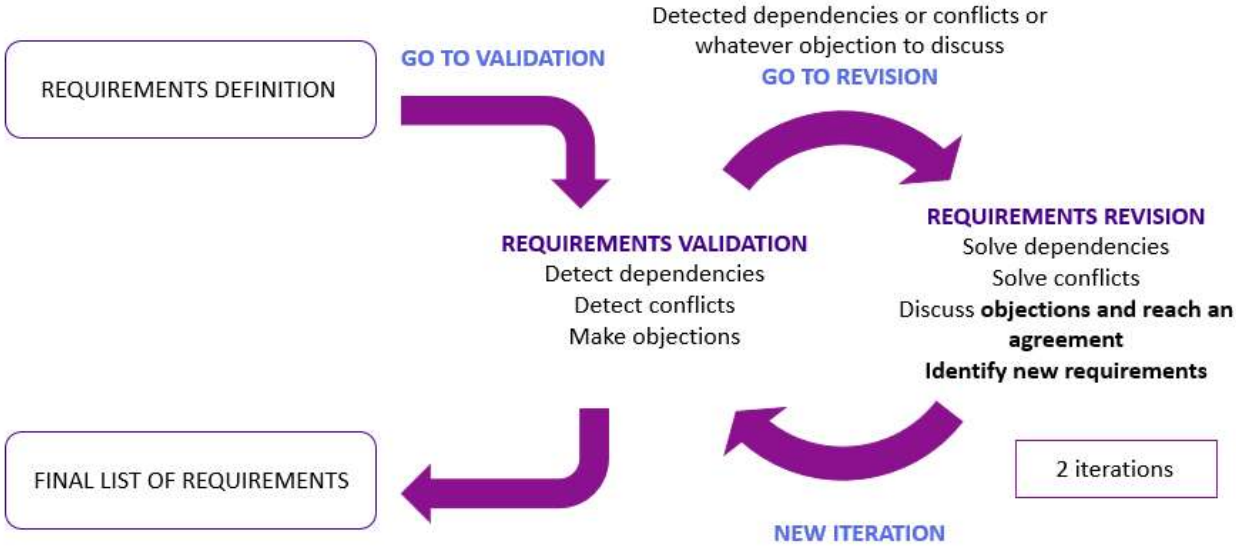


Figure 24. Volere iterative process

Once the final iteration is finished, all issues have been closed, and no more requirements are expected, the final list of requirements is available. The Volere web tool not only provides this final list but also allows to access the history of each requirement and its associated issues, so any consultant can keep track of the path that leads to the definition of each requirement.

In the case of PoDIUM, two iterations have been performed. The first one lasted one month (two weeks for the validation stage and two for the revision), while the last one took two more weeks. The objective of the second iteration was not only to detect issues for the new requirements but also to identify requirements that are cross-cutting to several Use Cases and fuse them. This process was successfully completed with a total list of 212 requirements.

During the iterative process, several dependencies, conflicts, and objections among the requirements were detected and solved by the consortium, for each one of the PoDIUM Use Cases. Those issues are presented and described in Sections 5.2.2 (Use Case 1) 5.3.2 (Use Case 2) 5.4.2 (Use Case 3), 5.5.2 (Use Case 4), and 5.6.2 (Use Case 5).

5. High-Level Requirements for PoDIUM Use Cases.

The requirements have been classified into six cross-cutting groups that are common for the five Use Cases, based on a software/hardware separation. There is one group for each of CAVs, Communications, Other Road Users, Service Layer, Supporting Infrastructure Management, and System Architecture (see Figure 12). The group that each requirement is encoded in the ID of the requirement namely as CAV, COM, ORU, SER, SIE and SYA respectively.
According to the approach presented in Section 4.1 and the Volere methodology described in Section 4.2.2, the high-level requirements for the PoDIUM solutions have been defined. This activity has been performed in a cooperative way among the members of the consortium.
The lists of requirements presented in this Section are the results of the two iterations performed following the Volere methodology. Each list corresponds to one of the PoDIUM Use Cases and, at the same time, it is classified into one of the six groups of requirements.

5.1. Cross-cutting high-level requirements.

The five PoDIUM Use Cases, while far from being independent, are all interrelated and therefore share common characteristics. For this reason, the project's consortium identified and formulated a series of high-level requirements that are transversal to the five Use Cases. These Cross-Cutting Requirements (CCR) are presented in the following table:

Table 10. PoDIUM Cross-cutting high-level requirements.

ID	Description	Type
CCR_001	At least one CAV shall be available in each Use Case	Operational requirements
CCR_002	Each CAV shall support cellular communication	Operational requirements
CCR_003	All non-automated CVs shall have a Human Machine Interface (HMI)	Operational requirements
CCR_004	All CAVs shall provide localisation with at least lane-level accuracy	Operational requirements
CCR_005	All CVs shall support localisation via GNSS	Operational requirements
CCR_006	At least one CAV shall be available in each Use Case	Operational requirements
CCR_007	The VRUs shall be able to exchange VAM messages	Functional and data requirements
CCR_008	The VRU app shall work on a smart device	Operational requirements
CCR_009	CAVs, CVs and connected VRUs devices need to support localisation	Operational requirements
CCR_010	The service layer shall provide Digital Twins (DT) functionality to describe the traffic situation on the road	Functional and data requirements

ID	Description	Type
CCR_011	The services can run either on the Edge or in the Cloud	Operational requirements
CCR_012	The services shall be able to process information ETSI C-ITS messages when communicating with CV, CAVs and/or connected VRUs	Functional and data requirements
CCR_013	The communications between the layer of services and end-users (CVs, CAVs and connected VRUs) shall be based on ETSI C-ITS messages	Functional and data requirements
CCR_014	The supporting infrastructure entities (SIE) such as ITS stations and Edge should support ETSI C-ITS messages.	Operational requirements
CCR_015	Long-range communications shall support 5G, unless only 4G is available	Operational requirements
CCR_016	Direct/Short-range communications shall support G5 or C-V2X (LTE PC5)	Operational requirements

5.2. Use Case 1: Cooperative Corridor Management in City of Ulm.

This chapter describes the high-level requirements for Use Case 1, introduced by the partners through the Volere tool.

5.2.1. List of high-level requirements

Table 11. Use Case 1 high-level requirements

ID	Description	Type
CAV_001	[UC1] Two connected and automated vehicles are available.	Functional and data requirements
CAV_002	[UC1] The connected and automated vehicles shall be able to send/receive CPM, CAM, and MCM via redundant communication paths from/to the edge server or RSU.	Functional and data requirements
CAV_003	[UC1] The CAVs shall be able to react on received MCMs (possibly with proprietary extensions) accordingly, limited to use case needs (e.g., overtaking, stopping).	Functional and data requirements
COM_010	[UC1] The scheduling system shall implement transparent, redundant forwarding of incoming packets.	Functional and data requirements
COM_011	[UC1] The communication shall be supported through a 5G cmWave (FR1) cellular network.	Operational requirements
COM_012	[UC1] The communication shall be supported through a 5G mmWave (FR2) cellular network.	Operational requirements
COM_013	[UC1] Communication shall be supported through an ad-hoc ITS-G5 network.	Operational requirements
COM_014	[UC1] Communication shall be supported through an ad-hoc mmWave (60 GHz) network.	Operational requirements

ID	Description	Type
COM_015	[UC1] The scheduling system shall gather statistics about the used physical transmission technologies.	Functional and data requirements
COM_016	[UC1] The scheduling system shall allow to limit of specific data streams to one or multiple communication channels.	Functional and data requirements
ORU_001	[UC1] VRUs shall be able to send VAM via smart devices to the edge server.	Functional and data requirements
SER_001	[UC1] The infrastructure shall provide an AMQP broker to collect and distribute relevant messages like ETSI CAM, CPM, MCM, and VAM (potentially with proprietary extensions).	Operational requirements
SER_002	[UC1] Digital twin on edge server or RSU shall be able to fuse and track data from infrastructure sensors and CAM/CPM/VAM from connected users and create a joint CPM with at least 1 Hz.	Functional and data requirements
SER_003	[UC1] A cooperative planer shall be available on the edge server/RSU and shall be able to plan cooperative maneuvers (MCM) between connected road users based on the CPM from the digital twin and the received data from the road users.	Functional and data requirements
SER_004	[UC1] A trust-building shall be available on the edge server/RSU and shall be able to assess the reliability of information sources based on redundant information from several sources.	Functional and data requirements
SIE_002	[UC1] The infrastructure sensors at the pilot site shall be available including object detectors and shall send their object detections to the edge server/RSU with a frequency of at least 5 Hz.	Functional and data requirements

5.2.2. Main Figures of the Validation and Revision Process

- **Dependencies**

«To send/receive the messages of CAV_002, SER_001 must be fulfilled. »

« To send the VAM of ORU_001, SER_001 must be fulfilled. »

5.3. Use Case 2: PDI for User-Centric, CCAM-enabled Traffic Management in Urban Corridors with High Priority Vehicles and VRUs.

This chapter describes the high-level requirements for Use Case 2, introduced by the partners through the Volere tool.

5.3.1. List of high-level requirements

Table 12. Use Case 2 high-level requirements

ID	Description	Type
CAV_018	[UC2] The IDIADA CVs shall equip a TCU with 5G SA connectivity	Functional and data requirements
CAV_019	[UC2] The IDIADA CAVs shall equip an HMI interface to show recommendations to the driver	Functional and data requirements
CAV_024	[UC2] The Emergency Vehicle (EV) shall equip an Android device to inform about real-time positioning and also provide warnings to the driver	Functional and data requirements
CAV_025	[UC2] The CV shall show its driver about the EVs approaching vehicle position	Functional and data requirements
CAV_036	[UC2] The IDIADA CAVs shall have a processing unit able to interact between the TCU, the HMI, and the internal vehicle systems	Functional and data requirements
CAV_037	[UC2 & UC3] Definition: TCU (Telematic Control Unit) / OBU (On-Board Unit)	Naming Conventions and Definitions
COM_001	[UC2] The platform shall deliver real-time events with a latency of less than 800 ms	Performance requirements
COM_007	[UC2 and UC4] Facilities Level: ITS applications aiming at conveying geographic road information and/or processing signal phase and timing should refer to MAP and SPAT services	Operational requirements
COM_019	[UC2] Facilities Level: The Connected Vehicles shall send CAM messages (according to ETSI EN 302 637-2) and may send CPM messages (according to ETSI TR 103 562)	Operational requirements
COM_020	[UC2] Facilities Level: The set of C-ITS messages received by the CAVs shall be CAM (according to ETSI EN 302 637-2), MCM* (according to ETSI TS 103 561), DENM (according to ETSI EN 302 637-3) and IVIM (according to CEN ISO/TS 19321)	Operational requirements
COM_033	[UC2 & UC3] All connected actors shall use 5G and/or C-V2X (LTE-PC5) communications technology	Functional and data requirements
ORU_005	[UC2] VRU's Manager shall be able to notify vehicles if VRUs are inside of a predefined dangerous surface.	Functional and data requirements
ORU_014	[UC2] The VRU-APP shall run work on a smartphone.	Relevant facts and assumptions
ORU_015	[UC2] The VRU-APP shall allow a VRU to subscribe to the services of a VRUM	Functional and data requirements

ID	Description	Type
ORU_016	[UC2] The VRU-APP shall request the VRU to provide some relevant personal data for the classification of the VRU	Functional and data requirements
ORU_017	[UC2] The VRU-APP shall notify VRUM about the beginning of a trip, the origin, and the expected destination	Functional and data requirements
SER_005	[UC2] The CRE shall estimate the probability of the occurrence of an incident between actors that interact on the road network.	The scope of the product
SER_006	[UC2] The CRE shall analyze the information provided by DT-MICRO within the time horizon managed by DT-MICRO.	Functional and data requirements
SER_007	[UC2] The CRE shall determine the Probability Density Function (PDF) of the position of each of the actors for each of the instants from the current instant to the time horizon.	Functional and data requirements
SER_008	[UC2] The CRE shall calculate the joint Probability Density Function for each of the pairs of actors.	Functional and data requirements
SER_009	[UC2] The CRE shall calculate the collision risk associated with an interaction from the probability of that interaction and the type of actors	Functional and data requirements
SER_010	[UC2] The CRE shall assign a loss value to each interaction depending on the type of the pair of actors involved	Functional and data requirements
SER_011	[UC2] If the risk of interaction exceeds a certain value, the CRE shall notify its clients	Functional and data requirements
SER_012	[UC2] The TMS shall share a data model with the possible origins and destinations of trips within the urban area	Functional and data requirements
SER_013	[UC2] The TMS shall process the information of the origins and destinations of the planned trips of connected vehicles to generate an M-OD of planned trips	The scope of the product
SER_014	[UC2] Each second the TMS shall receive the anonymized unique identifier, the GPS position, and the speed of each connected vehicle	Functional and data requirements
SER_015	[UC2] The TMS shall process the position and speed of each vehicle along time and update the M-OD data model each time a vehicle begins and ends a trip	Functional and data requirements
SER_016	[UC2] The TMS shall calculate the travel time of each vehicle moving through a link (road segment between two junctions) and record it in the link data model.	Functional and data requirements
SER_017	[UC2] For Each traffic control cycle the TMS shall calculate the average travel time of the vehicles driving along each link (road segment between two junctions) and update the result in the link data model.	Functional and data requirements

ID	Description	Type
SER_018	[UC2] The platform shall have an Emergency Vehicle Manager (EVM) able to receive the available corridors from the infrastructure and the updated location of the Emergency Vehicle. Also, this EVW shall report the EV location to the Aurora platform.	Functional and data requirements
SER_019	[UC2] The platform shall have a Connected Vehicle Manager (CVM) able to receive the CAM and CPM messages sent from the CVs (including the EV) and inform them about events sent from the infrastructure. The CAM and CPM messages shall be forwarded to Aurora	Functional and data requirements
SER_024	[UC2] AIC means Artificial Intelligence Cameras	Naming conventions and definitions
SER_026	[UC2] CRE means Collision Risk Estimator	Naming conventions and definitions
SER_027	[UC2] CV means Connected Vehicle, either autonomous or not	Naming conventions and definitions
SER_029	[UC2] DT means Digital Twin	Naming conventions and definitions
SER_030	[UC2] DT-GUI means Digital Twin â€“ Graphic User Interface	Naming conventions and definitions
SER_031	[UC2] VRU means Vulnerable Road User	Naming conventions and definitions
SER_032	[UC2] VRU-APP means Vulnerable Road User Application	Naming conventions and definitions
SER_033	[UC2] DT-MICRO means Digital Twin for high spatial and temporal resolution	Naming conventions and definitions
SER_034	[UC2] DT-TMS means Digital Twin for Traffic Management System	Naming conventions and definitions
SER_035	[UC2] VRUM means Vulnerable Road User Manager	Naming conventions and definitions
SER_036	[UC2] The CRE shall determine, for each pair of actors and from the PDF of each actor, the position and instant with maximum probability of finding both actors simultaneously	Functional and data requirements
SER_037	[UC2] TMS means Traffic Management System	Naming conventions and definitions

ID	Description	Type
SER_038	[UC2] M-OD means Origin-Destination Matrix	Naming conventions and definitions
SER_039	[UC2] TT-OD means Origin-Destination Travel Time	Naming conventions and definitions
SER_040	[UC2] The TMS shall calculate the TT-OD for each origin-destination pair as the average travel time for the path with minimum travel time between the origin and the destination	Functional and data requirements
SER_041	[UC2] A Link is a road segment between two junctions.	Naming conventions and definitions
SER_042	[UC2] The TMS shall calculate the aggregated delay of each entry to each junction per cycle	Functional and data requirements
SER_043	[UC2] Each time a CV enters a junction the TMS shall store a delay record in the junction model associated with the 'entry' and containing the delay of the vehicle	Functional and data requirements
SER_044	[UC2] The DT-GUI shall display the M-OD information by means of tables and suitable geographical representation methods.	Functional and data requirements
SER_045	[UC2] The DT-GUI shall display the TT-OD information by means of tables and suitable geographical representation methods.	Functional and data requirements
SER_046	[UC2] The DT-GUI shall display the delays by means of tables and suitable geographical representation methods.	Functional and data requirements
SER_047	[UC2] The TMS shall disseminate via de DT the information relative to the travel times per link.	Functional and data requirements
SER_053	[UC2] CAV means Connected Autonomous Vehicle	Naming conventions and definitions
SER_054	[UC2] CVM means connected Vehicle Manager	Naming conventions and definitions
SER_055	[UC2] EV means Emergency Vehicle	Naming conventions and definitions
SER_056	[UC2] EVM means Emergency Vehicle Manager	Naming conventions and definitions
SER_057	[UC2] The EVM shall notify the beginning of a trip of an EV through a predefined itinerary to the TMS	Functional and data requirements

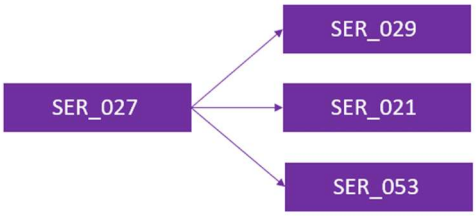
ID	Description	Type
SER_058	[UC2] The EVM shall periodically notify the TMS of the position and speed in its route through the predefined itinerary (if possible, the direction should also be included)	Functional and data requirements
SER_059	[UC2] The TMS shall estimate the arrival time of the EV to each traffic light and take the necessary actions to give traffic light priority to the EVs in their trip across predefined itineraries	Functional and data requirements
SER_060	[UC2] The CVM shall inform the CVs and CAVs about the EVs approaching their position	Functional and data requirements
SER_061	[UC2] The TMS shall disseminate through the DT information regarding the current and expected status of the traffic lights in real-time	Functional and data requirements
SER_062	[UC2] The CVM shall inform the CVs and CAVs regarding the current and expected status of the traffic lights.	Functional and data requirements
SER_063	[UC2] The DT-MICRO shall manage the information of the dynamic actors within a certain time horizon and spatial scope exchanged between CVM, VRUM end CRE.	The scope of the product
SER_064	[UC2] The AIC shall periodically provide the CRE with the following information about the VRU detected in its vision area: an anonymised unique identifier, position, VRU type, and, if possible, direction, speed, and behaviour type	Functional and data requirements
SER_065	[UC2] The VRUMs shall exchange information with the VRUs they have made a subscription to the services it shall offer.	The scope of the product
SER_066	[UC2] The AIC shall provide its information with a time granularity configurable in the interval [1,60] seconds.	Functional and data requirements
SER_067	[UC2] VRUs shall accept the privacy and personal data management policy of the VRUM services when they subscribe to them	Functional and data requirements
SER_068	[UC2] A VRUM shall periodically receive from VRU APPs information with the identification of each VRU, its position, its direction, and its speed.	Functional and data requirements
SER_069	[UC2] A VRUM shall be able to identify when a VRU is traveling on a mode of transport that does not require some of the usual VRU protection services when using that mode of transport.	Functional and data requirements
SER_070	[UC2] The VRUM shall disseminate through a DT-MICRO the information about each VRU, adding an anonymized unique identifier and the type of VRU, with no other personal information	Functional and data requirements
SER_071	[UC2] The VRUM shall provide its information with a time granularity configurable in the interval [1,60] seconds.	Functional and data requirements
SER_072	[UC2] VWD means Visual Warning Device	Naming conventions and definitions

ID	Description	Type
SER_073	[UC2] The TMS shall inform VRUs and other users of the road network of the current or imminent presence of an EV by activating a VWD	Functional and data requirements
SIE_001	[UC2] The traffic management system shall send the color of each traffic light in real-time with a prediction of the changes in the next N seconds to the platform, each time the color or the estimation change	Functional and data requirements
SIE_027	[UC2] AI cameras shall be able to detect predefined surfaces in the video by deep learning segmentation techniques.	Functional and data requirements
SIE_028	[UC2] AI cameras shall be able to detect predefined VRUs in the video by deep learning object detection techniques.	Functional and data requirements
SIE_029	[UC2] AI Cameras shall be able to detect if VRUs are inside of a predefined dangerous surface or not.	Functional and data requirements
SIE_030	[UC2] AI Camerasshall be able to communicate with VRU's manager to let the manager know of detected alerts.	Functional and data requirements
SIE_031	[UC2] AI Cameras shall be able to detect the trajectory of previously detected VRUs.	Functional and data requirements
SIE_032	[UC2] The EV shall periodically notify the EVM of the position and speed in its route through the predefined itinerary (if possible, the direction should also be included)	Functional and data requirements

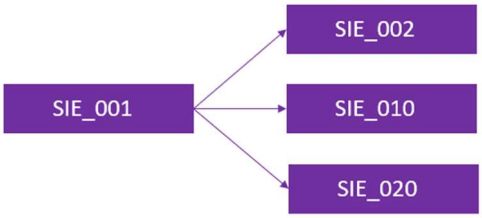
5.3.2. Main Figures of the Validation and Revision Process

- **Dependencies :**

« CAV_019 depends on the information provided by SER_060, but it is necessary to fill the gap between the 'information' that CAV shall receive according to CAV_019 and the 'recommendation' mentioned in CAV_019. The recommendation implies decision support functionality whose responsibility is undefined. »



« Some of these acronym definitions could be generalized for all Use cases. »



« UC4 and UC5 have considered the SIE 010: Edge and cloud should support CAM, IVIM, DENM, MAPEM, SPATEM, and VAM. Might it be applicable to UC1, UC2, and UC3 as well? The reason for selecting SIE 001, 002, and 020 with a dependency is just to point out the SIE requirement (SIE 010) and ask the relevant partners for UC1, UC2, and UC3 to check if we can somehow consider this requirement also applies to all of UCs. »

- **Objections:**

« Please create a requirement of type "Project constraints - Naming conventions and definitions" defining acronyms like TCU. »

5.4. Use Case 3: Real-time responsive PDI for CCAM-enabled Traffic Management in the Mediterranean Cross-Border Corridor.

This chapter describes the high-level requirements for Use Case 3, introduced by the partners through the Volere tool.

