FABRIC

Feasibility analysis and development of on-road charging solutions for future electric vehicles

Verification plan for ICT Solutions

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LIST OF ABBREVIATIONS

ABBREVIATION	DESCRIPTION
AAA	Authentication Authorisation Accounting
ANPR	Automatic Number Plate Recognition
Asn1	Abstract Syntax Notation 1
C/S CU	Charging Station Control Unit
CAN	Controller Area Network
CB	Circuit Breaker
CCU	Communication and Control Unit
CI	Charging Infrastructure
CIR	Charging Infrastructure Retrieval
CPC	Charging Procedure Control
CWD	Charge While Driving
DSO	Distribution System Operator
EV (FEV)	(Fully) Electric Vehicle
EVR	Electric Vehicle Retrieval
EVSE	Electric Vehicle Supply Equipment
FABRIC	Feasibility Analysis and development of on-road charging solutions for future electric vehicles
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
ICT	Information and Communications Technology

ID	Identity
ITS	Intelligent Transport System
KML	Keyhole Markup Language
LBC	Load Balancing Controller
LBS	Load Balancing System
LKS	Lane Keeping System
OBU	On-board unit
PE	Power Electronic
RCD	Residual Current Device
RF	Radio Frequency
RSU	Road Side Unit
SP	Sub-Project
V2X	Vehicle-to-X
VMU	Vehicle Management Unit
VRM	Vehicle Relationship Message
WGS-84	World Geodetic System 84
WP	Work-Package

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EXECUTIVE SUMMARY

This deliverable is part of WP26 of the FABRIC project and sets the framework for verification of the ICT applications for the project trials on dynamic charging of Electric Vehicles (EVs). The applications are being developed in parallel within WP25 “Design of ICT applications and development of components” and will be tested at sites in France (Satory, near Versailles) and Italy (Susa, near Turin).

Based on the use cases and requirements defined in WP22 (Deliverable D2.2.1: User needs, system concept and requirements for ICT solutions), this deliverable describes the overall procedure for the verification and validation of the Load Balancing System,(LBS) On-Board Unit (OBU), Backend, Charging Infrastructure (CI) and Lane Keeping System (LKS).

FABRIC will follow the systems engineering approach for ITS as guidance for its development and testing. Since the FABRIC system consists of components or blocks that pursue a common goal that cannot be achieved by each of them separately, we include both software and hardware, operated by the actors that are integrating them, and ITS parts of the system itself. The approach implies the traceability of specifications from customer requirements through production, operation and disposal, passing through test and maintenance phases. The commonly used “V” Model is followed (see Chapter 2) with the main focus on Unit Testing, Subsystem Verification, System Verification, and System Validation phases.

Unit tests are defined for each of the five individual ICT areas listed above. Unit testing applies only to the software / hardware components that are implemented or modified in the scope of FABRIC, omitting off-the-shelf components. The LBS, OBU, Backend, CI, and LKS developers have specified and will execute the individual component tests, which will be employed not only after the implementation of the components but also during their development.

The elements to be tested are as follows:

- Load Balancing System (LBS): Load monitoring, Load Balancing Controller infrastructure and Load Balancing Vehicle Controller.
- On-Board Unit (OBU): Input interfaces, Radio module, ITS-G5 custom messages.
- Backend: Communication management modules and interfaces, Data management modules and interfaces, Utilities modules and interfaces, Application support modules and interfaces, and Application modules and interfaces (e.g. notification and booking functions).
- Charging Infrastructure (CI): Authentication, Authorisation, Accounting (AAA), booking, monitoring, Charging Station Control Unit (C/S CU), and Web service.
- Lane-Keeping System (LKS): Lane feature detection and Driver guidance.

The systems are relevant to the French and Italian test sites, although the individual tests set out in this deliverable focus on the ICT system to be tested in Italy. Therefore some modifications will be introduced for the French site where some systems (notably the OBU and the CI) will be different.

1 INTRODUCTION

The FABRIC Integrated Project aims to study the potential of large-scale deployment of electro-mobility focusing on the technological feasibility, economic viability and socio-environmental sustainability of dynamic on-road charging of electric vehicles (EVs). SP2 of FABRIC concentrates on the Information and Communications Technology (ICT) development for on-road EV charging. Within this Sub-Project, WP25 is developing prototype on- and off-board ICT applications that are necessary for the testing and evaluation of the FABRIC dynamic charging solutions at the two test sites (in France and Italy).

Although the main focus of FABRIC is dynamic charging (while the vehicle is moving), the evaluation also applies to stationary charging (where the vehicle is stopped for a short time, e.g. from a few seconds to a minute or two, such as at traffic lights) and static charging (where the vehicle is parked). These three charging modes are more fully described in D2.2.1 “User needs and requirements”[4], whereas D4.3.2 “FABRIC Test Scenarios” [6] sets out the test cases for them. The lab tests described in the present deliverable cover all three modes. Effectively if the expected result is achieved for the dynamic charging mode, then it will also work for the static and stationary modes. But an unsuccessful result for the dynamic mode might still be successful for one or both of the other modes.

This deliverable, part of WP26 “Verification” defines the methodology for testing and verification of the ICT systems for the FABRIC trials. The FABRIC ICT applications and services being developed throughout WP25 will be tested and evaluated in WP26 to ensure their conformity with the specifications in D2.4.1 “Architecture and system specifications”[3] and the functionality requirements in D2.2.1 “User needs and requirements”[4].

This goal will be reached through an evaluation that will cover the following aspects:

- Definition and set up of the verification methodology
- Measurement of the ICT applications’ performance at the test sites
- Technical verification of the functionality of the ICT applications.

A step-by-step validation and evaluation procedure is followed, as for the development procedure. This method will allow the detection of potential problems at each step of the development and take appropriate actions on time which will considerably reduce the time required for the problem solving at a later stage.

This deliverable defines tests for five ICT systems, as follows:

- LBS: Load Balancing System
- OBU: On-Board Unit

- Backend
- CI: Charging Infrastructure
- LKS: Lane-Keeping System.

Note that some considerations such as user acceptance, authorisation, accounting, data privacy and provision of information by the DSO are not part of the FABRIC trials and hence not within the scope of the ICT developed in SP2. Data privacy considerations were already covered in D2.4.1 (ICT functional architecture and specifications) and all of these issues are relevant for the feasibility assessment part of FABRIC (SP5). One authorisation issue is the staging of the distance between vehicles entering the charging zone. This is not covered here as the test tracks in the FABRIC SP4 trials are short and only one vehicle will use them. However it is a consideration in SP5 in the case of a longer charging site on a public road.

It should be noted that a parallel activity in WP37 “Technological verification” is defining the methodology and verification tests for the charging (EVSE) solutions.

2 APPROACH

2.1 Testing and Evaluation Methodology

The FARIC Project employs the systems engineering approach for ITS as guidance for its development and testing. Since the FABRIC system is an artefact that consists of components or blocks that pursue a common goal that cannot be achieved by each of them separately, in the system we need to include both software and hardware, operated by the actors that are the integrating them, and ITS parts of the system itself. Each component of the system and its behaviour are tightly connected to the other components.

Therefore we need the systems engineering approach, which implies the traceability of specifications (WP24) from customer requirements through production, operation and disposal, passing through test and maintenance phases. In this sense it integrates all specialty groups forming a structured development process ("top-down" approach).

Considering the commonly used "V" Model in this approach, depicted in Figure 1, WP26 is mainly concerned with the Unit Testing, Subsystem Verification, System Verification, and System Validation phases, as indicated with orange markers in the following figure.

