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Northern Tyrrhenian Sea Port Authority System

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D2 - Pilot C-ITS infrastructure for the Port of Livorno: Description of IaaS, PaaS and SaaS components

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Abstract:

This deliverable is the outcome of the Article 4.1 of the project URSA MAJOR NEO - Agreement: “Pilot C-ITS infrastructure for the Port of Livorno: Description of IaaS, PaaS and SaaS components”. The document defines the description of IaaS components, i.e. IoT sensors, OBU and (eventual) RSU devices; PaaS components, i.e. platform modules; SaaS components for implementing the analysis framework and the design of IaaS, PaaS, SaaS verification modules.

URSA MAJOR neo

Porti di Livorno, Piombino, Capraia Isola, Portoferraio, Rio Marina, Cavo

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Executive Summary

This deliverable is the second outcome of the URSA MAJOR NEO agreement contract with the Northern Tyrrhenian Sea Port Authority System for the development of a Cooperative Intelligent Transportation System (C-ITS) at the port of Livorno. As detailed in Article 4 “Activity Timeline”, this document provides the description of the IaaS, PaaS and SaaS components.

Table of Acronyms

Acronym	Expanded form
3D	Three-Dimensional
AFV	Alternative Fuel Vehicle
AIS	Automatic Identification System
AMQP	Advanced Message Queuing Protocol
AUTOPILOT	Automated Driving Progressed by Internet of Things
API	Application Programming Interface
CAM	Cooperative Awareness Message
C-ITS	Cooperative Intelligent Transportation Systems
CNIT	Consorzio Nazionale Interuniversitario per le Telecomunicazioni
CoAP	Constrained Application Protocol
DENM	Decentralized Environmental Notification Message
ETSI	European Telecommunications Standards Institute
Fi-Pi-Li	Firenze-Pisa-Livorno
GLOSA	Green Light Optimal Speed Advisory
GPDR	General Data Protection Regulation
GPRS	General Packet Radio Service
H2020	Horizon 2020
HMI	Human-Machine Interface
IaaS	Infrastructure as a Service
ICT	Information and Communication Technologies
IEEE	Institute of Electrical and Electronics Engineers

IoT	Internet of Things
ITS	Intelligent Transportation Systems
IVI	Infrastructure to Vehicle Information
IVIM	IVI-Message
I2V	Infrastructure-to-Vehicle
LoRa	Long Range
LPWAN	Low-Power Wide Area Network
LSPs	Large-Scale Pilots
LTE	Long-Term Evolution
MAPEM	MapData Messages
M2M	Machine-to-Machine
MONI.C.A or MONICA	Monitoring and Control Architecture
MTC	M2M-Type Communications
OBU	On-Board Unit
PaaS	Platform as a Service
PMIS	Port Management Information System
REST	Representational State Transfer
RSU	Road-Side Unit
SaaS	Software as a Service
SGC	Strada di Grande Comunicazione
SPATEM	Signal Phase And Timing Extended Message
TPCS	Tuscan Port Community System
TTG	Time to Green
VGM	Verified Gross Mass

VMS	Variable Message Sign
V2V	Vehicle-to-Vehicle

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1 Introduction

This document provides a description of the IaaS, PaaS and SaaS components that are required to implement the pre-defined C-ITS services at the port of Livorno. The proposed C-ITS architecture is going to be developed in the scope of the Ursa Major Neo project, whose purpose is to optimize the operation of the logistics sector at the Italian pilot site, as well as to enhance safety and efficiency in the port business. Three use case scenarios were previously established, namely the bottleneck removal to prevent and solve potential traffic congestion, the safety information for real-time awareness about road hazards and the smart truck parking for operational fleet management in the port area. The definition and specification of the necessary ICT modules for the implementation of these use cases, involving road assistance to the fleet of trucks, was provided in the first deliverable to the Port Authority. In this second deliverable, the different components for the implementation of the required C-ITS services will be specified, namely in terms of infrastructure (IaaS), platform (PaaS) and software (SaaS). Detailed tenders will be provided in order to list the characteristics necessary for the procurement of the hardware and software modules. Furthermore, the design process of the IaaS, PaaS, SaaS verification modules will also be described.

2 Objective

The C-ITS infrastructure to be deployed at the port of Livorno aims to improve the operation of the logistics sector by enabling a set of Day 1 and Day 1.5 C-ITS services that support three different use case scenarios: bottleneck removal; safety information and smart truck parking. This infrastructure is composed by several components, in an IoT-based approach, that divides the system in 3 different layers:

- the sensors domain that includes the network sensors and actuators (OBUs, RSUs, HMI devices, parking sensors, etc.), as well as the communications infrastructure (e.g. gateways) that allows these sensors to exchange information with the central platform;
- the platform domain constituted by the oneM2M platform and its core services that manages all the IoT data and the interconnection between the sensors and the C-ITS services and third-party applications;
- the service domain composed by the C-ITS applications that need to be implemented in order to provide the basic functionalities behind the operation of the pre-defined use case scenarios.

Figure 1 provides an overview of the proposed C-ITS infrastructure, along with interaction between these three core domains.

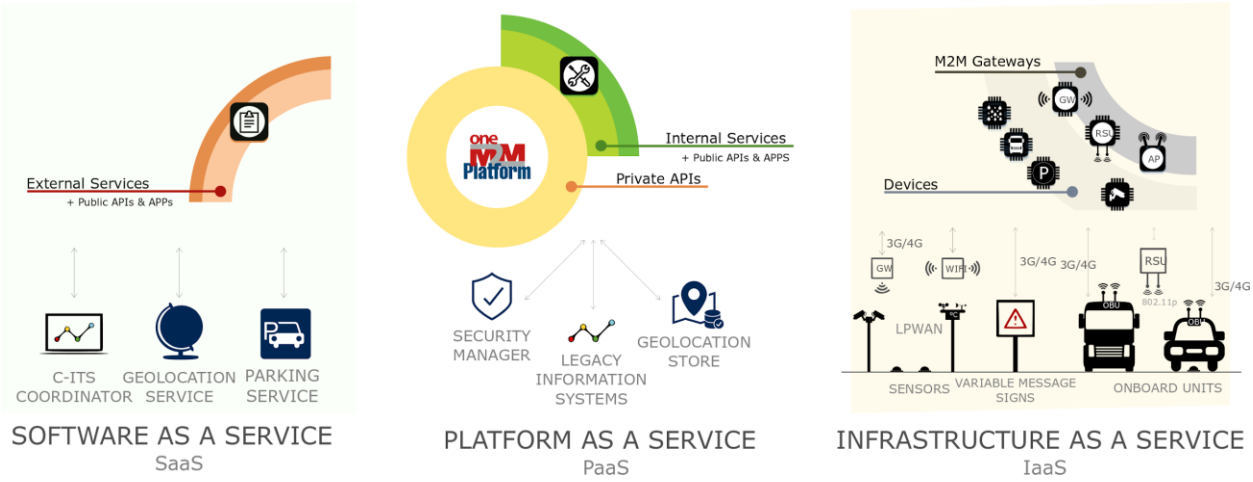


Figure 1 – Overview of the proposed C-ITS infrastructure.

After having defined, in the first deliverable, the overall system's architecture and the required C-ITS services for the implementation of the target use case scenarios, it is now necessary to specify the recommendations for tenders on the distinct system's components. For that purpose, the document will be structured as follows:

- IaaS components, i.e. IoT sensors, OBU and RSU devices;
- PaaS components, i.e. platform modules;
- SaaS components for implementing the analysis framework;
- Design of IaaS, PaaS, SaaS verification modules.

Figure 2 shows the block diagram of the current C-ITS architecture at the Port of Livorno and the building blocks that will need to be added or modified, in order to support the use cases defined in the URSA Major Neo project. In red, one can find the new or upgraded services and their interdependence with the remaining modules.

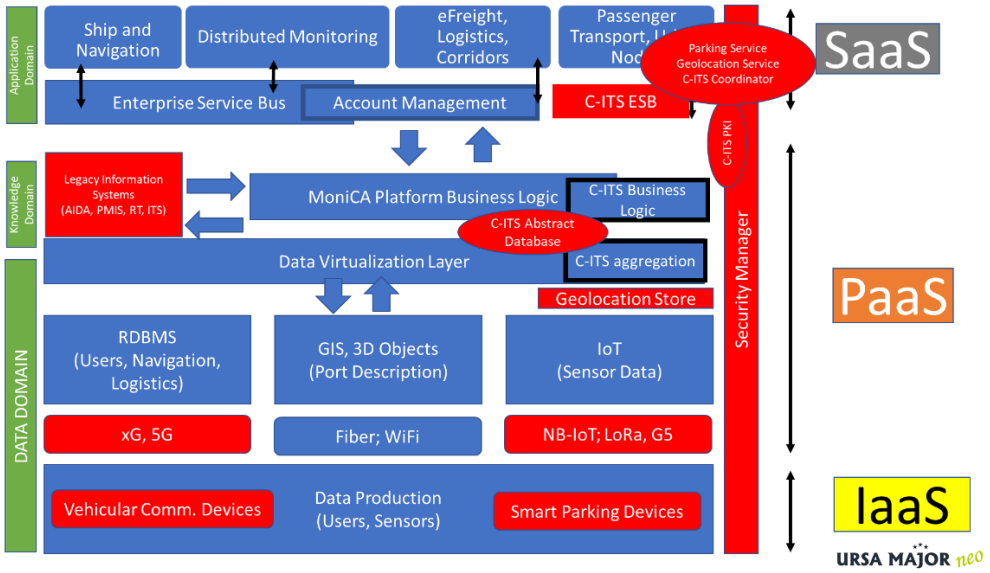


Figure 2 – Block diagram of the C-ITS architecture at the Port of Livorno.

3 IaaS components

In order to implement the intended use cases and C-ITS services, a physical infrastructure will be deployed. This infrastructure can be mainly decomposed in three different packages: the smart parking system; the vehicular communications units; and the internet data plans.

3.1 Smart Parking System

The smart parking system to be installed at the freight village, will be composed of wireless parking sensors that are able to detect the presence of vehicles in individual parking spots. As a result, each parking sensor must provide information regarding the state of a specific parking place, either free or occupied, and must also communicate its own status to the oneM2M platform, for instance if it is working properly or if it is defective. The number of sensors will depend on the desired parking lot coverage. Table 1 provides the details of the IaaS components for the smart parking system. The quantities are merely indicative.

Table 1: IaaS components for the smart parking system use case.

