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Automotive Intelligence for/at Connected Shared Mobility

Deliverable	***Report on requirements and specifications of electronic component and systems for L3 driving and L1e vehicle***		
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0.4		Claudio Russo	Review
1.0		Lorenzo Giraudi	Final and reviewed Version

Disclaimer

Table of contents

1 Executive/ Publishable summary

The following document is a report on the activity of **Task 1.3 "Requirements and specifications for L3 driving and multimodal CSM"** in which the partners defined and gathered the high level, functional requirements and defining specifications of the electronic component and systems (ECS) that will be at the basis of SC3 demo vehicle for L3 automated driving.

During this task, SC3 partners worked on the definition and gathering of requirements for the technologies to be integrated into the L3 vehicle that will be demonstrated in a real scenario. The first demonstrator **SCD3.1 Demo vehicle to demonstrate L3 automated with a Driver's Monitoring System** will integrate several Driver Monitoring Systems (DMS) modules, enhanced perception through multiple smart sensors, and a new embedded AI-based open platform. **SCD 3.2 L1e vehicle with natively integrated telematics** instead will feature a new 1e vehicle will build to natively integrate a customized telematics On Board Unit (OBU) with wireless short-range connectivity (BLE), wireless long-range (mobile network) connectivity for bi-directional

transmission to an ICT back-end platform as well as conventional wired

After a short introduction, the two demonstrators will be presented and described. In each section, the technologies are better described and the expected output are outliened.

2 Non publishable information

The whole deliverable is publicly available.

3 Introduction & Scope

3.1 Purpose and target group

SC3 partners worked in this first year to define in better detail what was described in the Grant Agreement. The output of this work is a preliminary architecture, a description of the two demonstrators, and a list of high-level requirements.

3.2 Contributions of partners

The following table details the contributions of the partners to the deliverable.

TABLE 1 PARTNER CONTRIBUTION

Chapter	Partner	Contribution
4.2.2.5	IFAG	Provision of µC/Communication/Sensor ECS (Chips and application oriented boards). AURIX® Design support for ECS integration and software developemnt
4.3.2.1	FEDDZ	e-moped description
4.2.2.5	IFI	Development of PMIC device to support the Aurix microcontroller. Support in the definition of the power management architecture of the number cruncher board.
4.2.2.5, 4.2.2.7, 4.3.2.2	I&M	Overall structure, Number Cruncher, scenarios, IBMC

4.2.2.2	POLITO	Physiological based drowsiness monitoring system
4.2.2.2	SAT	Physiological based drowsiness monitoring system
4.2.2.6, 4.2.2.3	UNIMORE	Smart City infrastructure and Behavioural based driver monitoring system
4.2.2.4, 4.2.2.6	VEM	Physiological based drowsiness monitoring system, OBU and Cloud infrastructure
4.2.2.6	WVIEW	Weather dection algorithm to be run on Smart City infrastructure using city camerasProvider of weather and environment video analytics, to use cameras along the roads as non dedicated sensors for monitoring weather and its effects on road pavement. WaterView analytics provide minute by minute updates on visibility, precipitation type and road conditions to be used as context data for vehicle decision making in assisted and partial autonomous driving

3.3 Relation to other activities in the project [I&M]

This task poses the basis for the whole development of Supply Chain 3. In this deliverable we gather the requirement that will affect SC3 activities in the next work packages. Moreover, SC3 gets technical inputs from other SC, in particular regarding the AURIX® and its safety PMIC.

4 Requirements and specifications of electronic component and systems for L3 driving and L1e vehicle

According to SAE [1], Level 3 of Automation driving consist of a system that is able to manage the vehicle under some environmental condition and scenarios. The human driver still needs to be alert because whenever some critical situation arises, the person needs to take the control of the vehicle in a timely manner. This change of control is called "Take over request". The system detects a fault or a change in the environment and decides that the driver needs to take the control of the vehicle. The system then sends some signal to the driver that can be haptic, visual, audio, or all of them. Since the driver is allowed to not be focused on the road, the system has to ensure a safe period for the driver to focus back on the environment. Finally, the driver takes control of the vehicle and the autonomous system stops influencing the actuators.

Supply chain 3 has the objective of working on an L3 vehicle focusing on technologies that allow a safe take over request. The high-level objective is to gather information from sensors that are both internal and external, local and remote, to make the best decision in that particular condition.

In addition, SC3 also works toward multimodal mobility by developing electrical motorbikes. SC3 tries to deliver the components needed for a shared fleet that could eventually reduce the number of vehicles in circulation thanks to the sharing economy.

On the project level, Supply chain 3 will work to tackle these high-level project objectives:

- **Obj. 2**: Develop scalable and embedded intelligence for edge and edge/cloud operation
- **Obj. 3:** Design silicon for deterministic low latency and build AI-accelerators for decision and learning
- **Obj. 5**: Design functional integrated ECS systems

The technology bricks developed by partners in SC3 try to address these objectives by themselves, and in addition, a final integrated use case will show how these technologies work together to perform better handling of critical scenarios.

4.1.1 State of the art

L3 autonomous vehicles pose a great issue in their limited ability to operate autonomously. Because of this some OEMs are considering skipping L3 and are developing directly L4 systems. The dynamic nature of the control transfer makes this system complex to manage. In fact, objective and subjective aspects need to be taken into consideration. The road geometry and the traffic density are two objective parts that influence the time needed for the driver to assess the situation and take control. The subjective ones include the driver experience, its attention level, and how the message is sent to the driver. Research shows that the most effective way is the combination of visual alerts on displays, audio ring tones, and voice requests together with haptic signals like vibrations. Current solutions monitor the driver's state and activity to enforce their vigilance since it has been shown that any Non-Driving Related Task decreases the level of awareness for a period of 15-27 seconds. [2] This lead to the need to track also driver activities not related to driving.

