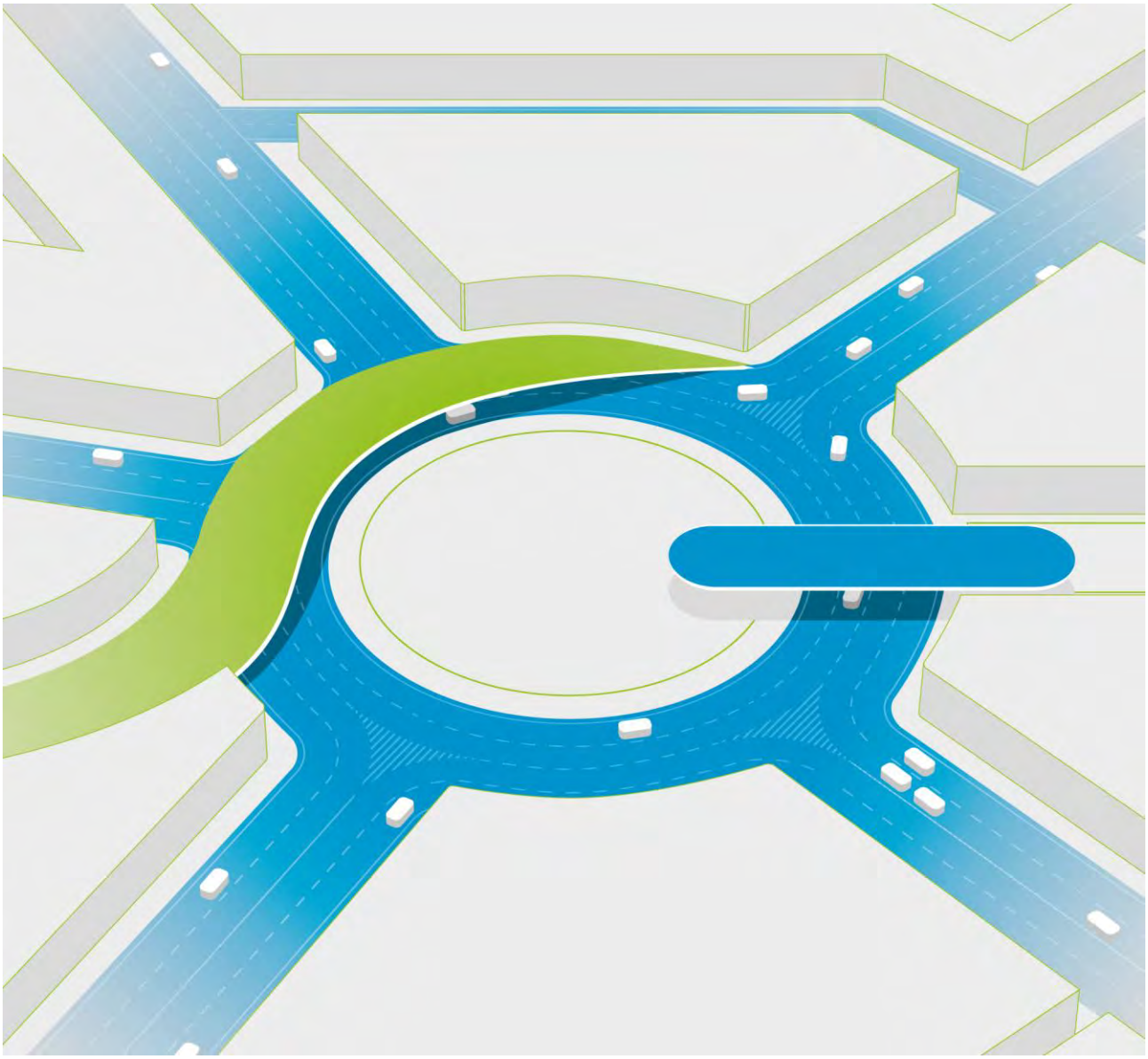
eCo-FEV combining infrastructures for efficient electric mobility

Deliverable D200.1

Use cases and requirements for an efficient cooperative platform



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Executive Summary

The eCo-FEV project aims at achieving a breakthrough in FEV introduction by proposing a general architecture for integration of FEVs with different infrastructure systems cooperating with each other – thus allowing precise EV telematics services and charging management services based on real time information.

The general concept of eCo-FEV is based on the development of innovative next generation E-mobility infrastructure by mutual system cooperation among FEV and independent FEV-related infrastructures being networked. The cooperative e-mobility infrastructure enables the information exchanges between independent infrastructure systems in order to provide efficient telematics and ITS services to FEV users.

The present deliverable specifies a list of use cases being targeted by the eCo-FEV project. Each use case is defined in a way to guide the system architecture design instead of imposing any system architecture. Therefore, the use cases are defined from a functional viewpoint. For each use case, a set of functional and operational requirements, which shall be supported by eCo-FEV system, are identified for the realization of these use cases.

The present deliverable will be provided to WP220 for architecture design and to WP230 for specification definition, to WP300 for development and to WP400 for testing purposes.

1. Introduction

The general concept of eCo-FEV is based on the development of innovative next generation E-mobility infrastructure by mutual system cooperation among FEVs and independent FEV-related infrastructures being networked. The cooperative e-mobility infrastructure enables the information exchange between independent infrastructure systems in order to provide efficient telematics and ITS services to FEV users. The proposed architecture is flexible and modular, being able to accommodate different infrastructure systems, satisfying local requirements at the implementation site and enable additional services, facilitating the exploitation of the system.

The present deliverable specifies a list of use cases being targeted by the eCo-FEV project. This deliverable is structured as following: chapter 2 gives the motivation to design the eCo-FEV system; chapter 3 follows a State-of-Art study and targeted innovation of the eCo-FEV system compared to such SoA; based on the presented motivated and SoA, a general presentation on the methodology being adopted by WP200 is presented in chapter 4; the list of use cases and relevant involved actors is given in chapter 5. For the sake of presentation, two levels of use cases are defined by the consortium, the primary use cases being the customer services being provided to FEV users or infrastructure operators, while the secondary use cases are common use cases being used by several primary use cases; chapter 6 and chapter 7 provide a detailed description and requirement definition of respectively secondary and primary use cases. For each use case, a use case diagram is used to illustrate the interaction of involved actors with the system. In addition, a use case synthesis is presented in chapter 8 to illustrate the interrelationships of eCo-FEV use cases. Finally, chapter 9 concludes the present deliverable.

The present deliverable will be used by WP220 for architecture design and by WP230 for specification definition, WP300 for development and to WP400 for testing purposes.

2. Project motivation, main novelties

The objectives of the eCo-FEV project are to simplify the usage of the Full Electrical Vehicles (FEVs) and to appease range anxiety related to the full electrical powertrain concept. To achieve these objectives the eCo-FEV proposes to play the role of facilitator between travelers and all operators participating in planning and realization of trips involving FEVs.

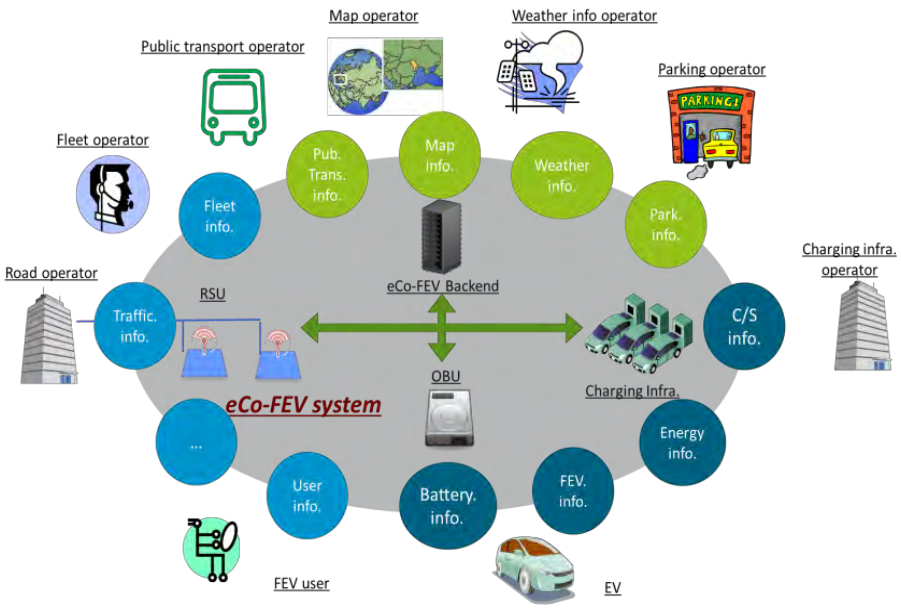

Figure 2.1: eCo-FEV ecosystem

FEV range anxiety is not only linked to the limited energy provided by FEV, but also impacted by a range of internal and environmental parameters, ranging from the user driving mode, usage of in-vehicle energy consuming systems, to weather conditions, traffic conditions etc. These multiple aspects potentially influence the user acceptability of FEV and therefore may delay the potential of mass market introduction of FEV, if not overcome. In different countries or regions, charging infrastructure is planned to be or already started to be deployed in order to further facilitate the usability of FEV. From user viewpoint, the FEV acceptability may also be impacted by the availability of charging infrastructure and charging services during and after the trips, in particular with the increasing penetration rate of FEV introduction. Therefore, it is the motivation of eCo-FEV project to propose a backend based mobility

platform in order to provide high quality mobility services in different situations that may be encountered by FEV user in daily usage. Such backend mobility platform provides personalized dynamic navigation and trip assistance services for FEV users, thanks to its real time data collection from different relevant infrastructure systems and from FEVs, as well as real time data processing functionalities that dynamically and continuously estimate the potential risks of energy shortage and charging needs of FEV, and in consequence dynamically adjust the trip plan of FEV users. This mobility platform not only presents a tool for OEMs and mobility service providers to satisfy user needs of FEV, but also implies new business potentials (and risks) for different stakeholders involved. In meanwhile other requirements such as user privacy, data openness, and standardization of information exchange interfaces are to be taken into account. The project proposes services for two classes of users: individual travelers and light urban delivery fleet drivers.

The main use cases for both classes of users are “trip planning” and “trip assistance”. For individual travelers trips can include supplementary option of multimodality (i.e. a trip mixing public transport and personal car usage). For urban delivery the trip planning is encompassed by the more general daily planning for the entire urban delivery fleet.

The principal novel characteristic of eCo-FEV is its employment of data-mining (i.e. cloud based “data collect” and “learning machine”) to optimize the trip planning and of what we term “trip monitoring” to reassure the trip realization. This new approach allows roadmap generations based on knowledge coming from historical data (driver and car behaviors, traffic and weather forecasts) and complete information about availability of charging spots. The real time functionality introduced by the “trip monitoring” permanently verifies the trip progress and the accessibility of the charging points. Thanks to the trip monitoring the driver will be always proposed the best solution to achieve his trip objectives.

Another novelty concerns the eCo-FEV business model in which we separate the role of so called “identity provider” from that called “service provider”. The “identity providers” are in charge of user subscriptions (i.e. identity and authorization management) and “service providers” deliver the services (e.g. charging, parking) to the users recognized by eCo-FEV “identity providers”. Some operators can play the both roles. Thanks to this approach we hope to limit the number of subscriptions the user has to accomplish and to simplify the payment processes when user is not in the vicinity of his home.

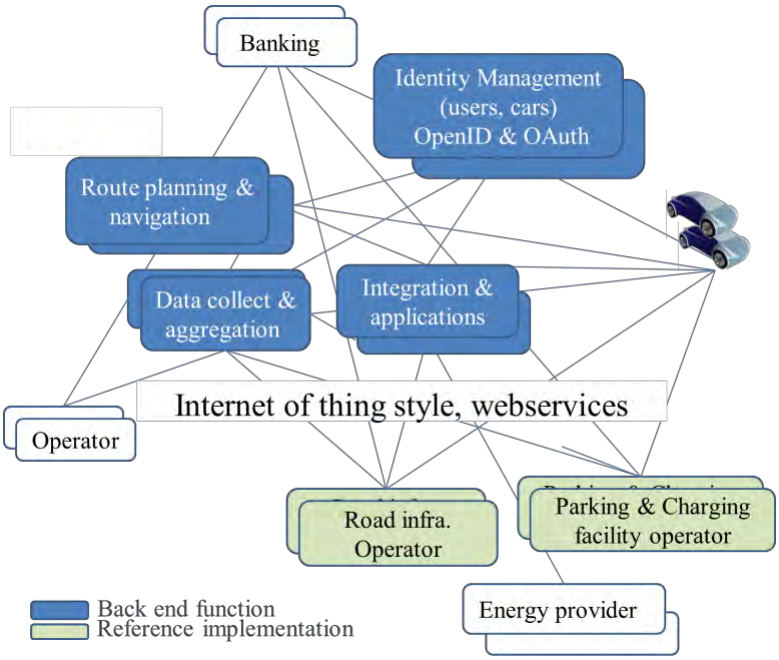

Figure 2.2: Business model flexibility

The Figure 2.2 proposes the high level view of the architecture. The components in blue will be implemented as a part of the eCo-FEV back-end infrastructure. The components in green are not included in the infrastructure but their "reference implementations" will be realized by the eCo-FEV project. All components on the Figure 2.2 are represented as multi-instantiated. The interfaces between all these components would require to be standardized to support the possibility of multi-instantiation and multi-sourcing.

The proposed novel functionalities rely on technological novelties introduced by the eCo-FEV project. These novelties address the FEV charging technology and the ICT solutions. In the domain of charging technology the eCo-FEV project builds a field test for charge while driving. In the ICT domain the project introduces "OpenID" (c.f. http://openid.net/specs/openid-authentication-2_0.html) necessary for the identity provider" and "service provider" paradigm deployment, "Mobile IP" (c.f. http://tools.ietf.org/html/rfc2002) ensuring the car addressability in spite of telecommunication access changes and "M2M CoAP" (c.f. http://tools.ietf.org/wg/core/draft-ietf-core-groupcomm/) optimized protocol for data collect functionalities.

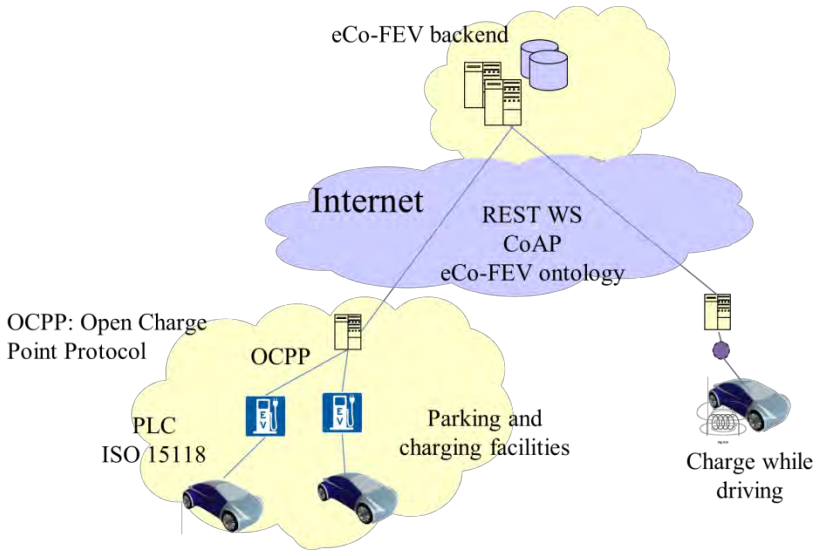

Figure 2.3: eCo-FEV technology

3. Innovation with respect to other relevant research initiatives

3.1. eCoMove (http://www.ecomove-project.eu/)

The goal of the eCoMove project is to develop "cooperative mobility systems and services for energy efficiency". Indeed, in order to lower energy consumption and CO2 emission, eCoMove seeks the development of an on-board driving assistance system supporting the driver in the choice of the greenest route and helping him to optimize its driving. Furthermore, the eCoMove project also develops traffic efficiency management applications to improve the overall traffic management in terms of energy consumption.

However, this project targets normal cars and improvement of current traffic flow and management measurements to improve energy efficiency. It does not take into account specificities of FEVs. As result, it does not study the collaboration needs of traffic management infrastructure and energy provision infrastructure and/or other relevant infrastructure systems. Moreover, FEV specific issues such as limited driving range and sparse charging infrastructure which may impact both traffic behavior and driver's experience are not considered in the scope of the project.