5.4.1. List of high-level requirements

Table 13. Use Case 3 high-level requirements

ID	Description	Type
CAV_020	[UC3] The IDIADA CAV shall respond to the speed/maneuver recommendations sent by the infrastructure autonomously [OPTIONAL]	Functional and data requirements
CAV_021	[UC3] The IDIADA CAVs shall have a processing unit able to interact between the TCU, the HMI, and the internal vehicle systems	Functional and data requirements
CAV_022	[UC3] The CAVs (Milla and IDIADA) shall be equipped with a TCU/OBU	Functional and data requirements
CAV_023	[UC3] The MILLA CAV shuttle shall respond to the speed/manoeuvre recommendations sent by the infrastructure automatically	Functional and data requirements
CAV_026	[UC3] The Milla shuttle CAV shall be capable of autonomously driving on the highway at SAE 4, with a speed that does not affect trucks, 80 km/h (potentially increased to 90km/h if technically feasible)	The scope of the work
CAV_028	[UC3] The Milla shuttle shall be remotely monitored and controlled by the "Shuttle Supervision Service" (human)	The scope of the work
CAV_029	[UC3] The OBUs/TCUs shall be equipped for 5G and C-V2X / LTE-PC5 connectivity simultaneously. They shall have a GNSS with lane-level accuracy.	Functional and data requirements

ID	Description	Type
CAV_030	[UC3] The infrastructure should integrate a connectivity strategy to guarantee that CAVs Fleet-Manager has a perception of the vehicle under the scope of the infrastructure (e.g. transmit geolocation of the CAV from infrastructure to Fleet Manager)	Functional and data requirements
CAV_031	[UC3] In case of an incident involving the CAV (Shuttle), the infrastructure shall inform the service owner about it.	Functional and data requirements
CAV_032	[UC3] In case of loss of direct communication between CAVs and its cloud fleet managers, the Cloud fleet managers should be able to have a secondary communication strategy, e.g. send an agnostic payload/packet through the V2X infrastructure	Functional and data requirements
CAV_033	[UC3] The OBUs/TCUs shall be able to send and receive messages with the Gateway in the formats selected. (adapted firmware)	Functional and data requirements
CAV_034	[UC3] The IDIADA CAV & each conventional (non-CAV) vehicle shall have an HMI device (e.g., tablet) to show traffic/manoeuvre recommendations to the drivers.	The scope of the work
CAV_035	[UC3] The use case shall take place with 2 CAVs (Milla, Idiada) and at least 2 additional Connected conventional vehicles.	The scope of the work
CAV_037	[UC2 & UC3] Definition: TCU (Telematic Control Unit) / OBU (On-Board Unit)	Naming conventions and definitions
COM_017	[UC3] Facilities Level: The CAV vehicles (different from the Shuttle) shall send CAM messages (according to ETSI EN 302 637-2) and may send CPM messages (according to ETSI TR 103 562)	Operational requirements
COM_018	[UC3] Facilities Level: The set of C-ITS messages received by the Shuttle and CAVs shall be CAM, CPM, MCM, DENM, IVIM, and Raw ITS messages	Operational requirements
COM_021	[UC3] Facilities Level: Shuttle shall transmit CAM messages at a frequency high enough to detect dangerous situations	The scope of the product
COM_022	[UC3] Access Technologies Level: Shuttle shall transmit Facilities messages using the cellular network and/or LTE-PC5	Operational requirements
COM_023	[UC3] The traffic management strategy messages transmitted by the infrastructure to the vehicles shall be related to a) modify max speed, b) modify distance from the car in front, and c) closed/open lane.	Functional and data requirements
COM_024	[UC3] The infrastructure shall transmit traffic information and alert messages to the vehicles (e.g. incident, obstacle / stopped vehicle, congestion ahead, etc.)	Functional and data requirements
COM_025	[UC3] 5G communications latency shall be sufficiently low to contribute to a total end-to-end latency lower than 250 ms (i.e. 8m @ 120km/h).	Functional and data requirements
COM_026	[UC3] Coverage of the 5G / C-V2X network shall have a 99% availability (i.e., less than 88 hours of annual downtime).	Functional and data requirements

ID	Description	Type
COM_033	[UC2 & UC3] All connected actors shall use 5G and/or C-V2X (LTE-PC5) communications technology	Functional and data requirements
ORU_008	[UC3] VRUs shall transmit VAM messages with their position, speed, and direction, using an Android application, at a frequency high enough to detect dangerous situations. These messages are transmitted over TCP/IPv4 and cellular networks.	The scope of the product
ORU_011	[UC3] Cellular phones of VRUs shall have an application, programmed on Android, that triggers an alarm when a vehicle (e.g., Milla shuttle) detected by the PoDIUM system is too close to the VRU and represents a threat to her/his safety	The scope of the product
ORU_012	[UC3] VRUs app shall receive CAMs, DENMs, and CPMs from the infrastructure, at a frequency high enough to detect dangerous situations (e.g., 1s). These messages are transmitted over TCP/IPv4 and cellular networks.	Operational requirements
ORU_018	[UC3] The shuttle passenger App shall be compatible with Android	Usability and humanity requirements
ORU_019	[UC3] The shuttle passenger App shall be responsive	Usability and humanity requirements
ORU_022	[UC3] The shuttle passenger App shall have a Fast check-in system to directly access the shuttle at the shuttle stop, without pre-reservation.	Functional and data requirements
ORU_023	[UC3] The shuttle passenger App shall provide travel-related information to the user	Functional and data requirements
ORU_024	[UC3] The shuttle passenger App shall offer a Reward miles program (discounts, CO2 info, etc.)	Functional and data requirements
ORU_025	[UC3] The shuttle passenger App shall feature a Dispatcher Optimizer, and offer optimal departure schedules to the user	Functional and data requirements
ORU_026	[UC3] The shuttle passenger App shall allow sending light packets from point to point	Functional and data requirements
SER_020	[UC3] The Gateways shall feed the Hub Edge with the incoming messages from the vehicles and VRUs	Operational requirements
SER_021	[UC3] Both Gateways shall have the same interfaces to communicate with the Hub Edge	Functional and data requirements
SER_048	[UC3] The Digital Twin (DT) shall have a Local Dynamic Map (LDM) that is updated using CAM, DENM, CPM, and VAM messages transmitted by vehicles and VRUs.	Operational requirements
SER_049	[UC3] The DT shall have an LDM that contains static road attributes	Operational requirements

ID	Description	Type
SER_050	[UC3] The DT at the Edge shall provide future expected trajectories of each road actor (vehicles and pedestrians) in short term (4 or 5 seconds)	Operational requirements
SER_079	[UC3] The DT shall calculate and store a local traffic status per each second (<1s), using as input the fusion of data sources (camera data, LDM data, obstacle/incident data), and transmit it to the Local TMC and Global TMC	Operational requirements
SER_080	[UC3] The MEC shall have a "Hub Edge Platform" module, over which is possible to deploy specific software components, incl. VA, TMC Edge, and DT.	The scope of the product
SER_081	[UC3] The Hub Edge Platform shall receive all data coming from local infrastructure, vehicles, and devices (via Gateways) and distribute them to the respective MEC software modules.	Functional and data requirements
SER_082	[UC3] The Hub Edge Platform shall transmit data, including traffic management information or speed/manoeuvre instructions to the vehicles in its local area (via Gateways).	Functional and data requirements
SER_083	[UC3] The MEC shall have a "Local TMC" module which will run on top of the "Hub Edge", which will process the traffic data.	Functional and data requirements
SER_084	[UC3] The Local TMC shall calculate the local traffic management strategies, for low latency (<1s).	Performance requirements
SER_085	[UC3] Video Analytics module shall receive real-time video feed, process it, and transmit the traffic perception info to the Local TMC. (also see comments)	Functional and data requirements
SER_086	[UC3] The Gateways shall allow the infrastructure (via Hub Edge) to send information to the road users (CAM, CPM, MCM, DENM, IVIM).	The scope of the product
SER_087	[UC3] The Hub Edge Platform shall send and receive data to/from the Hub Cloud Platform.	Functional and data requirements
SER_088	[UC3] The Hub Cloud Platform shall contain a data repository, a data management module, and a data gateway, and interconnects with the Global TMC and other components such as the Shuttle Supervision Service.	Functional and data requirements
SER_089	[UC3] The Global TMC shall construct the macroscopic global perception of traffic for multiple sections of the highway, and simulate and select the best global traffic management strategies, in <5s.	Performance requirements
SER_090	[UC3] The Gateways shall enable to transmit Facilities' messages over IPv4 over cellular networks	Operational requirements
SER_091	[UC3] The Gateways shall enable to transmit Facilities' messages over LTE-PC5 radio technology	Operational requirements
SER_092	[UC3] The Gateways shall translate messages between different radio technologies	Operational requirements

ID	Description	Type
SER_093	[UC3] The i2CAT Gateway shall optimize the Cooperative Awareness (CA) information transmitted to road users by aggregating CA information into CPM messages	Operational requirements
SER_097	[UC3] Video analytics shall be able to detect vehicles (moving or static), recognize their type/category, and capture their location, speed, and trajectory.	Functional and data requirements
SER_098	[UC3] Periodically (e.g., each 1s) the TMS shall calculate the average travel time of the vehicles driving along each highway section and store the result.	Functional and data requirements
SIE_017	[UC3] Each section of the highway shall feature 1 RSU (incl.5G antenna, gNode), with sufficient connectivity coverage for both directions and all the lanes.	Functional and data requirements
SIE_018	[UC3] The highway shall be equipped with at least 1 MEC from each country (i.e. side of the border). Lenovo SE350 or better performance Edge Served.	Functional and data requirements
SIE_019	[UC3] The highway shall feature at least 2 "Full HD" or "4K" cameras, connected and feeding real-time video footage to the local MEC (Edge Hub), directional, wide dynamic range to cover different light conditions, PoE powered, IP67 protection.	Functional and data requirements
SIE_020	[UC3] 5G network shall be offered at an available private frequency band. Such frequency band shall be selected according to national spectrum for private networks availability (priority for sub-6 bands) and gNode and CPE/UE equipment market maturity.	Functional and data requirements
SIE_021	[UC3] The infrastructure shall offer 4G connectivity at the service pickup-drop-off points, for the CAVs to connect to service-oriented applications	Functional and data requirements

5.4.2. Main Figures of the Validation and Revision Process

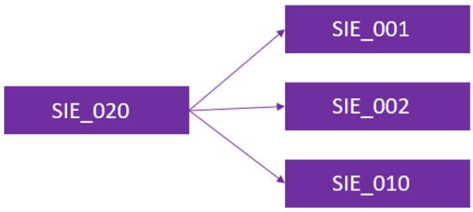
- **Conflicts :**

« CAV_019 does not apply to UC3 because CAV_034 already does. »

«There is an overlap (redundancy) and dependency between the two. CAV_22 can remove the phrase "5G SA and C-V2X connectivity", as it is implied in CAV_29. »

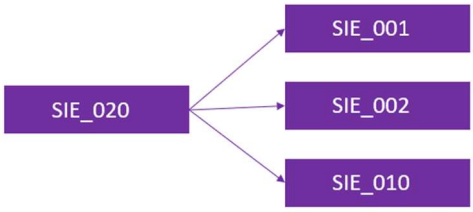
« CAV_023 to focus only on MILLA CAV and change to --> "[UC3] The MILLA CAV shuttle shall respond to the speed/manoeuvre recommendations sent by the infrastructure automatically". IDIADA CAV is covered by CAV_020. »

- **Dependencies :**



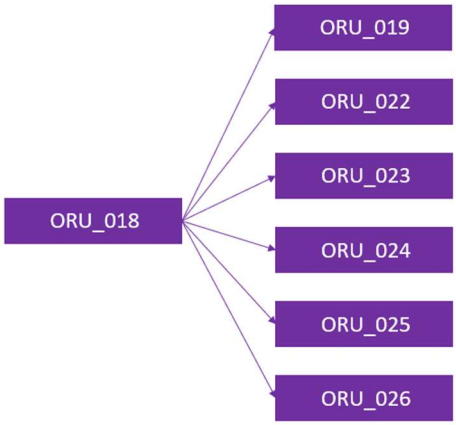
« UC4 and UC5 have considered the SIE 010: Edge and cloud should support CAM, IVIM, DENM, MAPEM, SPATEM, and VAM. Might it be applicable to UC1, UC2, and UC3 as well? The reason for selecting SIE 001, 002, and 020 with a dependency is just to point out the SIE requirement (SIE 010) and ask the relevant partners for UC1, UC2, and UC3 to check if we can somehow consider this requirement also applies to all of UCs. »

- **Objections:**



« UC4 and UC5 have considered the SIE 010: Edge and cloud should support CAM, IVIM, DENM, MAPEM, SPATEM, and VAM. Might it be applicable to UC1, UC2, and UC3 as well? The reason for selecting SIE 001, 002, and 020 with a dependency is just to point out the SIE requirement (SIE 010) and ask the relevant partners for UC1, UC2, and UC3 to check if we can somehow consider this requirement also applies to all of UCs. »

« Proposed to delete these requirements. »



« Clarification: The App --> " The MILLA shuttle passenger App »

«Minor clarification: SIE_17: Each "section" of the highway... SER_89: ... for multiple "sections" of the highway, ... »

5.5. Use Case 4: Trusted Cooperative Perception for Intersection Manoeuvre Assistance.

This chapter describes the high-level requirements for Use Case 4, introduced by the partners through the Volere tool.

5.5.1. List of high-level requirements

Table 14. Use Case 4 high-level requirements

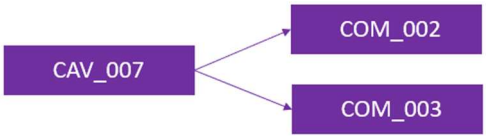
ID	Description	Type
CAV_005	[UC4] At least one Connected and Automated Vehicle (CAV) shall be available	The scope of the work
CAV_007	[UC4] CAV shall be equipped with C-V2X communication (PC5 and Uu)	The scope of the work
CAV_013	[UC4 and UC5] CAV shall implement an HMI to interact with the driver	The scope of the work
CAV_015	[UC4, UC5] GNSS positioning of CAV shall allow for lane-level accuracy	Performance requirements
CAV_016	[UC4] The vehicle on-board ITS station shall support CAM, IVIM, DENM, SPAT, MAP	Functional and data requirements
CAV_038	[UC4] The vehicle on-board ITS station shall support CAM	Functional and data requirements
CAV_039	[UC4] The vehicle on-board ITS station shall support IVIM	Functional and data requirements
CAV_040	[UC4] The vehicle onboard ITS station shall support DENM	Functional and data requirements
CAV_041	[UC4] The vehicle onboard ITS station shall support SPAT messages	Functional and data requirements
CAV_042	[UC4] The vehicle on-board ITS station shall support MAP messages	Functional and data requirements
CAV_046	[UC4] The vehicle on-board ITS station shall support CPM transmission functionality	Functional and data requirements
COM_003	[UC4 and UC5] Access Level: For short range communications ITS-G5 (ETSI EN 302 663) or C-V2X (3GPP Rel-14, Rel-15) systems shall be used	Operational requirements
COM_004	[UC4 and UC5] Transport Level: Data packets shall be transported via TCP (RFC 9293), IPv4 (RFC 791), IPv6 (RFC8200), and/or UDP (RFC768) protocols according to ITS application requirements	Operational requirements
COM_005	[UC4 and UC5] Facilities Level: ITS applications aiming at alerting users regarding a specific event detected on the road shall use Decentralized Environmental Notification Basic Service	Operational requirements
COM_006	[UC4 and UC5] Facilities Level: ITS applications aiming at creating awareness between vehicles and road users as well as supporting cooperative performance in the road network shall use Cooperative Awareness Basic Service	Operational requirements

ID	Description	Type
COM_007	[UC2 and UC4] Facilities Level: ITS applications aiming at conveying geographic road information and/or processing signal phase and timing should refer to MAP and SPAT services	Operational requirements
COM_009	[UC4 and UC5] Facilities Level: Position and time data to support ITS Applications shall be compliant with Position and Time (PoTi) services	Operational requirements
COM_027	[UC4 and UC5] Facilities Level: generation, transmission, and reception of information about mandatory and advisory road signage should be implemented through IVI service.	Operational requirements
COM_028	[UC4 and UC5] Facilities Level: generation, transmission, and reception of information about mandatory and advisory road signage should be implemented through IVI service.	Operational requirements
COM_029	[UC4] Access Level: For long-range communications 5G (3GPP Rel-15) cellular networks shall be used	Operational requirements
COM_031	[UC4] Facilities Level: ITS applications using CAM and DENM services should support the MQTT (ISO/IEC PRF 20922) publish-subscribe protocols	Operational requirements
SER_051	[UC4, UC5] The Digital Twin should collect data in real-time and make them available to applications using Open APIs	Functional and data requirements
SER_052	[UC4] Data coming from different sources can be fused to increase a "trust-index" of the information	Functional and data requirements
SER_074	[UC4] The infrastructure shall provide an AMQP broker to distribute ETSI messages (CAM + DENM + IVIM)	Functional and data requirements
SER_075	[UC4] The IMA shall be able to receive VRU-related messages via AMQP broker and MQTT	Functional and data requirements
SER_077	[UC4] The IMA shall dispatch messages by the following protocol AMQP (OASIS Advanced Message Queuing Protocol (AMQP) Version 1.0) (Basic Interface)	Functional and data requirements
SER_078	[UC4] The IMA shall be able to send TLA (traffic light assistance) data to the CAV	Functional and data requirements
SIE_010	[UC4, UC5] Edge and cloud should support CAM, IVIM, DENM, SPATEM, MAPEM, VAM	Functional and data requirements
SIE_032	[UC4] The Traffic Management System should manage SPATEM and MAPEM for traffic light intersections	Functional and data requirements
SYA_001	[UC4] On-Board Units (OBUs) and Road-Side Units (RSUs) must act as Trusted Computing Bases (TBC) and be able to check software integrity	The scope of the work

ID	Description	Type
SYA_002	[UC4] OBU and RSUs leverage software integrity verification at boot and run time and trigger the proper countermeasures in the event of violations	The scope of the work
SYA_003	[UC4] A special node (RSU or MEC or Cloud Server) shall be able to challenge OBUs and RSUs for verifying their trust status	The scope of the work
SYA_004	[UC4] OBUs and RSUs shall have their own digital identity in accordance with X.509-base PKI	The scope of the work
SYA_005	[UC4] Communications between from/to OBUs and RSUs shall be secured to preserve the data integrity and confidentiality	The scope of the work
SYA_006	[UC4] When and where possible software integrity verification shall be implemented in a privacy-preserving manner to avoid identification and linking	The scope of the work

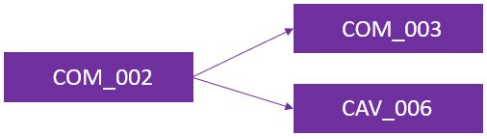
5.5.2. Main Figures of the Validation and Revision Process

- **Dependencies :**

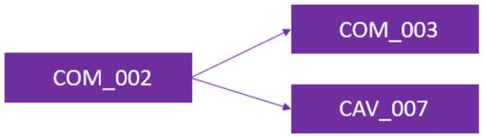


« Reference standards for CAV_007 are defined in COM_002 and COM_003. »

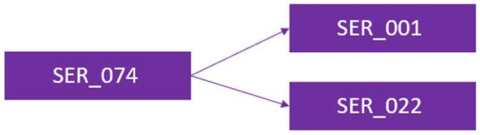
« CAV 006 and CAV 007 requirements might be combined in the following requirement applicable to UC4 and UC5: "CAV and CV shall be equipped with C-V2X communications PC5 and Uu". »



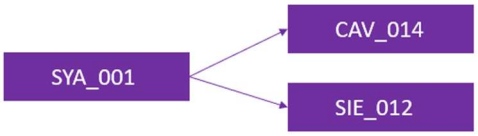
« Reference standard for CAV_006 are defined in COM_002 and COM_003»



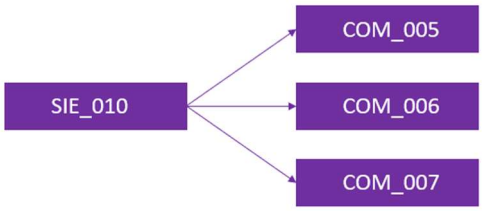
«Reference standard for CAV_007 are defined in COM_002 and COM_003»



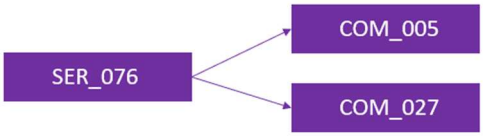
«Those requirements seem to be very similar. We can try to combine them and make it valid both for UC1 and UC4»



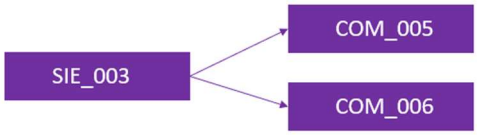
«CAV_014 depends on the fact that GNSS signals are transmitted inside the tunnel. »



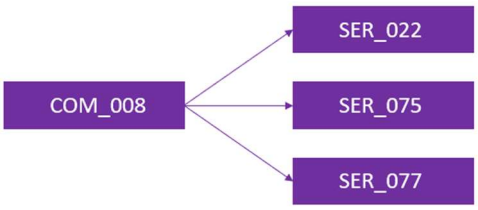
«Reference standard for SIE_010 are defined in COM_005, COM_006, COM_007 and COM_027»



« Reference standard for SER_076 are defined in COM_005 and COM_027»

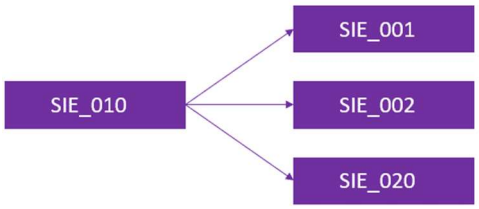


« Reference standard for SIE_003 are defined in COM_005 and COM_006»



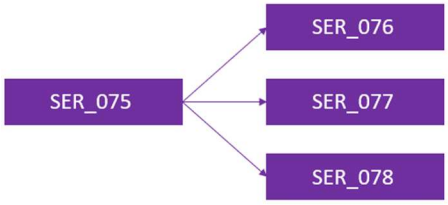
« Reference standard for SER_022, SER_075 and SER_077 are defined in COM_008»

« Reference standard for ORU_027 are defined in COM_007»



« UC4 and UC5 have considered the SIE 010: Edge and cloud should support CAM, IVIM, DENM, MAPEM, SPATEM, and VAM. Might it be applicable to UC1, UC2, and UC3 as well? The reason for selecting SIE 001, 002, and 020 with a dependency is just to point out the SIE requirement (SIE 010) and ask the relevant partners for UC1, UC2, and UC3 to check if we can somehow consider this requirement also applies to all of UCs. »

- **Objections :**



« Would it be possible to add a new requirement to include the definition of IMA?

5.6. Use Case 5: Risk Management in a Highway Tunnel.

This chapter describes the high-level requirements for Use Case 5, introduced by the partners through the Volere tool.

5.6.1. List of high-level requirements

Table 15. Use Case 5 high-level requirements

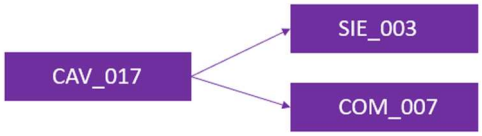
ID	Description	Type
CAV_004	[UC5] At least one Connected and Automated Vehicle (CAV) and one connected vehicle shall be available	The scope of the work
CAV_006	[UC5] Both the connected vehicle and CAV shall be equipped with C-V2X communication (PC5 and Uu)	The scope of the work
CAV_008	[UC5] CAV shall be used as the main demonstrator (alias: Host Vehicle)	Operational requirements
CAV_009	[UC5] The connected vehicle shall be used in some motorway scenarios, as the other vehicle communicating with CAV	Operational requirements
CAV_010	[UC5] CAV shall be capable of SAE level 3	Functional and data requirements
CAV_011	[UC5] CAV shall be capable of using V2X for actuation	Functional and data requirements
CAV_012	[UC5] CAV shall be capable of using V2X for advanced ODD estimation and SAE level reduction	Functional and data requirements
CAV_013	[UC4 and UC5] CAV shall implement an HMI to interact with the driver	The scope of the work
CAV_014	[UC5] The onboard system of both CAV and Connected Vehicle shall be capable of supporting GNSS in a tunnel	Functional and data requirements
CAV_015	[UC4, UC5] GNSS positioning of CAV shall allow for lane-level accuracy	Performance requirements
CAV_017	[UC5] The vehicle on-board ITS station shall support CAM, IVIM, DENM	Functional and data requirements
CAV_043	[UC5] The vehicle on-board ITS station shall support CAM	Functional and data requirements

ID	Description	Type
COM_003	[UC4 and UC5] Access Level: For short range communications ITS-G5 (ETSI EN 302 663) or C-V2X (3GPP Rel-14, Rel-15) systems shall be used	Operational requirements
COM_004	[UC4 and UC5] Transport Level: Data packets shall be transported via TCP (RFC 9293), IPv4 (RFC 791), IPv6 (RFC8200), and/or UDP (RFC768) protocols according to ITS application requirements	Operational requirements
COM_005	[UC4 and UC5] Facilities Level: ITS applications aiming at alerting users regarding a specific event detected on the road shall use Decentralized Environmental Notification Basic Service	Operational requirements
COM_006	[UC4 and UC5] Facilities Level: ITS applications aiming at creating awareness between vehicles and road users as well as supporting cooperative performance in the road network shall use Cooperative Awareness Basic Service	Operational requirements
COM_009	[UC4 and UC5] Facilities Level: Position and time data to support ITS Applications shall be compliant with Position and Time (PoTi) services	Operational requirements
COM_027	[UC4 and UC5] Facilities Level: generation, transmission, and reception of information about mandatory and advisory road signage should be implemented through IVI service.	Operational requirements
COM_028	[UC4 and UC5] Facilities Level: generation, transmission, and reception of information about mandatory and advisory road signage should be implemented through IVI service.	Operational requirements
COM_030	[UC5] Access Level: For long-range communications 4G (3GPP Rel-7 and following releases) cellular network shall be used	Operational requirements
COM_032	[UC5] Facilities Level: ITS applications using CAM and DENM services should support the AMQP (OASIS Advanced Message Queuing Protocol (AMQP) Version 1.0) publish-subscribe protocols	Operational requirements
SER_022	[UC5] The infrastructure shall provide an AMQP broker to distribute ETSI messages (CAM + DENM + IVIM)	Functional and data requirements
SER_023	[UC5] The infrastructure shall send ETSI messages (CAM + DENM + IVIM) to RSUs	Functional and data requirements
SER_051	[UC4, UC5] The Digital Twin should collect data in real-time and make them available to applications using Open APIs	Functional and data requirements
SER_094	[UC5] Tunnel Risk Level Assessment shall be published to make it available to all actors	The scope of the work
SER_095	[UC5] Tunnel Risk Level Assessment service shall access the tunnel's Digital Twin to calculate the current risk level regularly.	The scope of the work
SER_096	[UC5] RLA (Risk Level Assessment) is monitored by a Risk Manager Service (RMS) and it publishes notifications generated on any risk level change.	The scope of the work