Another condition that greatly influence the driver safety is sleepiness and drowsiness. Car manufacturers recognized the importance of preventing sleep while driving, and several approaches have been already proposed and deployed. The **vehicle-based** approaches are related to the analysis of the steering angle or the rapid acceleration/deceleration [3] [4]. Algorithms have been defined that, based on the above inputs, identify the impending drowsiness of drivers and prompt actions intended to raise awareness and avoid falling asleep while driving. **Behavioral-based** approaches are related to noncontact driver monitoring techniques, such as video acquisition and analysis, which compute features such as driver’s eyes blinking rate, and/or the percentage of the duration of closed eye [5] [6]. In case the blinking rate or the percentage of closed eye reaches pre-determined limits, mitigation actions are activated to prevent driving while sleeping. As far as accuracy is concerned, a recent work [7] reported that the vehicle-based approach reaches 63% accuracy (computed as the ratio of true positive + true negative, over true positive + true negative + false positive + false negative), while behavioral-based approaches using eyes blinking rate reach 78%. Unfortunately, vehicle-based approaches cannot be used together with autonomous driving systems, as the driving behavior depends on the autopilot and not on the human driver. Instread, behavioral-based approaches have higher accuracy and are typically very reactive, but those methods that are based solely on eye blinking rate may fall short in coping with some scenarios. For example, if the driver wears sunglasses the algorithm may not be able to identify the eyes blinking rate; most importantly, there are scenarios where the driver may fall asleep suddenly with the eyes still open such as in the case of microsleeps and subjects affected by OSAS (Obstructive Sleep Apnea Syndrome). This calls for solutions that jointly explore:

1. physiological-based approaches (based on heart rate, respiration rate, etc.) that can correctly predict drowsiness conditions over a longer time span (less reactive but very accurate)
2. behavioral-based methods that rely on more than just eyes and mouth observation but also on face orientation and hazardous behavior like texting while driving, smoking, etc (more suitable for very reactive decision making).

4.2 SCD 3.1: Demo vehicle to demonstrate L3 automated with a Driver's Monitoring System [UNIMORE, I&M]

Demonstrator SCD3.1 will focus on a level 3 passenger car. As previously said, the objective is to demonstrate technologies that allow a smart and comprehensive take over strategy. The developed system will monitor the driver, recognize his or her behaviour with the HMI, and leverage fixed smart cameras for detecting vulnerable road users and road condition.

A new system will be developed for predicting the sleeping onset of the driver. These information will be combined with a Driver Monitoring System for detecting the level of attention.

4.2.1 Scenario description

The demonstrator SCD3.1 will be demonstrated in the scenario 3.1.1, that will try to represent a critical situation that can happen in urban scenario.

- Scenario 3.1.1: Critical takeover request
  - The L3 vehicle is approaching a blind corner in autonomous mode at medium speed
  - The driver is distracted or drowsy
  - The weather is rainy or there is a puddle or another road condition after the corner that compromise the vehicle traction
  - A pedestrian is crossing right after the corner
  - A smart fixed camera that observes the street after the corner

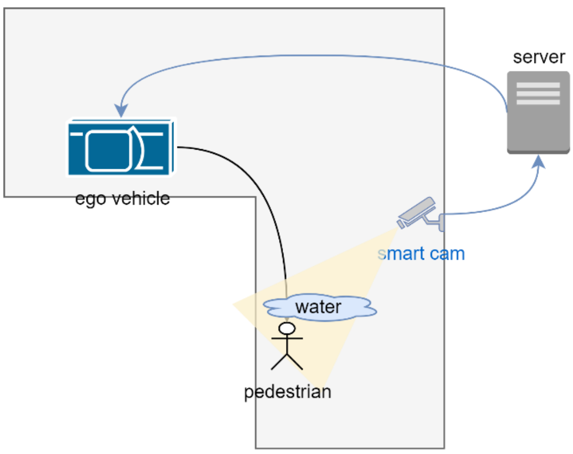

FIGURE 1: SCENARIO 1 REPRESENTATION

The demonstrator will take place in an area equipped with fixed cameras connected to an available backend. The aim is to have meaningful triggering conditions for the developed technologies.

4.2.2 High-level architecture

In the following section, the high-level architecture of the demonstrator is described. The system will be composed of internal and external sensors, the autonomous vehicle, one or more ECU for running the AI based software, and a remote infrastructure on the cloud to which are connected fixed city cameras.