Innovation and differences with respect to the project:

eCo-FEV introduces all the additional complexity related to energy management and electric mobility. It targets the infrastructure system architecture at a higher level, by proposing a cooperative scheme between traffic management infrastructure and other infrastructure systems, in order to bring the road energy efficiency a step forward. This requires that the FEV specific constraints and mobility needs are taken into account. As a matter of fact, the eCoMove architecture can be considered as a sub set of the eCo-FEV architecture.

Telematics and traffic management services provided via eCo-FEV by taking into account the requirements of other infrastructure systems can be considered as an additional scope of eCoMove, by enabling a safe and smooth introduction of FEV into the overall traffic flow.

3.2. ECOGEM (http://www.softeco.it/ecogem/objectives.aspx)

ECOGEM is developing an innovative Advanced Driver Assistance System (ADAS) dedicated to FEVs' navigation. Its goals are to optimize EVs energy consumption and to improve e-mobility experience by helping EV drivers to get range extension (charging) services in a simple and reliable way. The project focuses on on-board units sharing information with each other (V2V communications) and with a central platform (V2I and I2V communications) consolidating EV's individual information as well as traffic information or recharging points' information. Altogether, those interconnected subsystems allow to perform energy driven route optimization, traffic estimation and optimization and to design optimal charging strategies. However, this system does not integrate directly charging or road information infrastructures and does not seek to improve the charging management efficiency. It does not consider recent and promising range extension services such as charge while driving strategies (based on inductive charging) which may have significant impact on electric-mobility and traffic behavior.

Innovation and differences with respect to project:

eCo-FEV aims at achieving a deeper integration of the EVs and their back-end with road and charging infrastructures. It also considers original charging strategies (charge while driving) for generalization purpose as well as innovative decision making processes by considering a joint exploitation of the local view of EVs (on-board services) and the global view of their back-end (central platform services). In the eCo-FEV system, infrastructure can provide direct assistance and vehicle data processing function in order to provide recommendation, advice and warning to FEV user remotely.

eCo-FEV also proposes methodology to improve the charging management efficiency by seeking to balance the FEV charging demand and offer at the regional level.

3.3. ELVIRE (http://www.elvire.eu/)

With a clear focus on the driver experience, ELVIRE aims at introducing the relevant ICT and services required to fight range anxiety (the fear to get stranded due to unexpected energy shortage or inability to get range extension). It relies on the complementarity of specialized on-board and off-board services. The on-board unit is in charge of EVs operations (mainly

navigation). It is integrated to a dedicated HMI which allows the driver to communicate with its EV, to be constantly updated about his trip, the relevant charging infrastructure along his way and the battery status and to benefit from added value (commercial) services. Off-board services are achieved by a control and management center operated by a mobility provider and providing relevant information to EVs (charge infrastructures locations and availability) and electric utilities (electricity demand forecasts), and managing the charge infrastructure. In addition, roaming services are also developed in order for EV users to access charging possibilities (charging stations or battery switch stations), irrespective of the charge infrastructure operator or the mobility provider involved.

Innovation and differences with respect to project:

The ELVIRE concept appears to be very complementary to eCo-FEV. While it ensures tight integration of EVs with the charge infrastructure and provides effective services for EV customers, it doesn't integrate road infrastructure and traffic management services, and do not consider EVs back end to consolidate individual EVs data.

Secondly, instead of focusing on the charging applications and services, eCo-FEV targets at large range of applications and service for FEV users by a flexible architecture and common e-Mobility platform. This platform is designed in a way that new functions can be integrated to adapt to needs of future new use cases.

Finally, eCo-FEV targets at validation and integration of V2X infrastructure and communication capacities that will be deployed within EU. The eCo-FEV infrastructure and the vehicle should be able to communicate with each other via different communication media or protocols, taking into account the availability of the network, the communication cost, the communication needs etc. This capacity will improve the communication availability, reliability and continuity at reasonable communication cost.

3.4. e-Dash (http://edash.eu/)

The goal of the e-Dash project is to achieve the sustainable integration of EVs into the electricity grid, in order to support a high quality of service for EV drivers while ensuring the grid stability. This is a V2G project which considers the opportunity to do reverse charging in order to use batteries of an EV fleet as a virtual power plant, able to store energy temporarily during production peaks (due to wind or solar power plant) and to send it back to the grid during high consumption period. In one hand, e-Dash concentrates on the development of a

fleet operator back-end allowing data consolidation of large sets of EVs to estimate their global demand and supply capacity. On the other hand, this project seeks to develop demand clearing houses which are distributed entities taking care of the demand and supply behavior of the grid. Finally, a brokering entity integrates the information regarding electricity requirements of EVs fleets and grid segments in order to fix electricity tariffs dynamically. The rationale behind this system is that prices may act as a control variable that regulate electricity transfers and balance energy demand and supply continuously.

Innovation and differences with respect to project:

In eCo-FEV, load management will not be studied from a charge infrastructure perspective and V2G aspects will not be investigated neither since other projects such as e-Dash already take care of those research topics with more adapted means. Indeed, while e-Dash contributes to the integration of electric mobility into the global electricity transportation and distribution network, eCo-FEV takes care of the daily operation of FEVs. Consequently, eCo-FEV emphasizes skills and experiences in FEVs telematics, V2X telecommunications, distributed intelligence or inductive charging and includes test sites with a wide range of road and charge infrastructures in order to deliver and evaluate the required smart cooperative systems. On the contrary, the consortium does not include charge spot operators, electric utilities, or energy market operators which are required to undertake the analysis and management of the electricity grid. Anyhow, eCo-FEV and e-Dash are complementary projects that both contribute to pave the way to sustainable mobility, each one focusing on a specific aspect of electric mobility.

However, it should be noted that the energy provision infrastructure can be potentially integrated into eCo-FEV architecture supporting V2X service, thanks to the flexible architecture proposed by the eCo-FEV project. In a real deployment, this cooperation or integration will rely on the deployment needs and/or the business conception of the implementer.

3.5. iTETRIS (http://www.eurecom.fr/util/publidownload.fr.htm?id=2893)

iTETRIS is an integrated wireless and traffic platform for real-time road traffic management solutions.

With the identification of cooperative vehicular communication as an encouraging solution to real time traffic management problems, there have been efforts in evaluating more efficient communication technologies and applications. Field operational tests (FOTs) exist and provide precise evaluation tools but they have limitations. It is impractical to imagine evaluation of

large scale city like scenarios with thousands of vehicles by conducting FOTs. This converges to the need of large scale advanced simulation platforms.

The EU project iTETRIS addresses issues concerning realization of a large scale integrated traffic and communication simulation platform within realistic traffic scenarios with objectives of evaluating different management strategies, such as traffic jam detection for detecting in real time traffic jam situations by V2V communications, without intervention of traffic operation center, or personalized navigation, where vehicles establish connection with central station which provides navigation service based on personalized needs.

Innovation and differences with respect to project:

eCo-FEV may make use of the iTETRIS platform to simulate the large scale effect of the eCo-FEV system in order to understand the impact of the FEV with eCo-FEV technologies to the environment and overall urban traffic.

3.6. PowerUp (http://www.power-up.org)

The goal of the PowerUp project is to develop the Vehicle-2-Grid (V2G) interface, starting from specifying the lower layers, then designing the charging control protocol, prototyping and testing/demonstrating (in Torino and Goteborg); standardization of the V2G interface is targeted as well, in particular in liaising with the ongoing ISO/IEC bodies. PowerUp aims therefore at enabling the FEV integration into the emerging energy smart infrastructure, whose operations will be facilitated by PowerUp results. The infrastructure daily energy fluctuations would be smoothed by proper V2G implementations and re-usage of the FEV. In order to achieve those targets, it is fundamental that all FEVs are compatible with an all (European) smart-grid infrastructure.

Innovation and differences with respect to project:

PowerUp project was funded in the context of the first Call (2011) of the EU Commission and its Green Car Initiative, the call related to the in-vehicle systems for the FEVs.

eCo-FEV is submitted to the second Call (2012) in the same context, but targeting the off-vehicle systems and services for FEVs, in particular the “Integration of the FEV in cooperative transport Infrastructure” objective.

3.7. SMARTV2G

The objective of the V2G system aims at providing a smart vehicle to smart grid interface with a controlled flow of energy and power through safe, secure and energy efficient transfer of electricity and data. It defines functional architecture of the control system and develops interoperable technical and information processing specifications between vehicles and charging station. This communication will also ensure the secure identification of EV and EV user.

Innovation and differences with respect to project:

eCo-FEV does not take into account the vehicle interface with an energy smart grid. As a matter of fact, the eCo-FEV project uses the available communication between vehicle and charging station, trying to provide telematics services to FEV user.

The eCo-FEV and SMARTV2G are complementary with each other, a secure and reliable vehicle to charging station interface will facilitate the improvement of quality of service for all eCo-FEV use cases that make use of the information via this interface (e.g. identification, vehicle data, etc.). The eCo-FEV application will optimize the charging management FEV fleet in urban environments. This optimization contributes to a better estimation of the energy demand of the FEV fleet, which can be used for the optimization of the V2G management.

3.8. DRIVE C2X (http://www.drive-c2x.eu/project)

DRIVE C2X is a European IP project that realizes the Field Operational Test (FOT) of the cooperative system technologies and use cases. It targets at validating the standard compliant communication technologies of the Cooperative systems and applications in real traffic at EU scale, in order to pave the road for the deployment of cooperative systems. DRIVE C2X coordinates 7 EU national FoT sites in Finland, France, Germany, Italy, Netherlands, Spain and Sweden, aiming at the creation of a harmonized Europe-wide testing environment for C2X technologies. The results of this large-scale environment will be used to raise awareness in the general public, provide feedback to standard organizations and for initiating public-private ventures and hopefully leads to a successful road to market introduction.

Innovation and differences with respect to project:

The eCo-FEV project makes use of the cooperative system (V2X technologies) as one major communication infrastructure for communication. It will implement a standard compliant V2X communication platform. It also proposes a mechanism that enables the dynamic selection of communication profiles when multiple communication media are available. The specifications will be provided to standardization organization in ETSI as standard dissemination.

Furthermore, eCo-FEV also implements a standard compliant application layer protocol for FEV C/S PoI service that is currently under standardization in ETSI. The evaluation results will be provided to ETSI also as standard dissemination.

3.9. SCOREF (http://blog.inria.fr/scoref/)

The SCORE@F project is the French Cooperative ITS Field Operational Test (FOT) which is also part of the DRIVE C2X European project. While its main focus is on primary road safety applications, SCORE@F includes also some traffic management applications and mobility support applications. In particular SCORE@F is prototyping the Electric Vehicle POI Notification standard being currently under specification in ETSI TC ITS WG1. SCORE@F is also considering the multi-modal POI Notification insuring the liaison between private vehicles and public transports.

Innovation and differences with respect to project:

The eCo-FEV project will extend the work being realized in SCORE@F. In terms of architecture, the eCo-FEV proposes a general architecture for the cooperative smart infrastructure systems for FEV users as a social infrastructure, it brings one step forward the work realized in SCORE@F, in which the telematics services are provided by a third part telematics services provider via Internet. In terms of use cases, the eCo-FEV will provide variety of use cases for FEV, thanks to the comprehensive view that the e-mobility platform can offer from the cooperative infrastructure systems. eCo-FEV will enable FEV users to react on un-expected situations both in terms of driving and in terms of energy management.

3.10. LiSA

The Conseil général de l'Isère (CG38) is aware that we can no more only rely on the classic individual vehicle, that has reached its ecological limits, as well as the traditional collective transport buses that have reached their economic limits for the community. In light of this paradigm shift, the CG38 is developing and designing new mobility offers, such as LiSA.

The main goals of the LiSA project:

- To participate in a comprehensive range of mobility supply which have to be efficient and multi-modal;
- To test the efficiency of a new self-service one way inter-company car-sharing offer;
- To initialize a dynamic process between public and private actors in the field of innovative transports;
- To check the relevance of the operating tools and the uses of innovative technologies (location-based tools and smartphones);
- To demonstrate the environmental and economic interests of this new offer, that is complementary to a public self-service car-sharing supply;
- To have in the best time a LiSA "green" fleet (EV, hybrid vehicle).

LiSA is an innovative self-service car-sharing service, similar to Vélib® for bicycle. It's a one-way car-sharing service with no early booking process. LiSA offers a real time available fleet of vehicles and location based parking dispatched on the urban area of Grenoble.

During three years (2012-2015) this system of self-service vehicles will be tested by the employees of the LiSA "club" comprising local authorities and companies. The service is opened to business travel but also to personal travel.

The pooling of the service vehicles and their assigned parking, operated in real time thanks to new technologies and location-based mobile communications, will increase dramatically the rate of vehicle turnover and maximize the fleet needed by the LiSA club entities.

This system of self-service car sharing enables a reduction of the number of vehicles required and the corresponding parking spaces. In the same way, the extension to private journeys of employees will decrease the rate of car ownership.

Innovation and differences with respect to project: eCo-FEV technolgoies may be used as IT platform for services such as LiSA.

4. Methodological approach

4.1. General methodology

The WP200 work is split into three phases with distinct deliverables:

- Uses case definition and requirements
- System architecture
- System and component specifications (i.e. Specifications)

During the first phase, the system as a whole is considered and its interactions with the environment (users and other systems or "actors" according to UML vocabulary) are taken into account.

Many experiments with complex system development have shown that use cases are an easy way of starting the process of system design. Often, a set of use case is rich enough to imagine the components of a global system and to find the necessary compromises between project stakeholders. This approach helps to capture the most important interactions and to define a set of functional and operational requirements, giving guidelines for the next two phases.

The process of specifying the use case will be iterative. Each partner has a different point of view and observes the world from the perspective of his company's business. Hence, the proposed use cases reflect a partial perception. This leads to some inconsistencies which should be removed during the interaction with the system architecture specification. For this reason, in this step, eCo-FEV consortium does not assume any specific system architecture and therefore the whole system is seen as a black box from the viewpoint of external actors, even though there is a clear assumption in the concept of eCo-FEV that a back-end based mobility platform is to be designed. Nevertheless, the use case description may not be sufficiently specific at this step, and to some extends remain generic to lead to a full insight of the system components. Such issue should be overcome in the architecture and specifications phases. This use case design philosophy is motivated by the following considerations:

- eCo-FEV system involves a number of stakeholders. It is extremely important to our perspective to clearly define the roles and responsibilities of each stakeholder, while the eCo-FEV use cases are mainly focused on FEV user perspective only. Therefore,

further discussions involving stakeholders are required to clearly position the functionalities at different sub systems, driven by the user needs and use case requirements (even though high level). Therefore, it is too early at this stage in time to clearly assume any particular architecture.

- In order to scale up the deployment potential, it is important to enable a modular architecture design of eCo-FEV platform, in order to make the platform suitable to different deployment scenarios. Therefore, it is the belief of the eCo-FEV consortium at this point in time to miscorrelate the identification of a function and where the function should be implemented (e.g. a centralized platform vs distributed platform, a thin client vs heavy client).

During the second phase the overall architecture is defined by identifying the sub systems and their interaction, and the system will be further split into a set of sub components according to the requirements as defined in this document. In this phase of architecture design, a match of function and sub systems are defined, taking into account the specific constraints and requirements of test sites. Once the detailed architecture is defined, the use case (e.g. information exchange flow between sub systems for each use case) will be further specified.

Based on the results of the first two phases, the system specifications will be clarified to enable the development work in WP300. The final result will be a set of components and interfaces specifications. The interfaces will be human oriented or will be based on the machine-to-machine message oriented communication. In this step, the use case requirements are taken as input for system specifications and application specifications.

Figure 4.1 represents the proposed approach.