ID	Description	Type
SIE_003	[UC5] The ITS stations shall support CAM, IVIM, DENM	Functional and data requirements
SIE_010	[UC4, UC5] Edge and cloud should support CAM, IVIM, DENM, SPATEM, MAPEM, VAM	Functional and data requirements
SIE_011	[UC5] The system for indoor GNSS signal provision shall cover the entire length of the tunnel	Functional and data requirements
SIE_012	[UC5] A system for indoor GNSS signal provision shall be installed on a tunnel	The scope of the work
SIE_013	[UC5] RSU sensors shall be able to count and classify vehicles in and out of the tunnel in real-time	Functional and data requirements
SIE_014	[UC5] RSU sensors classification must consider at least the type of vehicle passing by	Functional and data requirements
SIE_015	[UC5] Infrastructure shall host a Digital Twin to maintain tunnel information	Functional and data requirements
SIE_016	[UC5] Tunnel Risk Level Assessment service shall access the tunnel's Digital Twin to calculate the current risk level regularly.	Functional and data requirements
SIE_022	[UC5] The ITS stations shall support CAM messages v1.4.1	Functional and data requirements
SIE_023	[UC5] The ITS stations shall support DEN messages v2.1.1	Functional and data requirements
SIE_024	[UC5] The ITS stations shall support IVIM messages v2.1.1	Functional and data requirements
SIE_025	[UC5] RLA (Risk Level Assessment) shall be monitored by a Risk Manager Service (RMS) and publish notifications generated on any risk level change.	The scope of the work

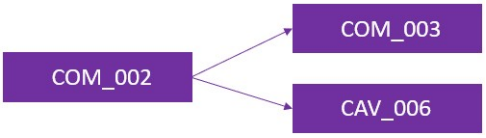
5.6.2. Main Figures of the Validation and Revision Process

- **Conflicts:**

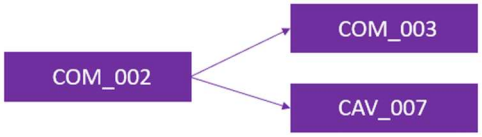


« SPAT and MAP applied to [UC5] per requirement COM_007 while neither vehicle (CAV_017) nor RSU (SIE_003) support SPAT and MAP

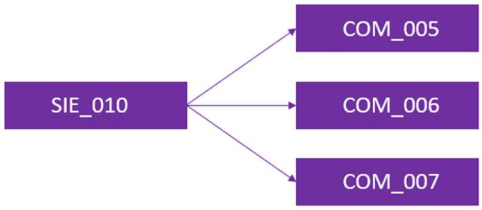
- **Dependencies:**



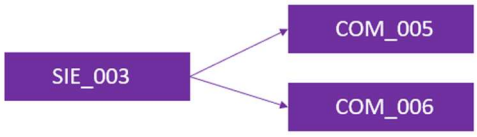
« Reference standard for CAV_006 are defined in COM_002 and COM_003»



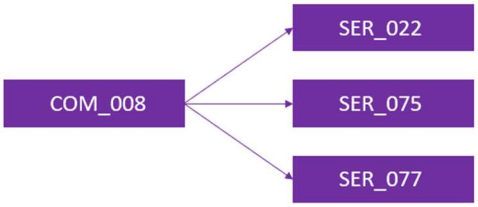
«Reference standard for CAV_007 are defined in COM_002 and COM_003»



«Reference standard for SIE_010 are defined in COM_005, COM_006, COM_007 and COM_027»

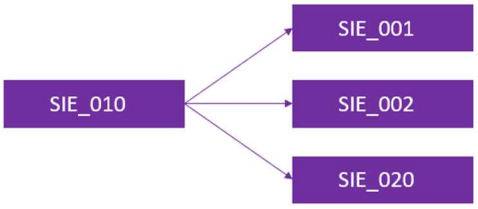


« Reference standard for SIE_003 are defined in COM_005 and COM_006»



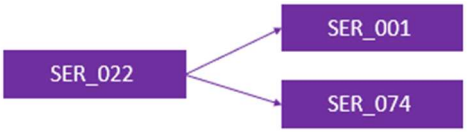
« Reference standard for SER_022, SER_075 and SER_077 are defined in COM_008»

« Reference standard for ORU_027 are defined in COM_007»

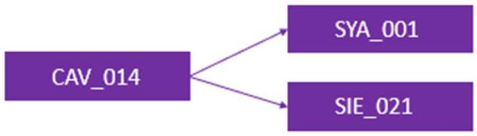


« UC4 and UC5 consider the SIE 010: Edge and cloud should support CAM, IVIM, DENM, MAPEM, SPATEM and VAM, and it might be also applicable to UC1, UC2 and UC3 »

« UC4 and UC5 have considered the SIE 010: Edge and cloud should support CAM, IVIM, DENM, MAPEM, SPATEM, and VAM. Might it be applicable to UC1, UC2, and UC3 as well? The reason for selecting SIE 001, 002, and 020 with a dependency is just to point out the SIE requirement (SIE 010) and ask the relevant partners for UC1, UC2, and UC3 to check if we can somehow consider this requirement also applies to all of UCs. »



« Those requirements seem to be very similar. We can try to combine them and make it valid both for UC1 and UC4»



« CAV_014 depends on the fact that GNSS signals are transmitted inside the tunnel. »

- **Objections:**

« 1) I would propose to refer to a system for indoor GNSS signal provision placed inside the tunnel, not simply a GNSS antenna inside the tunnel. 2) I don't understand "at least one GPSS antenna"? is it GNSS? what does at least one mean? Do you mean at least in one tunnel (e.g. dir. south/north)? »

6. Conclusions

This chapter presents the conclusions on the high-level requirements that PoDIUM Use Cases must implement. It focuses on summarising the differences and similarities in the technical frameworks found in the different Living Labs. As presented in Section 5, PoDIUM high-level requirements have been grouped into six categories: CAVs (CAV), Communications (COM), Other Road Users (ORU), Service Layer at Server Side (SER), Supporting Infrastructure Management (SIE), and System Architecture (SYA).

In the **CAVs high-level requirements (CAV)**, the topics addressed take into account vehicle needs to ensure the required level of performance and safety of the demonstrators. For example, the determination of the number of vehicles to be used in each Use Case, the ETSI C-ITS messages that the vehicles should be able to send/receive, the availability of C-V2X communications, the vehicles to be used in the different scenarios, the CAVs' SAE level, the means of communication with the driver, the warnings to be sent to the driver and the CAVs equipment (OBUs, HMI) required.

Concerning the **Communication high-level requirements (COM),** the focus has been to ensure the harmonised and efficient interaction among Connected and Automated Vehicles (CAVs), as well as between CAVs and other elements of the transportation ecosystem, such as infrastructure, VRUs and other road users. In this case, the requirements are oriented to specify the necessary protocols and technologies to be used in the communications.

Regarding **Other Road Users (ORUs),** the high-level requirements defined are focused on the equipment needs of VRUs (pedestrians, cyclists) or passengers. Aspects covered in this group of requirements include cellular phone requirements, VRU APP requirements, shuttle passenger APP requirements, and ETSI messages to be supported in each Use Case.

Regarding the high-level requirements of the **Service Layer at Server Side (SER)** one important point is to ensure that systems of each Use Case are designed, developed, and deployed to meet the users' needs while being secure, reliable, scalable, and interoperable. This group covers the ETSI messages to be collected and distributed by the infrastructure, Digital Twin requirements, Traffic Management System requirements, CAVs/VRUs manager requirements, AI Cameras requirements, IMA requirements and MEC requirements.

The **Supporting Infrastructure Management (SIE)** high-level requirements have been defined to ensure that the required supporting communication infrastructure will be available to support communications and data exchange between vehicles, infrastructure, and ORUs while optimizing the system's performance and ensuring interoperability. The topics treated in this group are ETSI Messages to be supported by the ITS Station, RSU sensors requirements and connectivity requirements on this supporting infrastructure.

Finally, the **System Architecture high-level requirements (SYA)** addresses the performance and security aspects of the different elements of the architecture, to ensure the required level of security, performance and reliability. It includes specifications of the OBUs to be deployed on the CAVs, VRUs and ORUs and RSUs specifications.

7. Annexes

Annex 1 : Record of the definition of high-level requirements with the Volere tool

MARIA TOMAS
ETRA INVESTIGACIÓN Y DESARROLLO

PoDIUM project requirements specification evolution

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	CAV_001
Description	[UC1] Two connected and automated vehicles are available.
Type	Functional and data requirements
Author	UDE
Rationale	CAVs are necessary to implement the use case.
Acceptance criteria	Vehicles are operational.
Priority	5
Comments	

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	CAV_002
Description	[UC1] The connected and automated vehicles shall be able to send/receive CPM, CAM, and MCM via redundant communication paths from/to edge server or RSU.
Type	Functional and data requirements
Author	UDE
Rationale	Communication between CAVs and RSU/edge server is necessary to implement the use case.
Acceptance criteria	Sending and receiving respective messages successfully through a redundant communication link.
Priority	5
Comments	

Dependency 364 detected by UULM (Alexander Scheible): To send/receive the messages of CAV_002, SER_001 must be available.

- **SER_001**

Id.	CAV_002
Description	[UC1] The connected and automated vehicles shall be able to send/receive CPM, CAM, and MCM via redundant communication paths from/to edge server or RSU.
Type	Functional and data requirements
Author	UDE
Rationale	Communication between CAVs and RSU/edge server is necessary to implement the use case.
Acceptance criteria	Sending and receiving respective messages successfully through a redundant communication link.
Priority	5
Comments	

Dependency 379 detected by ETRA I+D (MARIA TOMAS): CAV 006 and CAV 007 say that:" Both connected vehicles and CAVs shall be equipped with CV2X communications, PC5 and Uu". Would it be also applicable to UC1, UC2 and UC3? If yes, we might add a general requirement explaining this.

» Comment 1 by IDIADA (Jacint Castells (IDIADA)):
I could agree on creating a a general requirement, but making sure that special needs from a UC (e.g. CAV_002 which indicate GNSS lane-accuracy) are not included in this requirement but in a separate one

» Comment 2 by CRF (Filippo Visintainer):
CAV_006 merges the former CAV_007 and can be extended to all UC using C-V2X. Currently I noted UC4, UC5. Please comment to this post "Yes/No for UCx" if you want to extend

it to other UC. (Note: we are talking about PC5 and Uu, not ITS G5)

» Comment 3 by UDE (Martin Herrmann):
We do not use PC5 and Uu.

- **CAV_006**
- **CAV_007**
- **CAV_018**
- **CAV_029**

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**CAV_003**
Description	[UC1] The CAVs shall be able to react on received MCMs (possibly with proprietary extensions) accordingly, limited to use case needs (e.g., overtaking, stopping).
Type	Functional and data requirements
Author	UDE
Rationale	Required to implement use case.
Acceptance criteria	Vehicles fulfill MCM maneuver.
Priority	5
Comments	

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**CAV_004**
Description	[UC5] At least one Connected and Automated Vehicle (CAV) and one connected vehicle shall be available
Type	The scope of the work
Author	CRF
Rationale	The CAV is used to demonstrate UC5 in all the planned manoeuvres, while the connected vehicle is used for support in the V2V car following scenario.
Acceptance criteria	CAV is at least demonstrated up to decision making of SAE L3 (open road actuation possible up to L2)
Priority	5
Comments	CRF will provide the vehicles.

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**CAV_005**
Description	[UC4] At least one Connected and Automated Vehicle (CAV) shall be available
Type	The scope of the work
Author	CRF

Rationale	The CAV is used to demonstrate UC4 in the planned manoeuvres.
Acceptance criteria	CAV shall operate up to decision making. Actuation is not planned in urban scenario on open road.
Priority	5
Comments	CRF will provide the CAV prototype.

Id.

Id.	**CAV_006**
Description	[UC5] Both connected vehicle and CAV shall be equipped with C-V2X communication (PC5 and Uu)
Type	The scope of the work
Author	CRF
Rationale	Communicate with roadside unit and MEC
Acceptance criteria	The on-board system is interoperable with road infrastructure using Pc5 and Uu
Priority	5
Comments	PC5 and Uu are needed for the CAV PC5 is enough for connected (and non-automated) vehicle, Uu not strictly needed

1st it.

Dependency 366 detected by TIM (Ezio Chiocchetti): Reference standard for CAV_006 are defined in COM_002 and COM_003

» Comment 1 by TIM (Ezio Chiocchetti):
COM_002 Deleted. Dependency still valid for COM_003, kept as is

» Comment 2 by CRF (Filippo Visintainer):
CAV 6 refers to C-V2X; COM003 includes ITS-G5 which is not the case of CAV6. Both requirements should be kept.

- **COM_002**
- **COM_003**

1st rev.

2nd it.

Dependency 378 detected by ETRA I+D (MARIA TOMAS): CAV 006 and CAV 007 requirements might be combined in the following requirement applicable to UC4 and UC5: "CAV and CV shall be equipped with C-V2X communications PC5 and Uu"

- **CAV_007**

Dependency 379 detected by ETRA I+D (MARIA TOMAS): CAV 006 and CAV 007 say that:" Both connected vehicles and CAVs shall be equipped with CV2X communications, PC5 and Uu". Would it be also applicable to UC1, UC2 and UC3? If yes, we might add a general requirement explaining this.

» Comment 1 by IDIADA (Jacint Castells (IDIADA)):
I could agree on creating a a general requirement, but making sure that special needs from a UC (e.g. CAV_002 which indicate GNSS lane-accuracy) are not included in this requirement but in a separate one

» Comment 2 by CRF (Filippo Visintainer):
CAV_006 merges the former CAV_007 and can be extended to all UC using C-V2X. Currently I noted UC4, UC5. Please comment to this post "Yes/No for

2nd rev.

Id.	**CAV_006**
Description	**[UC4,UC5] Cooperative Vehicles (automated and not) shall be equipped with C-V2X communication (PC5 and Uu)**
Type	The scope of the work
Author	CRF
Rationale	Communicate with roadside unit and MEC
Acceptance criteria	The on-board system is interoperable with road infrastructure using Pc5 and Uu
Priority	5
Comments	PC5 and Uu are needed for the CAV PC5 is enough for connected (and non-automated) vehicle, Uu not strictly needed

UCx" if you want to extend it to other UC. (Note: we are talking about PC5 and Uu, not ITS G5)

» Comment 3 by UDE (Martin Herrmann):
We do not use PC5 and Uu.

- **CAV_002**
- **CAV_007**
- **CAV_018**
- **CAV_029**

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**CAV_007**
Description	[UC4] CAV shall be equipped with C-V2X communication (PC5 and Uu)
Type	The scope of the work
Author	CRF
Rationale	Needs to interoperate with the local infrastructure
Acceptance criteria	The on-board system is capable of interacting with road infrastructure
Priority	5
Comments	

Dependency 367 detected by TIM (Ezio Chiocchetti): Reference standard for CAV_007 are defined in COM_002 and COM_003

» Comment 1 by TIM (Ezio Chiocchetti):
COM_002 Deleted. Dependency still valid for COM_003, kept as is

» Comment 2 by CRF (Filippo Visintainer):
CAV_007 has been deleted (merged with CAV_006)

- **COM_002**
- **COM_003**

Dependency 378 detected by ETRA I+D (MARIA TOMAS): CAV 006 and CAV 007 requirements might be combined in the following requirement applicable to UC4 and UC5: "CAV and CV shall be equipped with C-V2X communications PC5 and Uu"

- **CAV_006**

Dependency 379 detected by ETRA I+D (MARIA TOMAS): CAV 006 and CAV 007 say that:" Both connected vehicles and CAVs shall be equipped with CV2X communications, PC5 and Uu". Would it be also applicable to UC1, UC2 and UC3? If yes, we might add a general requirement explaining this.

» Comment 1 by IDIADA (Jacint Castells (IDIADA)):
I could agree on creating a a general requirement, but making sure that special needs from a UC (e.g. CAV_002 which indicate GNSS lane-accuracy) are not included in this requirement but in a separate one

» Comment 2 by CRF (Filippo Visintainer):
CAV_006 merges the former CAV_007 and can be extended to all UC using C-V2X. Currently I noted UC4, UC5. Please comment to this post

"Yes/No for UCx" if you want to extend it to other UC. (Note: we are talking about PC5 and Uu, not ITS G5)

» Comment 3 by UDE (Martin Herrmann):
We do not use PC5 and Uu.

- **CAV_002**
- **CAV_006**
- **CAV_018**
- **CAV_029**

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**CAV_008**
Description	[UC5] CAV shall be used as the main demonstrator (alias: Host Vehicle)
Type	Operational requirements
Author	CRF
Rationale	The CAV is used to demonstrate UC5 in all the planned manoeuvres. The LL evaluation should be based on this vehicle.
Acceptance criteria	CAV is available throughout the pilot
Priority	3
Comments	Some features can be demonstrated also with the connected vehicle.

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**CAV_009**
Description	[UC5] The connected vehicle shall be used in some motorway scenarios, as the other vehicle communicating with CAV
Type	Operational requirements
Author	CRF
Rationale	Clarify the role of the vehicle playing the other vehicle (alias remote vehicle) in V2V scenarios
Acceptance criteria	Vehicle prototype available when needed in the trials involving V2V car following scenarios (C-ACC)
Priority	4
Comments	PC5 equipment is enough for the remote vehicle, Uu not strictly needed

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**CAV_010**
Description	[UC5] CAV shall be capable of SAE level 3
Type	Functional and

	data requirements
Author	CRF
Rationale	Demonstrate ODD exits
Acceptance criteria	Available level of automation are shown on the HMI
Priority	4
Comments	

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**CAV_011**
Description	[UC5] CAV shall be capable of using V2X for actuation
Type	Functional and data requirements
Author	CRF
Rationale	Change speed profile or disengage based on V2X events
Acceptance criteria	Speed profile based on V2X data
Priority	5
Comments	Lane change of CAV is demonstrated in LL with recommendation on HMI

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**CAV_012**
Description	[UC5] CAV shall be capable of using V2X for advance ODD estimation and SAE level reduction
Type	Functional and data requirements
Author	CRF
Rationale	Demonstrate the effect of road events on ODD and how C-V2X can support providing advance information on ODD
Acceptance criteria	HMI early warning on ODD exit
Priority	4
Comments	

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**CAV_013**
Description	[UC4 and UC5] CAV shall implement an HMI to interact with the driver
Type	The scope of the work
Author	CRF
Rationale	Demonstrate the in-vehicle system in the LL
Acceptance criteria	Touch screen display available
Priority	5
Comments	Display with minimal interaction via touch screen

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**CAV_014**
Description	[UC5] The on board system of both CAV and Connected Vehicle shall be capable of supporting GNSS in tunnel
Type	Functional and data requirements
Author	CRF
Rationale	Demonstrate availability of C-V2X and lane-level positioning in GNSS-denied environment
Acceptance criteria	C-V2X available throughout the tunnel, from V2I and V2V measurements
Priority	5
Comments	This requirement depends on the positioning solution supported by the local infrastructure. The two GNSS alternatives available in the LL will be tested.

Dependency 377 detected by LINKS (Guido Gavilanes): CAV_014 depends in the fact that GNSS signals are transmitted inside the tunnel.

» Comment 1 by LINKS (Guido Gavilanes):
this dependency was SIE_012 and not SIE_021; it was a mistake.

» Comment 2 by RETE (Manu Cañete):
SIE_021 keeps unchanged.

- **SYA_001**
- **SIE_021**

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**CAV_015**
Description	[UC4, UC5] GNSS positioning of CAV shall allow for lane-level accuracy
Type	Performance requirements
Author	CRF
Rationale	Geo-referencing of V2X information must be at lane-level, for vehicle control.
Acceptance criteria	<1.5 m
Priority	5
Comments	

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**CAV_016**
Description	[UC4] The vehicle on-board ITS station shall support CAM, IVIM, DENM, SPAT, MAP
Type	Functional and data requirements
Author	CRF
Rationale	Be aware of: other ITS stations (CAM), pass/stop messages (IVIM), VRU warnings (DENM), Traffic Light phases (SPAT), road topology (MAP)
Acceptance criteria	Messages correctly decoded
Priority	5
Comments	

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**CAV_017**
Description	[UC5] The vehicle on-board ITS station shall support CAM, IVIM, DENM
Type	Functional and data requirements
Author	CRF
Rationale	Be aware of: other ITS stations (CAM), lane/speed information (IVIM), road events (DENM)
Acceptance criteria	Messages correctly decoded
Priority	5
Comments	

Conflict 138 detected by CRF (Filippo Visintainer): SPAT and MAP applied to [UC5] per requirement COM_007 while neither vehicle (CAV_017) nor RSU (SIE_003) support SPAT and MAP

» Comment 1 by TIM (Ezio Chiocchetti):
Done

» Comment 2 by CRF (Filippo Visintainer):
Conflict resolved

- **COM_007**
- **SIE_003**

Id. **1st it.** **1st rev.** **2nd it.** **2nd rev.**

Id.	**CAV_018**
Description	[UC2] The IDIADA CVs shall equip a TCU with 5G SA connectivity
Type	Functional and data requirements
Author	IDIADA
Rationale	The CAV shall be able to communicate with the infrastructure
Acceptance criteria	The CAV is able to establish connections to the infrsatructure via 5G SA
Priority	5
Comments	

Objection 1407 made by ETRA I+D (Manolo Vivo): Please create requirement of type "Project constraints - Naming conventions and definitions" defining acronyms like TCU

» Comment 1 by IDIADA (Jacint Castells (IDIADA)):
Created requirement CAV_037

- **CAV_021**

Dependency 379 detected by ETRA I+D (MARIA TOMAS): CAV 006 and CAV 007 say that:" Both connected vehicles and CAVs shall be equipped with CV2X communications, PC5 and Uu". Would it be also applicable to UC1, UC2 and UC3? If yes, we might add a general requirement explaining this.

» Comment 1 by IDIADA (Jacint Castells (IDIADA)):
I could agree on creating a a general requirement, but making sure that special needs from a UC (e.g. CAV_002 which indicate GNSS lane-accuracy) are not included in this requirement but in a separate one

» Comment 2 by CRF (Filippo Visintainer):
CAV_006 merges the former CAV_007 and can be extended to all UC using C-V2X. Currently I noted UC4, UC5. Please comment to this post "Yes/No for UCx" if you want to extend it to other UC. (Note: we are talking about PC5 and Uu, not ITS G5)

» Comment 3 by UDE (Martin Herrmann):

We do not use PC5 and Uu.

- **CAV_002**
- **CAV_006**
- **CAV_007**
- **CAV_029**

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**CAV_019**
Description	[UC2 & UC3] The IDIADA CVs shall equip an HMI interface to show recommendations to the driver
Type	Functional and data requirements
Author	IDIADA
Rationale	The CAVs' drivers must have a way to receive visual information sent by the infrastructure
Acceptance criteria	All recommendations sent by the infrasturcture are shown in an HMI device (e.g. tablet)
Priority	4
Comments	

Dependency 376 detected by ETRA I+D (Manolo Vivo): CAV_019 depends on information provided by SER_060, but it is necessary to fill the gap between the 'information' that CAV shall receive according to CAV_019 and the 'recommendation' mentioned in CAV_019. The recommendation implies decision support functionality whose responsability is undefined.

» Comment 1 by IDIADA (Jacint Castells (IDIADA)):
Hi Manolo, the "recommendations" shall be defined by the Road Operator/Traffic Manager (TMC) and given to the drivers by the CVM using C-ITS messages (MCM, IVIM, DENM, etc.). Do we agree? Let's discuss it via meeting if needed.

» Comment 2 by ETRA I+D (Manolo Vivo):
This requires further anaylsis, as the TMC can only provide generic recommendations but cannot customise them for the particular position or circumstances of each vehicle.