Quantity	Description	Characteristics
50	Wireless parking sensor	- Low-Power Wide Area Network (LPWAN)

		protocol compliance (e.g. LoRa, SigFox, NB-IoT, etc.) - Minimum 5 years of expected battery life - IP67 enclosure (minimum) - Easy installation and without periodic maintenance
1	External connectivity	- IP connection to the oneM2M platform
1	Radio planning and installation	- Sensors installation - Gateway and pole placement and installation (if necessary) - System testing

Regarding the external connectivity component, different solutions are available. For example, if the parking sensors are enabled with NB-IoT technology, there is no need for additional gateway units, since the sensors communicate directly with the cellular network. However, if the solution relies on LoRa technology for instance, relay nodes (gateways) need to be included in order to connect with the oneM2M platform. In this case, the presence of redundant gateways may be beneficial, as they represent single point of failures in the network. Table 2 demonstrates a possible example of the external connectivity component present in table 1, in this case based on LoRa technology. Notice that other technological solutions are available to implement this external connectivity interface, LoRa is just one of the possibilities.

Table 2: Example of the external connectivity component for the smart parking system.

Quantity	Description	Characteristics
2	LoRa gateway	- LoRa protocol compliance for communication with the sensor units - Cellular network connectivity (2G/3G/4G) for IP communications - Minimum 5 years of expected battery life - IP65 enclosure - Pole included - Connectivity support for at least 30 sensors

3.2 Vehicular Communications System

Besides the parking system, vehicular communications platforms will be installed in the truck fleet and along the roadside of the port access route. These units based on Dedicated Short Range Communications (DSRC) technology, will be also equipped with cellular connectivity (LTE) for communications coverage outside the range of the ETSI ITS-G5 RSUs. Additionally, a human-machine interface (e.g. smartphone/tablet) will be available for graphical user interaction, so that the truck driver can visualize the parking lot status and can make reservation of a parking spot in advance, either automatically or in a manual way. Table 3 summarizes the details of the IaaS components for the vehicular communications system. The quantities are merely indicative.

Table 3: IaaS components for the vehicular communications system.

Quantity	Description	Characteristics
25	OBU DSRC platform	- Embedded PC with at least 32-bit operating system - 4GB RAM (minimum RAM capacity) - 16GB eMMC non-volatile storage memory Hard Drive (minimum storage capacity) - 16 GB microSD card industrial class 10 (minimum storage capacity) - Gigabit Ethernet port - USB ports - ETSI ITS-G5 radio module - LTE radio module - GPS positioning module - ETSI ITS-G5, LTE and GPS antenna interfaces (e.g. SMA, USB, etc.) - HMI connection (e.g. USB, Bluetooth, WiFi, etc.) - ETSI ITS-G5 protocol stacks supporting Day 1 and Day 1.5 services specified in the first deliverable - Enclosure automotive grade
25	IEEE 802.11p OBU's antenna	- Multiband, 4-cable Global Cellular/LTE, WiFi & GPS with 2 cables for 5850-5925 MHz frequency band operation - Surface-mount with Truck Mirror Mount adapter - Dust/Water protection: IP67 enclosure
2	RSU DSRC platform	- Embedded PC with at least 32-bit operating system - 4GB RAM (minimum RAM capacity)

		- 16GB eMMC non-volatile storage memory Hard Drive (minimum storage capacity) - 16 GB microSD card industrial class 10 (minimum storage capacity) - Gigabit Ethernet port - USB ports - ETSI ITS-G5 radio module - LTE radio module - GPS positioning module - ETSI ITS-G5, LTE and GPS antenna interfaces (e.g. SMA, USB, etc.) - ETSI ITS-G5 protocol stacks supporting Day 1 and Day 1.5 services specified in the first deliverable - IP65 enclosure
4	IEEE 802.11p RSU's antenna	- 5850-5925 MHz frequency band operation - Screwed to the RSU or Pole mount - IP65 enclosure
4	RSU LTE antenna	- Screwed to the RSU or Pole mount - IP65 enclosure
25	OBU's GPS antenna	- Magnetic mount - IP65 enclosure
2	RSU's GPS antenna	- Pole/Surface mount - IP65 enclosure
25	OBU's power supply regulator transformer	- DC-to-DC converter with power supply regulator transformer (input voltage from truck's power supply) - DC vehicle connector - 1m minimum cable length
2	RSU's power adapter	- Input voltage: 230V AC - 1m minimum cable length - Class 2 – IP67 enclosure
25	Human-Machine Interface (HMI)	- Connection with the DSRC platform (e.g. USB, WiFi, Bluetooth, etc.) - Interactive display (e.g. smartphone/tablet)
1	System installation	- RSUs and OBUs installation

		- System testing

3.3 Internet Data Plans

Finally, it is also necessary to guarantee cellular network connectivity in the OBU and RSU nodes, in order to enable hybrid communications in the vehicular network. For that purpose, internet plans with 24 months contract duration need to be established for the operation of the DSRC platforms. Furthermore, if the wireless parking system includes relay nodes for the communications between the sensor nodes and the oneM2M platform, the gateway units will also required a 24 months internet plan. Table 4 summarizes the details of the IaaS components for the vehicular communications system. The quantities are merely indicative.

Table 4: IaaS components for the internet data plans.

Quantity	Description	Characteristics
25	4G LTE internet plan (OBU)	- SIM cards - 24 months contract - 5GB/month (minimum data traffic)
2	4G LTE / Fiber internet plan (RSU)	- SIM cards (in case of 4G plan) - 24 months contract - 5GB/month (minimum data traffic)
2	4G LTE / Fiber internet plan (Gateway, if relay nodes are installed in the wireless parking system)	- SIM cards (in case of 4G plan) - 24 months contract - 5GB/month (minimum data traffic)

4 PaaS components

In the next sections the following naming convention will be the followed:

All components will be identified as **YX_AAZ.**

Where **Y** is the major component number, namely :

C - PAAS component number

S - SAAS component number

and **X** is the number providing an ordering within each major component.

AA represents the component subtype, namely :

FN - Component Function

IN - Component Interface

and **Z** is the number providing an ordering within each component.

The following conventions will be used for service requirement naming:

All requirements will be named as:

SR-XXX-[component]_NNN/VER

Where **XXX** represents the type of software requirement, namely:

CON - Software Configuration and Delivery

FUN - Functional

IMP - Design and Implementation Constraints

INT - Interfaces

OPE - Operational

PER - Performance

VVA - Verification, Validation and Acceptance

NNN is the number providing an ordering within each component. In the event of any conflict between the requirements and the specification, the latter shall govern.

VER is the issue of this document where the requirement was introduced or last changed

If the requirement applies to the entire component, the subcomponent identifier shall be omitted (YY_NNN instead of YY_AAZ_NNN).

The following components shall be integrated into oneM2M and MONI.C.A platforms: Geolocation Store (P**1**), C-ITS Abstract Database (P**2**), Legacy Information Systems (P**3**) and Security Manager (P**4**).

4.1 P1 - Geolocation Store

A geolocation data entity used to store ongoing road traffic events and vehicle positions. It enables the platform to answer in real-time to different requests, such as and not limited to approaching

vehicles, vehicles within a specific area or nearby vehicles.
The geolocation store is updated by the Geolocation Service through a pair of unique identifier and geolocalization point. Using only an unique identifier instead of the all message, it is expected to improve the database query performance.
Open source solutions, such as Tile38, can be used to assist the implementation of this platform component.

4.1.1 Service Requirements

Table 5: P1 Service Requirements

ID	Description
SR_FUN_P1_001	An authenticated client shall be capable of requesting notifications when a new object enters or exits a specific area (defined by radius or polygon)
SR_PER_P1_001	The store shall be optimized for storing and querying data that represents objects defined in a geometric space.
SR_FUN_P1_002	An authenticated client shall be able to create, remove or update ongoing geofences.
SR_FUN_P1_003	An authenticated client shall be capable of making spatial index queries with search methods such as nearby and within.
SR_INT_P1_001	An authenticated client shall be capable to subscribe to events (through webhooks, pub/sub channels or similar solutions)
SR_OPE_P1_001	It shall be an in-memory database.
SR_IMP_P1_002	It shall be easily scalable.
SR_CON_P1_001	The configuration aspects applicable for the project shall be defined in the Software Configuration Management Plan.
SR_INS_P1_001	Instructions shall be produced regarding the software installation.

4.2 P2 - C-ITS Abstract Database

A highly scalable database, used to persist data. It offers both geospatial and time range queries.

4.2.1 Service Requirements

Table 6: P2 Service Requirements

ID	Description
SR_PER_P2_001/1.0	It shall hold increasing amounts of data without sacrificing query performance
SR_PER_P2_002/1.0	The store shall be optimized for storing and querying data that represents objects defined in a geometric space.
SR_PER_P2_003/1.0	The store shall be optimized for storing and querying data defined in a time interval.
SR_FUN_P2_001/1.0	An authenticated client shall be capable of requesting all valid events.
SR_FUN_P2_002/1.0	An authenticated client shall be capable of with search methods such as nearby and within.
SR_FUN_P2_002/1.0	An authenticated client shall be capable of making time index queries with search methods such as between and since.
SR_OPE_P2_001/1.0	All data shall persist on disk.
SR_IMP_P2_002/1.0	It shall be easily scalable.
SR_CON_P2_001/1.0	The configuration aspects applicable for the project shall be defined in the Software Configuration Management Plan.
SR_INS_P2_001/1.0	Instructions shall be produced regarding the software installation.

4.3 P3 - Legacy Information Systems

The Legacy Information Systems component is responsible for interconnecting the oneM2M platform at the Port of Livorno with external sources of data, such as local or national ITS systems, other traffic management entities and weather or traffic related services (e.g. Waze, Google Traffic, Bing Traffic and Accuweather). The main goal is to retrieve information from those external sources, processing and transforming it into adequate and predefined data structures that can be published to specific oneM2M platform endpoints. Nevertheless, this module should also be developed by taking into account the possible future need of making data available to

external traffic management entities. An example of possible data types exchanged by this service are: the DATEX II encoded messages published by the National ITS station(s) and local ITS stations (e.g. road operators) and the retrieval of traffic data from external APIs. Regarding the DATEX II messages from certified external authorities, it should be also possible to forward this information to the RSUs without passing through the oneM2M platform.

The following set of data is of uttermost importance to the operation of the C-ITS Coordinator and should be gathered by the Legacy Information Systems module:

- Traffic prediction;
- Real Time Traffic information;
- Rerouting;
- Public Safety messages;
- Weather reports.

The most relevant information is then made available to the on-board units in the fleet of trucks, in order to implement the bottleneck removal scenario. In this use case, the C-ITS platform must validate the alternative routes suggested by third parties before forwarding them to the vehicles. The notifications of interest to the drivers are displayed in the HMI connected to each vehicle OBU and are received on a publisher-subscriber basis.

Figures 3 and 4 show a possible implementation of the Legacy Information Systems service. It offers the coding and decoding directives of different message types and encoding rules; such as and not limited to: CAMs, DENMs, IVIMs, SPATEMs, MAPEMs, DATEX II and the corresponding packet encoding rules. It allows the abstraction of service logic technical and implementation details from the consumers. Thus, external Data Providers can request data through the Enterprise Service Bus public APIs, which operates as a mediator with the platform data stores. On the other hand, the data collector, is constantly polling or subscribing to changes on external endpoints feeding the platform with the most recent data. The presented components shall be only used as a reference, a different implementation can be proposed.