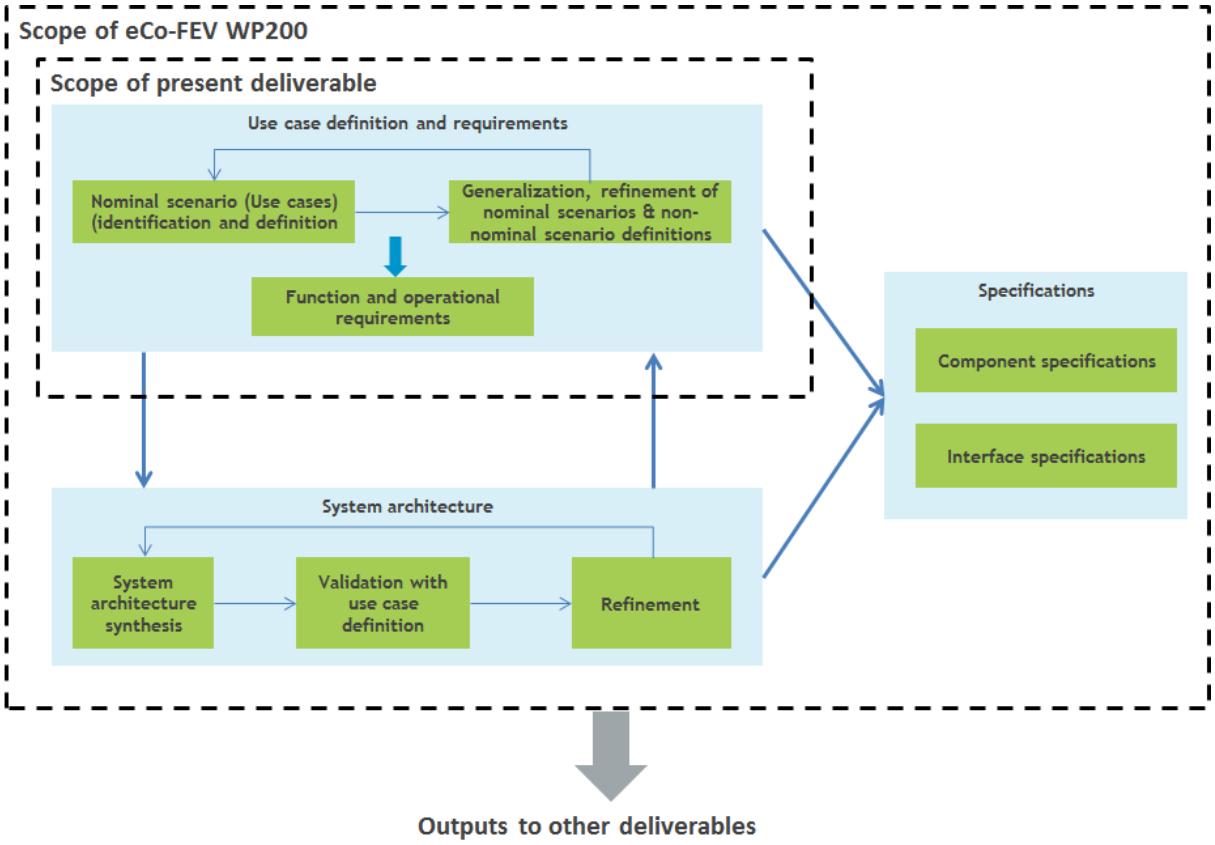

Figure 4.1: WP200 methodology overview

4.2. Use case description

For each use case, the following information is provided:

- UML use case diagram
- Textual description
- Functional and operation requirement table

The UML use case diagram represents the actors' interaction with the system and helps depicting the different types of actors of a system and the various ways that they interact with the system.

Actors are normally represented in a use case diagram as a stick figure. The term "actors" is frequently interchanged with the term "users"; however an actor does not necessarily have to be a human user. An actor could be another system or some other form of external input into the system. The actors in our use cases are modeled according to their role instead of their names. Any system user can hence take one or more roles.

In eCo-FEV, two levels of use cases are defined: primary and secondary. The primary use cases are delivering the high level functionality to the end-user. The secondary use cases provide the elementary functionalities which facilitate the primary use case construction.

For each described use case, a set of requirements that the eCo-FEV system shall satisfy are defined. The functional requirements refer to the functionalities of the eCo-FEV system that are required to realize the use case, while the operational requirements refer to the functionalities that are required to ensure the proper operation of the eCo-FEV system.

At this stage, the eCo-FEV consortium does not define any measurable operational parameters that shall be verified during the use case validation and evaluation test. Such measurable operational requirements will be defined during the definition of test cases. Therefore, the operational requirements as defined in the present deliverable are only qualitative requirements.

5. eCo-FEV use cases

5.1. eCo-FEV scope and actors

The objective of the eCo-FEV system is to simplify the usage of Full Electrical Vehicles (FEV). To achieve this objective the eCo-FEV system will play the role of facilitator between the travelers and already existing infrastructure operators. This system will provide communication interfaces to enable data exchanges between multiple infrastructures and with FEVs to guarantee advanced use cases and services to FEV users.

The Figure 5.1 represents the entire eCo-FEV general environment.

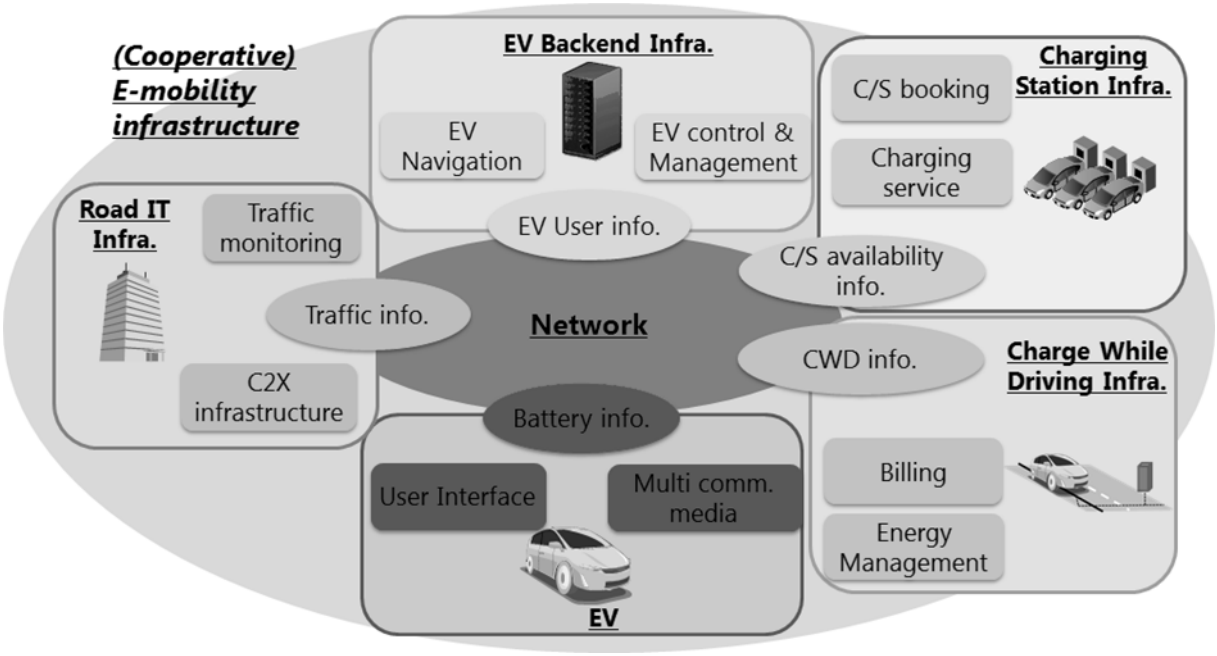

Figure 5.1: eCo-FEV general environment

The principal functions offered by the eCo-FEV system will be the trip planning and assistance during the trip. The system will help the traveler to respect the planned itinerary and, if necessary, to adapt it to environmental changes monitoring the FEV autonomy.

In order to guarantee this the pillars of the system will be:

- Charging and parking facilities booking
- Optimal balance between usage of individual FEV and public transport
- Rapidity of trip reconfiguration according to the traffic events
- Payment facilities.

Different **actors** of eCo-FEV system have been identified:

1. **eCo-FEV traveler:** any traveler using the eCo-FEV system. This may include FEV drivers, (FEV) passengers or any other road or public transportation system users.
2. **Fleet operator drivers**: they are special types of eCo-FEV travelers. They are driving FEVs from the fleet of FEV delivery fleet operator and are bounded to a fixed delivery schedule.
3. **FEV:** it is an electric powered vehicle which provides to the eCo-FEV system its level of autonomy as well as other in-vehicle information. Additionally, it provides means for the interaction between eCo-FEV system and eCo-FEV traveler.
4. **Road infrastructure operator:** the road infrastructure operator monitors and manages the road traffic and/or road side infrastructure systems. It will provide information on traffic conditions and events (accident, road works, road diversions, traffic restriction, etc.). It may refer to an urban traffic management center or a highway operator. Such operator is in charge of the Road Side Units (RSU). RSUs are equipment installed at road side, which support road traffic operators.
5. **Public transport operator:** including urban, regional, metro, train operators: This operator manages the public transportation.
6. **FEV delivery fleet operator:** a company that owns and manages fleets of FEVs for goods delivery. They operate also the charging facilities for their own vehicles. Every day they plan the delivery of goods to all their customers.
7. **Parking facility operator:** it manages parking facilities including FEV parking equipped with charging facilities. This operator provides the number of available parking places. If necessary it will offer booking and payment facilities. In some situations, the charging facilities will be managed by other specialized operators (i.e. charging facilities operator).
8. **Charging facility operator (conductive and inductive charging):** operator that provides charging services and energy to FEVs. It manages the Electric Vehicle Supply

Equipment. This operator will provide the number of its available charging places or traffic on the inductive charging lanes. If necessary it will offer booking and payment facilities. Multiple charging technologies may be offered by charging facility operators, e.g. power line based charging, inductive charging and inductive dynamic charging while driving.

9. **Weather info provider**: it reports real time or forecast weather. Weather conditions may have impact on the traffic condition and even on the FEV energy consumption.
10. **Banking service operator**: the banking service operator manages the payment and reimbursement procedure for FEV users and for other operators. This operator is trusted by all eCo-FEV actors. In one possible implementation, the banking service operator can be considered as a part of the eCo-FEV system.
11. **Map service provider**: the map service provider provides a map database and map content. In the scope of eCo-FEV, a commonly agreed map database (e.g. openStreetMap) will be used.

It should be noted that some other operators may be indirectly relevant to the above mentioned operators. These operators are not directly involved in FEV mobility but provide necessary support and services. For example, an energy provider provides energy to charging facilities operators and interacts with the charging facility operators to operate the energy provision as required by FEV.

Another important question relates to the global energy management (i.e. electric grid) and banking & payment facilities. The energy management is out of the project scope. Nevertheless, the information on the geo-localized energy requirement and its temporal variation will be evaluated by the eCo-FEV system. On the other hand, the banking and payment facility is retained within the project scope. The eCo-FEV system will have to deal with two main situations:

- traveler accounting are integrated into the eCo-FEV infrastructure and all services are paid to the eCo-FEV system which manages money flows between operators or its representatives
- the eCo-FEV system facilitates the link establishment between travelers and operators and travelers pay directly operators or its representatives

Given that various payment and billing services are already existing nowadays for web based services, it is not the goal of the eCo-FEV project to develop and validate any payment service

and money flow in back-end banking system. Therefore, the eCo-FEV project treats the banking and payment aspect only from accounting viewpoint, i.e. to validate the appropriate user consumption accounting while benefiting the e-mobility service. In a real deployment of the eCo-FEV system, the billing and payment procedure may be selected per implementation case.

5.2. eCo-FEV use case summary

In eCo-FEV, two levels of use cases are defined. The primary use cases provide directly services to the individual travelers or urban delivery drivers and operators. The secondary use cases support the realization of the primary use cases. A secondary use case may be used by multiple primary use cases.

The list of **primary eCo-FEV use cases** is illustrated in Table 5.1. The primary use cases are described in Section 7. As already mentioned, the project proposes services for two classes of users: individual travelers and light urban delivery fleet drivers. The main use cases for both classes of users are "trip planning" and "trip assistance". For individual travelers trips can include supplementary option of multimodality (i.e. a trip mixing public transport and personal car usage). For urban delivery the trip planning is encompassed by the more general daily planning for the entire urban delivery fleet.

Use case name	Short description
eCo-FEV subscription	This use case manages the registration processes of all eCo-FEV travelers to the eCo-FEV system. In particular, this use case verifies the identity of the eCo-FEV traveler, creates a list of its FEVs, and sets its preferences and subscription options. This use case also creates the necessary credentials to allow the eCo-FEV traveler to connect the eCo-FEV system.
Individual traveler use cases	
Ad hoc drive to facility assistance	This use case consists of providing guiding assistance for FEVs to drive to a charging facility.
Ad hoc trip assistance	This use case provides assistance for any ad hoc trip.
Free driving assistance	This use case delivers the FEV Driver assistance when the trip target is not known by the eCo-FEV system. The main objective of the assistance is to help the driver to avoid or to manage the autonomy issues. In addition, the eCo-FEV system informs him about the points of interest in his vicinity.
Trip assistance	Dynamically guide the eCo-FEV traveler during the trip until the destination taking into account traffic and weather conditions, preferences and battery status. The eCo-FEV system monitors the trip progress with regards to a travel plan. If unexpected situations are detected the trip plan or charging

	plan may be dynamically adjusted.
Trip planning	The eCo-FEV system provides the estimated route for the FEV traveler based on the transmitted request e.g. destination, expected arrival time/departure time, current battery level, etc. The proposed itinerary may provide a potential list of C/Ss for the eCo-FEV traveler. If the eCo-FEV system knows the FEV characteristics and estimated state of charge at the trip start, a potential charging plan may be proposed. A multimodal itinerary may be offered during the trip planning if public transport is available to reach the destination and according to the eCo-FEV traveler's preference.
Urban Delivery use cases	
Daily delivery planning	Based on the daily delivery requirements, this use case provides assistance to define the daily delivery plan for goods delivery operators.
Delivery assistance	This use case addresses the driver assistance during a planned route and schedule. If unexpected situations are detected the particular trip or the entire delivery planning can be adjusted.

Table 5.1: List of eCo-FEV primary use cases

The **secondary eCo-FEV use cases** are listed in Table 5.2 and are elaborated in Section 6.

Use case name	Short description
Trip monitoring	The eCo-FEV system monitors the FEV activities during the trip. It encompasses all monitoring use case which follow
POI monitoring and notification	The eCo-FEV system provides the Point of Interest (PoI) information to FEVs or eCo-FEV travelers.
Public transport monitoring	This use case monitors the state of public transports. The eCo-FEV system receives from public transport operators real time public transport and transport mode transit information e.g. public transport time tables, mode transit hub facilities, etc.
Traffic condition monitoring	This use case monitors traffic and weather condition.
Charging facilities accessibility monitoring	This use case is applied during a trip when the eCo-FEV traveler drives the FEV. It monitors the accessibility of any compatible charging point in the perimeter of the FEV autonomy or in the case of planned trip also the accessibility of the next programmed charging facility.
Charging monitoring	This use case is applied during a trip and when the "participating FEV" is under charge. It monitors the progress of the planned charging and in case of no respect of the expected SOC level; it verifies the consequences for the running trip.
Facilities access control	This use case is applied during the trip just before benefiting from booked facilities. It verifies the facility access authorization and if necessary also perform the payments of booked.
Facility booking	This use case books the necessary facilities for a trip.

Facility cancellation	This use case cancels a booking.
Facility payment	This use case handles the payment procedure.
Trip, facility choice and booking	Based on FEV planned itinerary, a set of accessible facilities along the trip is proposed by the eCo-FEV system to the eCo-FEV traveler. The necessary facilities (e.g. parking, charging stations, and public transport tickets) are booked and prepaid if required by concerned operators.
Individual traveler specific use case	
Trip adjustment	This use case helps the eCo-FEV traveler to adjust the trip according to environmental events, FEV autonomy issues or to plan changes. Environment events can be related to the traffic or weather condition alterations, to pre-booked facility (i.e. parking, charging station) availability issues or to difference between planned and actual FEV charging program.
Urban Delivery specific use case	
Delivery planning adjustment	This use case adjusts the planning in case of unexpected situations encountered during the delivery. If necessary or useful, the planning of the entire fleet can be adjusted.
Back office use cases	
Charging facility status monitoring	This use case is a part of back office services without a direct link with the end user functionality. It collects information about the availability status of all charging facilities from the eCo-FEV perimeter. This information is necessary for other use oriented use cases.
Vehicle Relationship Management	This use case is a part of back office services without a direct link with the end user functionality. It collects information from all trips and thanks to the data mining operations elaborates statistical models necessary for use cases requiring estimation/prediction of FEV autonomy, trip duration or the energy quantity required by the charging processes. The collected information includes SOCs, driving speeds, traffic and weather conditions and also the energy consumption during the charging processes.