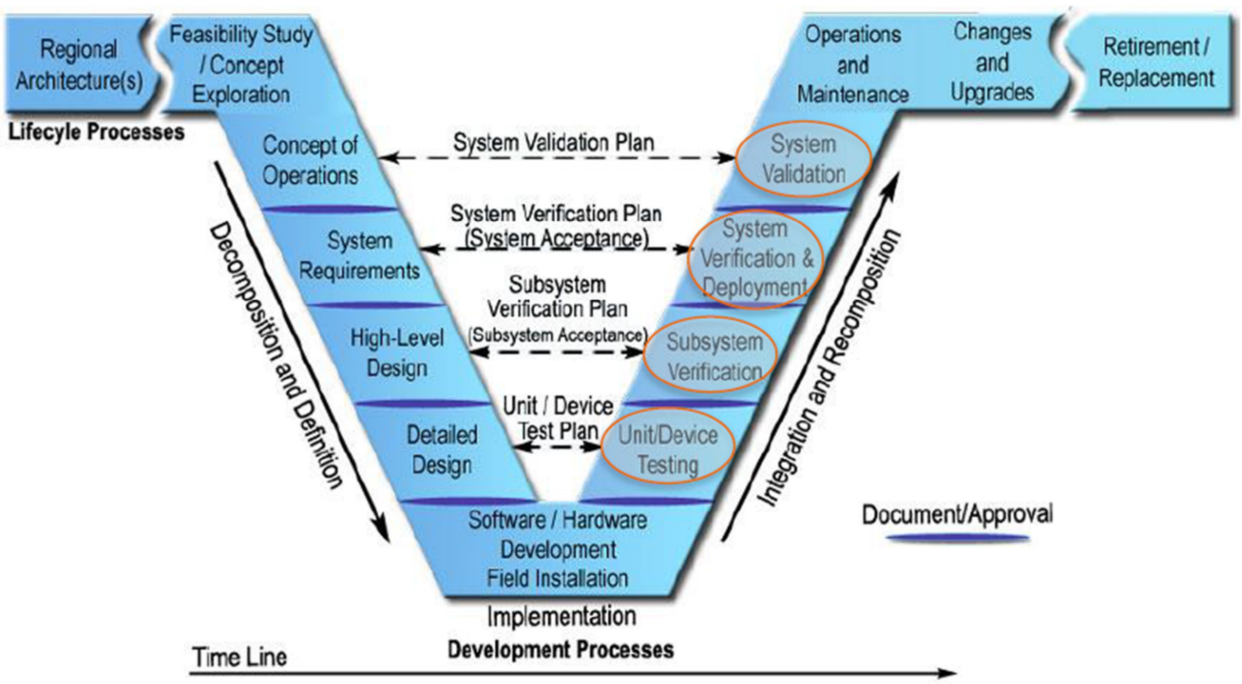

Figure 1: Main phases of the generic systems engineering approach

For developing the whole process we must analyse how FABRIC can be organised. In this sense, the V model describes the life cycle of it. The left side represents the system decomposition and requirements definition, followed by product and process design; while the right side represents system production, integration and verification.

Following this whole process, the evaluation will start with the unit testing of low-level individual components of the FABRIC ICT system defined in D2.2.1. The unit testing should verify the internal functionality of each component and that they meet the design specifications and requirements.

Once the individual components are verified, they are integrated to form the subsystems specified in the high-level design in D2.2.1, which will then be evaluated in the subsystem verification phase in order to confirm that all interfaces have been correctly implemented and all requirements have been satisfied for each subsystem.

The system verification phase is concerned with the evaluation of the system as a whole, ensuring that the system behaves as expected, taking the use cases defined in D43.1 [1] as the main input.

Once the FABRIC system is verified for its error-free design and operation, the last phase of the evaluation, system validation, ensures that the system is effective, for the given performance metrics, in meeting the intended purpose and needs defined at the beginning of the project.

The following four chapters of the present deliverable will describe in turn each of the above four phases of the evaluation methodology.

2.2 Unit Testing

Unit Testing in FABRIC SP2 will involve all the ICT applications/systems developed in WP25. These are:

- LBS
- OBU
- Backend
- CI
- LKS.

Each individual application therein will define its own set of unit tests. Unit testing applies only to the software / hardware components that are implemented or modified in the scope of FABRIC, omitting off-the-shelf components. The LBS, OBU, Backend, CI and LSK will specify and execute their individual component tests, which would be employed not only after the completion of implementation but also to be applied throughout the development. We will use a

template to define the lab tests and another template to define the field tests. The two templates are presented below

Table 1: Template for lab test

Test Case Id	Test Case Description	Expected Result	Actual Result	Remarks
1			PASS	
2			FAIL	
3				
4				

Table 2: Template for field test

Test Case Id	Test site(s): Italy/ France/ Both	Test Case Description	Expected Result	Actual Result	Remarks
1	Both			PASS	
2	Italy			FAIL	
3	France				
4					

3 VERIFICATION OF THE APPLICATIONS

3.1 Load Balancing System

3.1.1 Description

Load balancing aims at keeping the equilibrium between grid supply and demand taking into account many parameters relevant to the EV BMS, charging infrastructure operating characteristics, grid stability, power quality and user preferences. It is essential in, ensuring that net capacity and transformer limits of the grid will not be violated. Moreover it ensures that highly unpredictable energy sources can be integrated (wind, solar) by shaping the overall demand due to charging operations to match the available supply.

Note that DSO's provision of information is not included in the reference architecture and is not part of the trials. The tests described here relate only to verifying the module developed in D2.5.3,

3.1.2 Architectural overview

The following figure shows the architecture of the load balancing application and depicts the main components of the system.

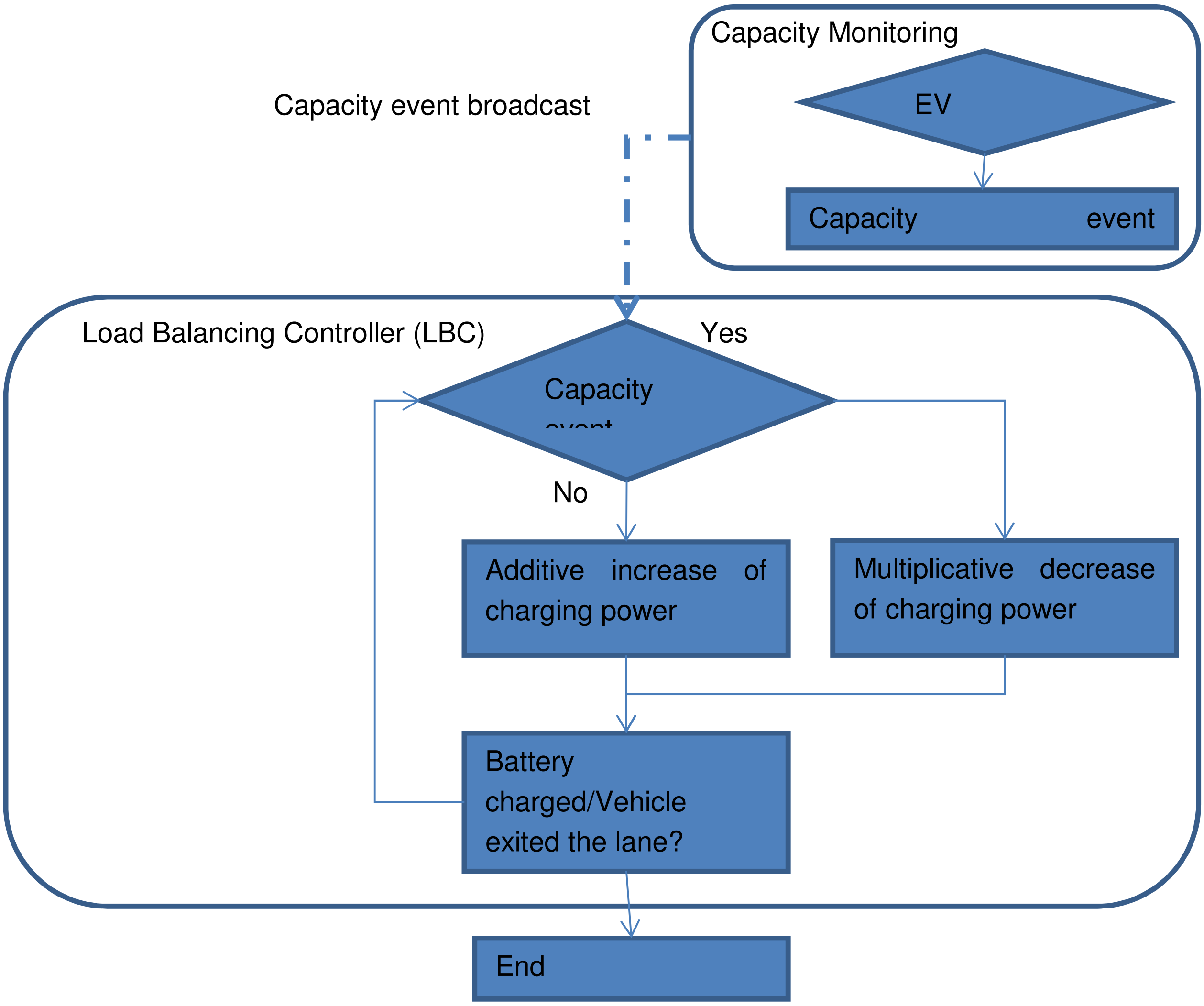

Figure 2: Architecture of the load balancing application

The Load balancing controller has been designed to be interfaced to external entities such as central regional charging controllers and DSOs on the basis of SSL based RFC6455 web socket connections as analysed in chapter 2 of D2.5.3, entitled “Load Balancing for Dynamic Wireless Charging: ICT standardisation and approach”