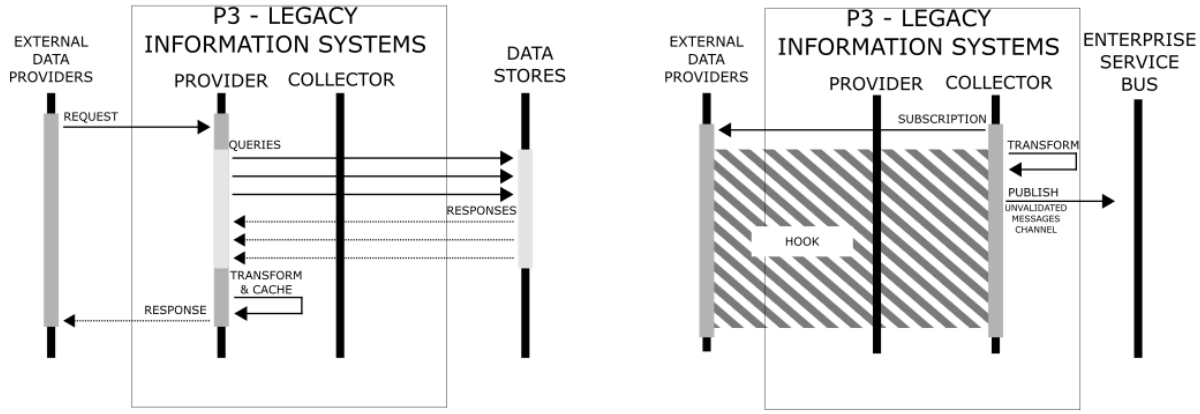


Figure 3 - Sequence Diagrams: Legacy Information Systems Service.

4.3.1 Service Components

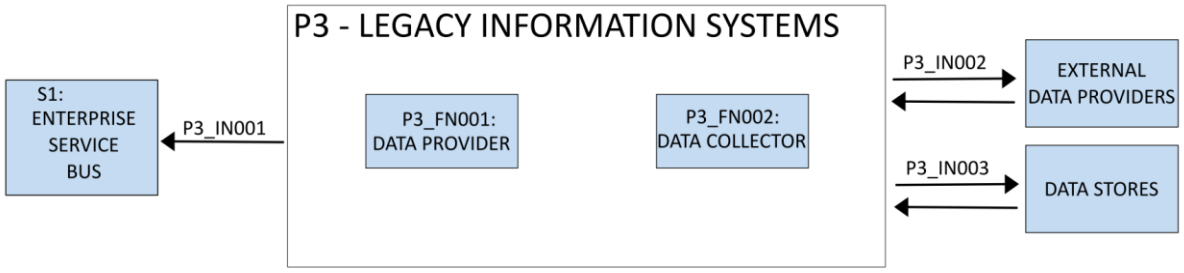


Figure 4 - Functional Block Diagram: Legacy Information Systems.

Table 7: P3 Service Components

ID	Description
P3_FN001	It collects and compiles information stored on the platform to distribute to other organizations. It reduces external dependencies to internal platform components.
P3_FN002	It collects and transforms data from multiple external data providers, either through subscription or periodically checking for updates. It allows services to be abstracted from external APIs technical details. It feeds the platform with extra information.

P3_IN001	Internal inter-component interface, used to publish data to the Enterprise Service Bus (P3) either through a messaging or RESTful communication.
P3_IN002	An interface by which the platform may conduct asynchronous dialogues (message interchanges) with external providers to request traffic related data.
P3_IN003	An internal inter-component interface by which the may conduct asynchronous dialogues to request traffic related data.

4.3.2 Service Requirements

4.3.2.1 Global

Table 8: P3 Global Service Requirements

ID	Description
SR-OPE_P3_001/1.0	The service shall be modular, easily integrated and loosely coupled.
SR-OPE_P3_002/1.0	The service components shall be independently scalable.
SR-IMP_P3_001/1.0	The service requirement analysis shall be performed using UML, including the production of use cases and interaction diagrams for the various message types.
SR-IMP_P3_001/1.0	The service design shall be performed using UML.
SR-CON_P3_002/1.0	The configuration aspects applicable for the project shall be defined in the Software Configuration Management Plan.
SR-INS-P3_001/1.0	Instructions shall be produced regarding how to install the software for any software components, interfaces and functions delivered for deployment .
SR-FUN-P3_003/1.0	The service shall provide the most up-to-date information at every request.

4.3.2.2 P3_FN001 - Data Provider

Table 9: P3 Data Provider Service Requirements

ID	Description
SR-FUN-P3_FN001_001/1.0	It shall be able to publish traffic management information according to the DATEX II protocol or other Facilities Layer message formats from the ETSI ITS standards.
SR-FUN-P3_FN001_002/1.0	It shall allow external services to request data regarding the current road traffic status.
SR-FUN-P3_FN001_003/1.0	It shall allow external services to request road traffic data regarding a specific timeframe.
SR-FUN-P3_FN001_004/1.0	It shall allow external services to request road traffic data regarding a specific area.
SR-FUN-P3_FN001_005/1.0	When a request is received it shall be decomposed in the appropriate data store queries and the response shall be published in the appropriate channels.

4.3.2.3 P3_FN002 - Data Collector

Table 10: P3 Data Collector Service Requirements

ID	Description
SR-FUN-P3_FN002_001/1.0	It shall automatically collect and filter traffic and weather information from the National ITS Station, other traffic management entities (typically in DATEX II protocol) and 3rd Party services (Google Traffic, Waze, AccuWeather, etc.)
SR-FUN-P3_FN002_002/1.0	It shall filter data in order not to publish duplicated information.
SR-FUN-P3_FN002_003/1.0	It shall decompose the received data and publish it into appropriate channels/topics/resources in the corresponding data formats (typically ETSI ITS Facilities Layer message formats, i.e. CAMs, DENMs, IVIMs, SPATEMs, MAPEMs).

4.3.3 Service Specifications

Regarding the module interface P3_IN001, the Legacy Information Systems shall communicate with the other components of oneM2M platform by using the following specifications:

Table 11: P3 (Internal) Communication Specifications

Network Protocol	**Transport Protocol**	**Application Layer**	**Message Type**
IPv4/IPv6	TCP	AMQP, HTTPs	CAM/DENM/IVIM/MAPEM/ SPATEM

For exchanging information (P3_IN002) with the National ITS Station, other traffic management entities and 3rd Party services (Google Traffic, Waze, AccuWeather, etc.), the Legacy Information Systems must use the following specifications:

Table 12: P3 (External) Communication Specifications

Network Protocol	**Transport Protocol**	**Application Layer**	**Message Type**
IPv4/IPv6	TCP	Websocket, HTTPs	DATEX II or 3rd Parties Data Formats

As a result, the Legacy Information Systems service is responsible for translating the external information received from the National ITS Station, other Traffic Management Entities and 3rd Party Applications (either in DATEX II or other data formats) into Facilities messages published to the platform. Conversely, if any external entity requires access to the oneM2M platform data, the Legacy Information Systems also needs to aggregate the Facilities messages and translate the information into DATEX II or other message structure.

4.4 P4 - Security Manager

The Security Manager is responsible for managing all security aspects of the C-ITS pilot site. It issues, monitors and authenticates different actors credentials, granting them access to ITS communications and services. The Security Manager also holds the task of managing the

whole life cycle of the security certificates and provides an appropriate protection of ITS users' privacy, through pseudonymity and unlinkability solutions. This module has to be integrated with the previously developed Public Key Infrastructure (PKI).

Figures 5 and 6 show a possible implementation of the Security Manager Service. Upon the reception of a message from an untrustworthy source, the Certificate Authority Module validates the message and publishes it to the appropriate channel (resource or topic). The misbehavior control will analyse the incoming message and audit the behaviour of the communication entity, releasing a report. Reports and requests from the TMC can trigger authorization changes that will be propagated to the CA through the emission of new certificates or the update of the CRL and TSL.

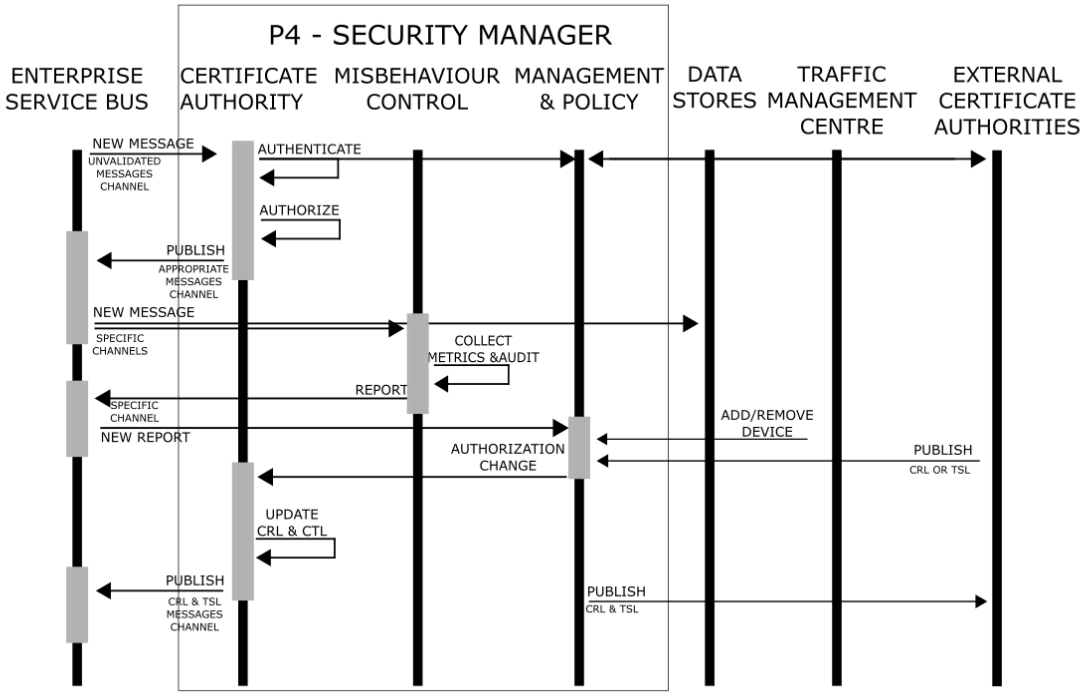


Figure 5 - Sequence Diagram: Security Manager Service.