Table 5.2: List of eCo-FEV secondary use cases

All (primary and secondary) use cases will be described by: use case number, use case name, short description, list of primary actors and pre-conditions.

In addition all use cases will be added the lists of functional and operational requirements. The functional requirements complete the description of the use cases by adding detailed information about the inputs, outputs or behavior of the use cases. The operational requirements include the information about the execution context, its environment, performances, security assumptions and the expected efficiency or accuracy.

6. Secondary use case and requirements definitions

6.1. Charging facilities accessibility monitoring

This use case is applied during trip runs when the eCo-FEV traveler drives the FEV.

It monitors the accessibility of any compatible charging point in the perimeter of the FEV autonomy.

In this use case, the eCo-FEV system verifies the accessibility of charging facilities for a FEV and eCo-FEV traveler. The eCo-FEV system first estimates a FEV's range considering its remaining battery charge. Dynamic information such as traffic condition and weather information are used for the range estimation. Within the estimated range, the charging facilities accessibility is verified according to vehicle charging system for different charging modes e.g. wired charging, static inductive charging, and inductive charge while driving. Such updates may be periodically done by the eCo-FEV system, taking into account periodically received information updates about parking availability, charging availability, and map updates.

The use case is defined in Table 6.1.

Use case element	Description
Use case number	201
Use case name	Charging facilities accessibility monitoring
Short description	This use case is applied during a trip when the eCo-FEV traveler drives the FEV. It monitors the accessibility of any compatible charging point in the perimeter of the FEV autonomy or in the case of planned trip also the accessibility of the next programmed charging facility.
Primary actor	FEV, eCo-FEV traveler, charging facility operator, map service provider, parking facility operator, road infrastructure operator, weather info provider
Pre-conditions	• FEV and travelers are subscribed to eCo-FEV platform. • The eCo-FEV system is connected to charging facility operator, map service provider, parking facility operator etc. • FEV and travelers are connected to eCo-FEV system.

Table 6.1: Use case description: Charging facilities accessibility monitoring

The use case diagram is as illustrated in Figure 6.1.

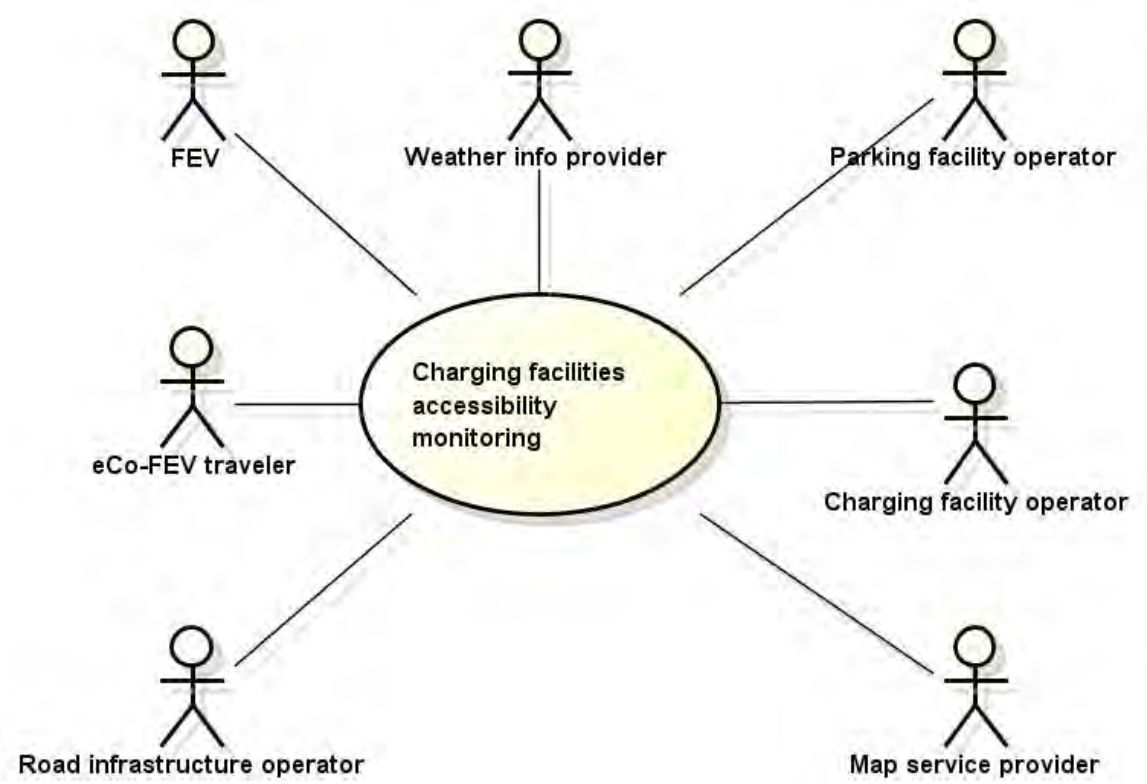

Figure 6.1: Use case diagram: Charging facilities accessibility monitoring

The functional and operational requirements of the use case are listed in Table 6.2.

Requirements	Description
	Functional requirements
FR201-1	In order to estimate the charging facility accessibility, the eCo-FEV system collects FEV charging system characteristics, e.g. charging mode and battery status of charge information (SoC).
FR201-2	In order to estimate the charging facility accessibility, the eCo-FEV system estimates the remaining range of the FEV autonomy. The estimation is based on the "Vehicle relationship management" data collect and statistical modelling.
FR201-3	To estimation the FEV autonomy, the eCo-FEV system takes into account traffic and weather conditions.
FR201-4	The eCo-FEV system collects real time charging facilities availability information.
FR201-5	Once the FEV autonomy is estimated, the eCo-FEV system checks the availability of any charging facilities and of the next programmed in case of "trip assistance" primary use case.

	Operational requirements
OR201-1	The eCo-FEV traveler and his FEV shall be authenticated by the eCo-FEV system.
OR201-2	Charging availability, weather and traffic information shall be updated periodically.
OR201-3	In case of potential issue of the charging facility accessibility, the eCo-FEV travelers should be notified immediately.
OR201-4	The FEV (or adequate personal device) shall provide an HMI to receive charging accessibility information

Table 6.2: Requirements: Charging facilities accessibility monitoring

6.2. Charging monitoring

This use case is applied during trip runs and when the "participating FEV" is under charge. It monitors the progress of the planned charging and in case of no respect of the expected SOC level; it verifies the consequences for the running trip.

The FEV transmits periodically its state of charge (SoC) and battery internal status information to the eCo-FEV system during the charging. The eCo-FEV system estimates the SoC evolution. In cases of unexpected deviations or technical faults the eCo-FEV traveler is informed about this problem.

The use case is defined in Table 6.3.

Use case element	Description
Use case number	202
Use case name	Charging monitoring
Short description	This use case is applied during a trip and when the "participating FEV" is under charge. It monitors the progress of the planned charging and in case of no respect of the expected SOC level; it verifies the consequences for the running trip.
Primary actor	Charging facility operator, FEV, eCo-FEV traveler.
Pre-conditions	• FEV and eCo-FEV travelers are subscribed to the eCo-FEV system. • The eCo-FEV system is connected to FEV and traveler. • The eCo-FEV traveler doing the trip using the FEV • The FEV is under charge • FEV and travelers are connected to charging facilities

Table 6.3: Use case description: Charging monitoring

The use case diagram is as illustrated in Figure 6.2.

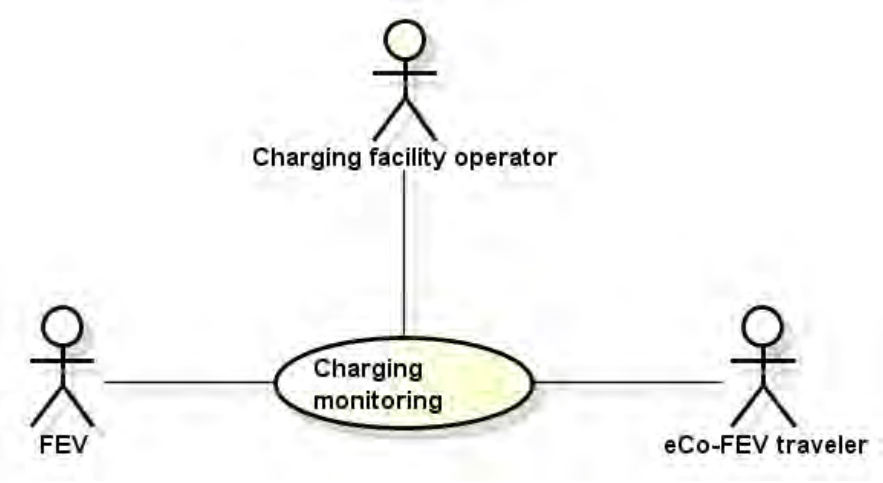

Figure 6.2: Use case diagram: Charging monitoring

The functional and operational requirements of the use case are listed in Table 6.4.

Requirements	Description
	Functional requirements
FR202-1	During the charging, the FEV shall transmit periodically the SoC and battery internal status information to the eCo-FEV system.
FR202-2	The eCo-FEV system shall be able to trigger a warning message to the FEV or to eCo-FEV traveler's personal device in case a problem is detected.
FR202-3	The eCo-FEV system shall be able to detect the battery fault and low SoC situations based on received information. Specific data mining algorithms may be developed for this function.
FR202-4	FEVs shall be able to receive and decode information sent from charging facilities operators and parking operators for the charging.
FR202-5	FEVs shall transmit charging activity report to eCo-FEV system.
FR202-6	FEVs shall transmit identity information and/or booking reference information to charging facilities operator.
FR202-7	eCo-FEV system shall inform eCo-FEV travelers of failure or low SoC information.
	Operational requirements
OR202-1	eCo-FEV travelers and FEVs should be authenticated to receive information related to charging progress.
OR202-2	eCo-FEV system shall handle updates of SoC and battery status periodically.
OR202-3	If charging facility operator is not able to satisfy the charging demand of a FEV, this information shall be transmitted to the FEV and the eCo-FEV traveler.
OR202-4	In case of charging failure, the charging facilities operator shall inform corresponding eCo-FEV travelers.

OR202-5	The FEV and eCo-FEV traveler personal device should provide an HMI for receive failure information from the eCo-FEV system.

Table 6.4: Requirements: Charging monitoring

6.3. Facility access control

This use case is applied during the trip just before benefiting from facilities (parking, charging and if possible the public transportation means). It treats the facility access authorizations and if necessary payments.

In this use case, the booking and access right of FEVs and eCo-FEV travelers to use charging facilities and parking facilities are controlled and verified. For the access control, the booking reference information should be verified by corresponding operators. For charging facility access control, other FEV related data may need to be provided and verified to confirm that FEV is suitable to use one or several charging mode facilities. If no booking is required, other access control strategies may be decided by operators.

If payment is required, this use case may include payment and billing secondary use case.

The use case is defined in Table 6.5.

Use case element	Description
Use case number	203
Use case name	Facility access control
Short description	This use case is applied during the trip just before benefiting from booked facilities. It verifies the facility access authorization and if necessary also perform the payments of booked.
Primary actor	FEV, eCo-FEV traveler, charging facilities operators, parking facility operators, public transport operator, passenger FEV Fleet operator
Pre-conditions	• Trip running • FEV user plans to enter the facility

Table 6.5: Use case description: Facility access control

The use case diagram is as illustrated in Figure 6.3.

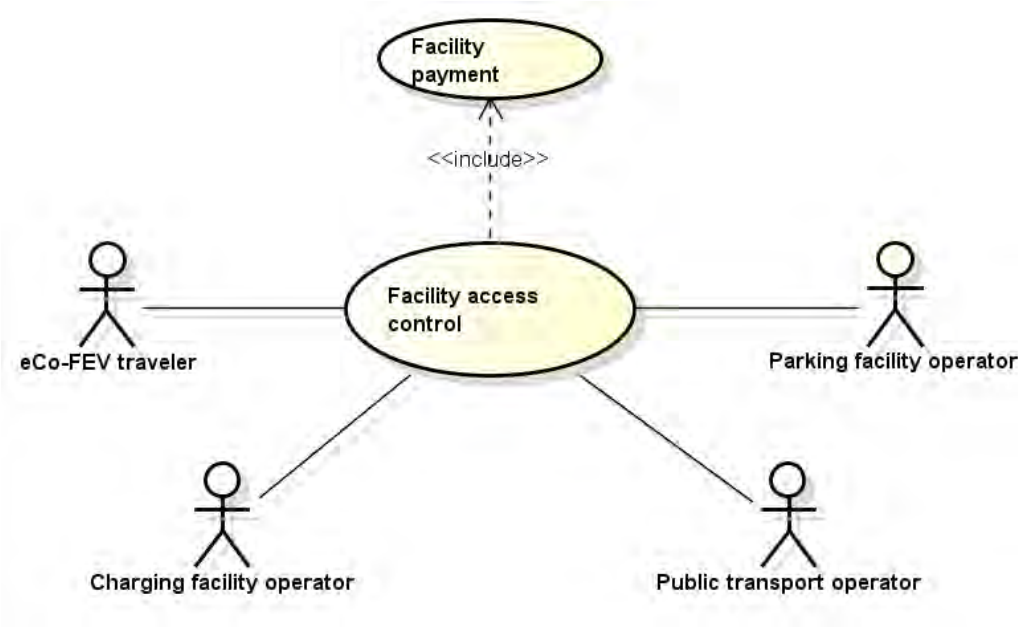

Figure 6.3: Use case diagram: Facility access control

The functional and operational requirements of the use case are listed in Table 6.6.

Requirements	Description
	Functional requirements
FR203-1	The eCo-FEV system shall transmit booking reference information and other access control related information to corresponding operators.
FR203-2	Operators shall transmit confirmation or deny information to the eCo-FEV.
FR203-3	If payment and billing is required and is not included in the booking phase or not covered by the eCo-FEV subscription options, eCo-FEV system shall provide functionalities to assist the payment procedure e.g. either as payment service provider or as intermediate actor to facilitate the payment procedure.
	Operational requirements
OR201-1	The eCo-FEV traveler and his FEV shall be authenticated by the eCo-FEV system.
OR203-2	Optionally, in case of no access right can be granted to eCo-FEV travelers, operators may provide alternative facilities information to eCo-FEV travelers.
OR203-3	In case of access to the charge while driving facilities the access control performances have to be compatible with the vehicle speed.
OR203-4	The eCo-FEV system shall protect user privacy data.

Table 6.6: Requirements: Facility access control

6.4. Facility booking

This use case books the necessary facilities for the trip under planning.

This use case handles the booking procedure for eCo-FEV travelers to different infrastructure operators. The list of necessary facilities comes from the trip planning or trip adjustment use cases. The eCo-FEV system will forward the booking request to corresponding operators. At receiving the request, the corresponding operator processes the booking request. The confirmation (or denial) information has to be returned to the eCo-FEV system.

The use case supports the FEV fleet delivery operator to book facilities for fleet FEVs.

If payment is required, this use case shall include the payment and billing secondary use case.

The use case is defined in Table 6.7.

Use case element	Description
Use case number	204
Use case name	Facility booking
Short description	This use case books the necessary facilities for a trip.
Primary actor	eCo-FEV traveler, charging facilities operator, parking facility operator, public transport operator, FEV Delivery Fleet Operator.
Pre-conditions	The FEV and eCo-FEV traveler are subscribed to the eCo-FEV system.

Table 6.7: Use case description: Facility booking

The use case diagram is as illustrated in Figure 6.4.