- **SER_060**

Conflict 135 detected by IDIADA (Jacint Castells (IDIADA)): CAV_019 does not apply to UC3 because CAV_034 already does

» Comment 1 by RETE (Manu Cañete):
CAV_019 for UC2. CAV_034 for UC3.

- **CAV_034**

Id.	✓ **CAV_019**
Description	**[UC2] The IDIADA CAVs shall equip an HMI interface to show recommendations to the driver**
Type	Functional and data requirements
Author	IDIADA
Rationale	The CAVs' drivers must have a way to receive visual information sent by the infrastructure
Acceptance criteria	All recommendations sent by the infrasturcture are shown in an HMI device (e.g. tablet)
Priority	4
Comments	

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**CAV_020**
Description	[UC2 & UC3] The IDIADA CAV shall respond to the recommendations sent by the infrastructure automatically [OPTIONAL]
Type	Functional and data requirements
Author	IDIADA
Rationale	The vehicle shall have autonomous

Conflict 136 detected by AAE (Harilaos Vasiliadis): CAV_023 to focus only on MILLA CAV, and change to --> "[UC3] The MILLA CAV shuttle shall repond to the speed/manoeuvre recommendations sent by the infrastructure automatically". IDIADA CAV is covered by CAV_020.

Id.	✓ **CAV_020**
Description	**[UC3] The IDIADA CAV shall repond to the speed/manoeuvre recommendations sent by the infrastructure autonomously [OPTIONAL]**
Type	Functional and data requirements
Author	IDIADA

	functions to apply the recommendations received
Acceptance criteria	The CAV, if feasible, comply with the recommendations sent by the infrastructure
Priority	5
Comments	

• **CAV_023**

Objection 1395 made by AAE (Harilaos Vasiliadis): Proposed not to combine Use Cases in the same Requirements. Split in two distinct requirement entries.

» Comment 1 by IDIADA (Jacint Castells (IDIADA)): *Created CAV_036 for UC2*

•**CAV_021**

Rationale	**The vehicle shall have autonomous functions to apply the recommendations received [OPTIONAL]**
Acceptance criteria	**The CAV shall comply with the recommendations sent by the infrastructure [OPTIONAL]**
Priority	5
Comments	

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**CAV_021**
Description	[UC2 & UC3] The IDIADA CAVs shall have a processing unit able to interact between the TCU, the HMI and the internal vehicle systems
Type	Functional and data requirements
Author	IDIADA
Rationale	A processing unit must give dissemination orders to the TCU and receive messages from this system, in order to forward them to the HMI and to the vehicle
Acceptance criteria	The processing unit orders are applicable by the TCU and the TCU messages are properly received and send to the HMI and the vehicle internal system
Priority	5
Comments	

Objection 1395 made by AAE (Harilaos Vasiliadis): Proposed not to combine Use Cases in the same Requirements. Split in two distinct requirement entries.

» Comment 1 by IDIADA (Jacint Castells (IDIADA)): *Created CAV_036 for UC2*

•**CAV_020**

Objection 1407 made by ETRA I+D (Manolo Vivo): Please create requirement of type "Project constraints - Naming conventions and definitions" defining acronyms like TCU

» Comment 1 by IDIADA (Jacint Castells (IDIADA)): *Created requirement CAV_037*

•**CAV_018**

Id.	**CAV_021**
Description	**[UC3] The IDIADA CAVs shall have a processing unit able to interact between the TCU, the HMI and the internal vehicle systems**
Type	Functional and data requirements
Author	IDIADA
Rationale	A processing unit must give dissemination orders to the TCU and receive messages from this system, in order to forward them to the HMI and to the vehicle
Acceptance criteria	The processing unit orders are applicable by the TCU and the TCU messages are properly received and send to the HMI and the vehicle internal system
Priority	5
Comments	

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**CAV_022**
Description	[UC3] The CAVs (Milla and IDIADA) shall be equipped with a TCU with 5G SA and C-V2X connectivity
Type	Functional and data requirements
Author	IDIADA
Rationale	The CAVs shall be able to communicate with the infrastructure
Acceptance criteria	The CAVs are able to establish connections to the infrastructure via 5G and C-V2X
Priority	5
Comments	

Conflict 137 detected by AAE (Harilaos Vasiliadis): There is an overlap (redundancy) and dependency between the two. CAV_22 can remove the phrase "5G SA and C-V2X connectivity", as it is implied in CAV_29

» Comment 1 by RETE (Manu Cañete): *Clarification for simultaneous use. Added GNSS requirement.*

• **CAV_029**

Id.	**CAV_022**
Description	**[UC3] The CAVs (Milla and IDIADA) shall be equipped with a TCU/OBU**
Type	Functional and data requirements
Author	IDIADA
Rationale	The CAVs shall be able to communicate with the infrastructure
Acceptance criteria	**The CAVs are able to establish connections to the infrastructure**
Priority	5
Comments	

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**CAV_023**
Description	[UC3] The CAVs shall repond to the recommendations

Conflict 136 detected by AAE (Harilaos Vasiliadis): CAV_023 to focus only on MILLA CAV, and

Id.	**CAV_023**
Description	**[UC3] The MILLA CAV shuttle shall repond to the**

	sent by the infrastructure automatically (MILLA, IDIADA) - [OPTIONAL - if technically feasible, for IDIADA CAV]
Type	Functional and data requirements
Author	IDIADA
Rationale	The manoeuvre recommendations received by the vehicles can be integrated in the autonomous driving behaviour/objective.
Acceptance criteria	The CAVs, if feasible, shall comply with the recommendations sent by the infrastructure
Priority	3
Comments	

change to --> "[UC3] The MILLA CAV shuttle shall repond to the speed/manoeuvre recommendations sent by the infrastructure automatically". IDIADA CAV is covered by CAV_020.

- **CAV_020**

	speed/manoeuvre recommendations sent by the infrastructure automatically
Type	Functional and data requirements
Author	IDIADA
Rationale	**The manoeuvre recommendations received by the vehicles can be integrated in the autonomous driving behavior/objective.**
Acceptance criteria	**The CAVs shall shall comply with the recommendations sent by the infrastructure**
Priority	3
Comments	

Id. **1st it.** **1st rev.** **2nd it.** **2nd rev.**

Id.	**CAV_024**
Description	[UC2] The Emergency Vehicle (EV) shall equip an Android device to allow the driver to choose the router and also receive indications and warnings
Type	Functional and data requirements
Author	IDIADA
Rationale	The EV driver must select the chosen route and be informed about warnings from the infrastructure
Acceptance criteria	The Android app sends and received the information successfully
Priority	4
Comments	

Id.	**CAV_024**
Description	**[UC2] The Emergency Vehicle (EV) shall equip an Android device to inform about real-time positioning and also provide warnings to the driver**
Type	Functional and data requirements
Author	IDIADA
Rationale	**The EV driver must receive warnings from the Traffic Manager and the location of the EV shall be sent to the Traffic Manager**
Acceptance criteria	The Android app sends and received the information successfully
Priority	4
Comments	

Id. **1st it.** **1st rev.** **2nd it.** **2nd rev.**

Id.	**CAV_025**
Description	[UC2] The CV shall show its driver about the EVs approaching to vehicle position
Type	Functional and data requirements
Author	ETRA I+D
Rationale	Drivers should colaborate with the EV by yielding right of way, keeping a lane empty and reducing their speed
Acceptance criteria	
Priority	5
Comments	By means of information provided by the CVM (requirement SER_050), originally coming from the TMS

	through the DT. EVs with which they are foreseen to meet in the same road segment or junction.

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**CAV_026**
Description	[UC3] The Milla shuttle CAV will be capable of autonomously driving on the highway at SAE 4, with a speed that does not affect trucks, 80 km/h (potentially increased to 90km/h if technically feasible)
Type	The scope of the work
Author	MILLA
Rationale	The Milla Shuttle can drive autonomously all along the context of the service
Acceptance criteria	The Milla Vehicle receives a command from the cloud to reach a destination. The Safety Driver will give the motion control of the vehicle to the Milla SAE4 Motion Controller.
Priority	5
Comments	

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**CAV_028**
Description	[UC3] The Milla shuttle shall be remotely monitored and controlled by the "Shuttle Supervision Service" (human)
Type	The scope of the work
Author	MILLA
Rationale	At any time, a human supervisor will be capable to inspect the state of the vehicle including the state of its sensors and navigation system, specially when it's in autonomous-driving-mode using isfm supervision platform
Acceptance criteria	Real time monitoring of the Milla Vehicle, including information of the sensors, motion properties, navigation state and a contextual video-stream.
Priority	5
Comments	

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**CAV_029**	Conflict 137 detected by AAE (Harilaos	Id.	**CAV_029**	Dependency 379 detected by

Description	[UC3] The OBUs/TCUs shall be equipped for 5G and C-V2X / LTE-PC5 connectivity. (hardware)
Type	Functional and data requirements
Author	RETE
Rationale	Following technology evolution trends towards 5G standards defined by 3GPPP.
Acceptance criteria	3GPP compliance
Priority	5
Comments	

Vasiliadis): There is an overlap (redundancy) and dependency between the two. CAV_22 can remove the phrase "5G SA and C-V2X connectivity", as it is implied in CAV_29

» Comment 1 by RETE (Manu Cañete):
Clarification for simultaneous use. Added GNSS requirement.

• **CAV_022**

Description	**[UC3] The OBUs/TCUs shall be equipped for 5G and C-V2X / LTE-PC5 connectivity simultaneously. They shall have a GNSS with lane-level accuracy.**
Type	Functional and data requirements
Author	RETE
Rationale	**Following technology evolution trends towards 5G standards defined by 3GPPP. PC5 & Uu interfaces should work simultaneously.**
Acceptance criteria	3GPP compliance
Priority	5
Comments	

ETRA I+D (MARIA TOMAS): CAV 006 and CAV 007 say that:" Both connected vehicles and CAVs shall be equipped with CV2X communications, PC5 and Uu". Would it be also applicable to UC1, UC2 and UC3? If yes, we might add a general requirement explaining this.

» Comment 1 by IDIADA (Jacint Castells (IDIADA)):
I could agree on creating a a general requirement, but making sure that special needs from a UC (e.g. CAV_002 which indicate GNSS lane-accuracy) are not included in this requirement but in a separate one

» Comment 2 by CRF (Filippo Visintainer):
CAV_006 merges the former CAV_007 and can be extended to all UC using C-V2X. Currently I noted UC4, UC5. Please comment to this post "Yes/No for UCx" if you want to extend it to other UC. (Note: we are talking about PC5 and Uu, not ITS G5)

» Comment 3 by UDE (Martin Herrmann):
We do not use PC5 and Uu.

• **CAV_002**
• **CAV_006**
• **CAV_007**
• **CAV_018**

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**CAV_030**
Description	[UC3] The infrastructure should integrate a connectivity strategy to guarantee that CAVs Fleet-Manager has a perception of the vehicle under the scope of the infrastructure (e.g. transmit geolocation of the CAV from infrastructure to Fleet Manager)
Type	Functional and data requirements
Author	MILLA

Rationale	Supposing a 5G connectivity loss, the infrastructure may facilitate a strategy for CAVs services owners to have the perception that the infrastructure has of the concerned vehicle.
Acceptance criteria	Cloud based applications are able to have monitoring data of their owned vehicles, using infrastructure's cloud-based interfaces
Priority	4
Comments	

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**CAV_031**
Description	[UC3] In case of incident involving the CAV (Shuttle), the infrastructure will inform to the service owner about it.
Type	Functional and data requirements
Author	MILLA
Rationale	In case of accident or alert sent by the vehicle, or that the infrastructure identifies an incident related to a CAV, this incident should be inmediatly reported to the CAVs owner, when the vehicle has lost communication with its servers
Acceptance criteria	Cloud based applications are able obtain information about an incidence with its concerned vehicles, throw the infrastructure in the internet side.
Priority	3
Comments	

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**CAV_032**
Description	[UC3] In case of loss of direct communication between CAVs and its cloud fleet managers, the Cloud fleet managers should be able to have a secondary communication strategy, e.g. send an agnostic payload/packet through the V2X infrastructure
Type	Functional and data requirements
Author	MILLA
Rationale	In case of loss of direct communication between CAVs and

	its cloud fleet managers, they should be able to have a secondary communication strategy
Acceptance criteria	The cloud server applications sends a status request embedded in a payload, with destination to a specific CAV. The specific CAV will send a status-response embed in a payload, addressed to the sender.
Priority	3
Comments	

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**CAV_033**
Description	[UC3] The OBUs/TCUs shall be able to send and receive messages with the Gateway in the formats selected. (adapted firmware)
Type	Functional and data requirements
Author	RETE
Rationale	Fulfilling compatibility and performance throught the whole end-to-end communication chain.
Acceptance criteria	Check features on OBU/TCU datasheet. Confirm with vendor and in lab.
Priority	4
Comments	

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**CAV_034**
Description	[UC3] The IDIADA CAV & each conventional (non-CAV) vehicle will have an HMI device (e.g. tablet) to show traffic / manoeuvre recommendations to the drivers.
Type	The scope of the product
Author	RETE
Rationale	The drivers must have a way to receive visual information sent by the infrastructure.
Acceptance criteria	All recommendations sent by the infrasturcture are shown in an HMI device (e.g. tablet)
Priority	4
Comments	

Conflict 135 detected by IDIADA (Jacint Castells (IDIADA)):
CAV_019 does not apply to UC3 because CAV_034 already does

» Comment 1 by RETE (Manu Cañete):
CAV_019 for UC2.
CAV_034 for UC3.

• **CAV_019**

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**CAV_035**

Added

Description	[UC3] The use case will take place with 2 CAVs (Milla, Idiada) and at least 2 additional Connected conventional vehicles.
Type	The scope of the work
Author	AAE
Rationale	At least 4 vehicles, in order to be able to receive sufficient data in each road section in mixed traffic conditions.
Acceptance criteria	4 total vehicles operating during the demonstration.
Priority	3
Comments	

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**CAV_036**
Description	[UC2] The IDIADA CAVs shall have a processing unit able to interact between the TCU, the HMI and the internal vehicle systems
Type	Functional and data requirements
Author	IDIADA
Rationale	A processing unit must give dissemination orders to the TCU and receive messages from this system, in order to forward them to the HMI and to the vehicle
Acceptance criteria	The processing unit orders are applicable by the TCU and the TCU messages are properly received and send to the HMI and the vehicle internal system
Priority	5
Comments	

Id.	1st it.	1st rev.	2nd it.	2nd rev.
CAV_036	Added			

Id.	**CAV_037**
Description	[UC2 & UC3] Definition: TCU (Telematic Control Unit) / OBU (On-Board Unit)
Type	Naming conventions and definitions
Author	IDIADA
Rationale	TCU and OBU are the acronyms for the communication devices equipped in the vehicles
Acceptance criteria	
Priority	1
Comments	From Objection OBJ_1407

Id.	1st it.	1st rev.	2nd it.	2nd rev.
CAV_037	Added			

Id.	CAV_038
Description	[UC4] The vehicle on-board ITS station shall support CAM
Type	Functional and data requirements
Author	CRF
Rationale	Be aware of other ITS stations and other vehicles
Acceptance criteria	Messages correctly decoded
Priority	5
Comments	

Id.	1st it.	1st rev.	2nd it.	2nd rev.
CAV_038	Added			

Id.	CAV_038
Description	**[UC4, UC5] The vehicle on-board ITS station shall support CAM**
Type	Functional and data requirements
Author	CRF
Rationale	Be aware of other ITS stations and other vehicles
Acceptance criteria	Messages correctly decoded
Priority	5
Comments	

Id.	CAV_039
Description	[UC4] The vehicle on-board ITS station shall support IVIM
Type	Functional and data requirements
Author	CRF
Rationale	Receive messages from infrastructure supporting intersection crossing, especially: time slot during which it is safe to cross.
Acceptance criteria	Messages correctly decoded
Priority	5
Comments	Part of CAV_016 (which refers to multiple messages). CAV_016 could be deleted in later stage.

Id.	1st it.	1st rev.	2nd it.	2nd rev.
CAV_039	Added			

Id.	CAV_039
Description	**[UC4, UC5] The vehicle on-board ITS station shall support IVIM**
Type	Functional and data requirements
Author	CRF
Rationale	Receive messages from infrastructure supporting intersection crossing, especially: time slot during which it is safe to cross.
Acceptance criteria	Messages correctly decoded
Priority	5
Comments	Part of CAV_016 (which refers to multiple messages). CAV_016 could be deleted in later stage.

Id.	CAV_040
Description	[UC4] The vehicle on-board ITS station shall support DENM
Type	Functional and data requirements
Author	CRF
Rationale	Receive message about VRU crossing the intersection
Acceptance criteria	Messages correctly decoded
Priority	5
Comments	Part of CAV_016 (which refers to multiple messages). CAV_016 could be deleted in later stage.

Id.	1st it.	1st rev.	2nd it.	2nd rev.
CAV_040	Added			

Id.	CAV_040
Description	**[UC4, UC5] The vehicle on-board ITS station shall support DENM**
Type	Functional and data requirements
Author	CRF
Rationale	Receive message about VRU crossing the intersection
Acceptance criteria	Messages correctly decoded
Priority	5
Comments	Part of CAV_016 (which refers to multiple messages). CAV_016 could be deleted in later stage.

Id.	1st it.	1st rev.	2nd it.	2nd rev.
CAV_041	Added			

Id.	CAV_041
Description	[UC4] The vehicle on-board ITS station shall support SPAT

Type	Functional and data requirements
Author	CRF
Rationale	Receive traffic light information from a signalized intersection
Acceptance criteria	Messages correctly decoded
Priority	5
Comments	Part of CAV_016 (which refers to multiple messages). CAV_016 could be deleted in later stage.

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**CAV_042**
Description	[UC4] The vehicle on-board ITS station shall support MAP message
Type	Functional and data requirements
Author	CRF
Rationale	Receive a local map of the intersection, for lane-level localization and lane awareness
Acceptance criteria	Messages correctly decoded
Priority	5
Comments	Need for a MAP message independently in any case, independetly from the fact that there is a traffic light or not

Added

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**CAV_043**
Description	[UC5] The vehicle on-board ITS station shall support CAM
Type	Functional and data requirements
Author	CRF
Rationale	Be aware of other ITS stations
Acceptance criteria	Messages correctly decoded
Priority	5
Comments	Part of CAV_017 (which refers to multiple messages). CAV_017 could be deleted in later stage.

Added

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**CAV_046**
Description	[UC4] The vehicle on-board ITS station shall support CPM transmission functionality
Type	Functional and data requirements

Author	CRF
Rationale	To send vehicle detections to the infrastructure
Acceptance criteria	Messages correctly encoded
Priority	5
Comments	Reception not needed for UC4

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**COM_001**
Description	[UC2] The platform shall deliver real time events with a latency of less that 800 ms
Type	Performance requirements
Author	ETRA I+D
Rationale	Events become obsolete in 1s
Acceptance criteria	Messages received must have a timestamp not older than current time minus 1s
Priority	5
Comments	

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**COM_002**
Description	[UC4 and UC5] Access Level: For long range communications 4G (3GPP Rel-7 and following releases) and/or 5G (3GPP Rel-15) cellular networks shall be used
Type	Operational requirements
Author	TIM
Rationale	Use of standard communications systems
Acceptance criteria	Verification of the type of the used network
Priority	5
Comments	

1st it.	1st rev.
Dependency 366 detected by TIM (Ezio Chiocchetti): Reference standard for CAV_006 are defined in COM_002 and COM_003 » Comment 1 by TIM (Ezio Chiocchetti): *COM_002 Deleted. Dependency still valid for COM_003, kept as is* » Comment 2 by CRF (Filippo Visintainer): *CAV 6 refers to C-V2X; COM003 includes ITS-G5 which is not the case of CAV6. Both requirements should be kept.* • **COM_003** • **CAV_006** Dependency 367 detected by TIM (Ezio Chiocchetti): Reference standard for CAV_007 are defined in COM_002 and COM_003 » Comment 1 by TIM (Ezio Chiocchetti): *COM_002 Deleted. Dependency still valid for COM_003, kept as is* » Comment 2 by CRF (Filippo Visintainer): *CAV_007 has been deleted (merged with CAV_006)* • **COM_003** • **CAV_007**	✖

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**COM_003**
Description	[UC4 and UC5] Access Level: For

1st it.	1st rev.
Dependency 366 detected by TIM (Ezio Chiocchetti): Reference standard	

Id.	✔ **COM_003**
Description	**[UC4 and UC5] Access Level: For**

	short range communications ITS-G5 (ETSI EN 302 637) or C-V2X (3GPP Rel-14, Rel-15, Rel-16) systems shall be used
Type	Operational requirements
Author	TIM
Rationale	Use of standard communications systems
Acceptance criteria	Verification of the type of the used network
Priority	5
Comments	

for CAV_006 are defined in COM_002 and COM_003

» Comment 1 by TIM (Ezio Chiocchetti):
COM_002 Deleted. Dependency still valid for COM_003, kept as is

» Comment 2 by CRF (Filippo Visintainer):
CAV 6 refers to C-V2X; COM003 includes ITS-G5 which is not the case of CAV6. Both requirements should be kept.

- **COM_002**
- **CAV_006**

Dependency 367 detected by TIM (Ezio Chiocchetti):
Reference standard for CAV_007 are defined in COM_002 and COM_003

» Comment 1 by TIM (Ezio Chiocchetti):
COM_002 Deleted. Dependency still valid for COM_003, kept as is

» Comment 2 by CRF (Filippo Visintainer):
CAV_007 has been deleted (merged with CAV_006)

- **COM_002**
- **CAV_007**

	short range communications ITS-G5 (ETSI EN 302 663) or C-V2X (3GPP Rel-14, Rel-15) systems shall be used
Type	Operational requirements
Author	TIM
Rationale	Use of standard communications systems
Acceptance criteria	Verification of the type of the used network
Priority	5
Comments	

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**COM_004**
Description	[UC4 and UC5] Transport Level: Data packets shall be transported via TCP (RFC 9293), IPv4 (RFC 791), IPv6 (RFC8200), and/or UDP (RFC768) protocols according to ITS application requirements
Type	Operational requirements
Author	TIM
Rationale	Use of standard communications systems
Acceptance criteria	Verification of the type of the used network
Priority	5
Comments	

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**COM_005**
Description	[UC4 and UC5] Facilities Level: ITS applications aiming at alerting users regarding a specific event detected on the road shall use Decentralized Environmental Notification Basic Service
Type	Operational requirements
Author	TIM

Dependency 368 detected by TIM (Ezio Chiocchetti):
Reference standard for SER_074 are defined in COM_005, COM_006 and COM_27

» Comment 1 by TIM (Ezio Chiocchetti):
kept requirement as is

- **COM_006**

Dependency 372 detected by TIM (Ezio Chiocchetti):
Reference standard

Rationale	Use of standard communications systems
Acceptance criteria	Verification of the used messages
Priority	5
Comments	As specified in ETSI "Intelligent Transport Systems (ITS);Vehicular Communications; Basic Set of Applications; Part 3: Specifications of Decentralized Environmental Notification Basic Service. Tech. rep. 302 637-3".

for SER_076 are defined in COM_005 and COM_027

» Comment 1 by TIM (Ezio Chiocchetti):
kept requirement as is

• **SER_076**
Dependency 374 detected by TIM (Ezio Chiocchetti): Reference standard for SIE_003 are defined in COM_005, COM_006 and COM_027

» Comment 1 by TIM (Ezio Chiocchetti):
kept requirement as is

• **COM_006**
• **SIE_003**
Dependency 375 detected by TIM (Ezio Chiocchetti): Reference standard for SIE_010 are defined in COM_005, COM_006, COM_007 and COM_027

» Comment 1 by TIM (Ezio Chiocchetti):
kept requirement as is

• **COM_006**
• **COM_007**
• **SIE_010**

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**COM_006**
Description	[UC4 and UC5] Facilities Level: ITS applications aiming at creating awareness between vehicles and road users as well as supporting cooperative performance in the road network shall use Cooperative Awareness Services
Type	Operational requirements
Author	TIM
Rationale	Use of standard communications systems
Acceptance criteria	Verification of the used messages
Priority	5
Comments	As specified in ETSI Intelligent Transport Systems (ITS); Vehicular Communications; Basic Set of Applications; Part 2: Specification of Cooperative Awareness Basic Service. Tech. rep. 302 637-2.