4.4.1 Service Components

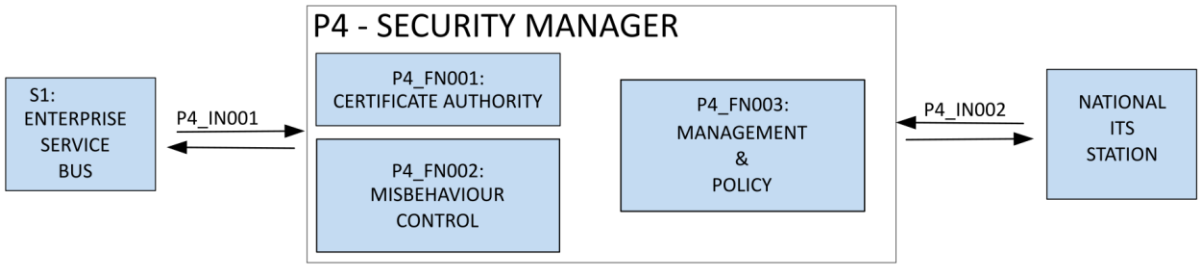


Figure 6 - Functional Block Diagram: Security Manager Service.

Table 13: P4 Service Components

ID	Description
P4_FN001	It is responsible for validating traffic related messages being sent to the platform. Moreover, it issues and monitors both Pseudonym and Enrollment certificates, keeping the correspondent attribution list. It is also responsible for issuing and signing Certificate Trust List (CTL) and Certificate Revocation List (CRL).
P4_FN002	The Misbehaviour Control, is responsible for auditing the behaviour of all communication entities and is also capable of revoking or permitting access to specific resources.
P4_FN003	The Management & Policy module is responsible for establishing and contributing to a secure communication exchange between all entities of the trust model. It is also responsible for the discovery of components, services and devices endpoints.

4.4.2 Service Requirements

4.4.2.1 Global

Table 14: P4 Global Service Requirements

ID	Description
SR-OPE-P4_001/1.0	The service shall be modular, easily integrated and loosely coupled.
SR-OPE-P4_002/1.0	The service components shall be independently scalable.

SR-IMP-P4_001/1.0	The service requirement analysis shall be performed using UML, including the production of use cases and interaction diagrams for the various message types design shall be performed using UML.
SR-IMP-P4_002/1.0	The service design shall be performed using UML.
SR-CON-P4_001/1.0	The configuration aspects applicable for the project shall be defined in the Software Configuration Management Plan.
SR-INS-P4_001/1.0	Instructions shall be produced regarding how to install the software for any software components, interfaces and functions delivered for deployment .

4.4.2.2 P4_FN001 - Certificate Authority

Table 15: P4 Certificate Authority Service Requirements

ID	Description
SR-FUN-P4_FN001_001/1.0	Any message from an unreliable source shall be validated.
SR-FUN-P4_FN001_002/1.0	It shall be able to check the authorization of a registered device.
SR-FUN-P4_FN001_003/1.0	It shall be able to emit/revoke enrollment certificates to other services.
SR-FUN-P4_FN001_004/1.0	It shall emit both the CTL and CRL.
SR-FUN-P4_FN001_005/1.0	It shall be able to emit/revoke pseudonym certificates to vehicles.
SR-FUN-P4_FN001_006/1.0	It shall keep a list of which certificates were emitted to every device/component/service.
SR-FUN-P4_FN002_007/1.0	It shall handle the communication with other CAs.

4.4.2.3 P4_FN002 - Misbehaviour Control

Table 16: P4 Misbehaviour Control Service Requirements

ID	Description
SR-FUN-P4_FN002_001/1.0	It shall be possible to give different resource access levels to registered components/devices/services.
SR-FUN-P4_FN002_002/1.0	It shall give accountability by keeping a list of all the authorizations provided.
SR-FUN-P4_FN002_003/1.0	It shall be possible to revoke authorization of already registered devices.
SR-FUN-P4_FN002_004/1.0	It shall be able to check the authorization of a registered device.
SR-FUN-P4_FN002_005/1.0	It shall audit and report on misbehaving devices.

4.4.2.4 P4_FN003 - Management & Policy

Table 17: P4 Management & Policy Service Requirements

ID	Description
SR-FUN-P4_FN003_001/1.0	It shall be possible to identify any registered component by its unique identifier.
SR-FUN-P4_FN003_002/1.0	It shall provide service discovery.
SR-FUN-P4_FN003_003/1.0	An unreliable source of information shall be able to register.
SR-FUN-P4_FN003_004/1.0	Upon device registration, a new channel/resource/topic shall be created at the Enterprise Service Bus.
SR-FUN-P4_FN003_005/1.0	It shall handle the communication with other CA.

4.4.3 Service Specifications

Regarding the module interfaces, the Security Manager has to communicate with the oneM2M platform using the following specifications:

Table 18: P4 (Internal) Communication Specifications

Network Protocol	Transport Protocol	Application Layer	Message Type

IPv4/IPv6	TCP	REST	CTL, CRL, Pseudonym Certificate List

For exchanging information with the National ITS Station, the Security Manager must use the following specifications:

Table 19: P4 (External) Communication Specifications

Network Protocol	Transport Protocol	Application Layer	Message Type
IPv4/IPv6	TCP	REST	CTL, CRL

As a result, the Security Manager replies to security requests coming from the oneM2M platform, by providing information regarding the Certificate Trust List (CTL), Certification Revocations List (CRL) and the Pseudonym Certificate List. Similarly, the Security Manager exchanges CTL and CRL information with the National ITS station, by issuing ETSI ITS related security requests and obtaining the corresponding responses.

5 SaaS components

The following modules shall be integrated in the oneM2M and MONI.C.A platforms: C-ITS Enterprise Service Bus (S1), Geolocation Service (S2), C-ITS Coordinator (S3) and Parking Service (S4).

5.1 S1 - C-ITS Enterprise Service Bus

It is the pillar for asynchronous communication between different services. It allows services to scale independently, reduces direct dependencies between services, hides implementation details. It immediately rejects invocations for a timeout period after the number of consecutive failures exceeds a specified threshold. It offers prioritization of requests, handles open connections and removes direct communication between the client and the Information Management. The C-ITS Enterprise Service Bus is the connection point between the various

architecture components. New resources/channels/topics can be created with different delivery guarantees, priorities and data types.
During the registration devices/services/components receive a unique identifier, a channel is also created which can be used to communicate with the registered device. Inter service communication is therefore enabled, since it ensures that every service can be contacted through its unique channel.
The necessary APIs described in this document must be integrated into the previously developed WSO2 implementation of the Enterprise Service Bus.

Table 20: S1 Service Requirements

ID	Description
SR_FUN_S1_001/1.0	This component shall allow authenticated users to create new channels/resources/topics with different delivery guarantees, priorities, security profiles and data types.
SR_FUN_S1_002/1.0	All channels/resources/topics shall have a unique identifier.
SR_FUN_S1_003/1.0	This module shall route messages to one or more destinations
SR_FUN_S1_004/1.0	It shall provide content and topic-based message routing using the publish–subscribe pattern
SR_PER_S1_001/1.0	It shall respond rapidly enough to all message receptions that sensible time-out parameters.
SR_IMP_S1_001/1.0	It shall be easily scalable.
SR_CON_S1_001/1.0	The configuration aspects applicable for the project shall be defined in the Software Configuration Management Plan.
SR_INS_S1_001/1.0	Instructions shall be produced regarding the software installation.

5.2 S2 - Geolocation Service

The aim of the Geolocation Service is to deliver up-to-date information to all vehicles connected to the oneM2M platform. In order to do so, it is necessary to be aware of the position of each vehicle, so that the relevant data in each geographic area is correctly delivered to all users. For that purpose the oneM2M platform receives and processes the latest CAMs and stores

the most recent positions of the vehicles in a geospatial database. This way, by consulting the platform database, the Geolocation Service can forward the incoming information regarding specific areas solely to the subscribed vehicles present in those regions. It also plays a key role in the communications system by deciding at each moment the most appropriate technology (cellular or ITS-G5) to disseminate the information to the road vehicles, depending on the network coverage of each technology. For instance, if the vehicle is within RSU coverage area, the Geolocation Service will decide to forward the messages through the ETSI ITS-G5 network, otherwise cellular communications will be employed.

Figures 7 and 8 show a possible implementation of the Geolocation Service. Clients are applications requesting georeferenced information regarding up-to-date road traffic information. Requests can be made by open APIs, hiding the technical details of the service. The request handlers offer prioritization of requests, authentication of clients and different request handlers can co-exist in order to divide the workload (either divided by client service, or message type e.g., CAM, DENM). On the other hand, the information manager is constantly polling or subscribing to changes on external endpoints feeding the platform with the most recent data, so that the position and status of the assets can be monitored in real-time. This function manages a list of available ITS Stations. It keeps the most updated status information of each ITS Station. The stored data is used to identify relevant endpoints to new traffic information. The presented components shall be only used as a reference, a different implementation can be proposed.

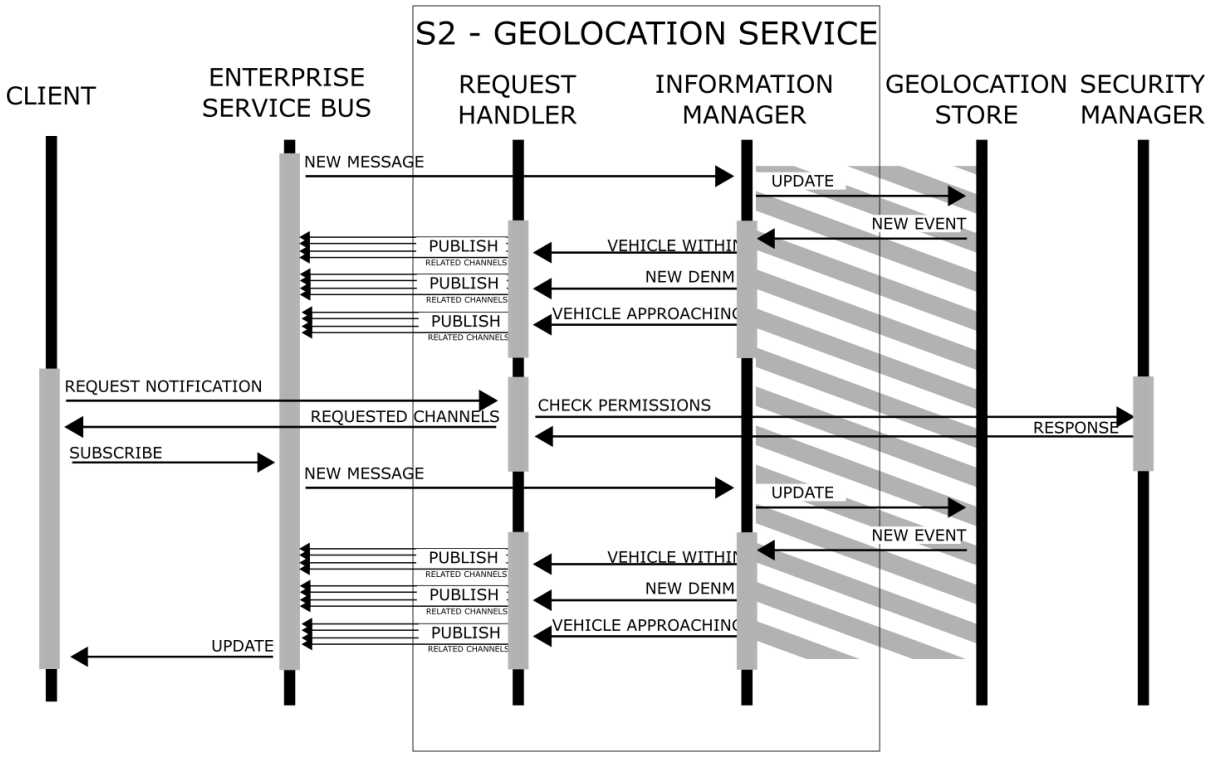


Figure 7 - Sequence Diagram: Geolocation Service.