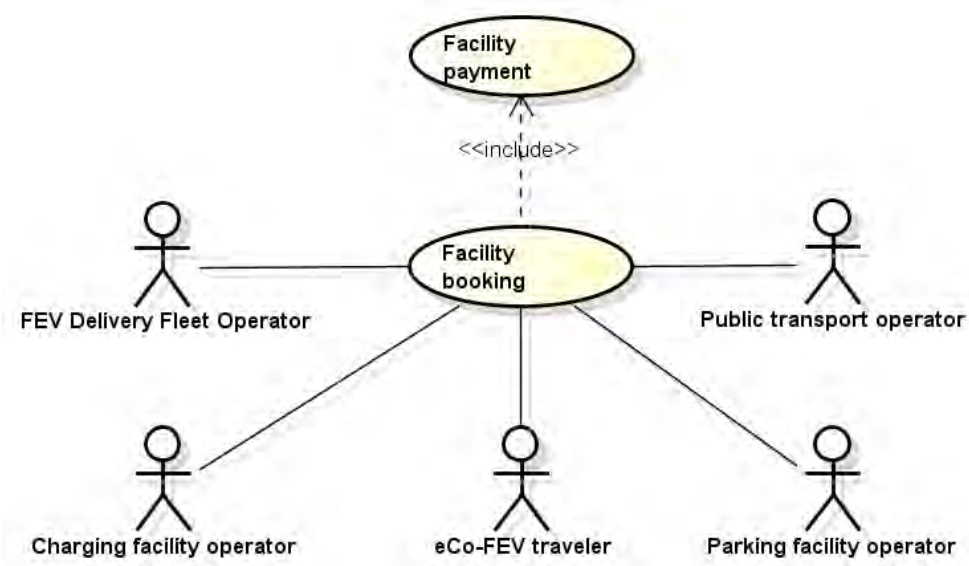

Figure 6.4: Use case diagram: Facility booking

The functional and operational requirements of the use case are listed in Table 6.8.

Requirements	Description
	Functional requirements
FR204-1	The eCo-FEV system shall transmit a booking request to the corresponding operators.
FR204-2	The eCo-FEV system shall be able to handle confirmation or deny information from Operators.
FR204-3	If a booking request is transmitted to the eCo-FEV system, the eCo-FEV system shall be able to forward the booking/cancellation request to the corresponding operators.
FR204-4	The eCo-FEV system may store the booking information as long as the booking is still valid.
FR204-5	Is case payment or billing is required for the booking, the operator shall trigger the payment and billing procedure.
	Operational requirements
FR204-1	If the booking is realized from a FEV, the FEV shall provide an HMI to eCo-FEV travelers to enter the booking and cancellation request.
OR204-2	The eCo-FEV traveler and his FEV shall be authenticated by the eCo-FEV system.
OR204-3	Booking reference provided by the operator shall allow identification of client and booking event.
OR204-4	In case booking failure or cancellation failure, the eCo-FEV system shall inform the FEV and eCo-FEV traveler.
OR204-5	The eCo-FEV system shall protect user privacy data.

Table 6.8: Requirements: Facility booking

6.5. Facility cancellation

This use case handles the cancelation procedure of booked facilities.

The cancellation request is transmitted to all concerned operators, which process the cancellation request. The booking reference and additional information may be required to cancel the booking. If necessary and possible the money refunding will be requested to be the banking operator.

The use case is defined in table below.

Use case element	Description
Use case number	205
Use case name	Facility cancellation
Short description	This use case cancels a booking.
Primary actor	eCo-FEV traveler, charging facilities operators, parking facility operators, public transport operator, FEV Delivery Fleet Operator.
Pre-conditions	The FEV and eCo-FEV travelers are subscribed to eCo-FEV system.

Table 6.9: Use case description: Facility cancellation

The use case diagram is as illustrated in figure below.

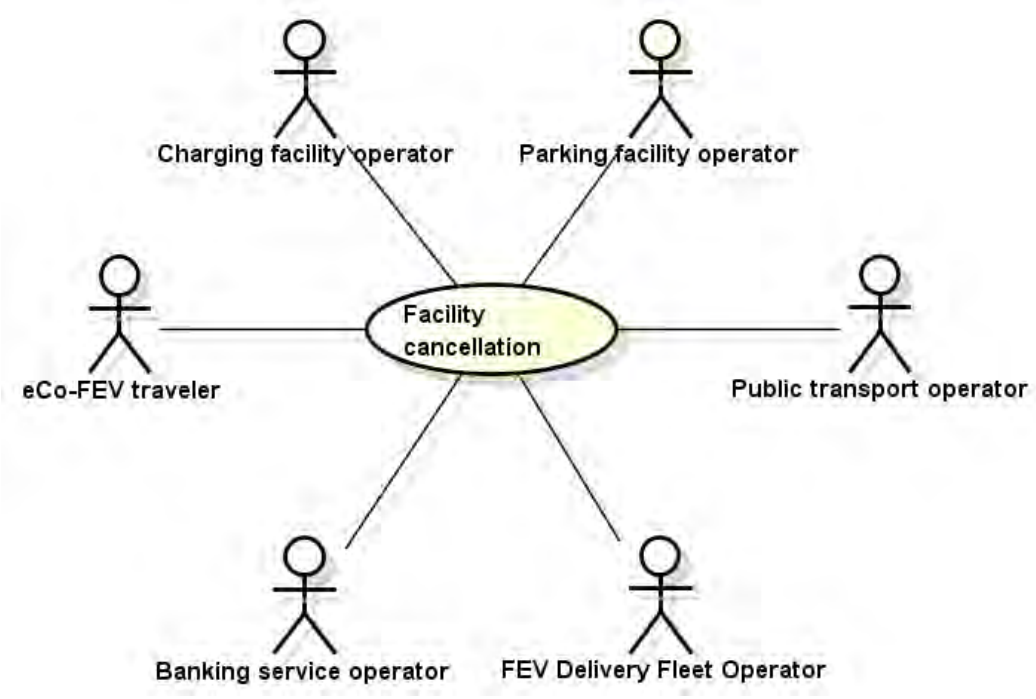

Figure 6.5: Use case diagram: Facility cancellation

The functional and operational requirements of the use case are listed in Table 6.8.

Requirements	Description
	Functional requirements
FR205-1	The eCo-FEV system shall be able to forward the cancellation request to the corresponding operators.
FR205-2	In case payment or billing is required for the booking and a booking cancellation request is received, the eCo-FEV system shall initiate the refunding request to the banking operator.
	Operational requirements
OR205-1	In case booking failure or cancellation failure, the eCo-FEV system shall inform the FEV and eCo-FEV traveler.
OR205-2	The eCo-FEV system shall protect user privacy data.

Table 6.10: Requirements: Facility cancellation

6.6. Facility payment

This use case treats the facility payment.

This use can be applied during the phase of trip programming or during the trip run just before benefiting from booked facilities.

This use case handles the payment and billing procedure for infrastructure operators, whenever payment/billing is required. Infrastructure operators may transmit directly the payment request to eCo-FEV travelers or to the eCo-FEV system, which will forward the payment request together with the consumption account information to corresponding eCo-FEV traveler. Then the eCo-FEV system establishes communication with a banking service operator for the payment/billing process. The confirmation (or denial) information will be sent to eCo-FEV travelers, either directly or via eCo-FEV system. The confirmation will also be transmitted to the corresponding infrastructure operators. Alternatively, the payment procedure may be realized directly between FEV travelers and banking service operators via e.g. personal devices, without passing through the eCo-FEV system.

The use case is defined in Table 6.11.

Use case element	Description
Use case number	206
Use case name	Facility payment
Short description	This use case handles the payment procedure.
Primary actor	eCo-FEV traveler, charging facilities operators, parking facility operators, public transport operator, FEV Delivery Fleet Operator.
Pre-conditions	• FEV and travelers are subscribed to eCo-FEV system.

Table 6.11: Use case description: Facility payment

The use case diagram is as illustrated in Figure 6.6.

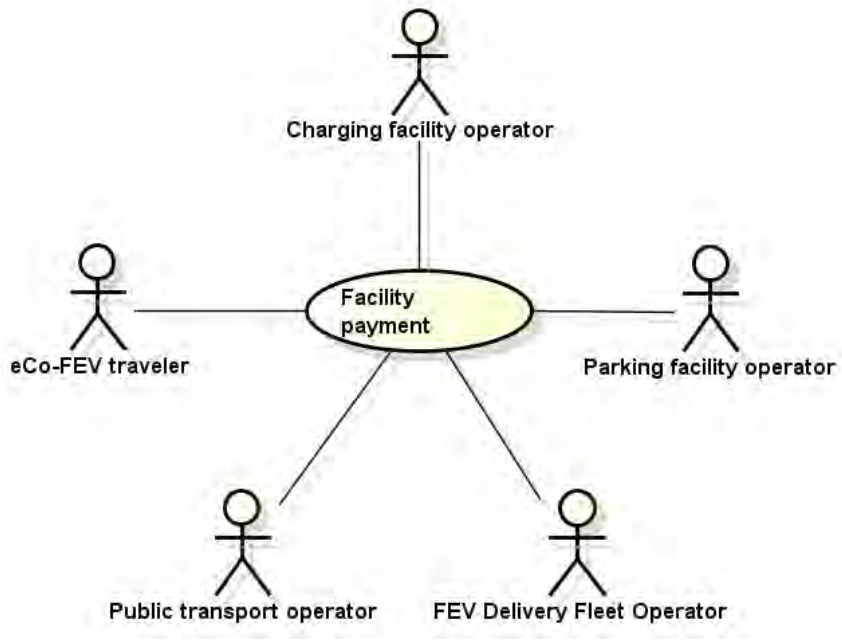

Figure 6.6: Use case diagram: Facility payment

The functional and operational requirements of the use case are listed in Table 6.12.

Requirements	Description
	Functional requirements
FR206-2	If payment is needed, the eCo-FEV system shall provide means to the eCo-FEV travelers to enter banking and payment information.
FR206-3	Corresponding operators shall transmit payment request to eCo-FEV travelers, if required.
FR206-4	Banking service operators shall process payment requests.
FR206-5	Operators shall transmit payment confirmation or denial information to eCo-FEV system. The eCo-FEV system shall forward this information to the corresponding traveler.
FR206-6	If a payment request is transmitted to eCo-FEV system, the eCo-FEV system shall forward the request to the corresponding FEV traveler.
	Operational requirements
OR206-1	The FEV and eCo-FEV traveler shall provide the required booking reference and payment information.
OR206-2	The eCo-FEV system shall protect user payment data.

Table 6.12: Requirements: Facility payment

6.7. Public transport monitoring

This use case is applied during running trip.

It monitors the state of public transports related to the running trip.

One of the main objectives of eCo-FEV is to integrate FEV mobility into urban and inter-urban multi-mode transportation systems. For eCo-FEV travelers, multimodality represents higher flexibility in order to reach the destination in time, in case of charging difficulties and long charging waiting times. In this secondary use case, the eCo-FEV system collects public transport information from public transport operators, including real time public transport time tables and real time management information, as well as multi-mode hub facilities information. An eCo-FEV traveler may also request the eCo-FEV system to provide location-based public transport information. An eCo-FEV traveler may request the public transport information in real time by sending a request to eCo-FEV system, which may transmit the information to the eCo-FEV traveler. The use case is defined in Table 6.13.

Use case element	Description
Use case number	207
Use case name	Public transport monitoring
Short description	This use case monitors the state of public transports. The eCo-FEV system receives from public transport operators real time public transport and transport mode transit information e.g. public transport time tables, mode transit hub facilities, etc.
Primary actor	FEV, eCo-FEV traveler, public transport operator.
Pre-conditions	• The eCo-FEV traveler is subscribed to eCo-FEV system • the eCo-FEV system is connected with public transport operator system

Table 6.13: Use case description: Public transport monitoring

The use case diagram is as illustrated in Figure 6.7.

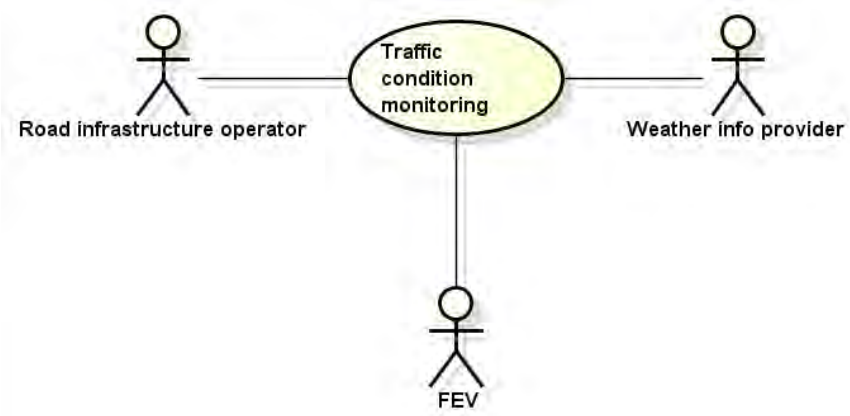

Figure 6.7: Use case diagram: Public transport monitoring

The functional and operational requirements of the use case are listed in Table 6.14.

Requirements	Description
	Functional requirements
FR207-1	If required by the use case, eCo-FEV travelers shall be able to send a request to the eCo-FEV system to provide location-based public transport information.
FR207-2	The FEV shall provide an HMI for eCo-FEV travelers to send requests and receive public transport information. If a personal device is used for this request, the personal device shall be able to send the request.
FR207-3	The eCo-FEV system shall be able to receive and decode public transport information from public transport operators.
FR207-4	Public transport information may be periodically pushed from public transport operators, or provided on-demand after request from the eCo-FEV system. Both communication modes shall be supported by eCo-FEV system.
FR207-5	The eCo-FEV system shall match the public transport information to the road topology and check the geographical relevance to a road segment or geographic area or to eCo-FEV travelers' location in case of request from traveler.
FR207-5	The eCo-FEV system shall include a public transport information database to store the updated traffic information.
FR207-6	If required by the use case, the eCo-FEV system shall be able to provide public transport information to the requested eCo-FEV traveler.
	Operational requirements
OR207-1	In case of communication failure, the eCo-FEV system shall be able to re-initiate the communication link when possible.
OR207-2	Public transport information database shall be updated periodically.

Table 6.14: Requirements: Public transport monitoring

6.8. Traffic condition monitoring

This use case is applied during trip runs. Alternatively, this use case may be triggered by eCo-FEV system without specific request from user.

It encompasses traffic and weather condition monitoring.

Those two distinct monitoring activities are considered together for the reason of the dependency of the weather condition on the prediction of the travel time.

FEV energy consumption varies based on unexpected traffic and driving conditions such as traffic jam and weather conditions. Therefore, in order to ensure a good quality of services for FEV users from the eCo-FEV system, the traffic condition information may be used to precisely guide the FEV users with regards to traffic conditions and weather conditions. Road traffic is monitored by road infrastructure operators such as urban traffic management centers or highway operators, from whom the real time traffic information may be received. Furthermore, eCo-FEV system may collect other related information from other operators, such as weather condition information from weather info operators.

The use case is defined in Table 6.15.

Use case element	Description
Use case number	208
Use case name	Traffic condition monitoring
Short description	This use case monitors traffic and weather condition.
Primary actor	FEV, road infrastructure operator, weather info provider.
Pre-conditions	eCo-FEV system is connected with traffic and weather info provider system.

Table 6.15: Use case description: Traffic condition monitoring

The use case diagram is as illustrated in Figure 6.8.

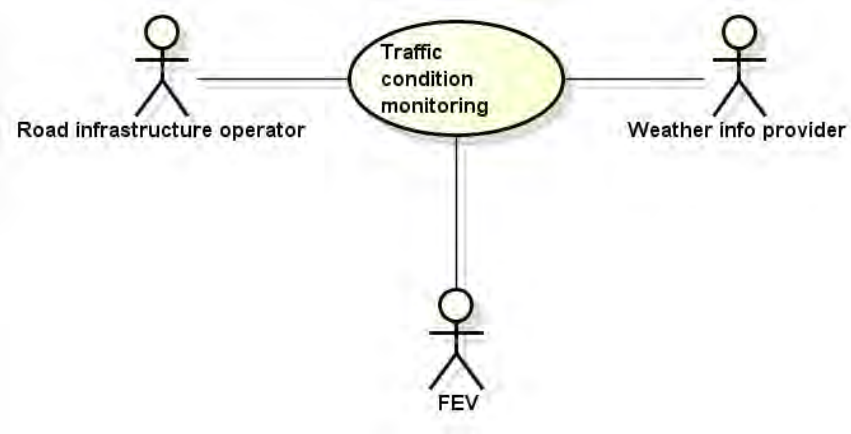

Figure 6.8: Use case diagram: Traffic condition monitoring

The functional and operational requirements of the use case are listed in Table 6.16.