Dependency 368 detected by TIM (Ezio Chiocchetti): Reference standard for SER_074 are defined in COM_005, COM_006 and COM_27

» Comment 1 by TIM (Ezio Chiocchetti):
kept requirement as is

• **COM_005**
Dependency 374 detected by TIM (Ezio Chiocchetti): Reference standard for SIE_003 are defined in COM_005, COM_006 and COM_027

» Comment 1 by TIM (Ezio Chiocchetti):
kept requirement as is

• **COM_005**
• **SIE_003**
Dependency 375 detected by TIM (Ezio Chiocchetti): Reference standard for SIE_010 are defined in COM_005, COM_006, COM_007 and COM_027

» Comment 1 by TIM (Ezio Chiocchetti):
kept requirement as is

• **COM_005**
• **COM_007**
• **SIE_010**

Id.	**COM_006**
Description	**[UC4 and UC5] Facilities Level: ITS applications aiming at creating awareness between vehicles and road users as well as supporting cooperative performance in the road network shall use Cooperative Awareness Basic Service**
Type	Operational requirements
Author	TIM
Rationale	Use of standard communications systems
Acceptance criteria	Verification of the used messages
Priority	5
Comments	As specified in ETSI Intelligent Transport Systems (ITS); Vehicular Communications; Basic Set of Applications; Part 2: Specification of Cooperative Awareness Basic Service. Tech. rep. 302 637-2.

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**COM_007**
Description	[UC4 and UC5] Facilities Level: ITS applications aiming

Dependency 369 detected by TIM (Ezio Chiocchetti): Reference standard for ORU_027 are

Id.	**COM_007**
Description	**[UC4] Facilities Level: ITS**

Id.	**COM_007**
Description	**[UC2 and UC4] Facilities Level:**

	at conveying geographic road information and/or processing signal phase and timing should refer to MAP and SPAT services
Type	Operational requirements
Author	TIM
Rationale	Use of standard communications systems
Acceptance criteria	Verification of the used messages
Priority	5
Comments	As defined in ETSI TS 103 301 "Intelligent Transport Systems (ITS); Vehicular Communications; Basic Set of Applications; Facilities layer protocols and communication requirements for infrastructure services"

defined in COM_007

» Comment 1 by TIM (Ezio Chiocchetti): *kept requirement as is*

• **ORU_027**
Dependency 375 detected by TIM (Ezio Chiocchetti): Reference standard for SIE_010 are defined in COM_005, COM_006, COM_007 and COM_027

» Comment 1 by TIM (Ezio Chiocchetti): *kept requirement as is*

• **COM_005**
• **COM_006**
• **SIE_010**

Conflict 138 detected by CRF (Filippo Visintainer): SPAT and MAP applied to [UC5] per requirement COM_007 while neither vehicle (CAV_017) nor RSU (SIE_003) support SPAT and MAP

» Comment 1 by TIM (Ezio Chiocchetti): *Done*

» Comment 2 by CRF (Filippo Visintainer): *Conflict resolved*

• **CAV_017**
• **SIE_003**

	applications aiming at conveying geographic road information and/or processing signal phase and timing should refer to MAP and SPAT services
Type	Operational requirements
Author	TIM
Rationale	Use of standard communications systems
Acceptance criteria	Verification of the used messages
Priority	5
Comments	As defined in ETSI TS 103 301 "Intelligent Transport Systems (ITS); Vehicular Communications; Basic Set of Applications; Facilities layer protocols and communication requirements for infrastructure services"

	ITS applications aiming at conveying geographic road information and/or processing signal phase and timing should refer to MAP and SPAT services
Type	Operational requirements
Author	TIM
Rationale	Use of standard communications systems
Acceptance criteria	Verification of the used messages
Priority	5
Comments	As defined in ETSI TS 103 301 "Intelligent Transport Systems (ITS); Vehicular Communications; Basic Set of Applications; Facilities layer protocols and communication requirements for infrastructure services"

Id. **1st it.** **1st rev.** **2nd it.** **2nd rev.**

Id.	**COM_008**
Description	[UC4 and UC5] Facilities Level: ITS applications using CAM and DENM services should support the following publish-subscribe protocols: MQTT (ISO/IEC PRF 20922) and/or AMQP (OASIS Advanced Message Queuing Protocol (AMQP) Version 1.0)
Type	Operational requirements
Author	TIM
Rationale	Use of standard communications systems
Acceptance criteria	Verification of the used messages
Priority	5
Comments	

Dependency 370 detected by TIM (Ezio Chiocchetti): Reference standard for SER_022 are defined in COM_008

• **SER_022**
Dependency 371 detected by TIM (Ezio Chiocchetti): Reference standard for SER_075 are defined in COM_008

• **SER_075**
Dependency 373 detected by TIM (Ezio Chiocchetti): Reference standard for SER_077 are defined in COM_008

• **SER_077**

Id. **1st it.** **1st rev.** **2nd it.** **2nd rev.**

Id.	**COM_009**
Description	[UC4 and UC5] Facilities Level: Position and time data to support ITS Applications shall be compliant with Position and Time (PoTi) services
Type	Operational requirements
Author	TIM

Rationale	Use of standard communications systems
Acceptance criteria	Verification of the used messages
Priority	5
Comments	As specified in ETSI EN 302 890-2 V2.1.1

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**COM_010**
Description	[UC1] The scheduling system shall implement transparent, redundant forwarding of incoming packets.
Type	Functional and data requirements
Author	UDE
Rationale	Redundant communication between vehicles, SPU and MEC.
Acceptance criteria	The scheduling system transparently forwards the incoming packets to all chosen interfaces.
Priority	5
Comments	

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**COM_011**
Description	[UC1] The communication shall be supported through a 5G cmWave (FR1) cellular network.
Type	Operational requirements
Author	UDE
Rationale	5G communication standard to be used.
Acceptance criteria	Message passing over communication link successful.
Priority	5
Comments	

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**COM_012**
Description	[UC1] The communication shall be supported through a 5G mmWave (FR2) cellular network.
Type	Operational requirements
Author	UDE
Rationale	5G communication standard to be used.
Acceptance criteria	Message passing over communication link successful.
Priority	3

Comments	

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**COM_013**
Description	[UC1] Communication shall be supported through an ad-hoc ITS-G5 network.
Type	Operational requirements
Author	UDE
Rationale	ITS-G5 communication standard to be used.
Acceptance criteria	Message passing over communication link successful.
Priority	3
Comments	

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**COM_014**
Description	[UC1] Communication shall be supported through an ad-hoc mmWave (60 GHz) network.
Type	Operational requirements
Author	UDE
Rationale	Ad-hoc mmWave communication standard to be used.
Acceptance criteria	Message passing over communication link successful.
Priority	3
Comments	

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**COM_015**
Description	[UC1] The scheduling system shall gather statistics about the used physical transmission technologies.
Type	Functional and data requirements
Author	UDE
Rationale	The scheduling system can gather statistics concerning throughput, latency, and packetloss.
Acceptance criteria	Statistics are gathered within a specified time interval.
Priority	3
Comments	

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**COM_016**
Description	[UC1] The scheduling system

	shall allow to limit specific data streams to one or multiple communication channels.
Type	Functional and data requirements
Author	UDE
Rationale	The system architecture allows to select appropriate communication channels depending on the data type.
Acceptance criteria	Different data streams are limited to one or multiple communication channels.
Priority	3
Comments	

Id. **1st it.** **1st rev.** **2nd it.** **2nd rev.**

Id.	**COM_017**
Description	[UC3] Facilities Level: The CAV vehicles (different from the Shuttle) shall send CAM messages (according to ETSI EN 302 637-2) and may send CPM messages (according to ETSI TR 103 562)
Type	Operational requirements
Author	IDIADA
Rationale	The CAV vehicles must inform the infrastructure about their location, dynamics and, additionally, they may report the detected objects form the perception sensors
Acceptance criteria	The LDM is updated with CAV location and dynamics data
Priority	5
Comments	

Id. **1st it.** **1st rev.** **2nd it.** **2nd rev.**

Id.	**COM_018**
Description	[UC3] Facilities Level: The set of C-ITS messages received by the Shuttle and CAVs shall be CAM (according to ETSI EN 302 637-2), CPM (according to ETSI TR 103 562), MCM* (according to ETSI TS 103 561), DENM (according to ETSI EN 302 637-3) and IVIM (acco
Type	Operational requirements
Author	IDIADA
Rationale	All connected vehicles shall be informed about the location and dynamics of other vehicles (CAM and CPM), about

Id.	**COM_018**
Description	**[UC3] Facilities Level: The set of C-ITS messages received by the Shuttle and CAVs shall be CAM, CPM, MCM, DENM, IVIM and Raw ITS messages**
Type	Operational requirements
Author	IDIADA
Rationale	All connected vehicles shall be informed about the location and dynamics of other vehicles (CAM and CPM), about recommendations from the infrastructure (MCM), about the hazards on the road (DENM) and

	recommendations from the infrastructure (MCM), about the hazards on the road (DENM) and about general road information (IVIM)
Acceptance criteria	All these types of message are received successfully by all the connected vehicles
Priority	5
Comments	

	about general road information (IVIM)
Acceptance criteria	All these types of message are received successfully by all the connected vehicles
Priority	5
Comments	**CAM (according to ETSI EN 302 637-2), CPM (according to ETSI TR 103 562), MCM* (according to ETSI TS 103 561), DENM (according to ETSI EN 302 637-3) and IVIM (according to CEN ISO/TS 19321)**

Id. **1st it.** **1st rev.** **2nd it.** **2nd rev.**

Id.	**COM_019**
Description	[UC2] Facilities Level: The Connected Vehicles shall send CAM messages (according to ETSI EN 302 637-2) and may send CPM messages (according to ETSI TR 103 562)
Type	Operational requirements
Author	IDIADA
Rationale	The CAV vehicles must inform the infrastructure about their location, dynamics and, additionally, they may report the detected objects form the perception sensors
Acceptance criteria	The LDM is updated with CAV location and dynamics data
Priority	5
Comments	

Id. **1st it.** **1st rev.** **2nd it.** **2nd rev.**

Id.	**COM_020**
Description	[UC2] Facilities Level: The set of C-ITS messages received by the CAVs shall be CAM (according to ETSI EN 302 637-2), MCM* (according to ETSI TS 103 561), DENM (according to ETSI EN 302 637-3) and IVIM (according to CEN ISO/TS 19321)
Type	Operational requirements
Author	IDIADA
Rationale	All connected vehicles shall be informed about the location and dynamics of other vehicles (CAM), about recommendations from the infrastructure (MCM), about the hazards on the road (DENM) and about general road information (IVIM)

Acceptance criteria	All these types of message are received successfully by all the connected vehicles
Priority	5
Comments	

Id. **1st it.** **1st rev.** **2nd it.** **2nd rev.**

Id.	**COM_021**
Description	[UC3] Facilities Level: Shuttle shall transmit CAM messages at a frequency high enough to detect dangerous situations
Type	The scope of the product
Author	UPC
Rationale	Use of standard communication systems; Proposal's FR02
Acceptance criteria	The LDM is updated often enough to predict the shuttle trajectory with a high level of confidence
Priority	5
Comments	

Id. **1st it.** **1st rev.** **2nd it.** **2nd rev.**

Id.	**COM_022**
Description	[UC3] Access Technolgies Level: Shuttle shall transmit Facilities messages using cellular network and/or LTE-PC5
Type	Operational requirements
Author	UPC
Rationale	Use of standard communication systems
Acceptance criteria	Facilities messages reach the Gateway independently on the radio technology that the shuttle uses
Priority	5
Comments	

Id. **1st it.** **1st rev.** **2nd it.** **2nd rev.**

Id.	**COM_023**
Description	[UC3] The traffic management strategy messages transmitted by the infractrcture to the vehicles shall be related to a) modify max speed, b) modify distance from car in-front, c) closed/open lane.
Type	Functional and data requirements
Author	AAE
Rationale	These are the main type of strategies that can be applied

Id.	**COM_023**
Description	[UC3] The traffic management strategy messages transmitted by the infractrcture to the vehicles shall be related to a) modify max speed, b) modify distance from car in-front, c) closed/open lane.
Type	Functional and data requirements
Author	AAE
Rationale	These are the main type of strategies

	in traffic management.
Acceptance criteria	All these types of messages are received successfully by all the connected vehicles / OBUs
Priority	5
Comments	

	that can be applied in traffic management.
Acceptance criteria	**All these types of messages are received successfully by all the connected vehicles / OBUs.**
Priority	5
Comments	

Id. **1st it.** **1st rev.** **2nd it.** **2nd rev.**

Id.	**COM_024**
Description	[UC3] The infrastructure shall transmit traffic information and alert messages to the vehicles (e.g. incident, obstacle / stopped vehicle, congestion ahead, etc.)
Type	Functional and data requirements
Author	AAE
Rationale	Messages for alerting CAVs or drivers of incidents ahead on the road are needed.
Acceptance criteria	All these types of messages are received successfully by all the connected vehicles / OBUs
Priority	5
Comments	

Id. **1st it.** **1st rev.** **2nd it.** **2nd rev.**

Id.	**COM_025**
Description	[UC3] 5G communications latency shall be sufficiently low to have a total end-to-end latency lower than 250 ms (i.e. 8m @ 120km/h).
Type	Functional and data requirements
Author	RETE
Rationale	250ms is the average human reation time, so being below that we can achieve improvements with respect to drivers. 5G SA targets latencies so low as 1 ms, becoming neglible compare with the rest of the chain.
Acceptance criteria	20 ms is a reasonable and achievable value with the current equipment, even to be improved with the brand new solutions.
Priority	3
Comments	

Id.	**COM_025**
Description	**[UC3] 5G communications latency shall be sufficiently low to contribute to a total end-to-end latency lower than 250 ms (i.e. 8m @ 120km/h).**
Type	Functional and data requirements
Author	RETE
Rationale	250ms is the average human reation time, so being below that we can achieve improvements with respect to drivers. 5G SA targets latencies so low as 1 ms, becoming neglible compare with the rest of the chain.
Acceptance criteria	20 ms is a reasonable and achievable value with the current equipment, even to be improved with the brand new solutions.
Priority	3
Comments	**Clarification: 250 ms is the total e2e latency. 5G as comm tech should contribute with the lowest latency to achieve such total e2e latency.**

Id. **1st it.** **1st rev.** **2nd it.** **2nd rev.**

Id.	**COM_026**
Description	[UC3] Coverage of the 5G / C-V2X network shall have a 99% availability (i.e. less than 88 hours annual downtime).
Type	Functional and data requirements
Author	RETE
Rationale	88 hours per year of unavailability seems reasonably. Higher availability can be achieved by increasing backups.
Acceptance criteria	Check 99% availability
Priority	2
Comments	

Id.	1st it.	1st rev.	2nd it.	2nd rev.
COM_027	Added		Conflict 139 detected by TIM (Ezio Chiocchetti): Duplicated Requirement » Comment 1 by TIM (Ezio Chiocchetti): *COM_028 deleted* » Comment 2 by TIM (Ezio Chiocchetti): *COM_027 as is* » Comment 3 by TIM (Ezio Chiocchetti): *Conflict solved* • **COM_028**	

Id.	**COM_027**
Description	[UC4 and UC5] Facilities Level: generation, transmission and reception of information about mandatory and advisory road signage should be implemented through IVI service.
Type	Operational requirements
Author	TIM
Rationale	Use of standard communications systems
Acceptance criteria	Verification of the used messages
Priority	5
Comments	Reference to ETSI TS 103 301 version 1.2.1.

Id.	1st it.	1st rev.	2nd it.	2nd rev.
COM_028	Added		Conflict 139 detected by TIM (Ezio Chiocchetti): Duplicated Requirement » Comment 1 by TIM (Ezio Chiocchetti): *COM_028 deleted* » Comment 2 by TIM (Ezio Chiocchetti): *COM_027 as is* » Comment 3 by TIM (Ezio Chiocchetti): *Conflict solved* • **COM_027**	✖

Id.	**COM_028**
Description	[UC4 and UC5] Facilities Level: generation, transmission and reception of information about mandatory and advisory road signage should be implemented through IVI service.
Type	Operational requirements
Author	TIM
Rationale	Use of standard communications systems
Acceptance criteria	Verification of the used messages
Priority	5
Comments	Reference to ETSI TS 103 301 version 1.2.1

Id.	1st it.	1st rev.	2nd it.	2nd rev.
COM_029	Added			

Description	[UC4] Access Level: For long range communications 5G (3GPP Rel-15) cellular networks shall be used
Type	Operational requirements
Author	TIM
Rationale	Use of standard communication systems
Acceptance criteria	Verification of the type of the used network
Priority	5
Comments	

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	COM_030			Id. COM_030
Description	[UC5] Access Level: For long range communications 4G (3GPP Rel-7 and following releases) cellular network shall be used			Description **[UC5] Access Level: For long range communications 4G cellular network shall be used**
Type	Operational requirements			Type Operational requirements
Author	TIM	Added		Author TIM
Rationale	Use of standard communication systems			Rationale Use of standard communication systems
Acceptance criteria	Verification of the type of the used network			Acceptance criteria Verification of the type of the used network
Priority	5			Priority 5
Comments				Comments

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	COM_031			Id. COM_031
Description	[UC4] Facilities Level: ITS applications using CAM and DENM services should support the MQTT (ISO/IEC PRF 20922) publish-subscribe protocols			Description [UC4] Facilities Level: ITS applications using CAM and DENM services should support the MQTT (ISO/IEC PRF 20922) publish-subscribe protocols
Type	Operational requirements	Added		Type Operational requirements
Author	TIM			Author TIM
Rationale	Use of standard communication systems			Rationale Use of standard communication systems
Acceptance criteria	Verification of the used messages			Acceptance criteria **Verification of the used protocol**
Priority	5			Priority 5
Comments				Comments

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	COM_032	Added
Description	[UC5] Facilities Level: ITS applications using CAM and DENM services should support the AMQP (OASIS Advanced Message Queuing Protocol (AMQP) Version 1.0) publish-subscribe protocols	

Type	Operational requirements
Author	TIM
Rationale	Use of standard communication systems
Acceptance criteria	Verification of the used protocol
Priority	5
Comments	

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**ORU_001**
Description	[UC1] VRUs shall be able to send VAM via smart devices to edge server.
Type	Functional and data requirements
Author	UDE
Rationale	Inclusion of VRUs into digital twin.
Acceptance criteria	Sending respective messages successful.
Priority	5
Comments	

Dependency 365 detected by UULM (Alexander Scheible): To send the VAM of ORU_001, SER_001 must be fulfilled.

- **SER_001**

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**ORU_002**
Description	[UC2] AI cameras must be able to detect predefined surfaces in the video by deep learning segmentation techniques.
Type	Functional and data requirements
Author	ETRA I+D
Rationale	
Acceptance criteria	
Priority	5
Comments	

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**ORU_003**
Description	[UC2] AI cameras must be able to detect predefined VRUs in the video by deep learning object detection techniques.
Type	Functional and data requirements
Author	ETRA I+D
Rationale	
Acceptance criteria	
Priority	5
Comments	

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**ORU_004**
Description	[UC2] AI Cameras must be able to

	detect if VRUs are inside of a predefined dangerous surface or not.
Type	Functional and data requirements
Author	ETRA I+D
Rationale	
Acceptance criteria	
Priority	5
Comments	

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**ORU_005**
Description	[UC2] VRU's Manager must be able to notify vehicles if VRUs are inside of a predefined dangerous surface.
Type	Functional and data requirements
Author	ETRA I+D
Rationale	
Acceptance criteria	
Priority	5
Comments	

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**ORU_006**
Description	[UC2] AI Cameras must be able to communicate with VRU's manager to let the manager know detected alerts.
Type	Functional and data requirements
Author	ETRA I+D
Rationale	
Acceptance criteria	
Priority	5
Comments	

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**ORU_007**
Description	[UC2] AI Cameras must be able to detect the trajectory of previously detected VRUs.
Type	Functional and data requirements
Author	ETRA I+D
Rationale	
Acceptance criteria	
Priority	5
Comments	

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**ORU_008**

Description	[UC3] VRUs shall transmit VAM messages with their position, speed and direction, using an Android application, at a frequency high enough to detect dangerous situations. These messages are transmitted over TCP/IPv4 and cellular network.
Type	The scope of the product
Author	UPC
Rationale	Use of standard communication systems; Proposal's FR02
Acceptance criteria	The LDM is updated often enough to predict the VRUs trajectory with a high level of confidence.
Priority	5
Comments	

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**ORU_009**
Description	[UC3] [OPTIONAL] C-ITS messages (e.g., VAM) will be extended, IF NEEDED, to include quality indicators so that receiving C-ITS stations can process the information considering their level of truthfulness.
Type	Operational requirements
Author	UPC
Rationale	Proposal definition: Page 7 Objective 4
Acceptance criteria	Verification of Messages extension in the receiver C-ITS station
Priority	1
Comments	

Objection 1394 made by AAE (Harilaos Vasiliadis): Proposed to delete these requirements.

» Comment 1 by UPC (Jordi Casademont): *These two requirements have been deleted.*

•**ORU_010**

✖

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**ORU_010**
Description	[UC3] [OPTIONAL] VRUs app shall compute quality indicators regarding the truthfulness of the data to be included in the VAM extension.
Type	Operational requirements
Author	UPC
Rationale	Proposal definition: Page 7 Objective 4
Acceptance criteria	Verification of Messages extension in the receiver C-ITS station
Priority	1
Comments	

Objection 1394 made by AAE (Harilaos Vasiliadis): Proposed to delete these requirements.

» Comment 1 by UPC (Jordi Casademont): *These two requirements have been deleted.*

•**ORU_009**

✖

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**ORU_011**
Description	[UC3] Cellular phones of VRUs shall have an application, programmed on Android, that triggers an alarm when a vehicle (e.g. Milla shuttle) detected by PODIUM system is too close to the VRU and represents a threat for her/his safety
Type	The scope of the product
Author	UPC
Rationale	Proposal definition: Page 4 "a major focus will be laid on the integration of Vulnerable Road Users (VRUs) in the overall PDI"; Pag 9, objective 9 "Increase road safety mainly for VRUs"; Proposal's FR-07
Acceptance criteria	Cellular phone of the VRU triggers an alarm when there is a risk of collision between a vehicle and the VRU
Priority	5
Comments	

Id.	**1st it.**	**1st rev.**	**2nd it.**	**2nd rev.**

Id.	**ORU_012**
Description	[UC3] VRUs app shall receive CAMs, DENMs and CPMs from the infrastructure, at a frequency high enough to detect dangerous situations (e.g. 1s). These messages are transmitted over TCP/IPv4 and cellular network.
Type	Operational requirements
Author	UPC
Rationale	Use of standard communication systems
Acceptance criteria	Cellular phone of the VRU triggers an alarm when there is a risk of collision between a vehicle and the VRU
Priority	5
Comments	

Id.	**1st it.**	**1st rev.**	**2nd it.**	**2nd rev.**

Id.	**ORU_013**
Description	[UC2] The EV shall periodically notify the EVM of the position and speed in its route through the predefined itinerary (if posible, direction should also be included)
Type	Functional and data requirements

Author	ETRA I+D
Rationale	
Acceptance criteria	
Priority	5
Comments	

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**ORU_014**
Description	[UC2] The VRU-APP shall run work on a smartphone.
Type	Relevant facts and assumptions
Author	ETRA I+D
Rationale	
Acceptance criteria	
Priority	5
Comments	

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**ORU_015**
Description	[UC2] The VRU-APP shall allow a VRU to subscribe to the services of a VRUM
Type	Functional and data requirements
Author	ETRA I+D
Rationale	
Acceptance criteria	
Priority	5
Comments	

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**ORU_016**
Description	[UC2] The VRU-APP shall request the VRU to provide some relevant personal data for the classification of the VRU
Type	Functional and data requirements
Author	ETRA I+D
Rationale	
Acceptance criteria	
Priority	5
Comments	Elderly? Reduced mobility? Cyclist? PMV user?