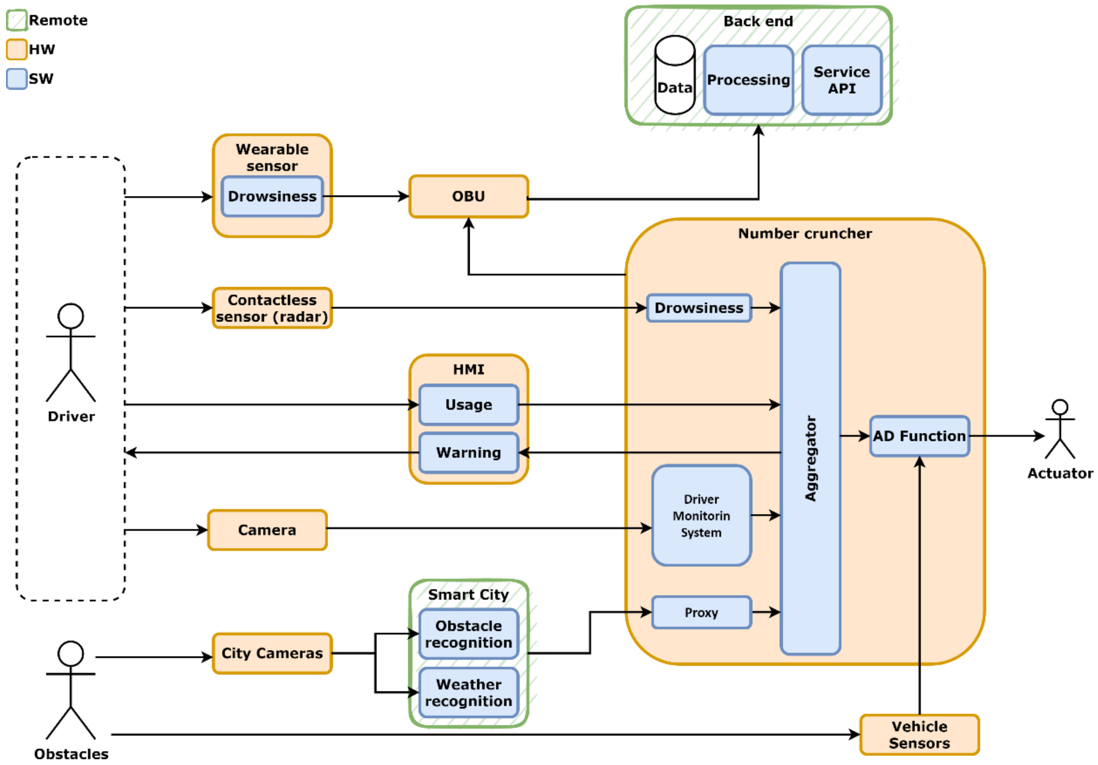

FIGURE 2: SCD3.1 ARCHITECTURE

4.2.2.1 Vehicle

In this supply chain, we are targeting a passenger car with functionalities according to Level 3 of SAE J3016. In these vehicles, the Automated Driving System (ADS) is able to perform all the tasks needed to drive the vehicle, called Dynamic Driving Task (DDT). The system is not designed to be reliable in all conditions, but only in a restricted Operational design domain (ODD). Because of this, the ADS must refuse to be engaged outside its ODD and detect if it is exiting the valid ODD. Finally, the user is responsible to be available as a fall-back whenever the ADS asks it.

On the technical level, this is achieved by a perception and decision-making system together with diverse sensors [8]. The inputs typically come from LIDAR, RADAR, and cameras but also from HD maps, vehicle odometry, and Inertial Measurement Unit (IMU). All this data is fused in the perception stack that recognizes and tracks other road users, localizes the ego vehicle in the physical world, and interprets the road signs. On the other hand, the Decision-Making system is responsible for the planning and actuation of a lawful trajectory given the current scenario.

SC3 is not focusing on the development of a new L3 architecture, but the goal is to improve the management of Take Over Request in case of critical scenarios. This will be achieved by gathering information from both the driver state and external information coming from fixed cameras.

4.2.2.2 Physiological-based drowsiness monitoring system

Traffic accidents are one of the leading causes of death worldwide. Several studies have proposed that sleepiness on wheel is an important factor in road accidents [9], and most of them pointed out the impact that sleep disorders, such as obstructive apnea (OSAS), have on sleepiness on wheel. [10]

Section 0 describes the pros and cons of the different techniques: vehicle based cannot be applied in autonomous mode, while behavioural-based are accurate and fast, but they can fail in particular situations.

For these reasons, physiological-based approaches to drowsiness detection could offer a significant improvement to the accuracy of driver monitoring systems. Being based on collecting physiological features about the driver, such as the heart rate, respiration rate, etc., the method could promptly identify and predict drowsiness conditions. On the one hand, physiological measures are independent of the actions the driver is performing and therefore they can be used in an automated driving scenario where the driver is passive, and we are mostly interested in detecting his/her level of attention, including possible drowsiness conditions. Moreover, physiological measures are not related to eye's movements, and therefore they can be used also for detecting drowsiness in subjects that may fall asleep with open eyes and, more, general levels of mental efficiency appropriate to the work to be accomplished.

In AI4CSM, parameters such as variations of the blood volume changes in the microvascular bed of tissue as measured using photoplethysmogram (PPG) will be used to analyze the driver drowsiness conditions, and a dedicated wearable device will be developed for this task. The device will be worn on the wrist and will be responsible for measuring the PPG and for running the drowsiness detection/prediction algorithms developed in the AI4CSM project. The wearable will be able to alert the driver by vibrating and also sending an alarm to the vehicle using wireless communication. Moreover, radar-based contact-less solution for driver monitoring will be evaluated: parameters such as respiration rate, heart rate, and heart rate variability will be measured using radar sensing and algorithms developed for drowsiness detection/prediction.

4.2.2.3 Behavioral-based driver monitoring system

The behavioral-based Driver Monitoring System (BB-DMS) developed in AI4CSM is an off-the-shelf component codenamed "CityBox". To circumvent the limitations of approaches based solely on eye blinking rate the CityBox tracks the driver's face using either RGB or IR cameras and performs various image post-processing tasks to accomplish the following goals :

- traditional behavioral-based drowsiness detection (based on observation of eyes and mouth);
- driver distraction detection by analyzing the face orientation (roll, pitch, yaw);
- driver identification (potentially strengthening the detection);
- dangerous behavior/distraction detection, (texting or using the smartphone while driving; lighting a cigarette, etc.).