Requirements	Description
	Functional requirements
FR208-1	The eCo-FEV system shall be able to receive and decode road traffic information from road traffic operators and/or other information providers e.g. weather info operators, using a specific protocol e.g. datex2 [3].
FR208-2	Road traffic information may be periodically pushed from road traffic operators, or provided on demand with request from eCo-FEV system. Both communication modes shall be supported by eCo-FEV system.
FR208-3	At receiving road traffic information, the eCo-FEV system shall be able to match traffic information to the road topology and check the geographical relevance of traffic information to one road segment or geographic area.
FR208-4	The eCo-FEV system shall store road traffic information.
	Operational requirements
OR208-1	In case of communication failure, the eCo-FEV system shall be able to re-initiate the communication link when possible.
OR208-2	The eCo-FEV system shall be able to verify the consistency of road traffic information received from multiple data sources.
OR208-3	Road traffic information database shall be updated periodically.

Table 6.16: Requirements: Traffic condition monitoring

6.9. Charging facility status monitoring

This use case collects information about the availability status of all charging facilities from the eCo-FEV perimeter. This information is necessary for other user oriented use cases.

Charging facility operators provide updated charging facility status information to the eCo-FEV system. The use case is defined in Table 6.15.

Use case element	Description
Use case number	209
Use case name	Charging facility status update
Short description	This use case monitors the charging facility status.
Primary actor	Charging facility operators.
Pre-conditions	The eCo-FEV system is connected to charging infrastructure operator system

Table 6.17: Use case description: Charging facility status monitoring

The use case diagram is as illustrated in Figure 6.8.

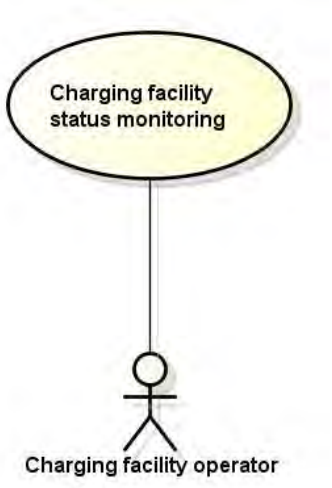

Figure 6.9: Use case diagram: Charging facility status monitoring

The functional and operational requirements of the use case are listed in Table 6.16.

Requirements	Description

	Functional requirements
FR209-1	The eCo-FEV system shall be able to receive and decode charging facility status information from charging facility operators.
FR209-2	Charging facility status information may be periodically pushed from charging facility operators or provided on demand with request from eCo-FEV system. Both communication modes shall be supported by eCo-FEV system.
FR209-3	The eCo-FEV system shall store charging facility status information.
FR209-4	At receiving charging facility status information, the eCo-FEV system shall be able to match charging facility information to the road topology and check the geographical relevance of charging facility information to one road segment or geographic area.
	Operational requirements
OR209-1	Charging facility status information database shall be updated periodically.

Table 6.18: Requirements: Charging facility status monitoring

6.10. Point of interest monitoring and notification

This use case is applied during or before trip.

It intercepts all "informational" notifications close to the eCo-FEV traveler interests and/or geographically close to the running trip. Alternatively, road infrastructure operators provide PoI information to the eCo-FEV system, which transmits the PoI information to eCo-FFV travelers within a specific geographical area.

The use case is defined in the table which follows.

Use case element	Description
Use case number	210
Use case name	PoI notification
Short description	The eCo-FEV system provides the Point of Interest (PoI) information to FEVs or eCo-FEV travelers.
Primary actor	eCo-FEV traveler, FEV, road infrastructure operator, map service provider
Pre-conditions	• The traveler and FEV are subscribed to the eCo-FEV system.

Table 6.19: Use case description: PoI notification

The use case diagram is as illustrated in the figure which follows.

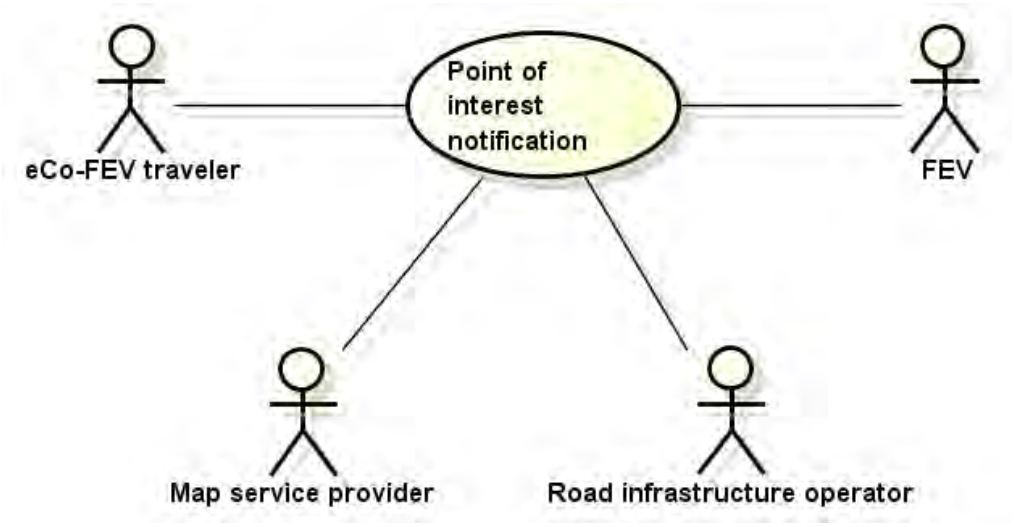

Figure 6.10: Use case diagram: PoI notification

The functional and operational requirements of the use case are listed in the table which follows.

Requirements	Description
	Functional requirements
FR210-1	The eCo-FEV system shall be able to filter the received PoI to a specific geographic area or position for transmission.
FR210-2	The eCo-FEV system shall be able to collect PoI information from PoI content operators.
FR210-3	The eCo-FEV system shall be able to store the PoI information, as long as it is still valid.
FR210-4	The eCo-FEV system shall be able to disseminate POI information.
FR210-5	FEVs shall be able to receive and decode POI information.
	Operational requirements
OR210-1	The FEV‘s shall provide an HMI to eCo-FEV travelers to set the requirements of a PoI request.
OR210-2	The eCo-FEV system shall verify the consistency of PoI information provided by different source.
OR210-3	The eCo-FEV system shall update the PoI content database periodically.

Table 6.20: Requirements: PoI monitoring and notification

6.11. Trip adjustment

This use case helps the eCo-FEV driver to adjust the trip according to environment events, to the FEV autonomy issues or to his plan evolution.

The environment events can be related to the traffic or weather condition alteration, to the pre-booked facility (i.e. parking, charging station) availability issues or to the notifications of non-respect of the already started FEV charging program.

This use case gives the possibility to perform any adjustment of trip plan and booking. The trip adjustment may be triggered by eCo-FEV traveler or may be triggered by eCo-FEV system in case it observes that original trip planning may not be satisfied due to e.g. traffic condition change, facility availability change, etc.

The use case is defined in Table 6.21.

Use case element	Description
Use case number	211
Use case name	Trip adjustment
Short description	This use case helps the eCo-FEV traveler to adjust the trip according to environmental events, FEV autonomy issues or to plan changes. Environment events can be related to the traffic or weather condition alterations, to pre-booked facility (i.e. parking, charging station) availability issues or to difference between planned and actual FEV charging program.
Primary actor	eCo-FEV travelers, FEV
Pre-conditions	• FEV and travelers are subscribed to eCo-FEV system. • Trip running

Table 6.21: Use case description: Trip adjustment

The use case diagram is as illustrated in Figure 6.11.

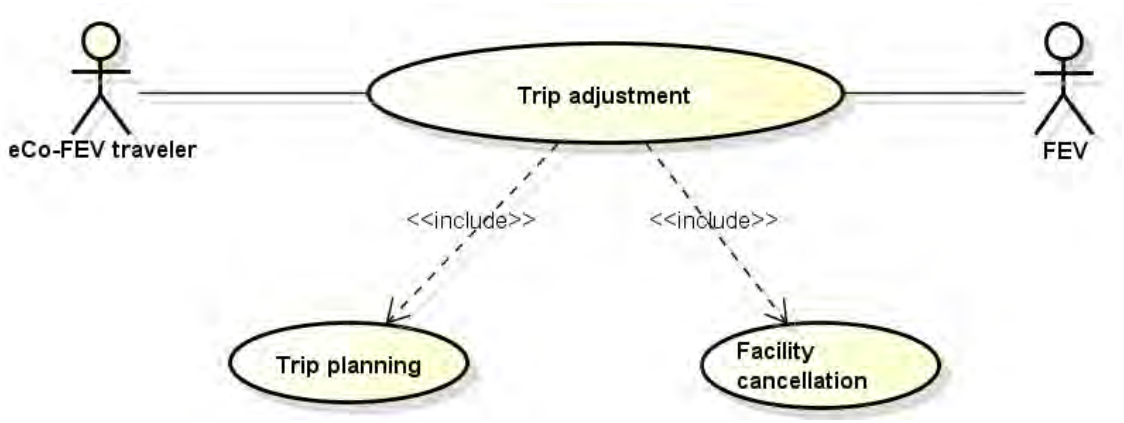

Figure 6.11: Use case diagram: Trip adjustment

The functional and operational requirements of the use case are listed in Table 6.22.

Requirements	Description
	Functional requirements
FR211-1	If trip adjustment is triggered by the eCo-FEV system, FEV and traveler shall confirm the adjustment to the eCo-FEV system.
FR211-2	The eCo-FEV system shall update relevant data base information according to the trip adjustment.
FR211-3	The eCo-FEV system shall be able adjust the trip in case requested by user or the impact on the original plan is judged too high.
FR211-4	The eCo-FEV system shall include functionalities to estimate the potential impact of a detected event to the trip, according to the user requirements on trip plan e.g. arrival time.
FR211-5	The eCo-FEV system shall interact with user to confirm the adjusted trip plan.
FR211-6	The eCo-FEV system shall interact with relevant facilities to change the booking plan or to cancel the original booking plan, based on the new trip plan.
	Operational requirements
OR211-1	The trip adjustment performance has to be fast enough to match the trip environment modification
OR211-2	The number of “adjustment” during the trip has to be limited
OR210-3	The traveler has to be proposed an adequate HMI (FEV or personal device) to adjust the trip

Table 6.22: Requirements: Trip adjustment

6.12. Trip, facility choice and booking

The use case proposes to the eCo-FEV traveler the set of previously elaborated trip proposal and asks him to choose one from that set.

Once trip chosen the necessary facilities (e.g. parking, charging stations, and public transport tickets) are booked and prepaid if required by concerned operators.

For all itineraries, the eCo-FEV system selects and proposes the accessible facilities along the planned itinerary, e.g. parking facility, public transport facility, charging facility etc. If required, the facilities are booked and paid according to traveler's selection.

The use case is defined in Table 6.23.

Use case element	Description
Use case number	212
Use case name	Trip, facility choice and booking
Short description	Based on FEV planned itinerary, a set of accessible facilities along the trip is proposed by the eCo-FEV system to the eCo-FEV traveler. The necessary facilities (e.g. parking, charging stations, and public transport tickets) are booked and prepaid if required by concerned operators.
Primary actor	FEV, eCo-FEV traveler, charging facilities operators, parking facility operators, public transport operator, Passenger FEV Fleet operator
Pre-conditions	• FEV and travelers are subscribed to eCo-FEV platform.

Table 6.23: Use case description: Trip, facility choice and booking

The use case diagram is as illustrated in Figure 6.12.

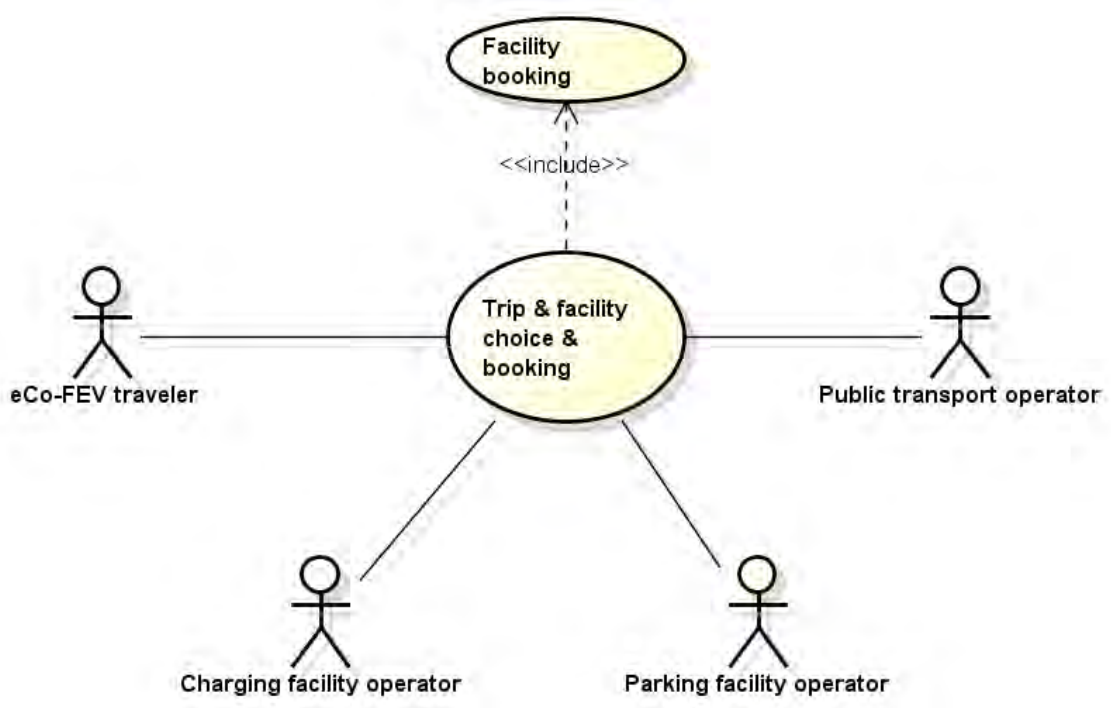

Figure 6.12: Use case diagram: Trip, facility choice and booking

The functional and operational requirements of the use case are listed in Table 6.24.

Requirements	Description
	Functional requirements
FR212-1	The eCo-FEV system shall trigger facility booking use case, if required.
FR212-2	The eCo-FEV system shall provide available facilities information to FEV travelers in order for him/her to confirm the choice.
FR212-3	The eCo-FEV system shall provide functionalities to assess the accessibility for user along the trip.
	Operational requirements
OR212-1	In case of no charging facility is available, the eCo-FEV system shall transmit the information to FEV and travelers.
OR212-2	In case of booking failure, the eCo-FEV system shall transmit the information to FEV and traveler.
OR212-3	The traveler has to be proposed an adequate HMI (FEV or personal device) to choose and confirm the facilities and trips.

Table 6.24: Requirements: Trip, facility choice and booking

6.13. Trip monitoring

This use case is applied during trip runs.

It encompasses all necessary specific monitoring processes.

This use case consists of the eCo-FEV system to monitor the FEV's trip from the beginning to the end, including travelling phase, charging phase and parking phase. For this purpose, the FEV transmits periodically, or upon triggering from eCo-FEV traveler, the activities report to the eCo-FEV system, as well as its position.

The use case is defined in Table 6.25.

Use case element	Description
Use case number	213
Use case name	Trip monitoring
Short description	The eCo-FEV system monitors the FEV activities during the trip.
Primary actor	FEV, eCo-FEV traveler
Pre-conditions	• FEV is subscribed to eCo-FEV platform. • Trip running

Table 6.25: Use case description: Trip monitoring

The use case diagram is as illustrated in the figure below.