5.2.1 Service Components

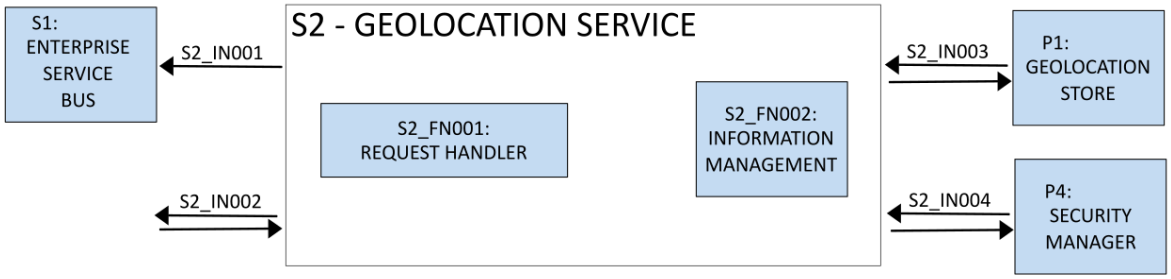


Figure 8 - Functional Block Diagram: Geolocation Service.

Table 21: S2 Service Components

ID	Description
S2_FN001	A message handler that immediately rejects invocations for a timeout period after the number of consecutive failures exceeds a specified threshold. It offers prioritization of requests, handles open connections and removes direct communication between the client and the Information Management.
S2_FN002	It holds the Geolocation Service business logic. It combines multiple queries to answer more complex requests. It can predict traffic jams and the affected vehicles.

5.2.2 Service Requirements

5.2.2.1 Global

Table 22: S2 Global Service Requirements

ID	Description
SR-OPE_S2_001/1.0	The service shall be modular, easily integrated and loosely coupled.
SR-OPE_S2_002/1.0	The service components shall be independently scalable.
SR-IMP_S2_001/1.0	The service requirement analysis shall be performed using UML, including the production of use cases and interaction diagrams for the various message types.
SR-IMP_S2_001/1.0	The service design shall be performed using UML.
SR-CON_S2_002/1.0	The configuration aspects applicable for the project shall be defined in the Software Configuration Management Plan.
SR-INS-S2_001/1.0	Instructions shall be produced regarding how to install the software for any software components, interfaces and functions delivered for deployment.

5.2.2.2 S2_FN001 - Request Handler

Table 23: S2 Request Handler Service Requirements

ID	Description
SR-FUN-S2_FN001_001/1.0	A valid DENM shall be published to an RSU channel if: - The RSU distance to the event is smaller or equal to the event relevanceDistance - The RSU distance to the event is smaller or equal to 500m.
SR-FUN-S2_FN001_002/1.0	A valid IVIM shall be published to an RSU channel if: - The RSU distance to the IVIM GeographicLocationContainer ReferencePosition is smaller than 500m.
SR-FUN-S2_FN001_003/1.0	Valid MAPEMs and SPATEMs shall be published to an RSU channel if: - The defined intersection is within RSU coverage area.
SR-FUN-S2_FN001_004/1.0	A valid DENM shall be published to a vehicle channel if: - The vehicle isn't in the RSU coverage area - The vehicle distance to the event is smaller or equal to the event relevanceDistance - The vehicle is moving towards the event
SR-FUN-S2_FN001_005/1.0	A valid CAM shall be published to a vehicle channel/resource/topic only if one of the following applies: - The vehicle 802.11p interface is faulty and the vehicle distance to the CAM referencePosition of the transmitting vehicle is smaller than 500m. - There is no RSU on the vicinity and the CAM defines a ProtectedCommunicationZone.
SR-FUN-S2_FN001_006/1.0	A valid IVIM shall be published to a vehicle channel if: - The vehicle distance to the GeographicLocationContainer ReferencePosition is smaller than 500m. - There is no RSU on the vicinity.

SR-FUN-S2_FN001_007/1.0	Valid MAPEMs and SPATEMs shall be published to a vehicle channel if: - There is no RSU on the vicinity. - The vehicle is approaching the defined intersection.
SR-FUN-S2_FN001_008/1.0	The Parking service shall be able to subscribe to notifications on approaching vehicles.
SR-FUN-S2_FN001_009/1.0	Clients shall be able to subscribe to events on a specific geofence. They shall be able to make spatial index queries with search methods such as approaching, within and nearby.
SR-IMP-S2_FN001_001/1.0	It shall guarantee message reception.
SR-IMP-S2_FN001_002/1.0	It shall be capable of prioritizing communication depending on data and destination.

5.2.2.3 S2_FN002 - Information Manager

Table 24: S2 Information Manager Service Requirements

ID	Description
SR-FUN-S2_FN002_001/1.0	The service shall keep an updated record of the following ITS stations attributes: - Heading - Speed - Latitude - Longitude - Driving Direction
SR-FUN-S2_FN002_002/1.0	The service shall translate the ETSI ITS Facilities messages into appropriate Geolocation Store inputs.
SR-FUN-S2_FN002_003/1.0	The service shall translate Geolocation Store outputs into appropriate ETSI ITS Facilities message.
SR-FUN-S2_FN002_004/1.0	It shall keep the Geolocation Store updated. Namely, remove canceled or outdated events, keep data consistent and ensure that vehicle position is updated correctly.

SR-FUN-S2_FN002_005/1.0	It shall create message unique identifiers to be used on the Geolocation store.
SR-FUN-S2_FN002_006/1.0	It shall keep a map of all valid event identifiers in use.
SR-FUN-S2_FN002_007/1.0	It shall keep a map of all valid vehicle identifiers.
SR-PER-S2_FN002_001/1.0	The service accuracy shall be less than 10 meters.

5.2.3 Service Specifications

Regarding the module interfaces, the Geolocation Service has to communicate with the oneM2M platform using the following specifications:

Table 25: S2 (Internal) Communication Specifications

Network Protocol	Transport Protocol	Application Layer	Message Type
IPv4/IPv6	TCP	AMQP, HTTPs, MQTTs	Defined by Service + CAM/DENM/IVIM/MAPEM/ SPATEM

As a result, whenever a new event is published into the platform, the Geolocation Service consumes this information, compares the information coverage area with the station positions and forwards it through the most appropriate communications channel. For this to work, the geospatial database needs to be properly implemented, i.e. the Geolocation Service needs to constantly store the most recent position of each vehicle in the oneM2M platform.

5.3 S3 - C-ITS Coordinator

The C-ITS Coordinator provides a console for the monitoring of the whole traffic system, being a frontend application of the oneM2M platform. It offers a set of tools for monitoring, controlling and managing the traffic at the port of Livorno and its access routes. It incorporates for instance, a web platform that allows the real-time visualization of each vehicle in the fleet of trucks and the state of each IoT sensor, e.g. parking spot occupation. The C-ITS Coordinator should also permit the integration and cross-validation of events with captured images from different traffic cameras. Based on all the available information, it can also be utilized to check past events and vehicle itineraries, as well as local and global traffic statistics.

Figures 9 and 10 show a possible implementation of the C-ITS Coordinator service. Before getting access to the web platform an user must be authenticated. During the authentication process the user is redirected by the Data Presentation to the Security Manager through the Auth User Interface page. The SM checks the user permissions and emits the unique authorization token wich can be used as unique communication channel/token/resource. Upon accessing the home page, the user is presented with a map of the port of livorno with all ongoing events and currents vehicle positions. Through the map, the user can access the security cameras feed, a RSU or vehicle information, create, update or cancel new events and request information on past events.

When the user accesses the vehicle page, all the information about a specific vehicle is presented, such as cargo, last and next stops, current position, velocity and heading. This a clear example of the CAM aggregation use case. In the vehicle information page, a user can notify a vehicle through a IVIM, request an alternative route, or reserve a parking spot. An additional use case will also be implemented, handling the weight verification requirement of the trucks vehicles at the port entrance. For that purpose, the Verified Gross Mass (VGM) value will be measured in a scale and this information will be stored in the oneM2M platform and displayed both at the web platform of the C-ITS Coordinator and at the Human-Machine Interface of the corresponding OBU device.

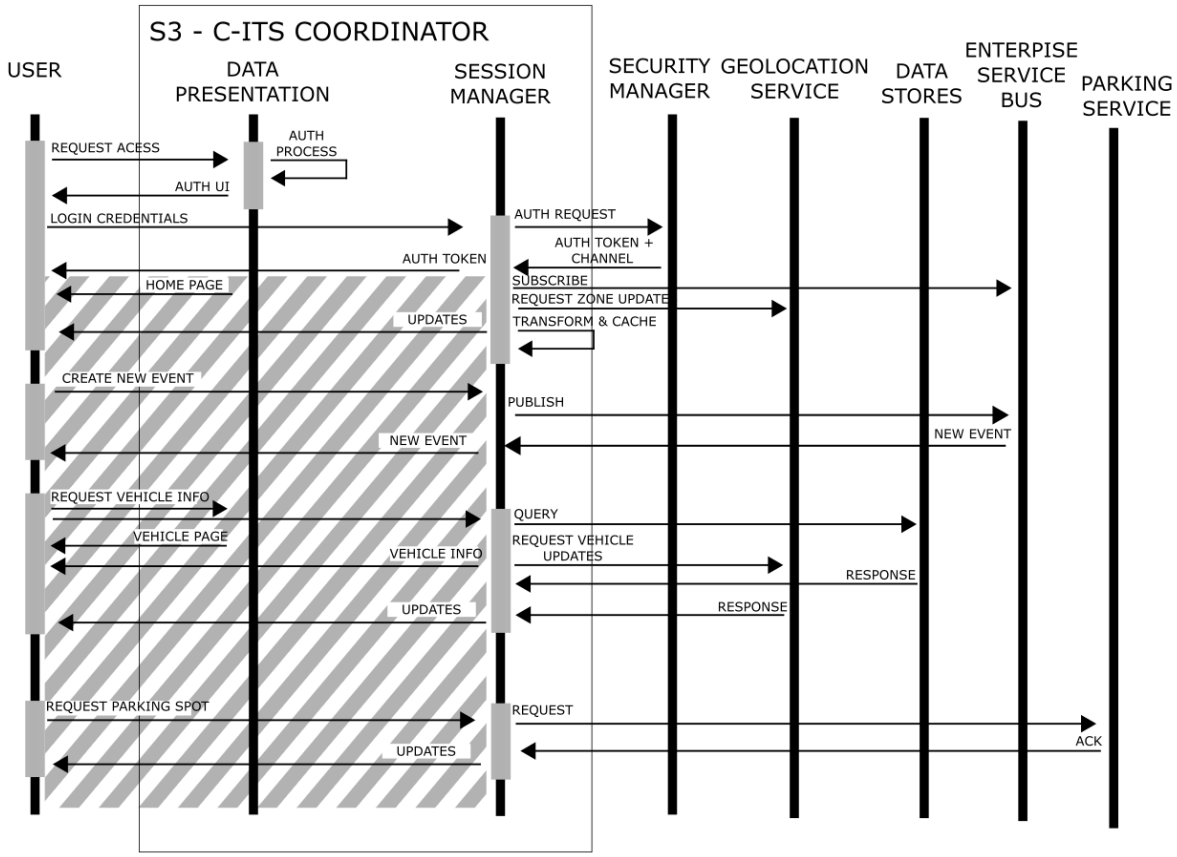


Figure 9 - Sequence Diagram: C-ITS Coordinator Service.