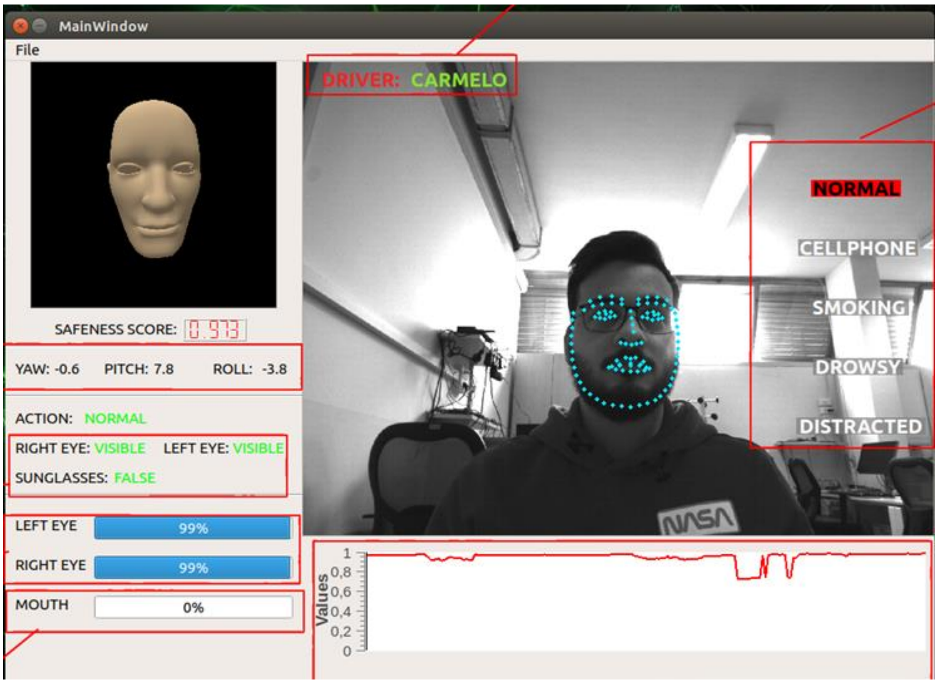

FIGURE 3: "CITYBOX" SCREENSHOT

The current prototype (Figure 3) is at TRL3, and cannot exhibit real-time performance due to the poor computational resources. The ambitious goal of reaching an 5-10 FPS for being adopted in the project will be achieved by porting it on the number cruncher platform by I&M.

4.2.2.4 *On-Board Unit (OBU)*

The on-board unit (OBU) consists of a telematic box specifically conceived by VEM for vehicular applications to enable web-based services for vehicle/fleet management, safety, and traceability. It shall be a flexible and very smart vehicular gateway able to track positions, recognize events, measure parameters, transmit data over a mobile network connection and receive remote commands from a remote-control center (i.e., TSPCC)

Even if not all operational requirements for this type of device were already known at the beginning or during the early phases of the project, VEM can leverage on its own industrial experience based on the development and production of commercial telematic devices and services for one of the major European telematic group. Therefore, the OBU prototype currently being designed will include several additional functionalities that are normally requested by the market for the following reasons:

1. to ensure enough flexibility to accommodate additional SW features to be developed if the project will identify and need them
2. to increase the chances of a commercial exploitation of the telematic box for the developing market of the shared electrical mobility

A list of the main features that have been currently included in OBU design requirement is as follows:

- Powerful microcontroller (CortexM4)
- 4G GSM modem
- GNSS receiver for accurate location services

- Integrated GSM & GNSS antennas (with the possibility to include an external GNSS antenna, if required by vehicular installation requirements)
- Internal back-up battery (to allow selected operation even when the vehicle is in key-off status)
- Two internal accelerometers and a gyroscope to measure driving dynamics, crashes and driving style
- Bluetooth Low Energy (BLE 4.0) communication module
- Several digital and analog I/O available by many different connectors providing possibility to connect to Serial and/or CAN ports
- CAN bus (both SAE J1939 and SAE J1979)
- The mechanical design might also include an optional additional cable/connector cover in case in IP65 protection is required

The OBU is the vehicular gateway enabling the bi-directional communications between the vehicle and the remote-control center (see TSP Control Centre section) where all data are stored processed and made available to the Service Providers. This long-range communication shall be carried out over a 4G mobile network and shall be fully transparent to both the Service Providers and the end-user.

4.2.2.5 Number cruncher platform

All the software described in this chapter needs an embedded platform for running these intensive tasks. This platform has to be powerful enough for handling the data and running AI algorithms. On the other side, the outcome of these calculations influence directly or indirectly the vehicle movement, thus there is a need to be reliable and safe. The platform can either be single or multiple different platforms communicating reliably and tackling different tasks and cooperating with one another, using a reliable communication bus with high bandwidth like Ethernet.

Standard CPUs do not perform well when executing neural network-based AI algorithms. These are highly parallel algorithms that can be sped up by dedicated hardware, like GPU, FPGA, and ASIC. FPGAs have high energy efficiency and good performances [11]. Unlike the other solutions, they can be programmed, changing the low-level architecture of the processing part, thus one can tinker with several possibilities or even update to the newest architecture since the AI field is still evolving rapidly. The downside of it is that it requires specialized knowledge in hardware synthesis. Knowing this, some manufacturers developed software libraries that allow deploying on the FPGA models that were described using popular AI frameworks (e.g. Tensorflow). Another advantage of FPGAs is that the programmable part can be used also for pre-processing and post-processing, thus creating a whole pipeline that reduces resource consumption. [12]

On the other hand, the complex processor cannot guarantee hard real-time constraints and are complex to certify from a safety point of view. Because of this, a possible solution consists in having a separate microcontroller that has all the needed safety features and can perform all the needed checks on the decision done by the platform.

Keeping this background in mind, I&M will design the AI-SDF board based on the joint operation of FPGA and a functional safety microcontroller developed by Infineon that can provide the additional computational capability. The Aurix microcontroller is indeed equipped with a Parallel Processing Unit supporting dedicated vector computation for machine learning purposes. The power management section will be also designed considering the need for functional safety requisites and in particular, a functional safety PMIC device will be used as a companion of the functional safety microcontroller.

4.2.2.6 Smart city and Cloud infrastructure

In the next years, the cities will become more equipped with smart infrastructure and sensors for gathering data and providing services. The smart city infrastructure targeted in SC3 comprises a number of edge devices, including the vehicles and a number of smart cameras placed along the streets. These smart cameras are capable of performing vulnerable road user (VRU) detection and trajectory prediction. The processed images can be sent to the centralized smart city server for further processing. Infrastructure-to-infrastructure (cameras-to-server) communication happens via Wired/Fiber media; vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communication happens via the Citybox through 4G/5G/DSRC wireless networks. Its basic scheme is shown in Figure 4.