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**ORU_017**
Description	[UC2] The VRU-APP shall notify VRUM about of the beginning of a trip, the origin and the expected destination
Type	Functional and data requirements
Author	ETRA I+D

Rationale	
Acceptance criteria	
Priority	5
Comments	

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**ORU_018**
Description	[UC3] The App will be compatible with Android
Type	Usability and humanity requirements
Author	ENIDE
Rationale	The application will be designed and developed in Android mobile OS
Acceptance criteria	Execution in Andorid OS
Priority	5
Comments	

Objection 1399 made by AAE (Harilaos Vasiliadis): Clarification: The App --> " The MILLA shuttle passenger App "

- **ORU_019**
- **ORU_022**
- **ORU_023**
- **ORU_024**
- **ORU_025**
- **ORU_026**

Id.	**ORU_018**
Description	**[UC3] The shuttle passenger App will be compatible with Android**
Type	Usability and humanity requirements
Author	ENIDE
Rationale	The application will be designed and developed in Android mobile OS
Acceptance criteria	Execution in Andorid OS
Priority	5
Comments	

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**ORU_019**
Description	[UC3] The App will be responsive
Type	Usability and humanity requirements
Author	ENIDE
Rationale	The application will be designed to adapt to differnt screen sizes and formats
Acceptance criteria	Execution in phones/tablets with diferent screen sizes and formats
Priority	5
Comments	

Objection 1399 made by AAE (Harilaos Vasiliadis): Clarification: The App --> " The MILLA shuttle passenger App "

- **ORU_018**
- **ORU_022**
- **ORU_023**
- **ORU_024**
- **ORU_025**
- **ORU_026**

Id.	**ORU_019**
Description	**[UC3] The shuttle passenger App will be responsive**
Type	Usability and humanity requirements
Author	ENIDE
Rationale	The application will be designed to adapt to differnt screen sizes and formats
Acceptance criteria	Execution in phones/tablets with diferent screen sizes and formats
Priority	5
Comments	

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**ORU_022**
Description	[UC3] The App shall have a Fast check-in system to directly access the shuttle at the shuttle stop, wihtout pre-reservation.
Type	Functional and data requirements
Author	ENIDE
Rationale	A system that allows adding fast booking on board/pickup point
Acceptance criteria	It will be posible for a passenger to access the shuttle without reservation and checking-in at arrival
Priority	5
Comments	

Objection 1399 made by AAE (Harilaos Vasiliadis): Clarification: The App --> " The MILLA shuttle passenger App "

- **ORU_018**
- **ORU_019**
- **ORU_023**
- **ORU_024**
- **ORU_025**
- **ORU_026**

Id.	**ORU_022**
Description	**[UC3] The shuttle passenger App shall have a Fast check-in system to directly access the shuttle at the shuttle stop, wihtout pre-reservation.**
Type	Functional and data requirements
Author	ENIDE
Rationale	A system that allows adding fast booking on board/pickup point
Acceptance criteria	It will be posible for a passenger to access the shuttle without reservation and checking-in at arrival
Priority	5
Comments	

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**ORU_023**
Description	[UC3] The App shall provide travel related information to the user
Type	Functional and data requirements
Author	ENIDE
Rationale	Estimated Time Arrival (ETA), Travel status, others, connection with other public transport based on static information.
Acceptance criteria	It will be posible to get information related to the service during the trip
Priority	4
Comments	

Objection 1399 made by AAE (Harilaos Vasiliadis): Clarification: The App --> " The MILLA shuttle passenger App "

- **ORU_018**
- **ORU_019**
- **ORU_022**
- **ORU_024**
- **ORU_025**
- **ORU_026**

Id.	**ORU_023**
Description	**[UC3] The shuttle passenger App shall provide travel related information to the user**
Type	Functional and data requirements
Author	ENIDE
Rationale	Estimated Time Arrival (ETA), Travel status, others, connection with other public transport based on static information.
Acceptance criteria	It will be posible to get information related to the service during the trip
Priority	4
Comments	

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**ORU_024**
Description	[UC3] The App shall offer a Reward miles program (discounts, CO2 info, etc.)
Type	Functional and data requirements
Author	ENIDE
Rationale	Offer users advantages and benefits, as well as information of interest (environmental impact, ecology, other data) for the frequent use of the shuttle.
Acceptance criteria	The user acount receives advantages and benefits related with the use of the shuttle
Priority	1
Comments	

Objection 1399 made by AAE (Harilaos Vasiliadis): Clarification: The App --> " The MILLA shuttle passenger App "

- **ORU_018**
- **ORU_019**
- **ORU_022**
- **ORU_023**
- **ORU_025**
- **ORU_026**

Id.	**ORU_024**
Description	**[UC3] The shuttle passenger App shall offer a Reward miles program (discounts, CO2 info, etc.)**
Type	Functional and data requirements
Author	ENIDE
Rationale	Offer users advantages and benefits, as well as information of interest (environmental impact, ecology, other data) for the frequent use of the shuttle.
Acceptance criteria	The user acount receives advantages and benefits related with the use of the shuttle
Priority	1
Comments	

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**ORU_025**
Description	[UC3] The App shall feature a Dispatcher Optimizer, and offer optimal departure schedules to the user
Type	Functional and data requirements
Author	ENIDE
Rationale	Suggest schedules where the passenger can fill in and optimize the use of the shuttle, proposing advantages for the use of this functionality (discounts on the trip, accumulation of miles in the miles program, etc.)
Acceptance criteria	The system will try to group the

Objection 1399 made by AAE (Harilaos Vasiliadis): Clarification: The App --> " The MILLA shuttle passenger App "

- **ORU_018**
- **ORU_019**
- **ORU_022**
- **ORU_023**
- **ORU_024**
- **ORU_026**

Id.	**ORU_025**
Description	**[UC3] The shuttle passenger App shall feature a Dispatcher Optimizer, and offer optimal departure schedules to the user**
Type	Functional and data requirements
Author	ENIDE
Rationale	Suggest schedules where the passenger can fill in and optimize the use of the shuttle, proposing advantages for the use of this functionality (discounts on the trip, accumulation of miles in the miles program, etc.)

	passengers optimizing the shuttle use
Priority	4
Comments	

Acceptance criteria	The system will try to group the passengers optimizing the shuttle use
Priority	4
Comments	

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**ORU_026**
Description	[UC3] The App will allow to send ligth packets from point to point
Type	Functional and data requirements
Author	ENIDE
Rationale	The app will implement a section for shipping light goods between points
Acceptance criteria	Small packages can be delivered to destination
Priority	3
Comments	

Objection 1399 made by AAE (Harilaos Vasiliadis): Clarification: The App --> " The MILLA shuttle passenger App "

- **ORU_018**
- **ORU_019**
- **ORU_022**
- **ORU_023**
- **ORU_024**
- **ORU_025**

Id.	**ORU_026**
Description	**[UC3] The shuttle passenger App will allow to send ligth packets from point to point**
Type	Functional and data requirements
Author	ENIDE
Rationale	The app will implement a section for shipping light goods between points
Acceptance criteria	Small packages can be delivered to destination
Priority	3
Comments	

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**ORU_027**
Description	The infrastructure could manage SPATEM and MAPEM for traffic light intersections
Type	Functional and data requirements
Author	SWM
Rationale	
Acceptance criteria	
Priority	4
Comments	

Dependency 369 detected by TIM (Ezio Chiocchetti): Reference standard for ORU_027 are defined in COM_007

» Comment 1 by TIM (Ezio Chiocchetti): *kept requirement as is*

- **COM_007**

Objection 1392 made by ETRA I+D (Ana Martínez): The requirement description should specify the Use Case to which it is adressed. It shall follow the following structure: [UCx] + textual description

- **SER_074**
- **SER_075**
- **SER_076**
- **SER_077**
- **SER_078**

Id.	**ORU_027**
Description	**[UC4] The infrastructure could manage SPATEM and MAPEM for traffic light intersections**
Type	Functional and data requirements
Author	SWM
Rationale	
Acceptance criteria	
Priority	4
Comments	

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**SER_001**
Description	[UC1] The infrastructure shall provide an AMQP broker to collect and distribute relevant messages like ETSI CAM, CPM, MCM, VAM (potentially with proprietary extensions).
Type	Operational requirements
Author	UDE
Rationale	Support of publish-subscribe protocols between vehicles and MEC.
Acceptance criteria	Sending and receiving respective

Dependency 364 detected by UULM (Alexander Scheible): To send/receive the messages of CAV_002, SER_001 must be available.

- **CAV_002**

Dependency 365 detected by UULM (Alexander Scheible): To send the VAM of ORU_001, SER_001 must be fulfilled.

- **ORU_001**

Dependency 380 detected by ETRA I+D (MARIA TOMAS): Those requirements seem to be very similar. We can try to combine them and make it valid both for UC1 and UC4

» Comment 1 by BRE (Paolo Faccin): *kept requirement as is. Requirement SER_022 is valid and limited to only those messages needed for the UC5 scenario*

	messages successful.
Priority	5
Comments	

» Comment 2 by BRE (Paolo Faccin):
SER_022 and SER_074 were initially a single requirement, it was broken up so as not to violate the rule that 'the requirement must start with the single reference UC [UCX]'. This objection was raised in the previous iteration.

» Comment 3 by UDE (Martin Herrmann):
Keep the Requirement SER_001 as is, to leave room for flexibility needed in UC1.

- **SER_022**
- **SER_074**

Id. **1st it.** **1st rev.** **2nd it.** **2nd rev.**

Id.	**SER_002**
Description	[UC1] Digital twin on edge server or RSU is able to fuse and track data from infrastructure sensors and CAM/CPM/VAM from connected users and create a joint CPM with at least 1 Hz.
Type	Functional and data requirements
Author	UDE
Rationale	Digital twin required as source of external information for use case.
Acceptance criteria	Fused CPM is created successfully with at least 1 Hz.
Priority	5
Comments	

Id. **1st it.** **1st rev.** **2nd it.** **2nd rev.**

Id.	**SER_003**
Description	[UC1] A cooperative planer shall be available on edge server/RSU and shall be able to plan cooperative maneuvers (MCM) between connected road users based on the CPM from the digital twin and the received data from the road users.
Type	Functional and data requirements
Author	UDE
Rationale	Cooperative maneuvers required for use case implementation.
Acceptance criteria	MCMs are successfully

	created.
Priority	5
Comments	

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**SER_004**
Description	[UC1] A trust building shall be available on edge server/RSU and shall be able to assess the reliability of information sources based on redundant information from several sources.
Type	Functional and data requirements
Author	UDE
Rationale	Trust building is required for use case implementation.
Acceptance criteria	Trust for different sources is calculated.
Priority	3
Comments	

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**SER_005**
Description	[UC2] The CRE shall estimate the probability of occurrence of an incident between actors that interact on the road network.
Type	The scope of the product
Author	ETRA I+D
Rationale	
Acceptance criteria	
Priority	5
Comments	

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**SER_006**
Description	[UC2] The CRE shall analyse the information provided by DT-MICRO within the time horizon managed by DT-MICRO.
Type	Functional and data requirements
Author	ETRA I+D
Rationale	
Acceptance criteria	
Priority	5
Comments	

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**SER_007**
Description	[UC2] The CRE shall determine the Probability Density

	Function (PDF) of the position of each of the actors for each of the instants from the current instant to the time horizon.
Type	Functional and data requirements
Author	ETRA I+D
Rationale	
Acceptance criteria	
Priority	4
Comments	

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**SER_008**
Description	[UC2] The CRE shall calculate the joint Probability Density Function for each of the pairs of actors.
Type	Functional and data requirements
Author	ETRA I+D
Rationale	
Acceptance criteria	
Priority	4
Comments	

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**SER_009**
Description	[UC2] The CRE shall calculate the collilion risk associated with an interaction from the probability of that interaction and the type of actors
Type	Functional and data requirements
Author	ETRA I+D
Rationale	
Acceptance criteria	
Priority	4
Comments	Proposed algorithm: The risk shall be calculated as the product of the 'loss' (see SER_010) multiplied by the interaction probability (see SER_036)

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**SER_010**
Description	[UC2] The CRE shall assign a loss value to each interaction depending on the type of the pair of actors involved
Type	Functional and data requirements
Author	ETRA I+D
Rationale	

Acceptance criteria	
Priority	4
Comments	

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**SER_011**
Description	[UC2] If the risk of an interaction exceeds a certain value, the CRE shall notify its clients
Type	Functional and data requirements
Author	ETRA I+D
Rationale	
Acceptance criteria	
Priority	5
Comments	The CRE shall notify a high risk interaction event containing the reference to the actors (VRU, vehicle), the kind of interaction and the risk value

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**SER_012**
Description	[UC2] The TMS shall share a data model with the possible origins and destinations of trips within the urban area
Type	Functional and data requirements
Author	ETRA I+D
Rationale	
Acceptance criteria	
Priority	5
Comments	

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**SER_013**
Description	[UC2] The TMS shall process the information of the origins and destinations of the planned trips of connected vehicles to generate an M-OD of planned trips
Type	The scope of the product
Author	ETRA I+D
Rationale	An OD matrix based upon planned trips is a good basis for the prediction of the behaviour of the traffic in the next period time
Acceptance criteria	
Priority	3
Comments	Both autonomous vehicles and other connected vehicles whose drivers make

	use of navigators shall share their planned trips when they start them.

Id. **1st it.** **1st rev.** **2nd it.** **2nd rev.**

Id.	**SER_014**
Description	[UC2] Each second the TMS shall receive the anonymized unique identifier , the GPS position and the speed of each connected vehicle
Type	Functional and data requirements
Author	ETRA I+D
Rationale	TMS shall track the trajectories of vehicles for different purposes
Acceptance criteria	
Priority	5
Comments	The anonymized unique identifier for a vehicle must not change ever, or at least for a period longer than any trip across the city

Id.	**SER_014**
Description	**[UC2] Each second the TMS shall receive the anonymized unique identifier, the georeferenced position and the speed of each connected vehicle**
Type	Functional and data requirements
Author	ETRA I+D
Rationale	TMS shall track the trajectories of vehicles for different purposes
Acceptance criteria	
Priority	5
Comments	The anonymized unique identifier for a vehicle must not change ever, or at least for a period longer than any trip across the city

Id. **1st it.** **1st rev.** **2nd it.** **2nd rev.**

Id.	**SER_015**
Description	[UC2] The TMS shall process the position and speed of each vehicle along time and update the M-OD data model each time a vehicle begins and ends a trip
Type	Functional and data requirements
Author	ETRA I+D
Rationale	
Acceptance criteria	
Priority	5
Comments	The M-OD shall be updated by increasing the count of vehicles in the current period for the O-D pair corresponding to the initial and final positions of the trip.

Id. **1st it.** **1st rev.** **2nd it.** **2nd rev.**

Id.	**SER_016**
Description	[UC2] The TMS shall calculate the travel time of each vehicle moving through a link (road segment between two junctions) and record it in the link data model.
Type	Functional and data requirements
Author	ETRA I+D
Rationale	The TMS shall statistically process

	travel times of vehicles through links and calculate the average travel times per link
Acceptance criteria	
Priority	5
Comments	The TMS shall match vehicle positions in real time with the coordinates of the links (road segment between two junctions), detect which vehicles drive through each link and calculate the time spent.

Id. **1st it.** **1st rev.** **2nd it.** **2nd rev.**

Id.	**SER_017**
Description	[UC2] Each traffic control cycle the TMS shall calculate an average travel time of the vehicles driving along each link (road segment between two junctions) and update the result in the link data model.
Type	Functional and data requirements
Author	ETRA I+D
Rationale	
Acceptance criteria	
Priority	5
Comments	

Id. **1st it.** **1st rev.** **2nd it.** **2nd rev.**

Id.	**SER_018**
Description	[UC2] The platform shall have an Emergency Vehicle Manager (EVM) able to receive the available corridors from the infrastructure and the updated location of the Emergency Vehicle. Also, this EVW shall report the EV location to the Aurora platform.
Type	Functional and data requirements
Author	IDIADA
Rationale	A module is required to gather information from the location of the Emergency Vehicle (EV) and the available corridors, as well as to provide traffic information from the infrastructure to the EV
Acceptance criteria	The module successfully receive and transmit the required messages
Priority	5
Comments	

Id. **1st it.** **1st rev.** **2nd it.** **2nd rev.**

Id.	**SER_019**
Description	[UC2] The platform shall have a Connected Vehicle Manager (CVM) able to receive the CAM and CPM messages sent from the CVs (including the EV), and inform them about events sent from the infrastructure. The CAM and CPM messages shall be forwarded to Aurora
Type	Functional and data requirements
Author	IDIADA
Rationale	A module is required to gather the messages generated by the Connected Vehicles (CVs) and to send them messages created by the infrastructure.
Acceptance criteria	The module successfully receive and transmit the required messages
Priority	5
Comments	

Id.	**1st it.**	**1st rev.**	**2nd it.**	**2nd rev.**

Id.	**SER_020**
Description	[UC3] The Gateways shall feed the Hub Edge with the incoming messages from the vehicles and VRUs
Type	Operational requirements
Author	IDIADA
Rationale	The Gateways are the interface of the Hub Edge with the vehicles/VRUs.
Acceptance criteria	The C-ITS messages sent by the vehicles/VRUs are successfully received by the Hub Edge from the Gateways
Priority	5
Comments	

Id.	**1st it.**	**1st rev.**	**2nd it.**	**2nd rev.**

Id.	**SER_021**
Description	[UC3] Both Gateways shall have the same interfaces with the upper layers (Hub Edge)
Type	Functional and data requirements
Author	IDIADA
Rationale	The presence of multiple Gateways must be transparent for the Hub Edge
Acceptance criteria	The Hub Edge have a unique single point of contact with the Gateways

Id.	**SER_021**
Description	**[UC3] Both Gateways shall have the same interfaces to communicate with the Hub Edge**
Type	Functional and data requirements
Author	IDIADA
Rationale	The presence of multiple Gateways must be transparent for the Hub Edge
Acceptance criteria	The Hub Edge have a unique single point of contact with the Gateways
Priority	5

Priority	5
Comments	

Comments	

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**SER_022**
Description	[UC5] The infrastructure shall provide an AMQP broker to distribute ETSI messages (CAM + DENM + IVIM)
Type	Functional and data requirements
Author	BRE
Rationale	Support of publish protocols between the infrastructure and MEC
Acceptance criteria	Messages correctly received by TIM broker
Priority	5
Comments	The infrastructure shall support AMQP (OASIS Advanced Message Queuing Protocol (AMQP) Version 1.0)

Dependency 370 detected by TIM (Ezio Chiocchetti): Reference standard for SER_022 are defined in COM_008

- **COM_008**

Dependency 380 detected by ETRA I+D (MARIA TOMAS): Those requirements seem to be very similar. We can try to combine them and make it valid both for UC1 and UC4

» Comment 1 by BRE (Paolo Faccin): *kept requirement as is. Requirement SER_022 is valid and limited to only those messages needed for the UC5 scenario*

» Comment 2 by BRE (Paolo Faccin): *SER_022 and SER_074 were initially a single requirement, it was broken up so as not to violate the rule that 'the requirement must start with the single reference UC [UCX]'. This objection was raised in the previous iteration.*

» Comment 3 by UDE (Martin Herrmann): *Keep the Requirement SER_001 as is, to leave room for flexibility needed in UC1.*

- **SER_001**
- **SER_074**

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**SER_023**
Description	[UC5] The infrastructure shall send ETSI messages (CAM + DENM + IVIM) to RSUs
Type	Functional and data requirements
Author	BRE
Rationale	CAVs must receive Infrastructure information
Acceptance criteria	Messages correctly encodde and received by RSUs
Priority	5
Comments	

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**SER_024**

Description	[UC2] AIC means Artificial Intelligence Cameras
Type	Naming conventions and definitions
Author	ETRA I+D
Rationale	Artificial Intelligence Cameras shall be used to identify and track VRUs
Acceptance criteria	
Priority	5
Comments	

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**SER_025**
Description	[UC5] The infrastructure shall send specific PODIUM messages
Type	Functional and data requirements
Author	BRE
Rationale	CAVs must receive Infrastructure information
Acceptance criteria	Messages correctly encoded and received by RSUs
Priority	5
Comments	

Id.	1st it.	1st rev.	2nd it.	2nd rev.
		✖		

Id.	**SER_026**
Description	[UC2] CRE means Collision Risk Estimator
Type	Naming conventions and definitions
Author	ETRA I+D
Rationale	
Acceptance criteria	
Priority	5
Comments	

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**SER_027**
Description	[UC2] CV means Connected Vehicle, either autonomous or not
Type	Naming conventions and definitions
Author	ETRA I+D
Rationale	
Acceptance criteria	
Priority	5
Comments	

Id.	1st it.	1st rev.	2nd it.	2nd rev.
			Dependency 381 detected by AAE (Harilaos Vasiliadis): Some of these acronym definitions could be generalised for all Use cases. • **SER_029** • **SER_031** • **SER_053**	

Id.	**SER_028**

Description	[UC5] The infrastructure shall be able to receive data for PODIUM messages
Type	Functional and data requirements
Author	BRE
Rationale	C-ITS Server must be able to receive data from UC5 and broadcast specific messages to other actors
Acceptance criteria	Messages correctly received by the C-ITS Server
Priority	5
Comments	

Id. **1st it.** **1st rev.** **2nd it.** **2nd rev.**

Id.	**SER_029**
Description	[UC2] DT means Digital Twin
Type	Naming conventions and definitions
Author	ETRA I+D
Rationale	
Acceptance criteria	
Priority	5
Comments	

Dependency 381 detected by AAE (Harilaos Vasiliadis): Some of these acronym definitions could be generalised for all Use cases.

- **SER_027**
- **SER_031**
- **SER_053**

Id. **1st it.** **1st rev.** **2nd it.** **2nd rev.**

Id.	**SER_030**
Description	[UC2] DT-GUI means Digital Twin – Graphic User Interface
Type	Naming conventions and definitions
Author	ETRA I+D
Rationale	
Acceptance criteria	
Priority	5
Comments	The human-machine interface of the Digital Twin

Id. **1st it.** **1st rev.** **2nd it.** **2nd rev.**

Id.	**SER_031**
Description	[UC2] VRU means Vulnerable Road User
Type	Naming conventions and definitions
Author	ETRA I+D
Rationale	
Acceptance criteria	
Priority	5
Comments	

Dependency 381 detected by AAE (Harilaos Vasiliadis): Some of these acronym definitions could be generalised for all Use cases.

- **SER_027**
- **SER_029**
- **SER_053**

Id. **1st it.** **1st rev.** **2nd it.** **2nd rev.**

Id.	**SER_032**

Description	[UC2] VRU-APP means Vulnerable Road User Application
Type	Naming conventions and definitions
Author	ETRA I+D
Rationale	
Acceptance criteria	
Priority	5
Comments	

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**SER_033**
Description	[UC2] DT-MICRO means Digital Twin for high spatial and temporal resolution
Type	Naming conventions and definitions
Author	ETRA I+D
Rationale	
Acceptance criteria	
Priority	5
Comments	Responsible of the quick and efficient exchange of information between actors (CV, VRU, EV)in proximity of each other, and the systems involved

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**SER_034**
Description	[UC2] DT-TMS means Digital Twin for Traffic Management System
Type	Naming conventions and definitions
Author	ETRA I+D
Rationale	
Acceptance criteria	
Priority	5
Comments	A subsystem of DT specifically dedicated to funcionality involving TMS

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**SER_035**
Description	[UC2] VRUM means Vulnerable Road User Manager
Type	Naming conventions and definitions
Author	ETRA I+D
Rationale	
Acceptance criteria	
Priority	5

Comments	

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**SER_036**
Description	[UC2] The CRE shall determine, for each pair of actors and from the PDF of each actor, the position and instant with maximum probability of finding both actors simultaneously
Type	Functional and data requirements
Author	ETRA I+D
Rationale	This shall be used both to calculate the probability of collision and to estimate the position and time of that eventual collision.
Acceptance criteria	
Priority	5
Comments	

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**SER_037**
Description	[UC2] TMS means Traffic Management System
Type	Naming conventions and definitions
Author	ETRA I+D
Rationale	
Acceptance criteria	
Priority	5
Comments	

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**SER_038**
Description	[UC2] M-OD means Origin-Destination Matrix
Type	Naming conventions and definitions
Author	ETRA I+D
Rationale	
Acceptance criteria	
Priority	5
Comments	

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**SER_039**
Description	[UC2] TT-OD means Origin-Destination Travel Time
Type	Naming conventions and definitions
Author	ETRA I+D
Rationale	

Acceptance criteria	
Priority	2
Comments	

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**SER_040**
Description	[UC2] The TMS shall calculate the TT-OD for each origin-destination pair as the average travel time for the path with minimum travel time between the origin and the destination
Type	Functional and data requirements
Author	ETRA I+D
Rationale	Only the path with minimum travel time shall be considered
Acceptance criteria	
Priority	2
Comments	From the results obtained from requirement SER_017 (the calculation of average travel time per link). An optimal path algorith shall determine the path with minimum time.