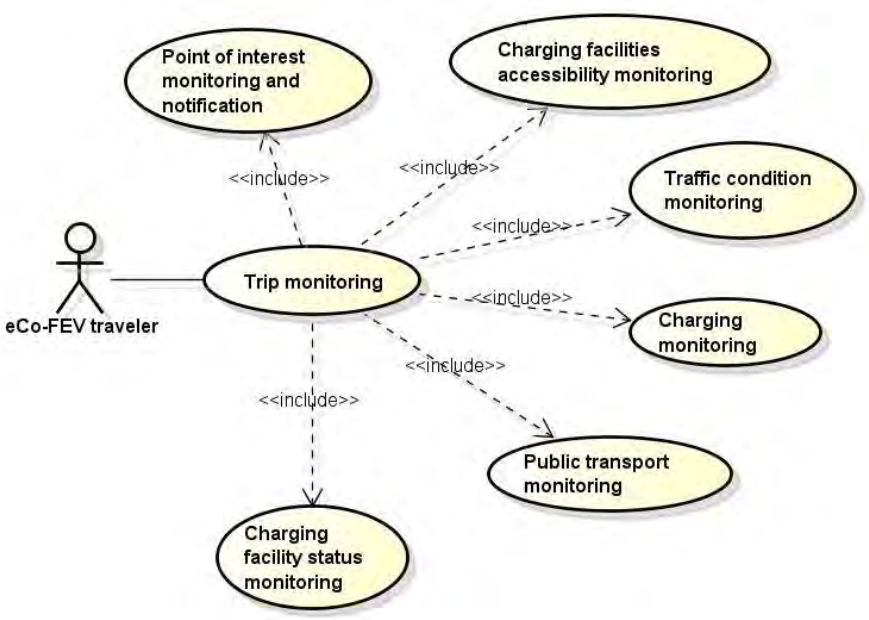

Figure 6.13: Use case diagram: Trip monitoring

The functional and operational requirements of the use case are listed in Table 6.26.

Requirements	Description
	Functional requirements
FR213-1	FEVs shall transmit periodically activity reports and position to the eCo-FEV system.
FR213-2	The eCo-FEV system should provide functionalities to authenticate FEV and/or eCo-FEV traveler.
FR213-3	FEV shall collect real time SoC, position and other required data from in vehicle system.
	Operational requirements
OR213-1	The performance of the "trip monitoring" has to be compatible with the running trip environment evolution.

Table 6.26: Requirements: Trip monitoring

6.14. Vehicle relationship management

This use case is a part of back office services without a direct link with the end user functionality. It collects information from all trips and thanks to the data mining operations elaborates statistical models necessary for use cases requiring estimation/prediction of FEV

autonomy, trip duration or the energy quantity required by the charging processes. The collected information includes SOCs, driving speeds, traffic and weather conditions and also the energy consumption during the charging processes.

The goal of this use case is the extraction of added values information regarding FEVs operations and needs, that will be exploited by the eCo-FEV system or charging facility operators. It is based on the near real time aggregation of FEVs data and is aimed at providing eCo-FEV traveler with relevant services supporting the seamless operation of their FEVs.

The use case will produce high level FEV's information upon request of the eCo-FEV system. Possible information includes:

- FEV range estimation in order to assess the reachability of specific PoI (final destination, parking or charging facilities…)
- Estimation of the current and forecasted SoC, energy consumption, or energy needs along the route
- Battery monitoring and diagnosis
- Defining guidelines to optimize the charging procedure according to battery characteristics and user preferences

Apart from FEV's specific features (battery's capacity, FEV's weight), these estimations will be extracted from historical datasets, reflecting the past states of the FEVs (SoC, energy consumption…), each measurement is geo-localized to exploit information related to route topology. The driving pattern of a particular eCo-FEV traveler might be estimated.
In addition, in order to leverage FEVs and eCo-FEV traveler's data with contextual information, VRM may also make use of traffic and weather information.

Finally, VRM services may also be used to extract primary pieces of information that will be used to compute the high level information required by the eCo-FEV system. Such primary information are the user's driving patterns or the battery's SoH (State of Health) that may be estimated from FEVs and users historical data and used to improve energy consumption & range estimation.

Additional functionalities, focusing not on the eCo-FEV traveler but on charging facilities operators may also be considered. For instance, VRM services may provide charging facilities with information regarding the evolution of the energy demand along the route, in areas

where charging infrastructure are located. Such information would help charging facility operators to assess the expected demand.

The use case is defined in the Table 6.27.

Use case element	Description
Use case number	214
Use case name	Vehicle Relationship Management (VRM)
Short description	This use case provides smart services for the extraction of added values information from aggregated FEVs data and complementary contextual information (traffic, weather…), to support a large panel of secondary UCs requiring elaborated estimation/prediction regarding the FEV status (range & energy needs estimation, guidelines charge planning, battery monitoring, …).
Primary actor	FEV, Charging Facility Operator, Weather Info provider
Pre-conditions	• The eCo-FEV traveler and FEV are subscribed to eCo-FEV system. • The eCo-FEV traveler shall be logged to eCo-FEV system.

Table 6.27 : Use case description: Vehicle relationship management

The use case diagram is as illustrated in the Figure 6.14

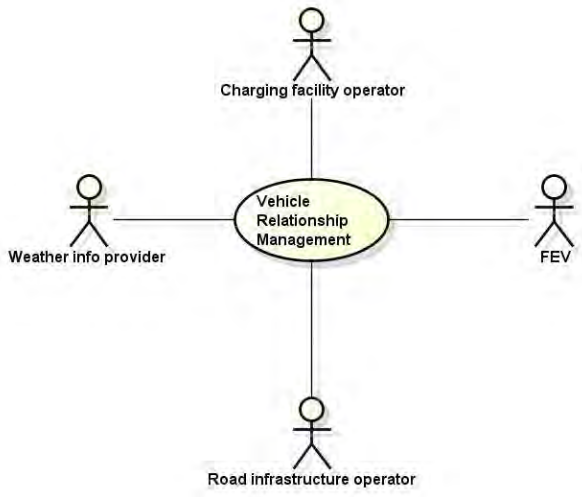

Figure 6.14: use case diagram: Vehicle relationship management

The functional and operational requirements of the use case are listed in the Table 6.28.

Requirements	Description
	Functional requirements
FR214-1	The eCo-FEV system shall be able to receive and shall store periodical FEV data and eCo-FEV traveler data.
FR214-2	The eCo-FEV system shall be able to receive and shall store traffic and weather information.
	Operational requirements
OR214-1	The accuracy and performance of the "trip monitoring" has to be compatible with the running trip environment evolution.

Table 6.28: Requirements: Vehicle relationship management

6.15. Delivery planning adjustment

This use case is the extension of trip adjustment; it provides adjustments of delivery planning of the urban delivery in case of any unexpected situations. The final adjustment shall be confirmed by fleet operator.

The use case is defined in Table 6.29.

Use case element	Description
Use case number	215
Use case name	Delivery planning adjustment
Short description	This use case adjusts the planning in case of unexpected situations encountered during the delivery. If necessary or useful, the planning of the entire fleet can be adjusted.
Primary actor	Fleet operator driver, FEV, FEV delivery fleet operator
Pre-conditions	• The fleet operator driver and FEV are subscribed to eCo-FEV system. • The fleet operator driver shall be logged in to the eCo-FEV system.

Table 6.29: Use case description: Delivery planning adjustment

The use case diagram is as illustrated in Figure 6.15.

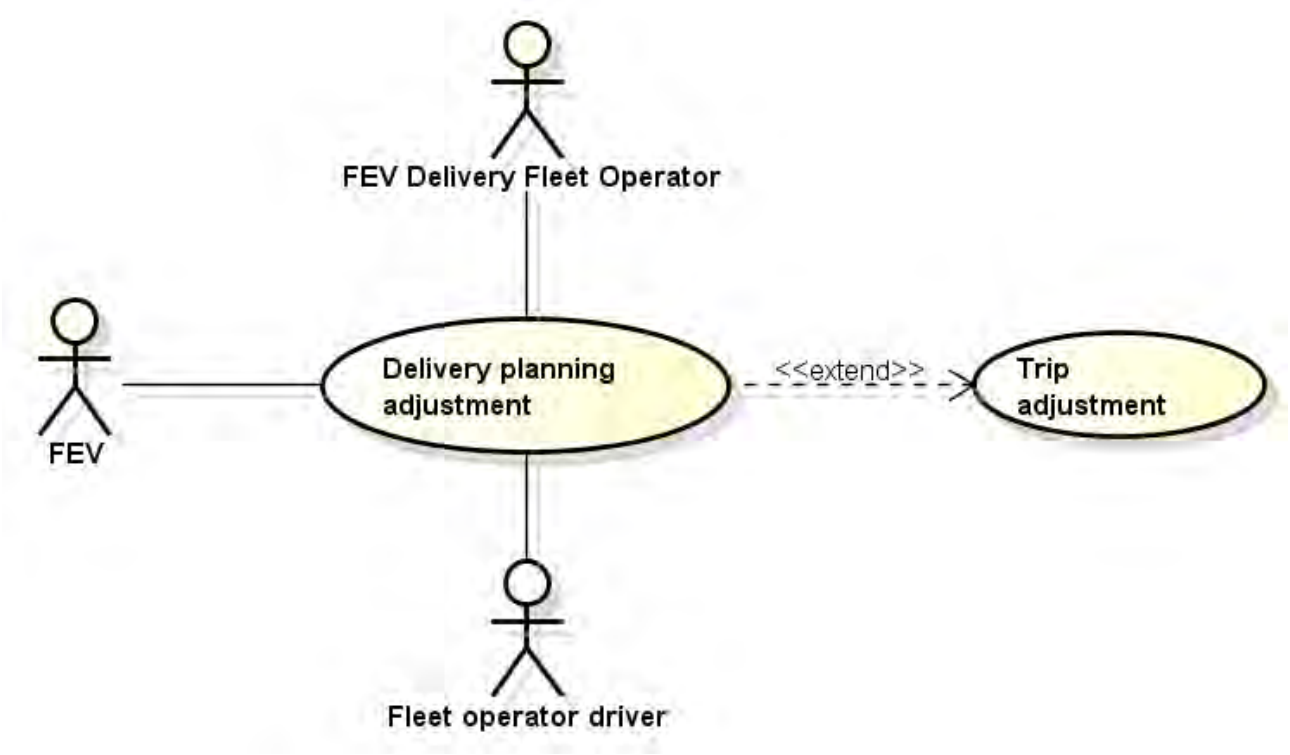

Figure 6.15: Use case diagram: Delivery planning adjustment

The functional and operational requirements of the use case are listed in Table 6.30.

Requirements	Description
	Functional requirements
FR215-1	Any trip adjustment shall be informed and confirmed by the fleet operator.
FR215-2	Any trip adjustment shall be informed and may be confirmed by fleet operator driver.

Table 6.30: Requirements: Delivery planning adjustment

7. Primary use case and requirements definitions

7.1. eCo-FEV subscription

The eCo-FEV travelers have to complete a registration process in order to use the eCo-FEV system. During this process, eCo-FEV travelers may express its preferences (e.g. choice of payment means and prepaid subscriptions) and may declare the FEVs. The eCo-FEV system creates and provides the credentials necessary to access the eCo-FEV system. In addition, the use case allows FEV Delivery Fleet Operator to subscribe its FEVs and fleet operator drivers.

The use case is defined in the table which follows.

Use case element	Description
Use case number	101
Use case name	eCo-FEV subscription
Short description	This use case manages the registration processes of an eCo-FEV traveler to the eCo-FEV system. In particular, this use case verifies the identity of the eCo-FEV traveler, creates a list of its FEVs, and sets its preferences and subscription options. This use case also creates the necessary credentials to allow the eCo-FEV traveler to connect the eCo-FEV system.
Primary actor	FEV, eCo-FEV travelers, FEV Delivery Fleet Operator
Pre-conditions	None

Table 7.1: Use case description: eCo-FEV subscription

The use case diagram is as illustrated in the figure which follows.

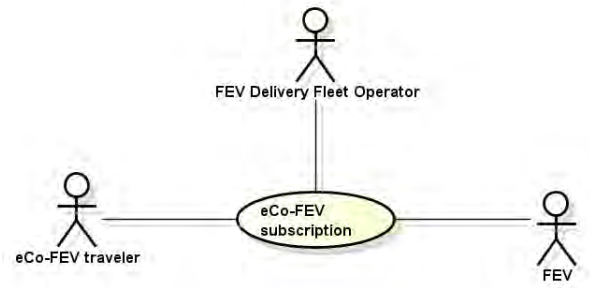

Figure 7.1: Use case diagram: eCo-FEV subscription

The functional and operational requirements of the use case are listed in the table which follows.

Requirements	Description
	Functional Requirements:
FR101-1	eCo-FEV travelers shall be able to provide their identity information to the eCo-FEV system
FR101-2	eCo-FEV travelers shall be able to provide information concerning its FEVs.
FR101-3	The eCo-FEV system shall manage the credentials (passwords or certificates) necessary to authenticate the eCo-FEV traveler.
FR101-4	The eCo-FEV system shall manage the processes of credential renewal and identity information update
FR101-5	The eCo-FEV system shall protect sensitive privacy data.
FR101-6	The eCo-FEV system shall update user subscription information regularly and delete outdated information.
FR101-7	The eCo-FEV system shall manage the validity, the updates of all issued credentials.

Table 7.2: Requirements: eCo-FEV subscription

7.2. Free driving assistance

In this use case, FEVs are driving without defined travel plan and destination. The eCo-FEV system will monitor the trip and provide real time information to the eCo-FEV traveler about its vicinity. In parallel to the autonomy monitoring and charging facility accessibility the eCo-FEV traveler is informed about the "Points of Interest" (POIs) present in his vicinity and according to his preferences.

If requested by eCo-FEV traveler, the "ad-hoc trip assistance" or "ad-hoc drive to charging facility assistance" use cases may be triggered.

The use case is defined in the table which follows.

Use case element	Description
Use case number	103
Use case name	Free driving assistance
Short description	This use case delivers the FEV Driver assistance when the trip target is not known by the eCo-FEV system. The main objective of the assistance is to help the driver to avoid or to manage the autonomy issues. In addition, the eCo-FEV system informs him about

	the points of interest in his vicinity.
Primary actor	eCo-FEV traveler, FEV
Pre-conditions	• The eCo-FEV traveler and FEV are subscribed to eCo-FEV system. • The eCo-FEV traveler doing the trip using the FEV without a set destination. • The eCo-FEV traveler shall be logged in to the eCo-FEV system.

Table 7.3: Use case description: Free driving assistance

The use case diagram is as illustrated in the figure which follows.

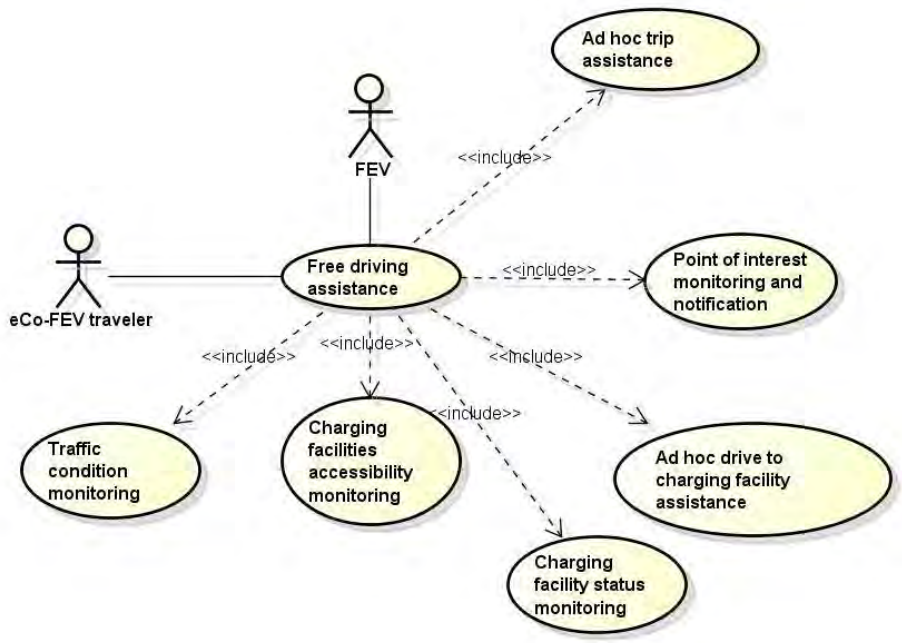

Figure 7.2: Use case diagram: Free driving assistance

The functional and operational requirements of the use case are listed in the table which follows.

Requirements	Description
	Functional requirements
FR103-1	The eCo-FEV system shall provide the PoI information relevant to an eCo-FEV traveler.
FR103-2	The eCo-FEV monitors the charging facility accessibility to secure the FEV autonomy.