3.1.3 Lab tests

3.1.3.1 Load Monitoring

Test case Id	Test case goal and description	Expected Result	Actual Result	Remarks
1	The load monitoring module receives information about the	Correct reception of an object/message that		

Test case Id	Test case goal and description	Expected Result	Actual Result	Remarks
	current demand of the system.	represents the overall load of the system		
2	The load monitoring module receives a threshold indicating the maximum power to be transmitted by the charging infrastructure to vehicles. This threshold is correctly received through the hosted web service interface from external entities such as DSO/Energy retailers.	Reception of an object/ message that indicates the set point of power that can be transmitted by the infrastructure to vehicles.		
3	The load monitoring module issues a capacity event broadcast if the overall load exceeds the overall power capacity of the grid.	Transmission of an object/message indicating that the maximum power transfer capacity of the system has been reached		

3.1.3.2 Load Balancing Controller Infrastructure

Test case Id	Test case goal and description	Expected Result	Actual Result	Remarks
1	The Load Balancing Controller receives a notification of a vehicle entering its dedicated charging zone from the charging procedure control module (charging procedure control module = the Italian test site CI energy management module naming.)	Reception of an object/message that indicates vehicle identification		
2	The Load Balancing Controller receives the	Reception of an object/message indicating		

Test case Id	Test case goal and description	Expected Result	Actual Result	Remarks
	capacity event broadcast status	that the overall power transfer capacity of the system has been reached		
3	The Load Balancing Controller sets the power to be transmitted from the primary coil to the secondary coil	A setpoint indicating the power to be transferred from the primary to the secondary coil is sent from the load balancing controller to the charging procedure control module.		
4	The Load Balancing Controller decreases the charging power rate once a capacity event broadcast is issued by the capacity monitoring module	The Load Balancing Controller transmits a power setpoint to the charging procedure control module. This setpoint indicates a reduction of the power to be transferred, from the primary to the secondary coil		
5	The Load Balancing Controller increases the charging power rate if a capacity event broadcast is not issued and the maximum charging rate negotiated between the vehicle and infrastructure has not reached its maximum value.	The Load Balancing controller increases the power transfer setpoint up to the nominal charging rate, as long as a congestion event is not received from the capacity module		
6	The Load Balancing Controller receives a notification of a vehicle exiting the dedicated charging zone	The Load Balancing Controller receives a notification of a vehicle exiting the dedicated charging zone from the charging procedure control module		

3.1.3.3 Load Balancing Vehicle Controller

Test case Id	Test case goal and description	Expected Result	Actual Result	Remarks
1	The vehicle can correctly receive the charging power set point from the load balancing controller	The Load Balancing Vehicle Controller correctly receives the setpoint indicating the power transfer rate.		
2	The Load Balancing Vehicle Controller can check the battery status and accept charging at a given charging power according to the set points indicated by the charging infrastructure	The Load Balancing Vehicle Controller sets the actual charging transfer power according to the power setpoint received and the battery status.		

3.1.4 Field tests

In the case of load balancing, lab tests must be re-executed in the field with the communication medium available on-site.

3.1.4.1 Load Monitoring

Test case Id	Test sites: Italy / France/ both	Test case goal and description	Expected Result	Actual Result	Remarks
1	Both	The load monitoring module receives information about the current demand of the system through the respective interface installed on site	Correct reception of an object/message that represents the overall load of the system over the respective Italian/French test site communications medium.		
2	Both	The load monitoring module receives a threshold indicating the maximum power to be transmitted by the	Reception of a object/message that demonstrates the setpoint of power that can be transmitted by		

Test case Id	Test sites: Italy / France/ both	Test case goal and description	Expected Result	Actual Result	Remarks
		charging infrastructure to vehicles. This threshold is correctly received through the hosted web service interface from external entities such as DSO/Energy retailers, through the communications medium installed on site	the infrastructure to vehicles through the web hosting environment for the Italian/French test site.		
3	Both	The load monitoring module issues a capacity event broadcast if the overall load exceeds the overall power capacity of the grid.. The broadcast is disseminated through the communication medium installed on site	Transmission of an object/message indicating that the maximum power transfer capacity of the system has been reached. The transmission is done through the communication medium installed at the Italian/ French site.		

3.1.4.2 Load Balancing Controller (LBC) Infrastructure

Test case Id	Test site(s): Italy/ France /both	Test case goal and description	Expected Result	Actual Result	Remarks
1	Both	The Load Balancing Controller (LBC) receives a notification	The LBC receives an object that indicates vehicle identification		

Test case Id	Test site(s): Italy/ France /both	Test case goal and description	Expected Result	Actual Result	Remarks
		of a vehicle entering its dedicated charging zone from the charging procedure control module (charging procedure control module = naming for the Italian test site CI energy management module.)	credentials from the charging procedure control module installed in the Italian/ French test site.		
2	Both	The LBC receives the capacity event broadcast through the communication medium installed on site.	Reception of an object/message, indicating that the overall power transfer capacity of the system has been reached. The object/message is received through the communications interface installed on the test site.		
3	Both	The LBC controls the power to be transmitted from the primary side to the secondary side of the vehicle through the communication medium available on site.	A setpoint indicating the power to be transferred from the primary to the secondary coil is sent from the load balancing controller to the charging procedure controller installed at the test site.		
4	Both	The LBC decreases the charging power rate once a capacity event	The LBC transmits a power setpoint, which indicates a reduction of		

Test case Id	Test site(s): Italy/ France /both	Test case goal and description	Expected Result	Actual Result	Remarks
		is issued by the capacity monitoring module	the power to be transferred, from the primary to the secondary coil		
5	Both	The LBC increases the charging power rate if a capacity event is not issued and the maximum charging rate negotiated between the vehicle and infrastructure has not reached its maximum value.	The LBC increases the power transfer setpoint up to the nominal charging rate, as long as a congestion event is not received from the capacity module, through the communication medium installed at the test site.		
6	Both	The LBC correctly receives a notification of a vehicle exiting the dedicated charging zone through the communication medium available on site.	The LBC receives an object/message indicating, a vehicle exit from the dedicated charging zone. This message is received from the charging procedure control module installed at the test site.		

3.1.4.3 Load balancing Vehicle Controller

Test case Id	Test site(s): Italy/ France /both	Test case goal and description	Expected Result	Actual Result	Remarks
1	Both	The vehicle can correctly receive the charging power set point from the load	The Load Balancing Vehicle controller correctly receives the set-point indicating the		

Test case Id	Test site(s): Italy/ France /both	Test case goal and description	Expected Result	Actual Result	Remarks
		balancing controller through the communication medium available on site	power transfer rate., through the communication medium installed at the Italian/French test site.		
2	Both	The Load Balancing Vehicle Controller can check the battery status and accept charging at a given charging power according to the set points indicated by the charging infrastructure	The Load Balancing Vehicle Controller sets the actual charging transfer power according to the power setpoint received, and the battery status.		

3.2 On-Board Unit

3.2.1 Description

The goal of the On Board Unit (OBU) is to establish a connection between the vehicle and the road infrastructure. The wireless ieee 802.11p technology (ETSI ITS-G5 UE regulation) has been selected as communication technology able to fulfil the projects' requirements. The same solution was adopted in the eCo-FEV [2] project because it guarantees:

- Maximum point-to-point latency below 100ms;
- Universal geo-localised routing protocol.

The OBU will also act as virtual CAN bus channel because the recharging status needs some vehicles' signals in order to manage the recharging operations of the electric vehicle. These messages are currently out of standard but the eCo-FEV project demonstrated that this technology is able to support this type of application; therefore in FABRIC we will further investigate the specification of charging messages constrained to ITS-G5 messages.