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**SER_041**
Description	[UC2] A Link is a road segment between two junctions.
Type	Naming conventions and definitions
Author	ETRA I+D
Rationale	The road network is modelled as a mesh formed by junctions connected by links
Acceptance criteria	
Priority	5
Comments	

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**SER_042**
Description	[UC2] The TMS shall calculate the aggregated delay of each entry to each junction per cycle
Type	Functional and data requirements
Author	ETRA I+D
Rationale	
Acceptance criteria	
Priority	5
Comments	As the SUM of the delays calculated from tracking

	individual CVs (requirement SER_043) during the cycle

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**SER_043**
Description	[UC2] Each time a CV enters a junction the TMS shall store a delay record in the junction model associated with the 'entry' and containing the delay of the vehicle
Type	Functional and data requirements
Author	ETRA I+D
Rationale	
Acceptance criteria	
Priority	5
Comments	

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**SER_044**
Description	[UC2] The DT-GUI shall display the M-OD information by means of tables and suitable geographical representation methods.
Type	Functional and data requirements
Author	ETRA I+D
Rationale	
Acceptance criteria	
Priority	5
Comments	

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**SER_045**
Description	[UC2] The DT-GUI shall display the TT-OD information by means of tables and suitable geographical representation methods.
Type	Functional and data requirements
Author	ETRA I+D
Rationale	
Acceptance criteria	
Priority	5
Comments	

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**SER_046**
Description	[UC2] The DT-GUI shall display the delays by means of tables and suitable geographical representation methods.

Type	Functional and data requirements
Author	ETRA I+D
Rationale	
Acceptance criteria	
Priority	5
Comments	

Id. **1st it.** **1st rev.** **2nd it.** **2nd rev.**

Id.	**SER_047**
Description	[UC2] The TMS shall disseminate via de DT the information relative to the travel times per link.
Type	Functional and data requirements
Author	ETRA I+D
Rationale	DT-GUI or any other module interested in the information may obtain it from the DT
Acceptance criteria	
Priority	5
Comments	

Id. **1st it.** **1st rev.** **2nd it.** **2nd rev.**

Id.	**SER_048**
Description	[UC3] The Digital Twin (DT) shall have an Local Dynamic Map (LDM) that is updated using CAM, DENM, CPM and VAM messages transmitted by vehicles and VRUs.
Type	Operational requirements
Author	UPC
Rationale	Proposal definition: Page 7 Objective 4; Proposal's FR-04
Acceptance criteria	Verification on the LDM
Priority	5
Comments	

Id. **1st it.** **1st rev.** **2nd it.** **2nd rev.**

Id.	**SER_049**
Description	[UC3] The DT shall have an LDM that contains static road attributes
Type	Operational requirements
Author	UPC
Rationale	Proposal definition: Page 7 Objective 4
Acceptance criteria	Verification on the LDM
Priority	3
Comments	

Id. **1st it.** **1st rev.** **2nd it.** **2nd rev.**

Id.	SER_050
Description	[UC3] The DT at the Edge shall will provide future expected trajectories of each road actor (e.g., vehicle, pedestrian, bicyclist, etc.) at short term (4 or 5 seconds)
Type	Operational requirements
Author	UPC
Rationale	Proposal definition: Page 7 Objective 4
Acceptance criteria	New CAM/VAM messages received by the DT are coherent with the estimated trajectories of the road actor
Priority	5
Comments	

Id.	SER_050
Description	**[UC3] The DT at the Edge shall will provide future expected trajectories of each road actor (vehicles and pedestrians) at short term (4 or 5 seconds)**
Type	Operational requirements
Author	UPC
Rationale	Proposal definition: Page 7 Objective 4
Acceptance criteria	New CAM/VAM messages received by the DT are coherent with the estimated trajectories of the road actor
Priority	5
Comments	

Id. **1st it.** **1st rev.** **2nd it.** **2nd rev.**

Id.	SER_051
Description	[UC4, UC5] The Digital Twin should collect data in real-time and make them available to applications using Open APIs
Type	Functional and data requirements
Author	LINKS
Rationale	The DT should work as an hub for the information collected from sensors, vehicles, RSU, VRU, etc...
Acceptance criteria	All collected data are on the DT
Priority	5
Comments	

Id. **1st it.** **1st rev.** **2nd it.** **2nd rev.**

Id.	SER_052
Description	[UC4] Data coming from different sources can be fused to increase a "trust-index" of the information
Type	Functional and data requirements
Author	LINKS
Rationale	Data fusion is helpful to verify a certain event from different sources
Acceptance criteria	
Priority	3
Comments	

Id. **1st it.** **1st rev.** **2nd it.** **2nd rev.**

Id.	SER_053
Description	[UC2] CAV means Connected Autonomous Vehicle

Dependency 381 detected by AAE (Harilaos Vasiliadis): Some of these acronym definitions could

Type	Naming conventions and definitions
Author	ETRA I+D
Rationale	
Acceptance criteria	
Priority	5
Comments	

be generalised for all Use cases.

- **SER_027**
- **SER_029**
- **SER_031**

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**SER_054**
Description	[UC2] CVM means connected Vehicle Manager
Type	Naming conventions and definitions
Author	ETRA I+D
Rationale	
Acceptance criteria	
Priority	5
Comments	

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**SER_055**
Description	[UC2] EV means Emergency Vehicle
Type	Naming conventions and definitions
Author	ETRA I+D
Rationale	
Acceptance criteria	
Priority	5
Comments	

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**SER_056**
Description	[UC2] EVM means Emergency Vehicle Manager
Type	Naming conventions and definitions
Author	ETRA I+D
Rationale	
Acceptance criteria	
Priority	5
Comments	

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**SER_057**
Description	[UC2] The EVM shall notify the beginning of a trip of an EV through a predefined itinerary to the TMS
Type	Functional and data requirements
Author	ETRA I+D
Rationale	

Acceptance criteria	
Priority	5
Comments	

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**SER_058**
Description	[UC2] The EVM shall periodically notify the TMS of the position and speed in its route through the predefined itinerary (if posible, direction should also be included)
Type	Functional and data requirements
Author	ETRA I+D
Rationale	
Acceptance criteria	
Priority	5
Comments	

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**SER_059**
Description	[UC2] The TMS shall estimate the arrival time of the EV to each traffic light and take the necessary actions to give traffic light priority to the EVs in their trip across predefined itineraries
Type	Functional and data requirements
Author	ETRA I+D
Rationale	
Acceptance criteria	
Priority	5
Comments	

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**SER_060**
Description	[UC2] The CVM shall inform the CVs and CAVs about the EVs approaching to their position
Type	Functional and data requirements
Author	ETRA I+D
Rationale	
Acceptance criteria	
Priority	5
Comments	EVs with which they are foreseen to meet in the same road segment or junction

Dependency 376 detected by ETRA I+D (Manolo Vivo): CAV_019 depends on information provided by SER_060, but it is necessary to fill the gap between the 'information' that CAV shall receive according to CAV_019 and the 'recommendation' mentioned in CAV_019. The recommendation implies decision support functionality whose responsability is undefined.

» Comment 1 by IDIADA (Jacint Castells (IDIADA)): *Hi Manolo, the "recommendations" shall be defined by the Road Operator/Traffic Manager (TMC) and given to the drivers by the CVM using C-ITS*

Id.	**SER_060**
Description	**[UC2] The CVM shall inform the CVs and CAVs about the EVs approaching to their position and provide generic recommendations**
Type	Functional and data requirements
Author	ETRA I+D
Rationale	
Acceptance criteria	
Priority	5
Comments	**- EVs with which they are foreseen to meet in the same road segment or junction - The recommendations shall be based upon generic recommendations provided by the**

messages (MCM, IVIM, DENM, etc.). Do we agree? Let's discuss it via meeting if needed.

» Comment 2 by ETRA I+D (Manolo Vivo):
This requires further anaylsis, as the TMC can only provide generic recommendations but cannot customise them for the particular position or circumstances of each vehicle.

• **CAV_019**

TMS (slow down, yield, leave free space), and CVM shall be in charge of customising, if possible, to the particular situation of each vehicle

Id. **1st it.** **1st rev.** **2nd it.** **2nd rev.**

Id.	**SER_061**
Description	[UC2] The TMS shall disseminate through the DT information regarding the current and expected status of the traffic lights in real time
Type	Functional and data requirements
Author	ETRA I+D
Rationale	
Acceptance criteria	
Priority	5
Comments	Comment: The traffic management system shall send the color of each traffic light in real time with the expected changes in the next N seconds to the platform, each time the color or the estimation change

Id. **1st it.** **1st rev.** **2nd it.** **2nd rev.**

Id.	**SER_062**
Description	[UC2] The CVM shall inform the CVs and CAVs regarding the current and expected status of the traffic lights.
Type	Functional and data requirements
Author	ETRA I+D
Rationale	
Acceptance criteria	
Priority	0
Comments	Information received from the TMS through the DT (see SER_061)

Id. **1st it.** **1st rev.** **2nd it.** **2nd rev.**

Id.	✔ **SER_062**
Description	[UC2] The CVM shall inform the CVs and CAVs regarding the current and expected status of the traffic lights.
Type	Functional and data requirements
Author	ETRA I+D
Rationale	
Acceptance criteria	
Priority	**3**
Comments	Information received from the TMS through the DT (see SER_061)

Id. **1st it.** **1st rev.** **2nd it.** **2nd rev.**

Id.	**SER_063**
Description	[UC2] The DT-MICRO shall manage the information of the dynamic actors within a certain

	time horizon and spatial scope exchanged between CVM, VRUM end CRE.
Type	The scope of the product
Author	ETRA I+D
Rationale	DT-MICRO is designed to have multiple instances dedicated to particular areas, for scalability and efficiency reasons
Acceptance criteria	
Priority	3
Comments	

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**SER_064**
Description	[UC2] The AIC shall periodically provide the CRE with the following information about the VRU detected in its vision area: anonymised unique dentifier, position, VRU type and, if possible, direction, speed and behaviour type
Type	Functional and data requirements
Author	ETRA I+D
Rationale	
Acceptance criteria	
Priority	3
Comments	The anonymised unique identifier associated with a VRU shall be immutable during the entire time interval that it has located that VRU. While the VRU is detected by the AIC, it must get the same identifier, but if the detection ends and, later on, the AIC detects it again, it may get a different identifier. The position in absolute geo-referenced coordinates, the direction in degrees (compass) and the speed in meters/second. There shall be an unequivocal classification of types of behaviour of the VRUs to be defined in later stage of the project.

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**SER_065**
Description	[UC2] The VRUMs shall exchange information with the VRUs they have made a subscription to the services it shall offer.

Type	The scope of the product
Author	ETRA I+D
Rationale	
Acceptance criteria	
Priority	5
Comments	

Id. **1st it.** **1st rev.** **2nd it.** **2nd rev.**

Id.	**SER_066**
Description	[UC2] The AIC shall provide its information with a time granularity configurable in the interval [1,60] seconds.
Type	Functional and data requirements
Author	ETRA I+D
Rationale	
Acceptance criteria	
Priority	5
Comments	

Id. **1st it.** **1st rev.** **2nd it.** **2nd rev.**

Id.	**SER_067**
Description	[UC2] VRUs shall accept the privacy and personal data management policy of the VRUM services when they subscribe to them
Type	Legal requirements
Author	ETRA I+D
Rationale	
Acceptance criteria	
Priority	5
Comments	

Id. **1st it.** **1st rev.** **2nd it.** **2nd rev.**

Id.	**SER_068**
Description	[UC2] A VRUM shall periodically receive from VRU APPs information with the identification of each VRU, its position, its direction and its speed.
Type	Functional and data requirements
Author	ETRA I+D
Rationale	
Acceptance criteria	
Priority	5
Comments	The position in absolute coordinates, the direction in degrees (compass) and the speed in meters/second.

Id. **1st it.** **1st rev.** **2nd it.** **2nd rev.**

Id.	**SER_069**
Description	[UC2] A VRUM shall be able to identify when a VRU is traveling on a mode of transport that does not require some of the usual VRU protection services when using that mode of transport.
Type	Relevant facts and assumptions
Author	ETRA I+D
Rationale	
Acceptance criteria	
Priority	1
Comments	If possible

Id.	**1st it.**	**1st rev.**	**2nd it.**	**2nd rev.**

Id.	**SER_070**
Description	[UC2] The VRUM shall disseminate through a DT-MICRO the information about each VRU, adding an anonymised unique identifier and the type of VRU, with no other personal information
Type	Functional and data requirements
Author	ETRA I+D
Rationale	
Acceptance criteria	
Priority	5
Comments	

Id.	**1st it.**	**1st rev.**	**2nd it.**	**2nd rev.**

Id.	**SER_071**
Description	[UC2] The VRUM shall provide its information with a time granularity configurable in the interval [1,60] seconds.
Type	Functional and data requirements
Author	ETRA I+D
Rationale	
Acceptance criteria	
Priority	5
Comments	

Id.	**1st it.**	**1st rev.**	**2nd it.**	**2nd rev.**

Id.	**SER_072**
Description	[UC2] VWD means Visual Warning Device
Type	Naming conventions and definitions
Author	ETRA I+D
Rationale	

Acceptance criteria	
Priority	2
Comments	Part of the road network infrastucture

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**SER_073**
Description	[UC2] The TMS must inform VRUs and other users of the road network of the current or imminent presence of an EV by activating a VWD
Type	Functional and data requirements
Author	ETRA I+D
Rationale	
Acceptance criteria	
Priority	2
Comments	VMD shall be part of the infrastructure of the road network

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**SER_074**
Description	The infrastructure shall provide an AMQP broker to distribute ETSI messages (CAM + DENM + IVIM)
Type	Functional and data requirements
Author	SWM
Rationale	
Acceptance criteria	
Priority	5
Comments	

Objection 1392 made by ETRA I+D (Ana Martínez): The requirement description should specify the Use Case to which it is adressed. It shall follow the following structure: [UCx] + textual description

- **SER_075**
- **SER_076**
- **SER_077**
- **ORU_027**
- **SER_078**

Id.	**SER_074**
Description	**[UC4] The infrastructure shall provide an AMQP broker to distribute ETSI messages (CAM + DENM + IVIM)**
Type	Functional and data requirements
Author	SWM
Rationale	
Acceptance criteria	
Priority	5
Comments	

Dependency 380 detected by ETRA I+D (MARIA TOMAS): Those requirements seem to be very similar. We can try to combine them and make it valid both for UC1 and UC4

» Comment 1 by BRE (Paolo Faccin):
kept requirement as is. Requirement SER_022 is valid and limited to only those messages needed for the UC5 scenario

» Comment 2 by BRE (Paolo Faccin):
SER_022 and SER_074 were initially a single requirement, it was broken up so as not to violate the rule that 'the requirement must start with the single reference UC [UCX]'. This objection was raised in the previous iteration.

» Comment 3 by UDE (Martin Herrmann):
Keep the Requirement SER_001 as is, to leave room for flexibility needed in UC1.

- **SER_001**

• **SER_022**

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**SER_075**
Description	The IMA shall be able to receive VRU related messages via AMQP broker and MQTT
Type	Functional and data requirements
Author	SWM
Rationale	
Acceptance criteria	
Priority	5
Comments	

Dependency 371 detected by TIM (Ezio Chiocchetti): Reference standard for SER_075 are defined in COM_008

• **COM_008**

Objection 1392 made by ETRA I+D (Ana Martínez): The requirement description should specify the Use Case to which it is adressed. It shall follow the following structure: [UCx] + textual description

•**SER_074**
•**SER_076**
•**SER_077**
•**ORU_027**
•**SER_078**

Id.	**SER_075**
Description	**[UC4] The IMA shall be able to receive VRU related messages via AMQP broker and MQTT**
Type	Functional and data requirements
Author	SWM
Rationale	
Acceptance criteria	
Priority	5
Comments	

Objection 1425 made by ETRA I+D (MARIA TOMAS): Would it be possible to add a new requirement to include the definition of IMA?

•**SER_076**
•**SER_077**
•**SER_078**

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**SER_076**
Description	The IMA shall be generate ETSI C-ITS messages (IVIM, DENM) based on VRU data
Type	Functional and data requirements
Author	SWM
Rationale	
Acceptance criteria	
Priority	5
Comments	

Dependency 372 detected by TIM (Ezio Chiocchetti): Reference standard for SER_076 are defined in COM_005 and COM_027

» Comment 1 by TIM (Ezio Chiocchetti):
kept requirement as is

• **COM_005**

Objection 1392 made by ETRA I+D (Ana Martínez): The requirement description should specify the Use Case to which it is adressed. It shall follow the following structure: [UCx] + textual description

•**SER_074**
•**SER_075**
•**SER_077**
•**ORU_027**
•**SER_078**

Objection 1425 made by ETRA I+D (MARIA TOMAS): Would it be possible to add a new requirement to include the definition of IMA?

•**SER_075**
•**SER_077**
•**SER_078**

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**SER_077**
Description	The IMA shall dispatch messages by the following protocol AMQP (OASIS Advanced Message Queuing Protocol (AMQP) Version 1.0) (Basic Interface)
Type	Functional and data requirements
Author	SWM
Rationale	
Acceptance criteria	
Priority	5
Comments	

Dependency 373 detected by TIM (Ezio Chiocchetti): Reference standard for SER_077 are defined in COM_008

• **COM_008**

Objection 1392 made by ETRA I+D (Ana Martínez): The requirement description should specify the Use Case to which it is adressed. It shall follow the following structure: [UCx] + textual description

•**SER_074**
•**SER_075**
•**SER_076**
•**ORU_027**
•**SER_078**

Id.	**SER_077**
Description	**[UC4] The IMA shall dispatch messages by the following protocol AMQP (OASIS Advanced Message Queuing Protocol (AMQP) Version 1.0) (Basic Interface)**
Type	Functional and data requirements
Author	SWM
Rationale	
Acceptance criteria	
Priority	5
Comments	

Objection 1425 made by ETRA I+D (MARIA TOMAS): Would it be possible to add a new requirement to include the definition of IMA?

•**SER_075**
•**SER_076**
•**SER_078**

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**SER_078**

Objection 1392 made by ETRA I+D (Ana Martínez): The

Id.	**SER_078**

Objection 1425 made by ETRA I+D (MARIA

Description	The IMA shall be able to send TLA (traffic light assistance) data to the CAV
Type	Functional and data requirements
Author	SWM
Rationale	
Acceptance criteria	
Priority	3
Comments	

requirement description should specify the Use Case to which it is adressed. It shall follow the following structure: [UCx] + textual description

- **SER_074**
- **SER_075**
- **SER_076**
- **SER_077**
- **ORU_027**

Description	**[UC4] The IMA shall be able to send TLA (traffic light assistance) data to the CAV**
Type	Functional and data requirements
Author	SWM
Rationale	
Acceptance criteria	
Priority	3
Comments	

TOMAS): Would it be possible to add a new requirement to include the definition of IMA?

- **SER_075**
- **SER_076**
- **SER_077**

Id. **1st it.** **1st rev.** **2nd it.** **2nd rev.**

Id.	**SER_079**
Description	[UC3] The DT shall calculate and store a local traffic status per each second (<1s), using as input the fusion of data sources (camera data, LDM data, obstacle/incident data), and transmit it to the Local TMC and Global TMC
Type	Operational requirements
Author	AAE
Rationale	Proposal definition: Page 7 Objective 4
Acceptance criteria	Verification of the DT
Priority	5
Comments	

Id. **1st it.** **1st rev.** **2nd it.** **2nd rev.**

Id.	**SER_080**
Description	[UC3] The MEC shall have a "Hub Edge Platform" module, over which is possible to deploy specific software components, incl. VA, TMC Edge, and DT.
Type	The scope of the product
Author	AAE
Rationale	Modular architecture, allows adaptability, easy updating, and future expansion
Acceptance criteria	The "Hub Edge Platform" is deployed and other modules connected to it, exchanging data
Priority	3
Comments	

Id. **1st it.** **1st rev.** **2nd it.** **2nd rev.**

Id.	**SER_081**
Description	[UC3] The Hub Edge Platform shall receive all data coming from local infrastructure, vehicles and devices (via Gateways) and

	distribute them to the respective MEC software modules.
Type	Functional and data requirements
Author	AAE
Rationale	The "Hub Edge Platform" is main receiver, translator and distributor of data / information
Acceptance criteria	Data inputs coming from Gateways and Video feeds.
Priority	3
Comments	

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**SER_082**
Description	[UC3] The Hub Edge Platform shall transmit data, including traffic management information or speed/manoevre instructions to the vehicles in its local area (via Gateways).
Type	Functional and data requirements
Author	AAE
Rationale	The "Hub Edge Platform" is main receiver, translator and distributor of data / information
Acceptance criteria	Data sent out by the Hub Edge Platform are received successfully by the Gateways
Priority	3
Comments	

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**SER_083**
Description	[UC3] The MEC shall have a "Local TMC" module which will run on top of the "Hub Edge", which will process the traffic data.
Type	Functional and data requirements
Author	AAE
Rationale	The Local TMC is the Traffic Management Centre at the Edge, which analyses real-time traffic data
Acceptance criteria	TMC deployed over the Hub Edge
Priority	3
Comments	

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**SER_084**
Description	[UC3] The Local TMC shall calculate the local traffic management

	strategies, for low-latency (<1s).
Type	Performance requirements
Author	AAE
Rationale	The Local TMC needs to respond to urgent events rapidly, for safery reasons
Acceptance criteria	Local perception and traffic strategy updated in under 1s.
Priority	3
Comments	

Id. **1st it.** **1st rev.** **2nd it.** **2nd rev.**

Id.	**SER_085**
Description	[UC3] Video Analytics module shall receive real-time video feed, process it, and transmit the traffic perception info to the Local TMC.
Type	Functional and data requirements
Author	AAE
Rationale	Video analytics are needed for gaining a understanding of traffic status in a certain area. The live feed is analysed via visual algorithms, and translated to "traffic data" (average speed, road occupancy, incidents detencted, etc)
Acceptance criteria	Video feed analysed in real time
Priority	3
Comments	

Id.	**SER_085**
Description	**[UC3] Video Analytics module shall receive real-time video feed, process it, and transmit the traffic perception info to the Local TMC. (also see comments)**
Type	Functional and data requirements
Author	AAE
Rationale	**Video analytics are needed for gaining a understanding of traffic status in a certain area. The live feed is analysed via visual algorithms, and translated to**
Acceptance criteria	Video feed analysed in real time
Priority	3
Comments	**The information that video analytics shall provide about the detected objects is: anonymised unique identifier, type of object (car or pedestrian), coordinates, and, if possible speed and direction.**

Id. **1st it.** **1st rev.** **2nd it.** **2nd rev.**

Id.	**SER_086**
Description	[UC3] The Gateways shall allow the infrastructure (via Hub Edge) to send information to the road users (CAM, CPM, MCM, DENM, IVIM).
Type	The scope of the product
Author	UPC
Rationale	Proposal definition: Page 7 Objective 4; Proposal's FR-01. The Gateways are the point of contact for the vehicles and VRUs with the infrastructure. All communications with such actors must pass through the Gateways

Acceptance criteria	Messages are received in the different OBU's
Priority	5
Comments	

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**SER_087**
Description	[UC3] The Hub Edge Platform shall send and receive data to/from the Hub Cloud Platform.
Type	Functional and data requirements
Author	AAE
Rationale	Local road part data (from MEC) are aggregated into global road data, creating global perception of the traffic status of the road. Stored and processed on the Cloud. Also the Cloud sends data (e.g. global traffic strategies) to the Edge.
Acceptance criteria	Interconnetions between Edge and Cloud are complete and validated.
Priority	3
Comments	

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**SER_088**
Description	[UC3] The Hub Cloud Platform shall contain a data repository, a data management module and data gateway, and interconnects with the Global TMC and other components such as the Shuttle Supervision Service.
Type	Functional and data requirements
Author	AAE
Rationale	Data repository stored the time-series of the Local traffic perceptions, as well as the global traffic perception at any given moment. The Shuttle Supervision Service of Milla will intercommunicate with the infrastructure. The Data management modules ensu
Acceptance criteria	The "Hub Cloud Platform" is deployed including all modules.
Priority	3
Comments	

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**SER_089**	Objection 1397 made by AAE (Harilaos Vasiliadis): Minor clarification: SIE_17: Each	Id. **SER_089**
Description	[UC3] The Global TMC will construct the macroscopic		Description **[UC3] The Global TMC will construct the macroscopic**

	global perception of traffic for multiple parts of the highway, and simulate and select the best global traffic management strategies, in <5s.
Type	Performance requirements
Author	AAE
Rationale	The Global TMC is the Traffic Management Centre at the Cloud, which analyses real time but also "historical" data, and intelligently selects the right TM strategies. The global perception and traffic strategies must be calculated and updated in under 5s.
Acceptance criteria	TMC deployed at the Cloud
Priority	3
Comments	

"section" of the highway... SER_89: ... for multiple "sections" of the highway, ...