5.3.1 Service Components

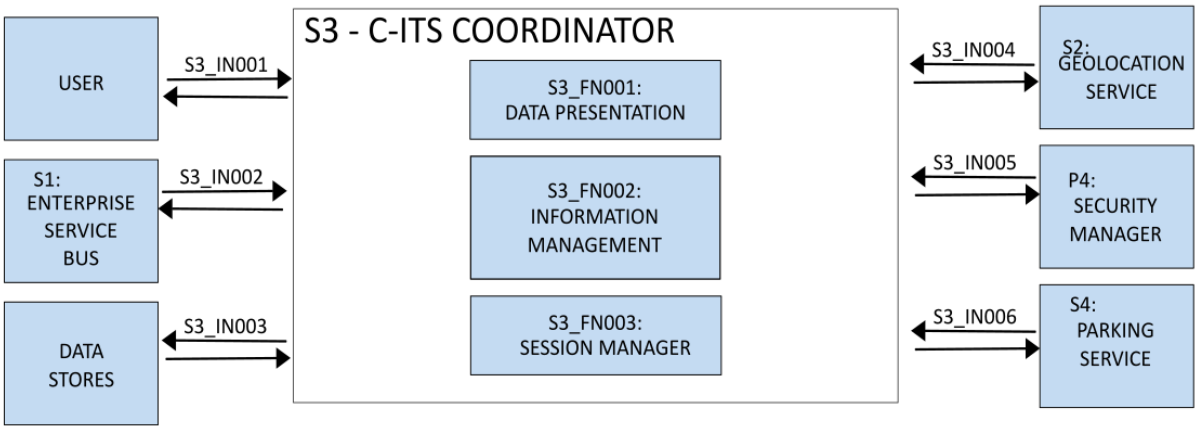


Figure 10 - Functional Block Diagram: C-ITS Coordinator Service.

Table 26: S3 Service Components

ID	Description
S3_FN001	High performance http router used as Web portal application for road-traffic monitoring, works as an interface for authorized users to visualize current road status, create and remove events, give and revogue devices privileges, etc. Additionally, it allows the visualization of parking spot occupancy and to create or remove parking requests.
S3_FN002	The information management function handles more complex requests. It holds the Traffic Management business logic: it can predict traffic jams and vehicles affected, provide alternative routes to remove bottleneck scenarios and suggest recommended speeds and temporary parking in a dynamic way.
S3_FN003	The session manager decouples the web client with the backend intricacies. It works as an API gateway, serving as mediator between the client and other services. It keeps the client session updated ensuring information consistency with other services.

5.3.2 Service Requirements

5.3.2.1 Global

Table 27: S3 Global Service Requirements

ID	Description
SR-OPE-S3_001/1.0	The service shall be modular, easily integrated and loosely coupled.
SR-OPE-S3_002/1.0	The service components shall be independently scalable.
SR-IMP-S3_001/1.0	The service requirement analysis shall be performed using UML, including the production of use cases and interaction diagrams for the various message types design shall be performed using UML.
SR-IMP-S3_002/1.0	The service design shall be performed using UML.

SR-CON-S3_001/1.0	The configuration aspects applicable for the project shall be defined in the Software Configuration Management Plan.
SR-INS-S3_001/1.0	Instructions shall be produced regarding how to install the software for any software components, interfaces and functions delivered for deployment .
SR-OPE-S3_003/1.0	This component shall only be used by an authenticated user.
SR-OPE-S3_004/1.0	Shall be executable in a common web browser (Mozilla Firefox, Chrome, IE) run on a Windows, Linux or MacOS based operating system.
SR-PER-S3_001/1.0	It shall respond rapidly enough to all message receptions with sensitive time-out parameters.

5.3.2.2 S3_FN001 - Data Presentation

Table 28: S3 Data Presentation Service Requirements

SR-FUN-S3_FN001_001/1.0	The component shall display a 2D representation of the covered area, current events and vehicles positions as the cartographic component of the web application.
SR-FUN-S3_FN001_002/1.0	The component shall allow the users to create, remove or update a parking spot request for a specific vehicle.
SR-FUN-S3_FN001_003/1.0	It shall be possible to request a specific parking spot to be blocked.
SR-FUN-S3_FN001_004/1.0	The component shall allow the users to request detailed information on a specific vehicle in real-time. Namely, current position, positions in the last day, cargo, destination and stops, and received/sent messages.
SR-FUN-S3_FN001_005/1.0	The component shall allow authorized users to give or revoke communication and access permissions.
SR-FUN-S3_FN001_006/1.0	The component shall allow users to create, update or delete traffic related events.

SR-FUN-S3_FN001_007/1.0	The component shall allow users to check parking lot occupancy.
SR-FUN-S3_FN001_008/1.0	When a new event is created it shall be propagated into the appropriate channels.
SR-FUN-S3_FN001_009/1.0	An authenticated user shall be capable of watching ongoing events on a specific area.
SR-FUN-S3_FN001_010/1.0	An authenticated user shall be capable of watching events within a specific timeframe.
SR-FUN-S3_FN001_011/1.0	An authenticated user shall be capable of watching traffic statistics.

5.3.2.3 S3_FN002 - Information Manager

Table 29: S3 Information Manager Service Requirements

SR-FUN-S3_FN002_001/1.0	It shall keep a record of best itineraries for each vehicle.
SR-FUN-S3_FN002_002/1.0	Upon detection of road impediments it shall inform affected vehicles and present possible workarounds.
SR-FUN-S3_FN002_003/1.0	It shall provide traffic prediction features .
SR-FUN-S3_FN002_004/1.0	It shall study traffic cameras captured images and detect road impediments.
SR-FUN-S3_FN002_005/1.0	Detected road events shall be propagated into appropriate channels.

5.3.2.4 S3_FN003 - Session Manager

Table 30: S3 Session Manager Service Requirements

SR-FUN-S3_FN003_001/1.0	It shall automatically terminate, idle or non-responding sessions.
SR-FUN-S3_FN003_002/1.0	Sessions shall be identified with an unique identifier.

SR-FUN-S3_FN003_003/1.0	It shall keep a registry of ongoing sessions and check for their specific permissions.
SR-IMP-S3_FN003_001/1.0	It shall guarantee message reception.
SR-IMP-S3_FN003_002/1.0	It shall be capable of prioritizing communication depending on data and destination.

5.3.3 Service Specifications

Regarding the module interfaces, the C-ITS Coordinator has to communicate with the oneM2M platform using the following specifications:

Table 31: S3 (Internal) Communication Specifications

Network Protocol	Transport Protocol	Application Layer	Message Type
IPv4/IPv6	TCP	Websocket, HTTPs, MQTTs	Defined by Service + CAM/DENM/IVIM/MAPEM/ SPATEM

As a result, whenever a new event is published into the oneM2M platform, the C-ITS Coordinator consumes this information and presents the event in the map interface. Conversely, whenever a new event is created in the dashboard by the traffic control operator, this information is published to the platform and confirmation response is received through the uplink.

5.4 S4 - Parking Service

The Parking Service enables the implementation of the smart parking use case, by managing the parking lot allocation and automatically assigning a spot to a vehicle approaching the parking infrastructure. For that purpose, it receives information from the oneM2M platform, based on notifications that are triggered whenever a truck crosses a virtual fence around the parking lot and needs to park for some period. This way, the Parking Service can optimize the parking lot occupation and the travelling efficiency of the fleet of trucks, by accessing the

geospatial database with the real-time position of each vehicle and the information regarding the occupancy status of each parking spot.

Figures 11 and 12 describe the most typical use cases for the parking service and its possible implementation. As the name implies the Parking Slot Management manages parking lot occupancy, it matches spots with requests, providing different priority levels. It also allows the TMC to request for parking slot blockage, stopping the allocation of that resource to requesting vehicles. To ensure the best possible slot allocation this component is always subscribed to updates on approaching vehicles on the Geolocation Service. The request handler, works as a middle man between devices and the Parking Slot Management, a priority queue capable of closing connections and prioritizing requests.

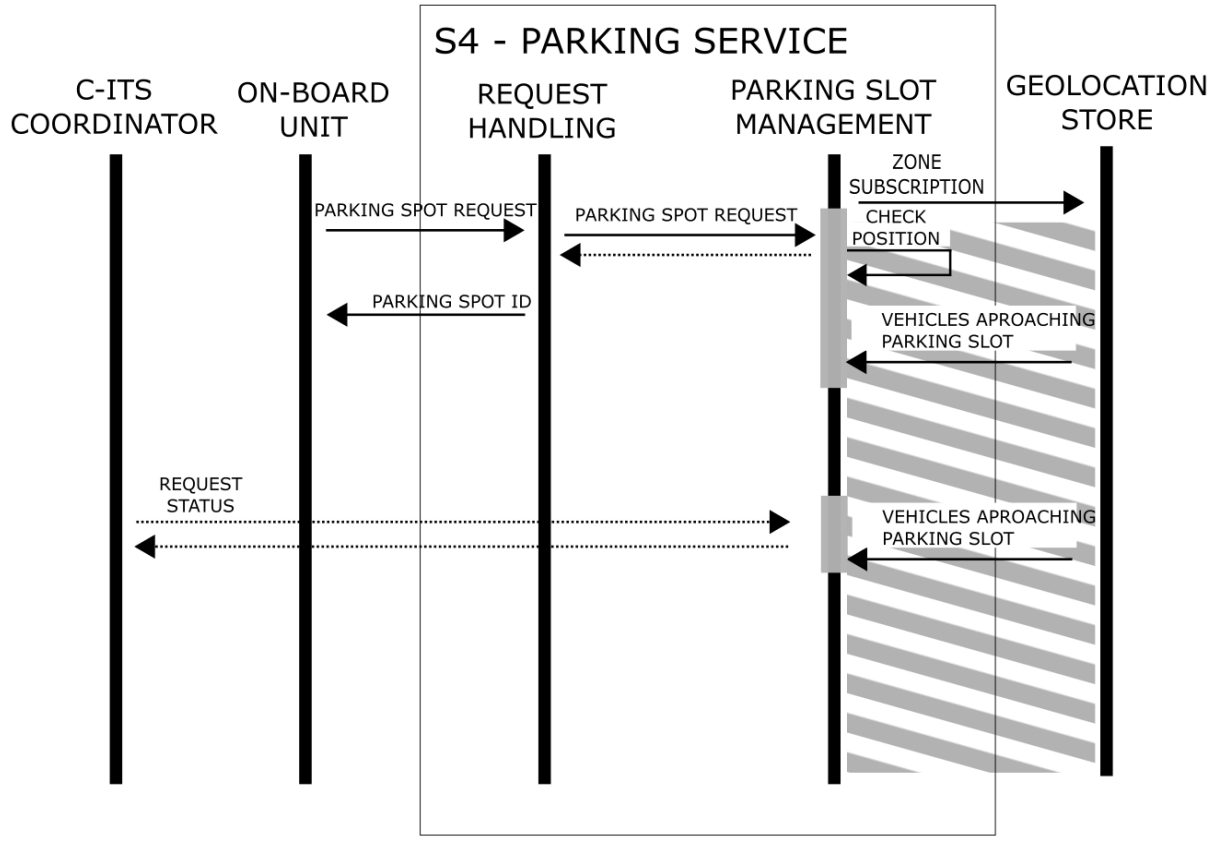


Figure 11 - Sequence Diagram: Parking Service.