3.2.2 Architectural Overview

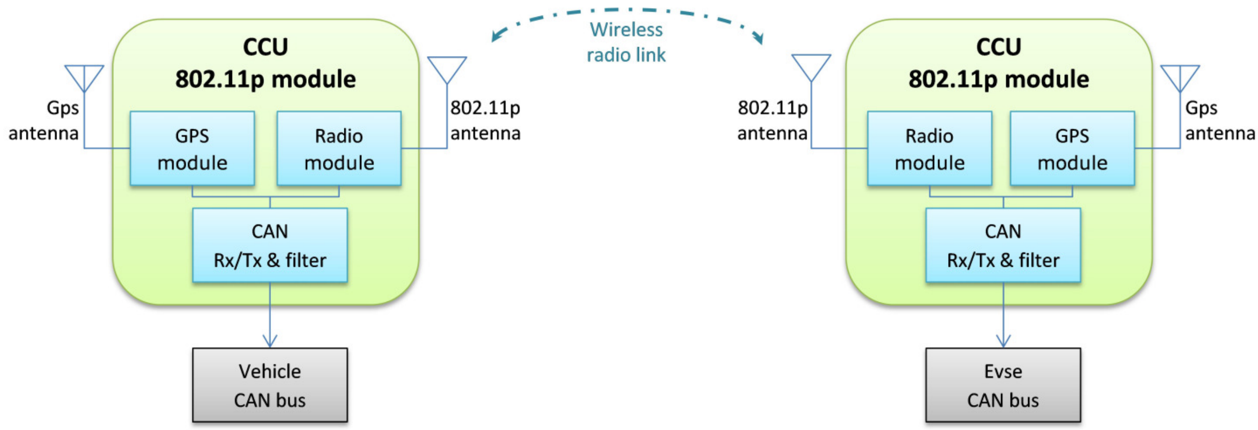

Figure 3: Communication between Vehicle and Road Infrastructure (radio module equipped on EVSE charging pad)

3.2.3 Lab Tests

The laboratory test sessions will check the correctness and the reliability of the functionalities implemented into the project. The test will be held under controlled conditions where real-life problems such as the lack of RF-signal or the multipath effect do not arise.

3.2.3.1 Lab test of the Input interfaces

The vehicles and the road infrastructure must collect some signals in order to notify the time of arrival at the recharging station or to communicate the need of charging.

Test case Id	Test case goal and description	Expected Result	Actual Result	Remarks
1	Get data from GNSS module.	The position in WGS-84 geodetic reference system. Verify that the GNSS module is correctly connected to the application responsible of the communication with the EVSE unit. Verify the suitability of GNSS position: fix quality and fix rate. Mean position accuracy		

Test case Id	Test case goal and description	Expected Result	Actual Result	Remarks
		of 10 meters is considered enough for the purposes of the project.		
2	Get vehicle signals from CAN bus. The CAN signals that should be exchanged between the vehicles and the EVSE station will be defined later on: during the integration of all the components. As starting point it will be used the same signals of eCo-FEV project.	The CAN signals decoded according to the definition of CAN database.		
3	Filter out unnecessary CAN messages. The signals that should be exchanged will be provided following the CAN DBC (Database Container) standard. According to this database it's possible to exclude unnecessary signals. The filtering module will be implemented considering as starting point the DBC of eCo-FEV project. Changes on the DBC will not impact on the operability of this module.	Only those messages necessary to manage the recharging process will be sent to the EVSE station in order to minimise the amount of data transmitted.		

3.2.3.2 Lab test of the Radio Module

The laboratory test will check the correctness of the messages exchanged between the ITS-G5 stations. The ITS-G5 ETSI standard is still under definition; therefore it is affected by periodic updates. According to that the messages exchanged between the Vehicles and the Road Side Unit will be different from the one implemented into the eCo-FEV project.

Test case Id	Test case goal and description	Expected Result	Actual Result	Remarks
1	Fill all the containers of ITS-G5 messages with input data.	Convert the data coming from GNSS module and CAN bus into the ETSI ITS-G5 format.		
2	Encode the ITS-G5 messages according to asn1 definition. CAM messages will be sent according to the last ITS-G5 asn1 syntax available on the official ETSI repository (current version 1051).	An ITS-G5 dissector validates that ITS-G5 messages are sent in the proper format.		
3	Explore all the possible input values in order to test the asn1 encoding module (event with out-of-scale data).	All the messages are generated without exceptions or anomalies.		
4	Decode the ITS-G5 messages according to asn1 definition.	All the ITS-G5 messages are received in the proper format without errors.		
5	Compare the decoded signals with the original values.	The received signals should be equal to the values available before the encoding.		
6	Maximum point-to-point latency below 100ms.	The maximum delay from transmission and reception has to not exceed the 100ms. Even at this level the system would only function at low speeds. In case the latency requirement is not met we should reduce the amount of data to be sent: reduce the generation rate of CAM.		
7	Data rate equals to 10Hz.	During the laboratory tests we don't expect to lose any		

Test case Id	Test case goal and description	Expected Result	Actual Result	Remarks
		packet. The ITS-G5 station should: send 10 messages per second and receive exactly 10 messages per second.		
8	Test the interoperability between V2X stations.	ITS-G5 stations are able to communicate without any error.		

3.2.3.3 Lab test of ITS-G5 custom messages

The FABRIC project will define some informative messages that the vehicle and the EVSE station could exchange in order to manage the recharging process.

Test case Id	Test case goal and description	Expected Result	Actual Result	Remarks
1	Collect the signals necessary to generate the ITS-G5 custom message.	Convert the data coming from CAN bus into the custom message.		
2	Encode the ITS-G5 messages according to asn1 custom syntax defined to fulfil recharging requirement.	Check that ITS-G5 messages are sent in the proper format.		
3	Explore all the possible input values in order to test the asn1 encoding.	All the messages are generated without exceptions or anomalies. If some errors occur at this level it's necessary to revise the asn1 syntax in order to avoid out-of-scale data.		

Test case Id	Test case goal and description	Expected Result	Actual Result	Remarks
4	Decode the ITS-G5 messages according to asn1 definition.	Check that ITS-G5 messages are received in the proper format without errors.		
5	Compare the decoded signals with the original values.	The received signals should be equal to the values available before the encoding.		
6	Maximum point-to-point latency below 100ms.	The maximum delay from transmission and reception not exceed the 100ms. In case the latency requirement is not met we should reduce the amount of data to be sent: reduce the generation rate of CAN messages or the overall number of signals to be sent.		
7	Data rate equals to 10Hz.	In laboratory test we don't expect to lose any packet. The ITS-G5 station should: send 10 messages per second and receive exactly 10 messages per second.		

3.2.4 Field Tests

The objective of the field tests is to validate the applications under real-life conditions. The OBUs will be integrated into the vehicle and into the shelter available at the test-site. The equipped vehicles will move around at variable speeds in order to validate the dynamic scenario.

3.2.4.1 Field test of the Input interfaces

The vehicles and the road infrastructure must collect some signals in order to notify the time of arrival at the recharging station and also to communicate the need of recharging.

Test case Id	Test sites: Italy / France/ both	Test case goal and description	Expected Result	Actual Result	Remarks
1	Italy	Validate GNSS behaviour in final test site. Verify how sky visibility and multipath effect impact on the performances of GNSS receiver.	The GNSS receiver should be able to evaluate the vehicle position within 15 meters accuracy.		
2	Italy	Check that CAN signals can be properly decoded into the vehicle after the integration of all the OBUs.	The CAN signals are properly decoded according to the definition of CAN database.		

3.2.4.2 Field test of the Radio Module

The field test will check the correctness of the messages exchanged between the ITS-G5 stations even if the vehicles are moving toward or away from EVSE station. The ITS-G5 ETSI standard is still under definition, therefore it is affected by periodic updates. According to that, the messages exchanged between the Vehicles and the Road Side Unit will be different from the one implemented in the eCo-FEV project.

Test case Id	Test sites: Italy / France/ both	Test case goal and description	Expected Result	Actual Result	Remarks
1	Italy	During field tests we expect to lose some packets when the vehicles	Find out the coverage of the two stations in the test-		

Test case Id	Test sites: Italy / France/ both	Test case goal and description	Expected Result	Actual Result	Remarks
		overcome the coverage area of the EVSE station. Check the maximum distance after which this losses are critical for the application.	site. If the coverage distance is too little we should add a Road Site Unit to enlarge the coverage area.		
2	Italy	Extend coverage area if it's available a vehicle that can see both the EVSE and another Vehicle (that is outside of the coverage area of the EVSE station).	The charging infrastructure operator is able to process the requests of a vehicle that is beyond the Road Side Unit (RSU) coverage area.		