» Comment 1 by AAE (Harilaos Vasiliadis):
Hari: Done for SER_089. However the "Rationale" text was cut short due to character limitations.

» Comment 2 by RETE (Manu Cañete):
Changed for SIE_017.

•**SIE_017**

	global perception of traffic for multiple sections of the highway, and simulate and select the best global traffic management strategies, in <5s.
Type	Performance requirements
Author	AAE
Rationale	**The Global TMC is the Traffic Management Centre at the Cloud.**
Acceptance criteria	TMC deployed at the Cloud
Priority	3
Comments	**Rationale: The Global TMC is the Traffic Management Centre at the Cloud, which analyses real time but also "historical" data, and intelligently selects the right TM strategies.**

Id. **1st it.** **1st rev.** **2nd it.** **2nd rev.**

Id.	**SER_090**
Description	[UC3] The Gateways shall enable to transmit Facilities messages over IPv4 over cellular networks
Type	Operational requirements
Author	UPC
Rationale	Proposal definition: Page 7 Objective 4
Acceptance criteria	Messages are received in OBU's connected by cellular network
Priority	5
Comments	

Id. **1st it.** **1st rev.** **2nd it.** **2nd rev.**

Id.	**SER_091**
Description	[UC3] The Gateways shall enable to transmit Facilities messages over LTE-PC5 radio technology
Type	Operational requirements
Author	UPC
Rationale	Proposal definition: Page 7 Objective 4
Acceptance criteria	Messages are received in OBU's connected by LTE-PC5
Priority	5
Comments	

Id. **1st it.** **1st rev.** **2nd it.** **2nd rev.**

Id.	**SER_092**
Description	[UC3] The Gateways shall translate messages

	between different radio technologies
Type	Operational requirements
Author	UPC
Rationale	In order to perform Cooperative Awareness (CA) service, all vehicles should receive CA information from other vehicles, independently on the radio technology that they use
Acceptance criteria	CA information is received by all OBUs
Priority	5
Comments	

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**SER_093**
Description	[UC3] The i2CAT Gateway shall optimize the Cooperative Awareness (CA) information transmitted to road users by aggregating CA information into CPM messages
Type	Operational requirements
Author	UPC
Rationale	In order not to saturate network resources and minimize transmission delay; Proposal's FR-03 and FR-05
Acceptance criteria	CA information is received by all OBUs
Priority	5
Comments	

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**SER_094**
Description	[UC5] Tunnel Risk Level Assessment will be published to make it available to all actors
Type	The scope of the work
Author	LINKS
Rationale	Splitting of the SIE_016 separating calculation and publication OBJ_1417
Acceptance criteria	
Priority	4
Comments	publisher will be a separate entity to the tunnel risk-level assesment service

Added

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**SER_095**

Added

Description	[UC5] Tunnel Risk Level Assesment service will access tunnel's Digital Twin to calculate the current risk level regularly.
Type	The scope of the work
Author	LINKS
Rationale	RLA service uses DT information and it is a separate entity, probably hosted on TCC.
Acceptance criteria	
Priority	4
Comments	this was previously SIE_016 that was supposed to be SER

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**SER_096**
Description	[UC5] RLA (Risk Level Assessment) is monitored by a Risk Manager Service (RMS) and it publishes notifications generated on any risk level change.
Type	The scope of the work
Author	LINKS
Rationale	Publication should be logically separated from RLA calculation.
Acceptance criteria	
Priority	4
Comments	comes from old SIE_025

Added

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**SIE_001**
Description	[UC2] The traffic management system shall send the color of each traffic light in real time with a prediction of the changes in the next N seconds to the platform, each time the color or the estimation change
Type	Functional and data requirements
Author	ETRA I+D
Rationale	Connected vehicles need to know the color of traffic lights ir real time, as well as a prediction of the changes in the next future.
Acceptance criteria	A client that subscribes to receive the changes in traffic lights for a given junction receives the correct informaiton in real time.
Priority	4

Dependency 382 detected by ETRA I+D (MARIA TOMAS): UC4 and UC5 have considered the SIE 010: Edge and cloud should support CAM, IVIM, DENM, MAPEM, SPATEM, VAM. Might it be applicable to UC1, UC2 and UC3 as well? The reason for selecting SIE 001, 002 and 020 with a dependency is just to point out the SIE requirement (SIE 010) and ask the relevant partners for UC1, UC2 and UC3 to check if we can somehow consider this requirement also applicable to all of UCs.

- **SIE_002**

Comments	While the color in real time must be real, the predictions should be considered as mere estimations, as the times of the color changes may be subect to modifications due to actions by the management system and/or traffic controller. The value of N is variable as it depends on the traffic control strategy applied to the junction. The potential receivers of the information must not expect preditions for more than 2 minutes in the future.

• **SIE_010**
• **SIE_020**

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**SIE_002**
Description	[UC1] The infrastructure sensors at the pilot site shall be available including object detectors and shall send their object detections to the edge server/RSU with a frequency of at least 5 Hz.
Type	Functional and data requirements
Author	UDE
Rationale	Infrastructure sensors are required for base line measurements in the use case.
Acceptance criteria	Object detections from infrastructure sensors received by RSU/edge server.
Priority	4
Comments	

Dependency 382 detected by ETRA I+D (MARIA TOMAS): UC4 and UC5 have considered the SIE 010: Edge and cloud should support CAM, IVIM, DENM, MAPEM, SPATEM, VAM. Might it be applicable to UC1, UC2 and UC3 as well? The reason for selecting SIE 001, 002 and 020 with a dependency is just to point out the SIE requirement (SIE 010) and ask the relevant partners for UC1, UC2 and UC3 to check if we can somehow consider this requirement also applicable to all of UCs.

• **SIE_001**
• **SIE_010**
• **SIE_020**

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**SIE_003**
Description	[UC5] The ITS stations shall support CAM, IVIM, DENM
Type	Functional and data requirements
Author	BRE
Rationale	Use of standard communications systems
Acceptance criteria	Messages correctly coded according to ETSI standards and received by CAVs over ITS-G5 channel
Priority	5
Comments	CAM v1.4.1 DENM v2.1.1 IVIM v.2.1.1

Dependency 374 detected by TIM (Ezio Chiocchetti): Reference standard for SIE_003 are defined in COM_005, COM_006 and COM_027

» Comment 1 by TIM (Ezio Chiocchetti):
kept requirement as is

• **COM_005**
• **COM_006**

Conflict 138 detected by CRF (Filippo Visintainer): SPAT and MAP applied to [UC5] per requirement COM_007 while neither vehicle (CAV_017) nor RSU (SIE_003) support SPAT and MAP

» Comment 1 by TIM (Ezio Chiocchetti): *Done*

» Comment 2 by CRF (Filippo Visintainer): *Conflict resolved*

- **COM_007**
- **CAV_017**

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**SIE_004**
Description	[UC5] The ITS stations shall support specific PODIUM messages
Type	Functional and data requirements
Author	BRE
Rationale	Use of standard communications systems
Acceptance criteria	Messages correctly coded according to ETSI standards and received by CAVs over ITS-G5 channel
Priority	5
Comments	Messages generated specifically for handling this scenario must be supported by the system

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**SIE_010**
Description	[UC4, UC5] Edge and cloud should support CAM, IVIM, DENM, SPATEM, MAPEM, VAM
Type	Functional and data requirements
Author	LINKS
Rationale	C-ITS messages should be correctly decoded/encoded by edge cloud applications
Acceptance criteria	Messages correctly decoded/encoded
Priority	5
Comments	

Dependency 375 detected by TIM (Ezio Chiocchetti): Reference standard for SIE_010 are defined in COM_005, COM_006, COM_007 and COM_027

» Comment 1 by TIM (Ezio Chiocchetti): *kept requirement as is*

- **COM_005**
- **COM_006**
- **COM_007**

Dependency 382 detected by ETRA I+D (MARIA TOMAS): UC4 and UC5 have considered the SIE 010: Edge and cloud should support CAM, IVIM, DENM, MAPEM, SPATEM, VAM. Might it be applicable to UC1, UC2 and UC3 as well? The reason for selecting SIE 001, 002 and 020 with a dependency is just to point out the SIE requirement (SIE 010) and ask the relevant partners for UC1, UC2 and UC3 to check if we can somehow consider this requirement also applicable to all of UCs.

- **SIE_001**
- **SIE_002**
- **SIE_020**

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**SIE_011**
Description	[UC5] The position of the GNSS antennas along the tunnel is such as to reach every part of the tunnel

Objection 1417 made by CRF (Filippo Visintainer): 1) I would propose to refer to a system for indoor GNSS signal provision placed inside the tunnel, not simply a GNSS antenna inside the

Id.	**SIE_011**
Description	**[UC5] The system for indoor GNSS signal provision shall cover the entire lenght of the tunnel**

Type	Functional and data requirements
Author	BRE
Rationale	The position of the GNSS antennas along the tunnel is such as to reach every part of the tunnel with a signal above the sensitivity threshold of the GNSS receivers used
Acceptance criteria	GNSS antennas signal is above the sensitivity threshold of the GNSS receivers used
Priority	4
Comments	

tunnel. 2) I don't understand "at least one GPSS antenna"? is it GNSS? what does at least one mean? Do you mean at least in one tunnel (e.g. dir. south/north)?

» Comment 1 by BRE (Paolo Faccin):
The content of the requiremet has been modified to agree with the observations. Furthermore the acceptance criteria has been revised

•**SIE_012**

Type	Functional and data requirements
Author	BRE
Rationale	The position of the GNSS antennas along the tunnel is such as to reach every part of the tunnel with a signal above the sensitivity threshold of the GNSS receivers used
Acceptance criteria	**Antennas should be placed in a way to keep GNSS signal inside the tunnel above the sensitivity of CAVs receivers (> -148 dBm)**
Priority	4
Comments	

Id. **1st it.** **1st rev.** **2nd it.** **2nd rev.**

Id.	**SIE_012**
Description	[UC5] At least one GPSS antenna shall be installed on a tunnel
Type	The scope of the work
Author	BRE
Rationale	Needs to broadcast GNSS signal to CAVs
Acceptance criteria	GNSS Antenna signal is correctly tramitted/received
Priority	5
Comments	

Objection 1417 made by CRF (Filippo Visintainer): 1) I would propose to refer to a system for indoor GNSS signal provision placed inside the tunnel, not simply a GNSS antenna inside the tunnel. 2) I don't understand "at least one GPSS antenna"? is it GNSS? what does at least one mean? Do you mean at least in one tunnel (e.g. dir. south/north)?

» Comment 1 by BRE (Paolo Faccin):
The content of the requiremet has been modified to agree with the observations. Furthermore the acceptance criteria has been revised

•**SIE_011**

Id.	**SIE_012**
Description	**[UC5] A system for indoor GNSS signal provision shall be installed on a tunnel**
Type	The scope of the work
Author	BRE
Rationale	Needs to broadcast GNSS signal to CAVs
Acceptance criteria	GNSS Antenna signal is correctly tramitted/received
Priority	5
Comments	

Id. **1st it.** **1st rev.** **2nd it.** **2nd rev.**

Id.	**SIE_013**
Description	[UC5] RSU sensors shall be able to count and classify vehicles in and out the tunnel in realtime
Type	Functional and data requirements
Author	LINKS
Rationale	
Acceptance criteria	
Priority	5
Comments	

Id. **1st it.** **1st rev.** **2nd it.** **2nd rev.**

Id.	**SIE_014**
Description	[UC5] RSU sensors classification must consider at least the type of vehicle passing by
Type	Functional and data requirements

Author	LINKS
Rationale	
Acceptance criteria	
Priority	4
Comments	

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**SIE_015**
Description	[UC5] Infrastructure shall host a Digital Twin to maintain tunnel information
Type	Functional and data requirements
Author	LINKS
Rationale	The nearest point to the tunnel is the TCC and it will host DT
Acceptance criteria	
Priority	4
Comments	

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**SIE_016**
Description	[UC5] Tunnel Risk Level Assesment service will access tunnel's Digital Twin to calculate the risk level and publish any risky condition to incoming vehicles
Type	Functional and data requirements
Author	LINKS
Rationale	RLA service uses DT information and it is a separate entity, probably hosted on TCC.
Acceptance criteria	
Priority	4
Comments	

Id.	**SIE_016**
Description	**[UC5] Tunnel Risk Level Assesment service will access tunnel's Digital Twin to calculate the current risk level regularly.**
Type	Functional and data requirements
Author	LINKS
Rationale	RLA service uses DT information and it is a separate entity, probably hosted on TCC.
Acceptance criteria	
Priority	4
Comments	

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**SIE_017**
Description	[UC3] Each part of the highway shall feature 1 RSU (incl.5G antenna, gNode), with sufficient connectivity coverage for both directions and all the lanes.
Type	Functional and data requirements
Author	RETE
Rationale	Best balance between number of deployed RSU and signal coverage.
Acceptance criteria	Coverage simulation and checking once deployed.
Priority	4

Objection 1397 made by AAE (Harilaos Vasiliadis): Minor clarification: SIE_17: Each "section" of the highway... SER_89: ... for multiple "sections" of the highway, ...

» Comment 1 by AAE (Harilaos Vasiliadis):
Hari: Done for SER_089. However the "Rationale" text was cut short due to character limitations.

» Comment 2 by RETE (Manu Cañete):
Changed for SIE_017.

•**SER_089**

Id.	**SIE_017**
Description	**[UC3] Each section of the highway shall feature 1 RSU (incl.5G antenna, gNode), with sufficient connectivity coverage for both directions and all the lanes.**
Type	Functional and data requirements
Author	RETE
Rationale	Best balance between number of deployed RSU and signal coverage.
Acceptance criteria	Coverage simulation and checking once deployed.
Priority	4
Comments	

Id.	**SIE_017**
Description	**[UC3] In the Spanish of the highway, at least 4 RSUs with C-V2X will be installed, with sufficient connectivity coverage for both directions and all the lanes and singular spots (i.e. service areas, rest zones...).**
Type	Functional and data requirements
Author	RETE
Rationale	Best balance between number of deployed RSU and signal coverage.
Acceptance criteria	Coverage simulation and

Comments	

	checking once deployed.
Priority	4
Comments	

Id. **1st it.** **1st rev.** **2nd it.** **2nd rev.**

Id.	SIE_018
Description	[UC3] The highway shall be equipped at least 1 MEC from each country (i.e. side of the border). Lenovo SE350 or better performance Edge Served.
Type	Functional and data requirements
Author	RETE
Rationale	According previous experiences in side projects.
Acceptance criteria	Performance assesstment
Priority	4
Comments	

Id.	SIE_018
Description	**[UC3] The highway shall be equipped with at least 2 MECs in the Spanish side and at least 1 MEC in the French side.(i.e. side of the border).**
Type	Functional and data requirements
Author	RETE
Rationale	According previous experiences in side projects.
Acceptance criteria	Performance assesstment
Priority	4
Comments	

Id. **1st it.** **1st rev.** **2nd it.** **2nd rev.**

Id.	SIE_019
Description	[UC3] The highway shall feature at least 2 FullHD cameras, connected and feeding real-time video footage to the local MEC (Edge Hub), directional, wide dynamic range to cover different light conditions, PoE powered, IP67 protection.
Type	Functional and data requirements
Author	RETE
Rationale	Cameras shall cover both directions and all the lanes. Current state-of-the-art makes easy reaching such features.
Acceptance criteria	Check parameters on datasheet
Priority	3
Comments	

Id.	SIE_019
Description	**[UC3] The highway shall feature at least 2 "Full HD" or "4K" cameras, connected and feeding real-time video footage to the local MEC (Edge Hub), directional, wide dynamic range to cover different light conditions, PoE powered, IP67 protection.**
Type	Functional and data requirements
Author	RETE
Rationale	Cameras shall cover both directions and all the lanes. Current state-of-the-art makes easy reaching such features.
Acceptance criteria	Check parameters on datasheet
Priority	3
Comments	

Id.	SIE_019
Description	**[UC3] The highway shall feature at least 5 FullHD or 4K cameras, connected and feeding real-time video footage to the local MEC (Hub Edge).**
Type	Functional and data requirements
Author	RETE
Rationale	Cameras shall cover both directions and all the lanes. Current state-of-the-art makes easy reaching such features.
Acceptance criteria	Check parameters on datasheet
Priority	3
Comments	**RETE shall provide at least 5 cameras, properly deployed to cover singular hotspots. Cameras should be directional, wide dynamic range to cover different light conditions, PoE powered, IP67 protection.**

Id. **1st it.** **1st rev.** **2nd it.** **2nd rev.**

Id.	SIE_020
Description	[UC3] Frequency band for 5G shall be selected according national spectrum for private networks availability (priority for sub-6 bands) and gNode and CPE

Id.	SIE_020
Description	**[UC3] 5G network shall be offered at an available private frequency band. Such frequency band shall be selected according to national spectrum**

Dependency 382 detected by ETRA I+D (MARIA TOMAS): UC4 and UC5 have considered the SIE 010: Edge and cloud should support CAM, IVIM, DENM,

Id.	SIE_020
Description	**[UC3] 5G network shall be offered at an available private frequency band. 5G Network shall cover the whole demo area, both directions, all**

	equipment market maturity.
Type	Functional and data requirements
Author	RETE
Rationale	Spanish spectrum regulator seems to be willing to provide suitable spectrum for 5G private networks deployment. Looking for the best balance between frecuency bands and equipment availability.
Acceptance criteria	Frequency license granted. Equipment availability for such frequency.
Priority	5
Comments	

	for private networds availability (priority for sub-6 bands) and gNode and CPE/UE equipment market maturity.
Type	Functional and data requirements
Author	RETE
Rationale	Spanish spectrum regulator seems to be willing to provide suitable spectrum for 5G private networks deployment. Looking for the best balance between frecuency bands and equipment availability.
Acceptance criteria	Frequency license granted. Equipment availability for such frequency.
Priority	5
Comments	**Clarification for frequency band: to provide the best balance between frequency availability and devices maturity.**

MAPEM, SPATEM, VAM. Might it be applicable to UC1, UC2 and UC3 as well? The reason for selecting SIE 001, 002 and 020 with a dependency is just to point out the SIE requirement (SIE 010) and ask the relevant partners for UC1, UC2 and UC3 to check if we can somehow consider this requirement also applicable to all of UCs.

- **SIE_001**
- **SIE_002**
- **SIE_010**

	lanes and including singular spots (i.e. service area, rest zones...).
Type	Functional and data requirements
Author	RETE
Rationale	Spanish spectrum regulator seems to be willing to provide suitable spectrum for 5G private networks deployment. Looking for the best balance between frecuency bands and equipment availability.
Acceptance criteria	Frequency license granted. Equipment availability for such frequency.
Priority	5
Comments	**Clarification for frequency band: to provide the best balance between frequency availability and devices maturity. 1st option: same frequencies and telcos than 5GMED (Spain: Vodafone n78; France: FreeMobile n78) 2nd option: Private network spectrum (n40, n77, n78, mmW) depending on availability. Such frequency band shall be selected according to national spectrum for public or private networds availability (priority for sub-6 bands) and gNode and CPE/UE equipment market maturity.**

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**SIE_021**
Description	[UC3] The infrastructure shall offer 4G connectivity at the service pickup-dropoff points, for the CAVs to connect to service-oriented applications
Type	Functional and data requirements
Author	RETE
Rationale	The CAV that develops a client-oriented-service need to be able to communicate with the service-dispatcher at least in the libration points
Acceptance criteria	The CAV always reachs communication with its client-service-oriented servers, at some known spots

Dependency 377 detected by LINKS (Guido Gavilanes): CAV_014 depends in the fact that GNSS signals are transmitted inside the tunnel.

» Comment 1 by LINKS (Guido Gavilanes):
this dependency was SIE_012 and not SIE_021; it was a mistake.

» Comment 2 by RETE (Manu Cañete):
SIE_021 keeps unchanged.

- **CAV_014**
- **SYA_001**

	that will usually be pickup-dropoff points
Priority	3
Comments	

Id.	1st it.	1st rev.	2nd it.	2nd rev.
Id.	**SIE_022**			
Description	[UC5] The ITS stations shall support CAM messages v1.4.1			
Type	Functional and data requirements			
Author	BRE			
Rationale	Use of standard communications systems	Added		
Acceptance criteria	Messages correctly coded according to ETSI standards and received by CAVs over ITS-G5 channel			
Priority	5			
Comments				

Id.	1st it.	1st rev.	2nd it.	2nd rev.
Id.	**SIE_023**			
Description	[UC5] The ITS stations shall support DENMmessages v2.1.1			
Type	Functional and data requirements			
Author	BRE			
Rationale	Use of standard communications systems	Added		
Acceptance criteria	Messages correctly coded according to ETSI standards and received by CAVs over ITS-G5 channel			
Priority	5			
Comments				

Id.	1st it.	1st rev.	2nd it.	2nd rev.
Id.	**SIE_024**			
Description	[UC5] The ITS stations shall support IVIM messages v2.1.1			
Type	Functional and data requirements			
Author	BRE			
Rationale	Use of standard communications systems	Added		
Acceptance criteria	Messages correctly coded according to ETSI standards and received by CAVs over ITS-G5 channel			
Priority	5			
Comments				

Id.	1st it.	1st rev.	2nd it.	2nd rev.
Id.	**SIE_025**	Added		

Description	[UC5] RLA (Risk Level Assessment) is monitored by a Risk Manager Service (RMS) and it publishes notifications generated on any risk level change.
Type	The scope of the work
Author	LINKS
Rationale	publication is logically separated from RLA calculation.
Acceptance criteria	
Priority	4
Comments	

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**SYA_001**
Description	[UC4] On-Board Units (OBUs) and Road-Side Units (RSUs) must act as Trusted Computing Bases (TBC) and be able to check software integrity
Type	The scope of the work
Author	LINKS
Rationale	
Acceptance criteria	
Priority	4
Comments	

Dependency 377 detected by LINKS (Guido Gavilanes): CAV_014 depends in the fact that GNSS signals are transmitted inside the tunnel.

» Comment 1 by LINKS (Guido Gavilanes):
this dependency was SIE_012 and not SIE_021; it was a mistake.

» Comment 2 by RETE (Manu Cañete):
SIE_021 keeps unchanged.

- **CAV_014**
- **SIE_021**

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**SYA_002**
Description	[UC4] OBU and RSUs leverage software integrity verification at boot and run time and trigger the proper countermeasures in the event of violations
Type	The scope of the work
Author	LINKS
Rationale	
Acceptance criteria	
Priority	4
Comments	

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**SYA_003**
Description	[UC4] A special node (RSU or MEC or Cloud Server) must be able to challenge OBUs and RSUs for verifying their trust status
Type	The scope of the work
Author	LINKS

Rationale	
Acceptance criteria	
Priority	4
Comments	

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**SYA_004**
Description	[UC4] OBUs and RSUs must have their own digital identity in accordance with X.509-base PKI
Type	The scope of the work
Author	LINKS
Rationale	
Acceptance criteria	
Priority	4
Comments	

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**SYA_005**
Description	[UC4] Communications between from/to OBUs and RSUs must be secured to preserve the data integrity and confidentiality
Type	The scope of the work
Author	LINKS
Rationale	
Acceptance criteria	
Priority	4
Comments	

Id.	1st it.	1st rev.	2nd it.	2nd rev.

Id.	**SYA_006**
Description	[UC4] When and where possible software integrity verification must be implemented in a privacy-preserving manner to avoid identification and linking
Type	The scope of the work
Author	LINKS
Rationale	
Acceptance criteria	
Priority	4
Comments	

Requirement modified on revision
Requirement deleted on revision