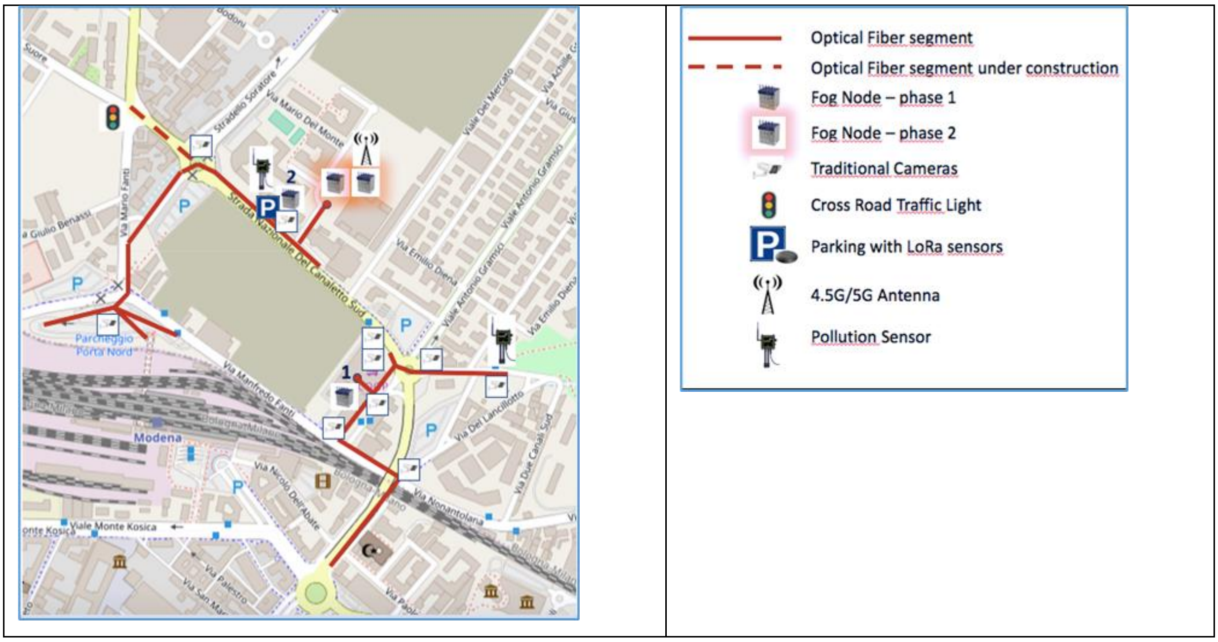

FIGURE 4: MASA SCHEME AND MAP

UNIMORE has good relationships with the Modena Automotive Smart Area (MASA) [13] that complies with the previous description, but the discussion is not limited to it. Any Smart City infrastructure with these characteristic will suffice.

Depending on the degree of „smartness“ of the sensor/camera, and its computational capabilities, the detector/prediction task can be either run on the camera itself, or on the server. While the former case is preferable, due to the lowest latency for transmitting meta-data to the server instead of HD images, it requires edge devices with appropriate computational capabilities. For this reason, currently only a small number of smart cameras (<10) are installed within the experimental area.

The Figure 5 shows how the information will flow from the camera to the server, in case computation is performed on the edge device. In green, target latencies are highlighted to reach what we call "real-time distributed city awareness". The information flow is the same also in the case where computation is done on-cloud, but in this case, (measured) latencies are 8-10x higher.

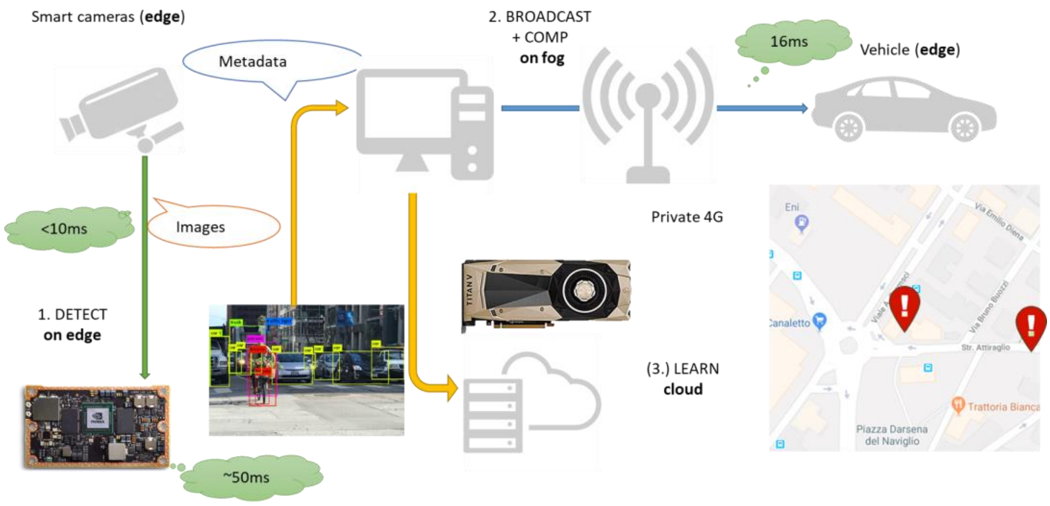

FIGURE 5: SMART CITY DATA FLOW

On this flexible infrastructure, the analytics from WVIEW will be ported. Such algorithms get the images from fixed cameras and can get weather data at a very local level. The AI algorithm detects precipitation intensity and type (rain or snow) and how they affect visibility. Even more importantly, they can detect possible snow deposit on road or flooding that may be dangerous for vehicles stability. All these information will be gathered, mixed with other sources and placed on a digital map which will be shared with the vehicle.

Alongside the shared and public city infrastructure, a private backend on the cloud is also considered. It is in charge for gathering, storing, and processing the telematic data collected and transmitted by the On-Board Unit (OBU) in the vehicle. From now on it will be called Telematic Service Provider Control Centre (TSPCC).

A basic version of a TSPCC instance suitable to the purpose of the AI4CSM project shall be developed and deployed and operated by VEM in its private hybrid cloud environment. In addition to store and process the incoming data, it will provide simplified methods for HMI presentation (e.g., maps, events, warnings…etc.) and suitable web API available to authorized third parties for possible service development and demonstrations.

The integration with TSP Control Centre (TSPCC) shall be guaranteed by the establishment of a long-range communication over a 4G channel on a public mobile network.

Whenever appropriate, the OBU shall open a private APN (Access Point Name) connection dependent of the mobile provider used and connects the servers installed in the Viasat Group corporate network data center, where the communication Front-End service is running.

The Front End shall permit the bi-directional data exchange in full-duplex modality to receive data from the OBU and to send at the same time commands to OBU.