3.3 Backend

3.3.1 Description

The Backend is envisioned as the gateway between FABRIC and the EV. It will handle all communications with the EV and the end-users and in that way reduce the load for the core FABRIC electric mobility platform.

The following lab and field test description is based on the deliverable D400.1 [5] of the eCo-FEV project. Essentially, the most relevant tests have been selected to be performed also in FABRIC.

3.3.2 Architectural Overview

The following figure gives an overview of the backend architecture.

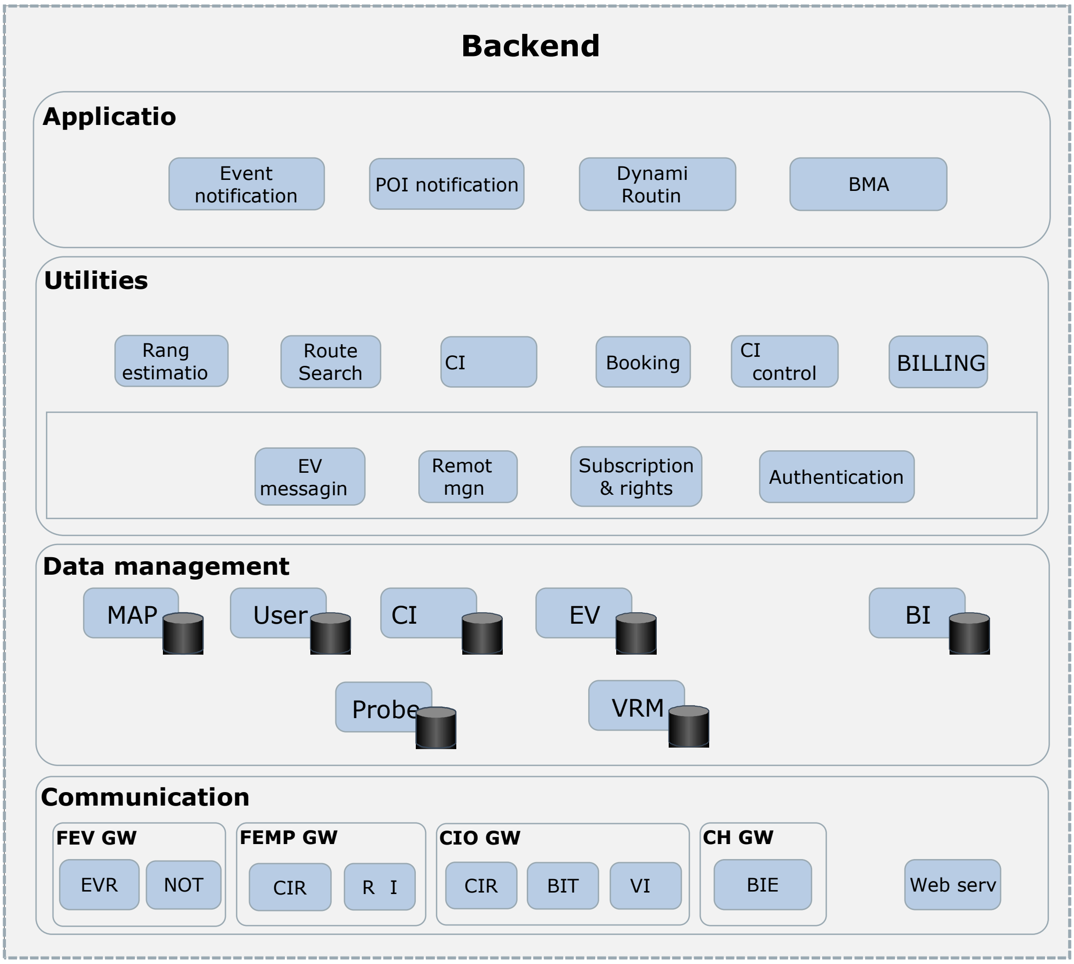

Figure 4: Backend functional architecture

3.3.3 Lab Tests

The goal of the lab tests is to check the correctness, performances, and reliability of the Backend under controlled laboratory conditions. The verification of the EV backend subsystem mainly consists of verification of the Backend components and interfaces.

3.3.3.1 Lab test of the Communication management modules and interfaces

The communication management modules interface with other sub systems and external infrastructure systems for data collection and data distribution. It also ensures the information exchange with other Backend modules, e.g. database modules at data management layer.

3.3.3.1.1 EV information retrieval

Test case Id	Test case Description	Expected Result	Actual Result	Remarks
1	Decode EVR message	EVR message is successfully received and decoded		
2	EVR message rate	Receiving rate of EVR reception is identical of EVR transmission		

3.3.3.1.2 Notification support

Test case Id	Test case Description	Expected Result	Actual Result	Remarks
1	Encode notification (NOT) message	Notification message is successfully encoded and transmitted		
2	Notification (NOT) message content	Notification message includes required content for receiving vehicle to inform FABRIC users, including notification type, relevant position and time, targeted destination EV.		
3	Notification (NOT) request	The module is able to process request from any Backend component and informs the processing result		

3.3.3.1.3 Charging Infrastructure Information Retrieval

Test case Id	Test case Description	Expected Result	Actual Result	Remarks
1	Decode CIR status message	Received CIR status message		

Test case Id	Test case Description	Expected Result	Actual Result	Remarks
		is correctly decoded		
2	Encode CIR information retrieval request message	Backend sends request to charging operator to retrieve CIR info		
3	CIR information retrieval request	The module is able to process request from any Backend component and informs the processing result		

3.3.3.2 Lab test of the Data management modules and interfaces

The Data Management module includes the components and databases to store and manage the various data that are necessary for the applications and their components.

3.3.3.2.1 User Information Management

Test case Id	Test case Description	Expected Result	Actual Result	Remarks
1	User information access request	The module is able to process user information access request and provides response, if the requesting party is confirmed to be authorised to access the user information database		
2	User information data base update	The module is able to update the user information database		

3.3.3.2.2 Charging Infrastructure Information Management

Test case Id	Test case Description	Expected Result	Actual Result	Remarks
1	CIR information access	The module is able to process CIR information access request and provides response		
2	CIR information push	The module is able to push the CIR information to requesting component when an update of the requesting data is detected		
3	CIR information database update	The module is able to update the CIR information database when received by Backend		
4	Location referencing	The module should convert the location referencing data of the received CIR information message to a location referencing data (i.e. openStreetMap) compliant to the usage of Backend applications		

3.3.3.2.3 Vehicle information management

Test case Id	Test case Description	Expected Result	Actual Result	Remarks
1	Vehicle information access request	The module is able to process vehicle information access request and provides response, if the requesting party is confirmed to be authorised to access the vehicle information database		

Test case Id	Test case Description	Expected Result	Actual Result	Remarks
2	Vehicle information data base update	The module is able to update the vehicle information database		

3.3.3.2.4 Probe information management

Test case Id	Test case Description	Expected Result	Actual Result	Remarks
1	Probe information access	The module is able to process *probe* information access request and provides response		
2	Probe information push	The module is able to push the p*robe* information to requesting component when an update of the requesting data is detected		
3	Probe information database update	The module is able to update the probe information database when received by Backend		
4	Location referencing	The module should convert the location referencing data of the received VRM to a location referencing data (i.e. openStreetMap) compliant to the usage of Backend applications		

3.3.3.3 Lab test of the Utilities modules and interfaces

The Utilities module includes utilities and components that support the operation of the high level applications.

3.3.3.3.1 Authentication

Test case Id	Test case Description	Expected Result	Actual Result	Remarks
2	User ID acquisition	The module receives request from user to access to an application, then sends request to ask for user ID information.		
3	Check the validity of openID provider	The openID provider as included in user ID is recognised by the requesting application		
4	Redirect user to ID provider	Send information to user in order to redirect him/her to openID provider for authentication		
5	Trust verification	Backend negotiates the trust level with ID providers for a given user		
6	Authentication token verification	Backend verifies the authentication token provided by user for user authentication		
7	Authentication response	Backend provides verification result to user as authentication response		
8	Temp token request	The module sends request to acquire a temp token when requested by an application.		
9	Authorisation request	The module sends authorisation request to user		

Test case Id	Test case Description	Expected Result	Actual Result	Remarks
		for authorisation to access to user data		
10	Access token request	The module sends request to acquire an access token when requested by an application, after receiving confirmation from user.		