5.4.1 Service Components

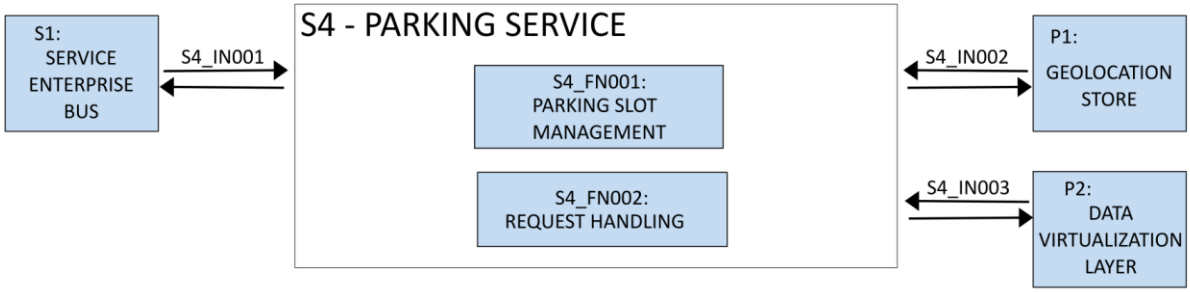


Figure 12 - Functional Block Diagram: Parking Service.

Table 32: S4 Service Components

ID	Description
S4_FN001	It matches the request characteristics (cargo, size, expected arrival time) with current parking availability, providing the most suitable parking spot to requesting vehicles.
S4_FN002	It handles parking space requests, allows the prioritization of specific cargo, works as a prioritization queue for the parking slot management.

5.4.2 Service Requirements

5.4.2.1 Global

Table 33: S4 Global Service Requirements

ID	Description
SR-OPE-S4_001/1.0	The service shall be modular, easily integrated and loosely coupled.
SR-OPE-S4_002/1.0	The service components shall be independently scalable.
SR-IMP-S4_001/1.0	The service requirement analysis shall be performed using UML, including the production of use cases and interaction diagrams

	for the various message types design shall be performed using UML.
SR-IMP-S4_002/1.0	The service design shall be performed using UML.
SR-CON-S4_001/1.0	The configuration aspects applicable for the project shall be defined in the Software Configuration Management Plan.
SR-INS-S4_001/1.0	Instructions shall be produced regarding how to install the software for any software components, interfaces and functions delivered for deployment .

5.4.2.2 S4_FN001 - Parking Slot Management

Table 34: S4 Parking Slot Management Service Requirements

ID	Description
SR-FUN-S4_FN001_001/1.0	It shall be possible to request a specific parking spot.
SR-FUN-S4_FN001_002/1.0	It shall be possible to block reservation requests to specific parking slot.
SR-FUN-S4_FN001_003/1.0	It shall be possible to request statistics on a specific parking lot or even parking space.
SR-FUN-S4_FN001_004/1.0	It shall be possible to cancel a parking request.
SR-FUN-S4_FN001_005/1.0	It shall be possible to request a specific parking lot or space status.
SR-FUN-S4_FN001_006/1.0	Upon parking spot request the service shall identify the arrival time and book a spot accordingly.
SR-FUN-S4_FN001_007/1.0	When a requesting vehicle is in the proximity of the parking lot, the service shall check if there isn't a more suitable parking spot.

5.4.2.3 S4_FN002 - Request Handling

Table 35: S4 Request Handling Service Requirements

ID	Description
SR-IMP-S4_FN002_001/1.0	It shall guarantee message reception.
SR-IMP-S4_FN002_002/1.0	It shall be capable of prioritizing requests depending on cargo, proximity and destination.

5.4.3 Service Specifications

Regarding the module interfaces, the Parking Service has to communicate with the oneM2M platform using the following specifications:

Table 36: S4 (Internal) Communication Specifications

Network Protocol	Transport Protocol	Application Layer	Message Type
IPv4/IPv6	TCP	AMQP, HTTPs, MQTTs	Defined by Service

As a result, whenever a new service request is received (triggered by the approach of fleet vehicle to the parking lot), the Parking Service verifies the parking spaces availability, reserves a free parking spot and forwards this information to the vehicle through the oneM2M platform.

6 OBU HMI

The OBU must provide a human machine interface (HMI) to the driver, providing useful information about its journey/destination and safety information from the C-ITS platform. The application should also allow the report of traffic events by the fleet of vehicles, in order to warn the C-ITS Coordinator service about the occurrence of hazards on the road, so that they can be disseminated to the other vehicles. This HMI may be either implemented in an external device, such as a smartphone/tablet, or in the on-board dashboard of the vehicle. The main goal of this mobile application is to develop the three predefined use cases, namely the safety information, the bottleneck removal and the smart truck parking. For that purpose, the Day 1 and Day 1.5 C-ITS services specified in the first deliverable must be implemented in the OBU HMI. An additional

use case scenario, regarding the weight verification requirement at the port loading zone, will also be implemented.

6.1 HMI Requirements

A set of requirements must be fulfilled by the OBU HMI, in order to implement the previously mentioned use cases. These are summarized in the following table.

Requirement	Description
Navigation System	The mobile application must use and present dynamic maps to the driver, with information regarding the position of the vehicle on the road, the recommended route (specially important for the bottleneck removal use case) at each moment and the localization of traffic events. The navigation system should be available both online and offline.
Localization	The application must provide high accuracy localization of the vehicle based on GPS data and possibly wireless network information.
DSRC Platform Connectivity	The device in which the HMI is implemented, must utilize an appropriate technology (e.g. USB, Bluetooth, WiFi) for exchanging information with the DSRC platform (CAM, DENM, IVIM, SPATEM/MAPEM and other service defined messages).
Tracking and Events Database	The mobile application should be able to register and store in an internal database the complete route of each vehicle during a configurable time interval (e.g. 24h, 1 week, …), as well as all the events registered during that period.
Event Generation	The HMI should allow the manual report of traffic events by the vehicle users, so that this information can be forwarded to the oneM2M platform and to the other vehicles in the vicinity.
Event Management	The application must constantly compute the distance from the vehicle to the received event notifications and display it to the driver. The event visualization should be managed according to this distance, as well as to the time validity of each event and its geospatial coordinates. It must also verify and discard the existence of duplicated events.
Parking Service	The parking service use case must be implemented in the mobile application, by automatically providing a reserved place to the vehicle when approaching the parking lot. The number of the parking spot must be displayed to the truck driver in the HMI. The option for manually requesting the reservation of a parking place should also be contemplated.

Safety Information	The C-ITS messages regarding safety information must be displayed to the driver, based on the Day 1 and Day 1.5 C-ITS services selected in the first deliverable.These notifications should be shown based on rules described in the event management requirement.
Update Support	The mobile application should support the need for future updates.
Driver Attention	The HMI must not cause driver inattention to the road, so it should be simple and showing only essential information, in order to avoid user distraction.

6.2 HMI Specifications

6.2.1 Safety Information

Regarding the safety information use case, the HMI on the OBU device must display event notifications to the driver with the corresponding traffic hazard and the associated distance to the event. Additionally, the mobile application should also allow the report of events by the vehicle users, so that these can be disseminated to other vehicles in the vicinity, as well as to the C-ITS Coordinator. In the following table, some examples of possible graphical representations are presented for the case of DENM packets (ETSI TS 102 869-1 V1.3.1). Other messages, such as IVIMs, MAPEMs and SPATEMs, should also be analysed to support the full range of Day 1 and Day 1.5 C-ITS services described in the first deliverable. The notifications displayed by the mobile application in this use case are originated from the C-ITS Coordinator and Legacy Information Systems services or are received directly from the other ETSI ITS-G5 stations in the vicinity (either RSUs or OBUs).

Safety Event	**Causecode**	**Sub-causecode**	**Symbol**
Planned road works	3: Roadworks	0: unavailable	
		3: slow moving road maintenance	
		0: unavailable	

Animal on the road	11: Hazardous Location – Animal on the road	1: wild animal	
		3: small animal	
People on the Road	12: Human presence on the road	0: unavailable	
Obstacle on the road	10: Hazardous Location – Obstacle on the road	0: unavailable	
Unprotected accident area	2: Accident	0: unavailable	
		1: multi vehicle accident	
		2: heavy accident	
		5: accident involving hazardous materials	
Reduced Visibility	18: Adverse weather conditions - Visibility	0: unavailable	

6.2.2 Bottleneck Removal

With respect to the Bottleneck Removal use case, the mobile application should provide an alternative route in case of traffic congestion or road closure. It should also try to avoid situations that decrease traffic efficiency, e.g. shockwave damping. For that purpose, the application must process the notifications received from the C-ITS Coordinator and the Legacy Information Systems services, other OBUs and RSUs in the road and possibly from 3rd party applications. The goal is to optimize the trajectory of the fleet of trucks in terms of time and fuel consumption, by providing the most convenient route to the driver. Whenever a road segment is unavailable or highly congested, this information should be displayed to the user and an alternative route must be provided. A possible representation of such scenario is depicted in figure 13.