The data received shall route on a Rabbit's messaging queue where different services carry out some actions as the saving on a Data Base for the storage in the TSPCC or used to manage the value-added services made available by the TSPCC

The TSPCC shall also provide a system of Web Services publicly exposed to permits the sharing of the information with external service providers.

The OTA (Over-The-Air) protocol established between the OBU and the Front End shall be composed by two layers, the *Transmission Protocol* and the *Application Protocol*.

The "Transmission Protocol" is intended to guarantee the data transportation and delivery to the TSPCC and encapsulates the information. Every message must be acknowledged by the receiver. As initial assumption, the protocol shall be composed by the following elements:

- Header
- Message property
- Body length
- Device ID
- Timestamp
- FE Application ID
- Body Data
- CRC

Suitable "Application Protocols" shall be defined and developed to transmit the information among the peers and changes according to the specific action or data requested by TSP Control Centre. Based on the use cases shall be identified so far , specific messages will be defined and implemented to enable the transmission

4.2.2.7 Aggregator

The blocks described above generate a great amount of data about the current internal and external situation. These pieces of information can be correlated ones another to get the big picture of the current situation. The aggregator is software piece that does exactly this. The expected inputs are:

- The human behaviour pattern recognized by the interaction with the infotainment system
- The human drowsiness level recognized by the drowsiness monitoring system
- The human identity and level of attention coming from the driver monitoring system
- The weather and road condition recognized by fixed cameras and sent over wireless communication
- The presence of pedestrians recognized by on vehicle sensors and remote smart cameras

The aggregator must collect all this info and fuse them to detect critical scenarios and trigger compensating actions like the takeover request to the user. It will be the component acting at the vehicle level by issuing high level commands.

4.2.3 Requirements and KPI

The partners in SC3 defined the requirements for development, integration and testing. Such requirements are gathered in a living document on the shared folder in the format of an Excel file to be updated, revised and completed as the project goes on. In the following some of the requriements are presented as an example.

TABLE 2: AI4CSM_WP1_SCD3.1_48

Req. ID	AI4CSM_WP1_SCD3.1_48
Description	The AI-SDF shall be able to infer AI models with hardware acceleration
Rationale	Provide a platform to run AI applications
Metrics	1 TOP/S with a latency sensor-to-inference smaller then 100ms, tested using benchmark applications
Owner	I&M

TABLE 3: AI4CSM_WP1_SCD3.1_49

Req. ID	AI4CSM_WP1_SCD3.1_49
Description	The AI-SDF shall have an AURIX® processor
Rationale	Provide safety integrity and AI acceleration
Metrics	yes/no
Owner	I&M

TABLE 4: AI4CSM_WP1_SCD3.1_45

Req. ID	AI4CSM_WP1_SCD3.1_45
Description	Smart City Cloud servers should be able to collect at least 12 images per minute from city cameras.
Rationale	The CAM weather analytics return values every minute made robust and reliable by processing multiple images within the previous minute.
Metrics	12 frames per minute
Owner	WVIEW

TABLE 5: AI4CSM_WP1_SCD3.1_47

Req. ID	AI4CSM_WP1_SCD3.1_47
Description	The CAM applications shall provide low visibility and rainfall/snowfall warnings, with 1 minute time granularity
Rationale	Provide low latency warnings on hazardous weather conditions
Metrics	Update latency <= 1 minute
Owner	WVIEW

TABLE 6: AI4CSM_WP1_SCD3.1_39

Req. ID	AI4CSM_WP1_SCD3.1_39
Description	The wearable drowsiness sensor shall have an autonomy sufficient for meet a whole work shift. The sensor autonomy shall be 10 hours minimum.
Rationale	Ensure that the sensor operates for the whole working shift of a professional driver
Metrics	Time >= 10 hours
Owner	VEM

TABLE 7: AI4CSM_WP1_SCD3.1_60

Req. ID	AI4CSM_WP1_SCD3.1_60
Description	The OBU shall capable to establish a long range communication through 4G network to transmit the measured parameters from the vehicle
Rationale	Verify the correct transfer of information between the OBU and the TPSCC
Metrics	Binary = true or false
Owner	VEM

TABLE 8: AI4CSM_WP1_SCD3.1_6

Req. ID	AI4CSM_WP1_SCD3.1_6
Description	The "Citybox" shall implement Behavioral-based Driver Monitoring (BB-DMS) using a camera frame video stream for reactive detection of drowsiness and dangerous behavior/distraction detection
Rationale	The "Citybox" will enable camera-based, real-time, complementary drowsiness detection and driver distraction detection
Metrics	Binary = true or false
Owner	UNIMORE

TABLE 8: AI4CSM_WP1_SCD3.1_8

Req. ID	AI4CSM_WP1_SCD3.1_8
Description	The "Citybox" detection tasks shall exhibit timing predictability behaviour
Rationale	The detection tasks need to be performed with a predictable and bound latency time to ensure a suitable response time for applying countermeasures. The timing

	of these operations will have to comply to a given quality of service requirement, specified as a maximum latency increase value
Metrics	Binary = true or false
Owner	UNIMORE

TABLE 9: AI4CSM_WP1_SCD3.1_12

Req. ID	**AI4CSM_WP1_SCD3.1_12**
Description	The AI-SDF shall have a functional safety PMIC to supply Aurix microprocessor
Rationale	The supply of Aurix is needed to comply with ISO26262 standard and provide Safety Analysis Summary Report
Metrics	SASR
Owner	IFI

TABLE 10: AI4CSM_WP1_SCD3.1_13

Req. ID	**AI4CSM_WP1_SCD3.1_13**
Description	The PMIC device shall provide the following voltage rails for Aurix: - 0.95V supply for microcontroller core; - 3.3V or 5V supply for microcontroller front-end
Rationale	Aurix device requires a dedicated high-power regulator compliant with AEC-Q100.
Metrics	• 7A capability on 0.95V rail • 1A on 3.3V/5V rail
Owner	IFI

4.3 SCD 3.2: L1e vehicle with natively integrated telematics

This second demonstrator focuses on an electrical moped with a maximum velocity of 45km/h. The so-called e-moped are battery-powered two-wheel vehicles suited for urban mobility since they are light-weight, space-efficient, and do not affect air quality. If used in a free-floating shared service, they can contribute to reducing the use of private vehicles, along with other sharing services and public transport [14]. SCD3.2 consists of an electric e-moped natively connected to the cloud, allowing remote data collection and fleet management.