3.3.3.3.2 ID provider and rights managements

Test case Id	Test case Description	Expected Result	Actual Result	Remarks
1	ID provider	The module provides functionalities and interfaces as defined in openID protocol		
2	User data access management	The module provides functionalities and interfaces as defined in OAuth protocol		

3.3.3.4 Lab test of the Application modules and interfaces

The Application support module includes the high level applications for FABRIC Electric Mobility Platform.

3.3.3.4.1 Event notification

Test case Id	Test case Description	Expected Result	Actual Result	Remarks
1	Notification request and response	The module is able to receive user requests for notification and sends response to user		
2	Notification message trigger	The module sends notification request and notification content to notification support module		
3	Event relevance check	The module is able to verify if a detected event is relevant for a user.		

3.3.3.4.2 Booking and cancellation

Test case Id	Test case Description	Expected Result	Actual Result	Remarks
1	Booking request and response	The module is able to receive user requests for charging station booking and sends response to user		
2	Booking schedule result message	The module sends *booking schedule result* notification to requesting user.		
3	Cancellation result message	The module sends cancellation result notification to requesting user.		

Test case Id	Test case Description	Expected Result	Actual Result	Remarks
4	Authentication	The module sends requests to authentication module for user authentication.		
5	Booking request	The module is able to send booking request to CI operator and receives response from CI operator.		
6	Booking cancellation request	The module is able to send booking cancellation request to CI operator and receives response from CI operator.		

3.3.4 Field tests

The goal of the field tests is to validate the results obtained from the lab tests in realistic field environment.

3.3.4.1.1 EV information retrieval

Test case Id	Test sites: Italy / France/ both	Test case Description	Expected Result	Actual Result	Remarks
1	Italy	Decode EVR message	EVR message is successfully received and decoded		
2	Italy	EVR message rate	Receiving rate of EVR reception is identical of EVR transmission		

3.3.4.1.2 Notification Support

Test case Id	Test sites: Italy / France/ both	Test case Description	Expected Result	Actual Result	Remarks
1	Italy	Encode notification (NOT) message	Notification message is successfully encoded and transmitted		
2	Italy	Notification (NOT) message content	Notification message includes required content for receiving vehicle to inform FABRIC users, including notification type, relevant position and time, targeted destination EV.		
3	Italy	Notification (NOT) request	The module is able to process request from any Backend component and informs the processing result		

3.3.4.1.3 Charging Infrastructure Information Retrieval

Test case Id	Test sites: Italy / France/ both	Test case Description	Expected Result	Actual Result	Remarks
1	Italy	Decode CIR status message	Received CIR status message is correctly decoded		
2	Italy	Encode CIR information retrieval request message	Backend sends request to charging operator to retrieve CIR info		
3	Italy	CIR information	The module is able to		

Test case Id	Test sites: Italy / France/ both	Test case Description	Expected Result	Actual Result	Remarks
		retrieval request	process request from any Backend component and informs the processing result		

3.3.4.2 Field test of the Data Management modules and interfaces

The Data Management module includes the components and databases to store and manage the various data that are necessary for the applications and their components.

3.3.4.2.1 User information management

Test case Id	Test sites: Italy / France/ both	Test case Description	Expected Result	Actual Result	Remarks
1	Italy	User information access request	The module is able to process user information access request and provides response, if the requesting party is confirmed to be authorised to access the user information database		
2	Italy	User information data base update	The module is able to update the user information database		

3.3.4.2.2 Charging Infrastructure Information management

Test case Id	Test sites: Italy / France/ both	Test case Description	Expected Result	Actual Result	Remarks
1	Italy	CIR information access	The module is able to process CIR information access request and provides response		
2	Italy	CIR information push	The module is able to push the CIR information to requesting component when an update of the requesting data is detected		
3	Italy	CIR information database update	The module is able to update the CIR information database when received by Backend		
4	Italy	Location referencing	The module should convert the location referencing data of the received CIR information message to a location referencing data (i.e. openStreetMap) compliant to the usage of Backend applications		

3.3.4.2.3 Vehicle information management

Test case Id	Test sites: Italy / France/ both	Test case Description	Expected Result	Actual Result	Remarks
1	Italy	Vehicle information access request	The module is able to process vehicle information access request and provides response, if the requesting party is confirmed to be authorised to access the vehicle information database		
2	Italy	Vehicle information data base update	The module is able to update the vehicle information database		

3.3.4.2.4 Probe management

Test case Id	Test sites: Italy / France/ both	Test case Description	Expected Result	Actual Result	Remarks
1	Italy	Probe information access	The module is able to process *probe* information access request and provides response		
2	Italy	Probe information push	The module is able to push the p*robe* information to requesting component when an update of the requesting data is detected		

Test case Id	Test sites: Italy / France/ both	Test case Description	Expected Result	Actual Result	Remarks
3	Italy	Probe information database update	The module is able to update the probe information database when received by Backend		
4	Italy	Location referencing	The module should convert the location referencing data of the received VRM to a location referencing data (i.e. openStreetMap) compliant to the usage of Backend applications		

3.3.4.3 Field test of the Utilities modules and interfaces

The Utilities module includes utilities and components that support the operation of the high level applications.

3.3.4.3.1 Authentication

Test case Id	Test sites: Italy / France/ both	Test case Description	Expected Result	Actual Result	Remarks
2	Italy	User ID acquisition	The module receives request from user to access to an application, then sends request to ask for user ID information.		
3	Italy	Check the validity of openID provider	The openID provider as included in user ID is recognised by the requesting application		

Test case Id	Test sites: Italy / France/ both	Test case Description	Expected Result	Actual Result	Remarks
4	Italy	Redirect user to ID provider	Send information to user in order to redirect him/her to openID provider for authentication		
5	Italy	Trust verification	Backend negotiates the trust level with ID providers for a given user		
6	Italy	Authentication token verification	Backend verifies the authentication token provided by user for user authentication		
7	Italy	Authentication response	Backend provides verification result to user as authentication response		
8	Italy	Temp token request	The module sends request to acquire a temp token when requested by an application.		
9	Italy	Authorisation request	The module sends authorisation request to user for authorisation to access to user data		
10	Italy	Access token request	The module sends request to acquire an access token when requested by an application, after receiving confirmation from user.		

3.3.4.3.2 ID provider and rights management

Test case Id	Test sites: Italy / France/ both	Test case Description	Expected Result	Actual Result	Remarks
1	Italy	ID provider	The module provides functionalities and interfaces as defined in openID protocol		
2	Italy	User data access management	The module provides functionalities and interfaces as defined in OAuth protocol		

3.3.4.4 Field test of the Application modules and interfaces

The Application module includes the high level applications for the FABRIC Electric Mobility Platform.

3.3.4.4.1 Event notification

Test case Id	Test sites: Italy / France/ both	Test case Description	Expected Result	Actual Result	Remarks
1	Italy	Notification request and response	The module is able to receive user requests for notification and sends response to user		
2	Italy	Notification message trigger	The module sends notification request and notification content to notification support module		
3	Italy	Authentication	The module sends requests to authentication module		

Test case Id	Test sites: Italy / France/ both	Test case Description	Expected Result	Actual Result	Remarks
			for authentication.		
4	Italy	Event relevance check	The module is able to verify if a detected event is relevant for a user.		

3.3.4.4.2 Booking and cancellation

Test case Id	Test sites: Italy / France/ both	Test case Description	Expected Result	Actual Result	Remarks
1	Italy	Booking request and response	The module is able to receive user requests for charging station booking and sends response to user		
2	Italy	Booking schedule result message	The module sends *booking schedule result* notification to requesting user.		
3	Italy	Cancellation result message	The module sends cancellation result notification to requesting user.		
4	Italy	Authentication	The module sends requests to authentication module for user authentication.		
5	Italy	Booking request	The module is able to send booking request		

Test case Id	Test sites: Italy / France/ both	Test case Description	Expected Result	Actual Result	Remarks
			to CI operator and receives response from CI operator.		
6	Italy	Booking cancellation request	The module is able to send booking cancellation request to CI operator and receives response from CI operator.		

3.4 Charging Infrastructure

3.4.1 Description

The charging infrastructure is mainly divided into two cooperating components (or subsystems): the *C/S CU* of EVSE and the *EVSE Operator.*

The EVSE Operator subsystem is the backend for the charging infrastructure. It communicates with a set of C/S CUs, for gathering and monitoring status information, and also triggering some actions, such as booking. It implements the Server-side of the AAA for the charging process. On the other hand it communicates with the Backend for reporting the status of the charging facilities (monitoring) and providing accounting information.