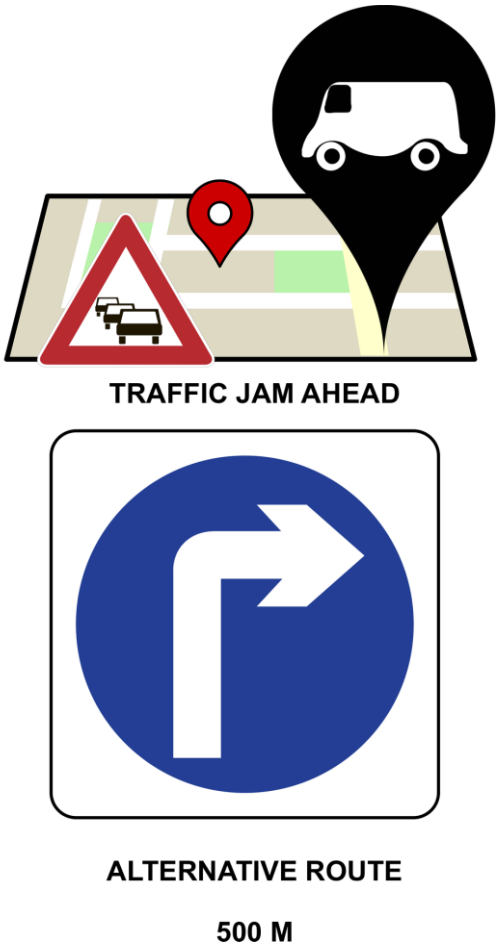


Figure 13 - Bottleneck Removal use case on the Human-Machine Interface.

Apart from suggesting an alternative route, it may also be necessary to recommend

different average speeds or even temporary parking at the freight village, in order to avoid congestion and wait for an entry slot.

6.2.3 Parking Service

The HMI should also implement the Parking Service use case, by providing a reserved place to the vehicle whenever it is driving to the parking lot. The reservation process is automatically performed by the Parking Service component, so the mobile application only needs to display this information when receives the notification with the assigned parking place number. The application may also allow a manual request of a parking spot by the driver, that should be forwarded to the Parking Service component for processing. The messages exchanged in this use case are defined by the service and should be in agreement between the mobile application and the Parking Service component on the C-ITS platform. Figure 14 depicts a possible representation of the Parking Service use case in the mobile application.

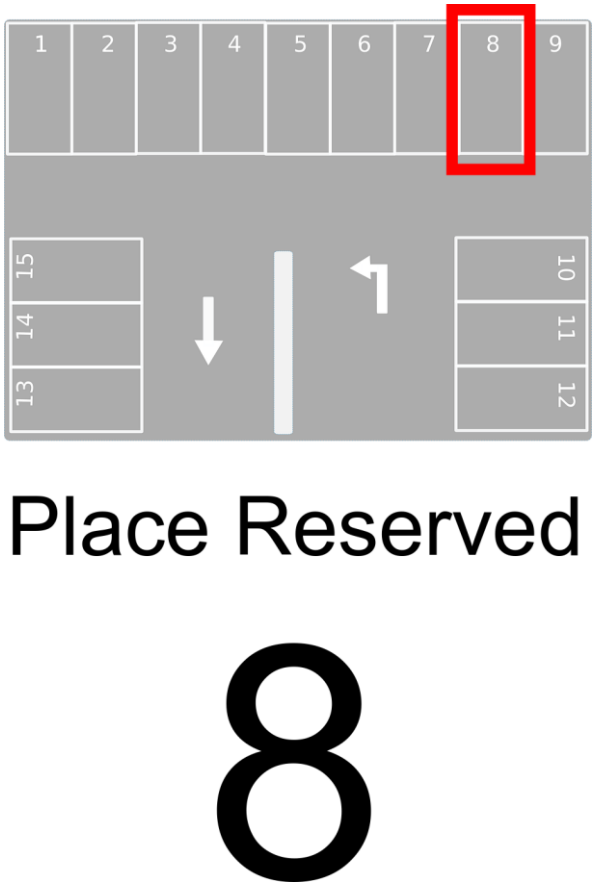


Figure 14 - Parking Service use case on the Human-Machine Interface.

6.2.4 Weight Verification Service

Finally, an additional use case will also be deployed, which consists of verifying the weight of a fleet vehicle at the port area. This measurement of the Verified Gross Mass (VGM) will be performed in a specific scale with the obtained value being displayed both on the web platform of the C-ITS Coordinator module and on the OBU HMI of the corresponding value. Figure 15 depicts a possible representation of the Weight Verification Service use case in the mobile application.

Figure 15 - Weight Verification Service use case on the Human-Machine Interface.

7 Specification of Verification modules

In order to validate the correct implementation of the four uses cases, a set of different verification tests will need to be performed. For that purpose, all the previously defined service components, network and infrastructure devices will need to be deployed and properly working. The C-ITS platform will be tested both from the perspective of an operator at the Port Authority, as well as from the point of the view of the truck drivers. The following pilot tests should be performed by using both ETSI ITS-G5 and LTE communications technologies, so that the operation of both interfaces can be validated in areas with different network coverages. The C-ITS platform must also exhibit in real-time the position of all vehicles belonging to the fleet of trucks (based on the periodic messages transmitted by the vehicles), allowing the Port Authority to monitor and control the location of its assets in the map and visualize the ones that might affected by a traffic jam or a safety event.

7.1 Safety Information

The verification of the Safety Information use case will be carried out by generating road safety events and verifying its correct visualization both at the Port Authority and at the mobile application on the OBU device. In order to validate the dissemination of an event warning generated by an external traffic management entity, a national ITS station or a third party application, the report of such event will be simulated at the Port Authority by manually introducing a traffic hazard at the C-ITS Coordinator component of the C-ITS platform. This notification needs to be forwarded afterwards to the fleet of vehicles by the LTE or the ITS-G5 network, depending on the event location. The symbol and the distance to the event will be displayed to the driver in the HMI of the OBU. Figure 16 presents an example of a road works warning that can be manually added in the map of the C-ITS Coordinator for alert dissemination and visualization on the mobile applications of the vehicles.

Code	Symbol	Description	Scenario
3:0		**Road Works Warning**	

Figure 16 - Example of safety information event generated in the TMC component.

The validation of this pilot test will be performed in the following way:

1 - Manually add a safety event on the map of the C-ITS Coordinator component at the Port Authority;
2 - Verify the reception of a warning notification, exhibited on the HMI, at the OBUs approaching the event location.

Similarly, the fleet of vehicles should also be able to notify the C-ITS Coordinator about the occurrence of road hazards. For instance, if a truck driver detects an accident on the road, it should report this situation to the TMC, so that it can disseminate this information to the rest of the fleet, other vehicles equipped with vehicular communications capabilities and possibly to external traffic management entities or a National ITS Station. Figure 17 presents an example of a multi-accident warning that can be manually introduced by the truck driver on the mobile application connected to the OBU device that will forward this information to the oneM2M platform and the TMC service.

Code	Symbol	Description	Scenario
2:1		**Accident Warning**	

Figure 17 - Example of safety information event generated in the mobile application at the OBU.

The validation of this pilot test will be performed in the following way:

1 - Manually generate a safety event on the mobile application of the OBU device;
2 - Verify the reception of the safety notification on the map of the C-ITS Coordinator component at the Port Authority;
3 - Verify the reception of the warning notification, exhibited on the OBUs approaching the event location, through direct V2V communications;
4 - Verify the reception of the warning notification, exhibited on the OBUs approaching the event location and disseminated by the C-ITS platform after the reporting vehicle leave the place.

7.2 Bottleneck Removal

The Bottleneck Removal use case will be tested by simulating a stationary traffic event in the C-ITS Coordinator service at the Port Authority. Ideally, the implementation of this use case

should be evaluated by verifying the operation of the C-ITS platform under the presence of a notification (e.g. traffic jam, road closure, etc.) from a third party application, such as Google Traffic or Waze, or from an external traffic management entity or National ITS Station. However, these events can not be controlled, so the feasible way to test this use case is by generating this situation in a virtual manner, as described for the Safety Information pilot tests. Figure 18 presents an example of a bottleneck scenario warning that can be manually added in the map of the C-ITS Coordinator for alert dissemination and visualization on the mobile applications of the vehicles.

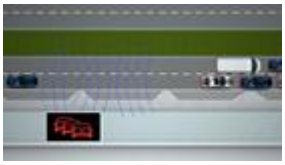
Code	Symbol	Description	Scenario
1:5		**Traffic Stationary**	

Figure 18 - Example of a bottleneck scenario event virtually generated in the TMC component.

In addition to the warning displayed in figure 18, or other causes of bottleneck such as road closure, the C-ITS platform must present an alternative route to the fleet of trucks. This alternative route should be displayed both in the TMC service at the Port Authority, as well as on the mobile application connected to the OBUs.

The validation of this pilot test will be performed in the following way:

1 - Manually introduce a bottleneck event on the map of the C-ITS Coordinator component at the Port Authority;
2 - Verify the automatic generation of an alternative route on the map of the TMC;
3 - Verify the exhibition of the bottleneck warning notification and the alternative route on the mobile application of the OBUs approaching the event location.

Additionally, the bottleneck event could also be reported by a driver of the fleet. Therefore, this test should be validated in the following way:

1 - Manually generate a bottleneck event on the mobile application of the OBU device;
2 - Verify the reception of the bottleneck notification on the map of the C-ITS Coordinator component at the Port Authority;

3 - Verify the automatic generation of an alternative route on the map of the TMC;
4 - Verify the exhibition of the bottleneck warning notification and the alternative route on the mobile application of the OBUs approaching the event location.

7.3 Parking Service

Regarding the Parking Service implementation, this use case will be evaluated by simply verifying the allocation of a free parking place whenever a fleet vehicle directs to the parking lot. This allocation should be triggered within a predefined distance to the parking infrastructure. The parking spot assignment needs to be visualized immediately after being allocated both in C-ITS Coordinator service at the Port Authority, as well as on the mobile applications of the OBU devices.

The validation of this pilot test will be performed in the following way:

1 - Verify the automatic allocation of a free parking place to the vehicle moving to the parking lot within a predefined range in the map of the TMC service at the Port Authority;
2 - Verify the automatic allocation of a free parking place to the vehicle moving to the parking lot within a predefined range in the mobile application of the OBU device.

If necessary, the mobile application should also allow the manual request for a parking spot by a truck driver. In this case, the validation will be performed in the following way:

1 - Manually request for a parking spot in the mobile application of an OBU device;
2 - Verify the allocation of a free parking place to the vehicle moving to the parking lot in the map of the TMC service at the Port Authority;
3 - Verify the allocation of a free parking place to the vehicle moving to the parking lot in the mobile application of the OBU device.

7.4 Weight Verification Service

The implementation of the Weight Verification Service will be evaluated by simply verifying the exhibition of VGM value both in the C-ITS Coordinator component at the Port Authority, as well as on the mobile application of the OBU device installed in the fleet truck being weighed.

The validation of this pilot test will be performed in the following way:

1 - Position the fleet truck on top of the vehicle scale;
2 - Verify the exhibition of the VGM value on the Human-Machine Interface of the OBU

device installed in the same vehicle;

3 - Verify the exhibition of a Weight Verification notification in the web platform of the C-ITS Coordinator component at the Port Authority, including the vehicle identifier and the measured VGM value.