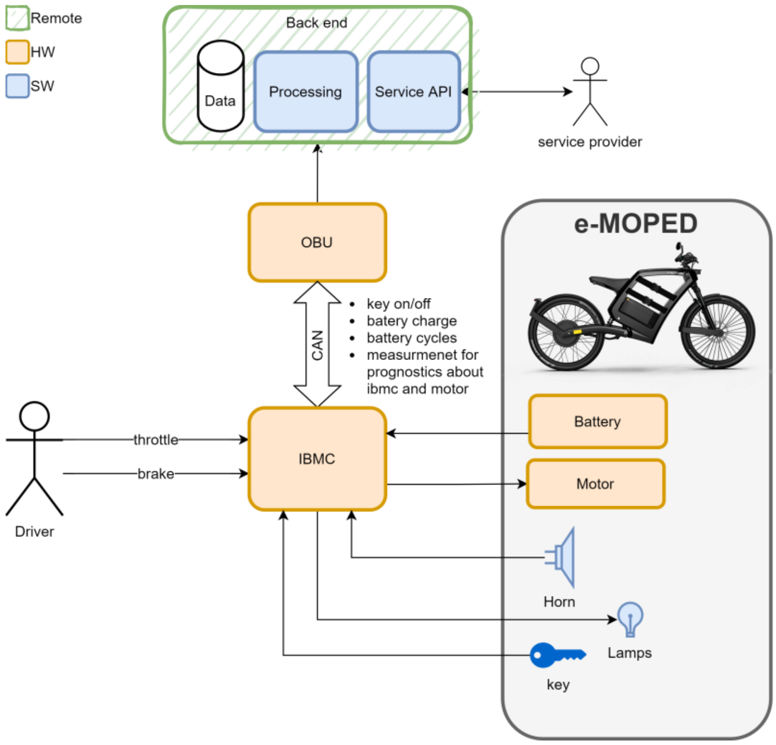

FIGURE 6: SCD3.2 ARCHITECTURE

4.3.1 Scenario description

Demonstrator SCD3.2 will be demonstrated in scenario 3.2.1, which will showcase the integrated e-moped on the road while logging the relevant working data to the backend.

- Scenario 3.2.1: Cloud-connected e-moped
  - e-moped with Integrated Body Motor Controller (IBMC) and telematic On Board Unit (OBU)
  - IBMC and OBU exchange data over CAN, the OBU gathers the data and sends it to the backend
  - Data can be visualized and possibly used for fleet management, technical validation, and prognostics

4.3.2 High level architecture

In the following section, the architecture components are described.

4.3.2.1 L1e Bike

The FEDDZ E-Moped L1e vehicle is operated mainly in urban environment for individual mobility and is with its electric drive system a CO2 free vehicle. The challenge for an OEM of such “electric micro mobility vehicles”, is to provide a efficient service level to the customers which can be individual persons and up to professional fleet operators. With this demand the FEDDZ E-Moped offers an ideal platform for the partners in the AI4CSM project to develop needed connectivity functions and systems software/ hardware for such. These solutions developed together with the partners and applied in the FEDDZ E-Moped can be used in general in all kinds of mobility vehicles in similar use.

All the partners in the AI4CSM project can implement in a efficient way their technologies and solutions in the FEDDZ E-Moped as a street legal EU L1e homologated vehicle to demonstrate, test and validate in a real use case environment.

FEDDZ as the OEM of the vehicle likes to focus on a constantly monitoring of the most critical operational parameters of the L1e vehicle, such as safety risks, performance, maintenance, upgrading, informing in this way on potential service needed or imminent failure of a vehicle subsystem. Having the capability of a location and tracking function combined to be securely update the vehicular SW over-the-air (OTA) will save time for the end-user and cost for the OEM, to increase the efficiency in the post-sale maintenance and customer service.

4.3.2.2 IBMC

Both internal combustion and electrical motorbikes need a body controller ECU for managing lamps, horns, commands from the driver, and the key for power on and off. Electrical ones instead of an engine control unit need a multi-phase inverter for driving the motor. Current EU regulations impose that the maximum speed for this kind of vehicle is limited to 45km/h and the maximum continuous rated power of 4 kW [15]. Thus the ECU has to enforce these limits. Finally, the battery needs to be monitored and kept in a healthy range. This surveillance is typically performed by communicating with a dedicated Battery Monitoring System (BMS).

In SC3 the Integrated Body Motor Controller will be developed and it will integrate the above-mentioned features, here summarized:

- 4kW power stage
- Management of all auxiliary body vehicle functions for a light electric vehicle.
- Surveillance of battery status by communication with the BMS

The IBMC will save both space and cost by integrating several functions in the same platform. Finally, wherever possible, it will be designed so that it can be easily upscaled to target other categories of vehicles, thus expanding the field of applicability.

The IBMC will be able to send runtime data to the OBU, including:

- Brake command
- Driving mode
- Battery current, voltage and estimated state of charge
- Throttle
- Current loop saturation
- Capacitor, powerstage and motor temperature
- Available and requested torque
- Voltages and currents (on the d and q axes)

This data will be uploaded and geotagged with position and timestamp. This extensive information can be used for testing and validation in the first stage. After that, it can be used for the management of a shared fleet of vehicles and for fault detections and predictive maintenance.

4.3.2.3 OBU + Backend

The OBU and backend used in this simulator are functionally identical to the one described for SCD3.1 (respectively in Section 4.2.2.4 and Section 4.2.2.6). The OBU might be physically different in form factor, but the features are the same.

4.3.3 Requirements and KPI

The partners in SC3 defined the requirements for development, integration and testing. Such requirements are gathered in a living document on the shared folder in the format of an Excel file to be updated, revised and completed as the project goes on. In the following some of the requriements are presented as an example.