Besides the AAA, booking and monitoring functionalities the C/S CU for CWD includes retrieving the EV's plate number from an Automatic Plate Number Recognition (ANPR) camera on one hand and, using the CAN Bus for communication with the EV the rest of the EVSE components on the other hand.

3.4.2 Architectural Overview

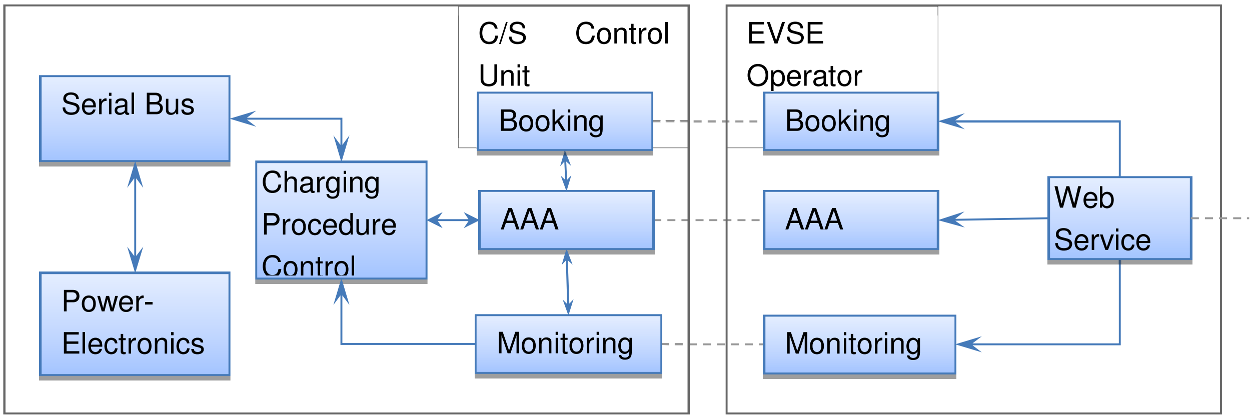

Figure 5: Charging Infrastructure components, spanning over the C/S CU and EVSE Operator entities

3.4.3 Lab Tests

The goal of the lab tests is to check the correctness, performances, and reliability of the CI under controlled laboratory conditions. The verification of the CI subsystem mainly consists of verification of the CI Modules and their interfaces.

3.4.3.1 AAA Module and Interfaces

The *AAA* functionality is realised jointly by the two corresponding entities on the *C/S CU* and *EVSE Operator* components. Hence, the tests need to ensure that each of those two entities performs the expected tasks properly, and that the interactions between them also fulfil the required functionality. Furthermore, the AAA component interacts with other components within the Charging Infrastructure subsystem, such as Charging Procedure Control (CPC) and Monitoring. These interactions also need to be covered in the subsystem testing.

Test Case Id	Test Case Description	Expected Result	Actual Result	Remarks
1	C/S CU_AAA ID acquisition	Right ID of EV can be acquired at the AAA frontend		
2	C/S CU_AAA authentication request	Make sure that the interaction between the two AAA components result in either success or rejection, in case the ID is authorised or not, respectively.		
3	EVSE_Operator_AAA	Make sure that the interaction		

Test Case Id	Test Case Description	Expected Result	Actual Result	Remarks
	authentication response	between the two AAA components result in either success or rejection, in case the ID is authorised or not, respectively.		
4	EVSE_Operator_AAA Accounting	Actually charged energy in kWh can be determined and retained at EVSE-Operator		

3.4.3.2 Booking Module and Interfaces

The Booking component is also realised on the two entities, similar to the AAA component; a booking request arriving at the EVSE-Operator's Web-service Component will be routed to the respective Charge point where the C/S CU would lock this Charge point for the respective EV ID.

Test Case Id	Test Case Description	Expected Result	Actual Result	Remarks
1	Booking routing	Booking request (or cancellation) is routed to the respective C/S CU		
2	Booking execution	The C/S CU locks the charge point for the respective EV ID		
3	Booking timeout	The C/S CU cancels the booking in case the EV does not show up at the respective charge point after a given timeout		

3.4.3.3 Monitoring Module and Interfaces

The Monitoring Component at each charging station sends status information to the monitoring component at the EVSE-Operator, which in its turn makes this information available to other subsystems using the Web-service component.

Test Case Id	Test Case Description	Expected Result	Actual Result	Remarks
1	AAA Status	C/S CU sends the AAA status to the EVSE-operator including the logged (charging) in EV ID and their meter values		
2	CPC Status	The C/S CU sends the CPC status to the EVSE operator including the power at which the EV is charging, the internal status of the CPC state, and eventually the electrical failures in case they occur (CB, RCD …)		
3	Booking status	The monitoring component retains the information of the bookings and booking cancellations		

3.4.3.4 Charging Procedure Control and Interfaces

The Charging procedure control is implemented on the C/S CU. It communicates with the power electronic over a protocol to be defined in the eCo-FEV Project.

Test Case Id	Test Case Description	Expected Result	Actual Result	Remarks
1	CAN communication to the PE (Road)	Send and receive CAN messages to and from the PE (Road)		
2	CAN communication to the PE (On Board)	Send and receive CAN messages to and from the PE (On Board)		
3	CAN communication to the	Send and receive CAN messages to and from the		

Test Case Id	Test Case Description	Expected Result	Actual Result	Remarks
	VMU	VMU		
4	ANPR data acquisition	Acquire the plate number from the ANPR camera		
5	Sending monitoring information	Monitoring information available upon request		
6	AAA communication	FADIUS implementation on the C/S CU sends authentication request and accounting messages		
7	State Machine validation	Stand-alone validation of the State Machine according to the specification		

3.4.3.5 Web Service Module and Interfaces

The Web service module is implemented at the EVSE Operator. Its main responsibility is to provide the Backend with information about the charging infrastructure, after gathering these from the different C/S CUs. It mainly retrieves the information of the EVSE-Operator Components and implements the external interface with the Backend.

Test Case Id	Test Case Description	Expected Result	Actual Result	Remarks
1	Information retrieval from the EVSE-Operator Component	Necessary Information available at the EVSE-operator components are represented at the web service component		
2	Interface with the Backend	Web service implementation for pushing the status changes of any charge point to the Backend		

3.4.4 Field Tests

For the Field Test, the environment differs from the Lab test according to the setup of each test site. That's why it is needed to conduct the Field test for each test site to ensure the correct functionality of the Charging Infrastructure subsystem, by testing each module and its interfaces at each test site.

3.4.4.1 AAA Module and Interfaces

The AAA functionality is realised jointly by the two corresponding entities on the C/S CU and EVSE Operator components. Hence, the tests need to ensure that each of those two entities performs the expected tasks properly, and that the interactions between them also fulfil the required functionality. Furthermore, the AAA component interacts with other components within the Charging Infrastructure subsystem, such as Charging Procedure Control (CPC) and Monitoring. These interactions also need to be covered in the subsystem testing.

Test Case Id	Test sites: Italy / France/ both	Test Case Description	Expected Result	Actual Result	Remarks
1	Italy	C/S CU_AAA ID acquisition	Right ID of EV can be acquired at the AAA frontend		
2	Italy	C/S CU_AAA authentication request	Make sure that the interaction between the two AAA components result in either success or rejection, in case the ID is authorised or not, respectively.		
3	Italy	EVSE_Operator_AAA authentication response	Make sure that the interaction between the two AAA components result in either success or rejection, in case the ID is authorised or not, respectively.		
4	Italy	EVSE_Operator_AAA Accounting	Actually charged energy in kWh can be		

Test Case Id	Test sites: Italy / France/ both	Test Case Description	Expected Result	Actual Result	Remarks
			determined and retained at EVSE-Operator		

3.4.4.2 Booking Module and Interfaces

The *Booking* component is also realised on the two entities, similar to the AAA component; a booking request arriving at the EVSE-Operator's Webservice Component will be routed to the respective Charge point where the C/S CU would lock this charge point for the respective EV ID.