TABLE 11: AI4CSM_WP1_SCD3.2_52

Req. ID	**AI4CSM_WP1_SCD3.2_52**
Description	IBMC shall be able to drive the motor according to the following profile:
Rationale	This is the needed current profile for the given motor at steady state
Metrics	ΔT = 30 minutes Bike Speed = 35km/h Phase current rms = 40A Measured in lab environment, tested and validated on vehicle
Owner	I&M

TABLE 12: AI4CSM_WP1_SCD3.2_54

Req. ID	**AI4CSM_WP1_SCD3.1_49**
Description	IBMC shall be able to manage the body devices.
Rationale	It must fulfill its role of body controller.
Metrics	Correctly control and read: - display - horn - lights - kickstand sensor
Owner	I&M

TABLE 13: AI4CSM_WP1_SCD3.2_68

Req. ID	**AI4CSM_WP1_SCD3.2_68**
Description	The IBMC shall fit inside the FEDDZ vehicle chassis.
Rationale	The IBMC shall fit inside the volume assigned to it.
Metrics	Fit in 180x170x80mm
Owner	FEDDZ

5 Conclusion

5.1 Contribution to overall picture

In this document, the progress of SC3 activities in T1.3 is summarized. In particular, being the first task of the project, it aimed to define the demonstrators, the technologies needed, and the interactions between them.

The first demonstrator, SCD 3.1, focuses on an electric vehicle with L3 autonomous level to increase its situational awareness by employing: driver monitoring systems, including drowsiness predictions and distraction detection, and cloud connections for weather, VRU, and road condition detection.

The second and last demonstrator, SCD3.2, instead delivers a fully functional electrical moped based on an integrated solution for body and motor control, alongside a telematic onboard unit for native cloud connection.

5.2 Relation to the state-of-the-art and progress beyond it

The following table summarizes the state of the art and the progress for each key technology described above. This is just a summary of what is reported in the previous sections.

TABLE 14: STATE OF THE ART

Topic	Description
L1e vehicle with native connection	During the project, a new two wheel electric based motor will be developed with integrated functons and native telematic features for cloud communication. In the L1e there are no COTS systems that can control the motor and the body with one single platform. The IBMC solves this issue by integrating the two functions thus saving space and costs. This eases the integration in a volume-constrained environment.
IFI / PMIC	
NumberCruncher	GPUs are the state of the art for AI inference and in the last years, they are doing the jump from the cloud to the automotive sectors. Lately, AI-specific engines are being added to SoC, with integer arithmetic and a high number of operations per second. FPGAs instead offer performances, energy efficiency, and programmability, at the cost of higher complexity. Unfortunately, these do not offer a high safety integrity level and the SotA safety oriented µC are not able to execute parallel processing tasks to enable efficient computation on AI algorithms. Thus, next generation AURIX® will hold a dedicated PPU (parallel processing unit) to cover this topic Because of the increased computation power of the Aurix, new power supply must be designed.Current Power Management IC supporting functional safety micro controller devices in the automotive environment have a current demand up to approximately 2A for core logic. The need for more computational logic is nevertheless showing a tremendous boost of power consumption that will bring the next generation micro controller already in the range of 7A (or more) current. Moreover, the advancement in technology scaling is moving the voltage set from current 1.25V to 0.9V-1V with

	consequent increase of needed precision (absolute value) for the regulated voltage that combined with larger load step dynamic response will further challenge the DCDC architecture and regulation scheme. A
Driver monitoring system	Behavioral-based monitoring systems that use cameras can fall short in drowsiness detection in some scenarios (sunglasses, open eye sleeping, etc). This will be compensated by physiological-based monitoring that analyzes biometric parameter to also predict the sleep onset. On the other hand, behavioral-based systems detect distraction due to other activities like texting and smoking. The two approaches will be combined to get the best of both worlds.
Weather detection	Weather data on conditions and phenomena that may affect driving are usually obtained by dowscaling weather data collected from weather forecasts or sparse sensor networks, thus affecting their latency (more than 30 minutes) and significance (low spatial granularity may generate error in assessing actual weather conditions along the road). Gathering low latency and high granular weather data and road pavement conditions information directly from the road infrastructure, by using weather video analytics that leverage traffic cameras installed along the road, is a game changing approach, that completely redefine the concept of Road Weather Information System, abating the costs for weather monitoring while multiplying the number of observation points. The system not only provides hyper local information on the weather conditions around the vehicle, but can also be used to generate an informative digital horizon on the weather ahead, to improve assisted and autonomous driving in taking in time the best decision for safety.

5.3 Impacts to other WPs, Tasks and SCs

Task 1.3 laid the foundation for the development carried on by SC3 partners. In particular, the requirements that will be used for development and that will be validated at the end have been defined. Each partner collaborated with the other focusing in particular on interfaces between the technologies, in order to allow a good integration. For partners involeved in other SCs like IFI and IFAG, those requirements influnce and are influenced by the other activites.

5.4 Contribution to demonstration

All the partners contribute in their way to the final demonstrator. At this stage, the contribution consists in the definition of the scenarios and the technologies.

Partner	Description
IFI, IFAG, and I&M	IFI, IFAG, and I&M put requirements on the PMIC, the Aurix and the whole AI-SDF platform that will fulfill the role of Number Cruncher. This will be used in the demonstrator as a platform to run AI algorithms in SCD3.1
FEDDZ	In this task the requiremetns for the e-moped are defined. The resulting vehicle will be used in SCD3.2
POLITO, POLITO, SAT, UNIMORE, VEM	The activity of defining requirements for a diverse monitoring strategy will result in a driver monitoring system that includes distraction detection and sleeping onset prediction, to be used and shown in the demonstrator.

VEM	VEM defined the requirements for the OBU and backend infrastructure that will be used in both demonstrator SCD3.1 and SCD3.2.
WVIEW	WaterView provides its weather and road analytics in a docker environment, to be installed on the MASA serves, where images taken from MASA cameras will be processed. Telemetry on weather and road pavement conditions, as well as alerts related to predefined risky weather conditions, will be published via MQTT queues minute by minute, to be used by the aggregator together with other data from the vehicle

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