Test Case Id	Test sites: Italy / France/ both	Test Case Description	Expected Result	Actual Result	Remarks
1	Italy	Booking routing	Booking request (or cancellation) is routed to the respective C/S CU		
2	Italy	Booking execution	The C/S CU locks the charge point for the respective EV ID		
3	Italy	Booking timeout	The C/S CU cancels the booking in case the EV does not show up at the respective charge point after a given timeout		

3.4.4.3 Monitoring Module and Interfaces

The Monitoring Component at each charging station sends status information to the monitoring component at the EVSE-Operator, which in its turn makes this information available to other subsystems using the Web-service component.

Test Case Id	Test sites: Italy / France/ both	Test Case Description	Expected Result	Actual Result	Remarks
1	Italy	AAA Status	C/S CU sends the AAA status to the EVSE-operator including the logged (charging) in EV ID & their meter values		
2	Italy	CPC Status	The C/S CU sends the CPC status to the EVSE operator including the power at which the EV is charging, the internal status of the CPC state, and eventually the electrical failures in case they occur (CB, RCD …)		
3	Italy	Booking status	The monitoring component retains the information of the bookings and booking cancellations		

3.4.4.4 Charging Procedure Control and Interfaces

The Charging procedure control is implemented on the C/S CU. It communicates with the power electronic over a protocol to be defined in the eCo-FEV Project.

Test Case Id	Test sites: Italy / France/ both	Test Case Description	Expected Result	Actual Result	Remarks
1	Italy	CAN communication to the PE (Road)	Send and receive CAN messages to and from the PE (Road)		
2	Italy	CAN communication to the PE (On Board)	Send and receive CAN messages to and from the PE (On Board)		

Test Case Id	Test sites: Italy / France/ both	Test Case Description	Expected Result	Actual Result	Remarks
3	Italy	CAN communication to the VMU	Send and receive CAN messages to and from the VMU		
4	Italy	ANPR data acquisition	Acquire the plate number from the ANPR camera		
5	Italy	Sending monitoring information	Monitoring information available upon request		
6	Italy	AAA communication	FADIUS implementation on the C/S CU sends authentication request and accounting messages		
7	Italy	State Machine validation	Stand-alone validation of the State Machine according to the specification		

3.4.4.5 Web Service Module and Interfaces

The Web service module is implemented at the EVSE Operator. Its main responsibility is to provide the Backend with information about the charging infrastructure, after gathering these from the different C/S CUs. It mainly retrieves the information of the EVSE-Operator Components and implements the external interface with the Backend.

Test Case Id	Test sites: Italy / France/ both	Test Case Description	Expected Result	Actual Result	Remarks
1	Italy	Information retrieval from the EVSE-Operator Component	Necessary Information available at the EVSE-operator components are represented at the web service component		
2	Italy	Interface with the Backend	Web service implementation for pushing the status changes of any charge point to the Backend		

3.5 Lane Keeping System

3.5.1 Description

The lane detection system aims to specify the position of the electric vehicle inside the lane. This positioning will assist the drivers to align their vehicle with the charging coils. The system is depicted in Figure 6.

3.5.2 Architectural overview

The LKS relies on a camera to read the image of the road. The software detects the presence of the lane lines inside the image of the road. The software informs the driver to go right or left in order to align the vehicle charging coil with the road charging coil.

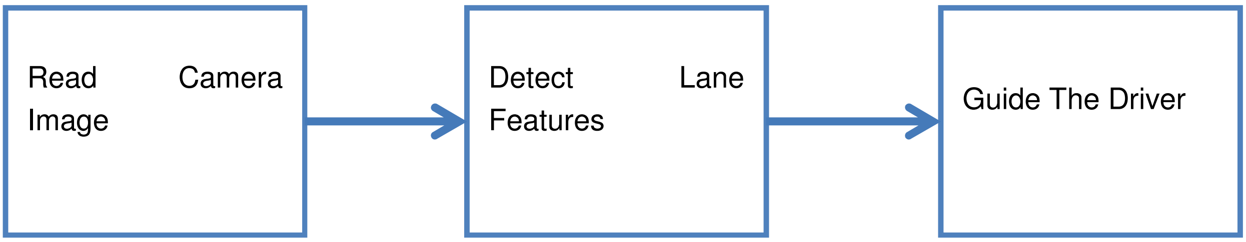

Figure 6: Lane keeping system description

3.5.3 Lab Tests

The goal of the lab tests is to check the correctness, performances, and reliability of the Lane Keeping System under controlled laboratory conditions.

Test case Id	Test case goal and description	Expected Result	Actual Result	Remarks
1	Lane Marking Extraction	Lane marking extracted		
2	Calculation of the lateral distance between the vehicle and the marking lane	The lateral distance estimation error should be less than 5 centimetres		
3	Road image display on the user interface	The user interface should display the image of the road		
4	Vehicle lane coloration on the user interface	The user interface should colour the vehicle lane on the road image		
5	Lane mark coloration on the user interface	The user interface should colour the lane mark on the road image		
6	Latency	Latency should be below 0.2 seconds		
7	Lane Detection in curved road	The user interface should colour the lane mark detected in a curved road		
8	Lane detection in straight road	The user interface should colour the lane mark detected in a straight road		
9	Lane detection in shadowed road	The user interface should colour the lane mark detected in a shadowed road		
10	Lane detection in good illumination	The user interface should colour the lane detected in a good illumination		

Test case Id	Test case goal and description	Expected Result	Actual Result	Remarks
11	Lane detection in poor illumination	The user interface should colour the lane detected in a poor illumination		
12	Driver guidance	The user interface should display a message to assist the driver to align the charging coil of the vehicle with the charging coil of the road		

3.5.4 Field Tests

For the field tests, the environment differs from the lab test according to the setup of each test site. That's why it is needed to conduct the field test for each test site to ensure the correct functionality of the LKS.

Test case Id	Test sites: Italy / France/ both	Test case goal and description	Expected Result	Actual Result	Remarks
1	both	Lane Marking Extraction	Lane marking extracted		
2	both	Calculation of the lateral distance between the vehicle and the marking lane	The lateral distance estimation error should be less than 5 centimetres		
3	both	Road image display on the user interface	The user interface should display the image of the road		
4	both	Vehicle lane coloration on the user interface	The user interface should colour the vehicle lane on the road image		
5	both	Lane mark coloration on the user interface	The user interface should colour the lane		

Test case Id	Test sites: Italy / France/ both	Test case goal and description	Expected Result	Actual Result	Remarks
			mark on the road image		
6	both	Latency	Latency should be below 0.2 seconds		
7	both	Lane Detection in curved road	The user interface should colour the lane mark detected in a curved road		
8	both	Lane detection in straight road	The user interface should colour the lane mark detected in a straight road		
9	both	Lane detection in shadowed road	The user interface should colour the lane mark detected in a shadowed road		
10	both	Lane detection in good illumination	The user interface should colour the lane detected in a good illumination		
11	both	Lane detection in poor illumination	The user interface should colour the lane detected in a poor illumination		
12	both	Driver guidance	The user interface should display a message to assist the driver to align the charging coil of the vehicle with the charging coil of the road		

4 CONCLUSIONS

This deliverable presented the tests related to the ICT applications required for the demonstration within the FABRIC project. These tests concern five systems:

- LBS: Load Balancing System
- OBU: On-Board Unit
- Backend
- CI: Charging Infrastructure
- LKS: Lane-Keeping System.

The systems are relevant to the French and Italian test sites, although the individual tests set out in this deliverable focus on the ICT system to be tested in Italy. Therefore some modifications were introduced for the French site where certain systems (notably the OBU and the Charging Infrastructure) are different and these are reported in Deliverable 2.6.2.

The results of the tests at the Italian site were reported in a first version of Deliverable D2.6.2 in June 2016, whereas a revision of this deliverable will be made at the end of 2016 to incorporate the results of the tests at the French site.

5 REFERENCES

[1] Yannis Damousis et al., FABRIC Deliverable D4.3.1, “Final use cases”, 2014

[2] eco-FEV project website, www.eco-fev.eu, Accessed: 22/11/2015

[3] Yannis Damousis et al., FABRIC Deliverable D2.4.1, “ICT functional architecture and specifications”. 2015

[4] Andrew Winder et al., FABRIC Deliverable D2.2.1, “User needs, system concept and requirements for ICT solutions”, 2014

[5] Fikret Sivrikaya et al., eCo-FEV Deliverable D400.1, “Evaluation Methodology, Test and Evaluation Plan”, 2014

[6] Mehmet Emre et al., FABRIC Deliverable D4.3.2, “FABRIC Test Scenarios”, 2014