FR103-3	The eCo-FEV system should provide functionalities to authenticate FEV and/or eCo-FEV traveler.
FR103-4	When requested by user, the eCo-FEV system shall be able to plan a trip for user to reach the accessible charging facilities.
FR103-5	The eCo-FEV system shall include functionalities to check the relevance of traffic and weather condition with regards to FEV position and driving direction.
FR103-6	If judged relevant, the eCo-FEV system shall provide functionalities to inform user of traffic and weather condition in its vicinity.
	Operational requirement
OR103-1	The event notification to eCo-FEV user should be with short delay.
OR103-2	The charging facility accessibility and traffic and weather condition should be update and refreshed periodically.
OR103-3	The accuracy and performance of the “trip monitoring” has to be compatible with the running trip environment evolution.

Table 7.4: Requirements: Free driving assistance

7.3. Trip planning

The trip planning corresponds to the pre-starting phase of travelling. In some situation (e.g. using the FEV for a touristic visit without precise target, driving on the well-known route) the planning can be omitted.

When planned, the trip can be characterized by many features like:

- multiple or simple destinations
- one way or round trip qualifier
- trip timing, schedule and duration constraints
- multimodality acceptance qualifier
- transportation type (passenger or goods)
- parking and charging preferences

In this use case, the eCo-FEV traveler issues a navigation request to the eCo-FEV system. The eCo-FEV system calculates the route according to the request. If requested by eCo-FEV traveler, the eCo-FEV system may select and book the required facilities along the calculated route. As already mentioned routes are calculated taking into consideration the historical data collected by the eCo-FEV backend trough so called Vehicle Relationship Management all other data-mining functionalities.

The use case is defined in the table which follows.

Use case element	Description
Use case number	104
Use case name	Trip planning
Short description	The eCo-FEV system provides the estimated route for the FEV traveler based on the transmitted request e.g. destination, expected arrival time/departure time, current battery level, etc. The proposed itinerary may provide a potential list of C/Ss for the eCo-FEV traveler. If the eCo-FEV system knows the FEV characteristics and estimated state of charge at the trip start, a potential charging plan may be proposed. A multimodal itinerary may be offered during the trip planning if public transport is available to reach the destination and according to the eCo-FEV traveler's preference.
Primary actor	eCo-FEV traveler, FEV, public transport operator
Pre-conditions	• The eCo-FEV traveler and FEV are subscribed to eCo-FEV system. • The eCo-FEV traveler shall be logged in to the eCo-FEV system.

Table 7.5: Use case description: Trip planning

The use case diagram is as illustrated in the figure which follows.

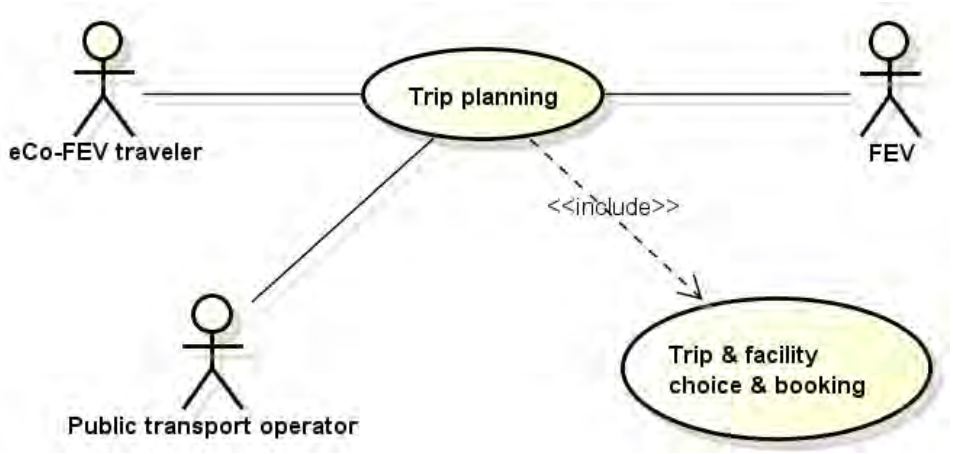

Figure 7.3: Use case diagram: Trip planning

The functional and operational requirements of the use case are listed in following table.

Requirements	Description
	Functional requirements
FR104-1	The eCo-FEV system shall provide means to eCo-FEV travelers to set the requirements of trip planning including start/destination position, expected departure/arrival time.

FR104-2	The eCo-FEV system shall be able to calculate the itinerary based on eCo-FEV traveler's request.
FR104-3	If multimode trip planning is preferred by eCo-FEV traveler, the eCo-FEV system shall be able to provide a multimode trip plan based on public transport information provided by public transport operator.
FR104-4	In case of trip planned before the trip, the eCo-FEV system may take into account weather and traffic forecast information for trip planning. Otherwise (real time trip planning request), the eCo-FEV system may take into account current weather and traffic information for trip planning
FR104-5	The eCo-FEV system should take into account charging facility availability information for trip planning compliant to the user request (departure time, expected arrival time etc.)
FR104-6	The eCo-FEV system should provide functionalities to authenticate FEV and/or eCo-FEV traveler.
FR104-7	For the route calculation and charging plan calculation, the eCo-FEV system shall consider FEV remaining autonomy range.
FR104-8	The eCo-FEV system shall provide means for user to enter the trip planning request.
FR104-9	The eCo-FEV system shall interact with user to confirm the trip plan.
FR104-10	In case booking is requested by user, the eCo-FEV system shall interact with facility operator to realize the booking.
	Operational requirements
OR104-1	For the trip planning, the traffic and weather condition should be updated.
OR104-2	In case of multimode trip planning, the public transport information should be updated.
OR104-3	For trip planning, the eCo-FEV system shall decode the user requirements information (e.g. start position, destination position) to a format compliant to the map database being used for route calculation.
OR104-4	User should be equipped with HMI to enter the trip plan request.

Table 7.6: Requirements: Trip planning

7.4. Trip assistance

The eCo-FEV system provides assistance for a planned trip in order to reach destination in an optimized way. When unexpected situations happen, e.g. traffic jam, charging availability changes, etc., the eCo-FEV system may trigger the trip adjustment use case and modify the trip itinerary and charging plan accordingly.

The use case is defined in Table 7.7.

Use case element	Description
Use case number	105

Use case name	Trip assistance
Short description	Dynamically guide the eCo-FEV traveler during the trip until the destination taking into account traffic and weather conditions, preferences and battery status. The eCo-FEV system monitors the trip progress with regards to a travel plan. If unexpected situations are detected, the itinerary and/or charging plan may be adjusted.
Primary actor	eCo-FEV traveler, FEV
Pre-conditions	• The eCo-FEV traveler and FEV are subscribed to eCo-FEV system. • The eCo-FEV traveler shall be logged in to the eCo-FEV system. • The trip is planned.

Table 7.7: Use case description: Trip assistance

The use case diagram is as illustrated in the figure which follows.

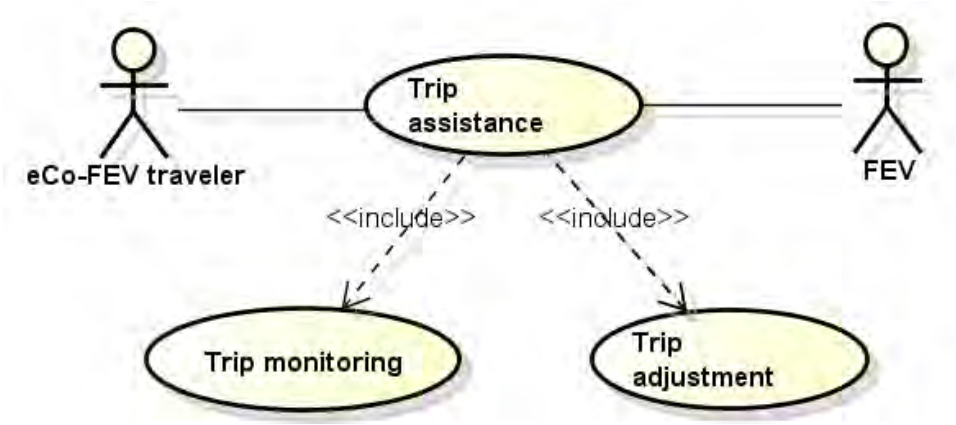

Figure 7.4: Use case diagram: Trip assistance

The functional and operational requirements of the use case are listed in the table which follows.

Requirements	Description
	Functional requirements
FR105-1	The eCo-FEV system shall be able to estimate the impact of an event on the FEV's trip, e.g. impact on travel time, impact on charging plan, or the modified user travel plan.
FR105-2	The eCo-FEV system should provide functionalities to authenticate FEV and/or eCo-FEV traveler.
FR105-3	When requested by user, the eCo-FEV system shall be able to readjust the trip plan.
FR105-4	The eCo-FEV system shall include functionalities to check the relevance of traffic and weather condition with regards to FEV position and driving direction.
FR105-5	If judged relevant, the eCo-FEV system shall provide functionalities to inform user of

	traffic and weather condition in its vicinity.
FR105-6	In case original trip plan cannot be respected, the eCo-FEV system should trigger the recalculation of route calculation and charging plan.
FR105-7	The eCo-FEV system shall interact with charging infrastructure system to confirm the modification of charging plan.
FR105-8	The eCo-FEV system shall interact with user to confirm the modification of trip plan and/or charging plan.
FR105-9	For trip readjustment, the eCo-FEV system should update the route calculation, taking into account the traffic and weather confirmation, charging facility availability condition and FEV autonomy range condition.
	Operational requirement
OR105-1	The event notification to eCo-FEV user should be with short delay.
OR105-2	The charging facility accessibility and traffic and weather condition should be update and refreshed periodically.
OR105-3	The accuracy and performance of the “trip monitoring” has to be compatible with the running trip environment evolution.
OR105-4	User should be equipped with an HMI to request and confirm the trip assistance request the trip plan adjustment.
OR105-6	When user reaches the destination, the eCo-FEV system should terminate the use case.

Table 7.8: Requirements: Trip assistance

7.5. Ad hoc drive to charging facility assistance

This use case consists of providing guiding assistance for eCo-FEV travelers to drive to a charging facility.

The use case is defined in Table 7.9.

Use case element	Description
Use case number	106
Use case name	Ad hoc drive to charging facility assistance
Short description	This use case consists of providing guiding assistance for FEVs to drive to a charging facility.
Primary actor	eCo-FEV traveler, FEV
Pre-conditions	• The eCo-FEV traveler and FEV are subscribed to eCo-FEV system. • The eCo-FEV traveler shall be logged in to the eCo-FEV system.

Table 7.9: Use case description: Ad hoc drive to charging facility assistance

The use case diagram is as illustrated in Figure 7.5.

Figure 7.5: Use case diagram: Ad hoc drive to charging facility assistance

The functional and operational requirements of the use case are listed in Table 7.10.

Requirements	Description
	Functional requirements
FR106-1	The eCo-FEV system shall be able to plan the trip itinerary to a selected charging facility.
FR106-2	The eCo-FEV system shall estimate the arrival time to a charging facility in order to plan the charging booking.
FR106-3	In case of availability change of a charging facility, the eCo-FEV system shall try to adjust the planned trip.
FR106-4	The eCo-FEV system should provide functionalities to authenticate FEV and/or eCo-FEV traveler.
FR106-5	The eCo-FEV system shall interact with user to confirm the trip plan to the selected charging facility.
FR106-6	The eCo-FEV system shall consider the traffic and weather condition while planning the trip to the charging facility.
FR106-7	The eCo-FEV system shall estimate the accessibility of charging facility with regards to FEV charging and remaining range.
FR106-8	The eCo-FEV system shall provide functionalities to inform users the calculated route to the selected charging facility.
	Operational requirement
OR 106-1	User should be equipped with a HMI to select the charging facility and set it as trip destination.
OR106-2	In case the selected charging facility is not reachable by FEV, the eCo-FEV system should inform user. In addition, the eCo-FEV system may propose alternative charging possibilities to user.

OR106-3	The accuracy and performance of the "trip monitoring" has to be compatible with the running trip environment evolution.

Table 7.10: Requirements: Ad hoc drive to charging facility assistance

7.6. Ad hoc trip assistance

This use case provides the assistance to the eCo-FEV traveler to drive to a fixed destination (different from charging station). It is composed by two phases:

1. Planning
2. Driving

The use case is defined in Table 7.11.

Use case element	Description
Use case number	107
Use case name	Ad hoc trip assistance
Short description	This use case provides assistance for any ad hoc trip.
Primary actor	eCo-FEV traveler, FEV
Pre-conditions	• The eCo-FEV traveler and FEV are subscribed to eCo-FEV system. • The eCo-FEV traveler shall be logged in to the eCo-FEV system.

Table 7.11: Use case description: Ad hoc trip assistance

The use case diagram is as illustrated in Figure 7.6.

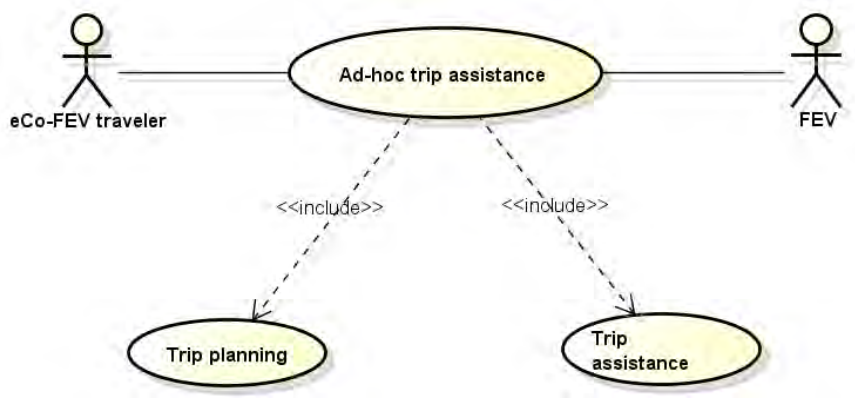

Figure 7.6: Use case diagram: Ad hoc trip assistance

The functional and operational requirements of the use case are listed in Table 7.10.

Requirements	Description
	Functional requirements
FR107-1	The eCo-FEV system shall be able to plan the trip itinerary to a fixed destination.
FR107-2	The eCo-FEV system shall provide the means to input the fixed destination.
FR107-3	The eCo-FEV system should provide functionalities to authenticate FEV and/or eCo-FEV traveler.
FR107-4	For route calculation, the eCo-FEV system shall take into account the traffic and weather condition.
FR107-5	For route calculation, the eCo-FEV system shall take into account the charging facility availability condition.
FR107-6	For route calculation, the eCo-FEV system shall take into account the FEV autonomy condition.
FR107-7	The eCo-FEV system shall include functionalities to check the relevance of traffic and weather condition with regards to FEV position and driving direction.
FR107-8	The eCo-FEV system shall be able to estimate the impact of an event on the FEV‘s trip, e.g. impact on travel time, impact on charging plan.
FR107-9	If judged relevant, the eCo-FEV system shall provide functionalities to inform user of traffic and weather condition in its vicinity.
FR107-10	In case original trip plan cannot be respected, the eCo-FEV system should trigger the recalculation of route calculation and charging plan.
FR107-11	The eCo-FEV system shall interact with charging infrastructure system to confirm the modification of charging plan.
FR107-12	The eCo-FEV system shall interact with user to confirm the modification of route and/or charging plan.
	Operational requirement

OR107-1	The event notification to eCo-FEV user should be with short delay.
OR107-2	The charging facility accessibility and traffic and weather condition should be update and refreshed periodically.
OR107-3	The accuracy and performance of the "trip monitoring" has to be compatible with the running trip environment evolution.
OR107-4	User should be equipped with an HMI to request and confirm the trip assistance request the trip plan adjustment.
OR107-5	When user reaches the destination, the eCo-FEV system should terminate the trip assistance.

Table 7.12: Requirements: Ad hoc trip assistance

7.7. Delivery planning

This use case provides assistance to define the schedule of a daily delivery for goods delivery operators. This assistance takes into account the traffic and weather conditions and provides charging plan for the entire fleet. The delivery plan is dependent on the delivery requirements (i.e. delivery addresses and timing) and defines the optimal solution for the set of routes for the entire FEV fleet. As for "trip planning" (i.e. the use case dedicated to individual drivers) routes are calculated taking into consideration the historical data collected by the eCo-FEV backend trough so called Vehicle Relationship Management all other data-mining capacities.

The use case is defined in Table 7.13.

Use case element	Description
Use case number	108
Use case name	Delivery planning
Short description	Based on the daily delivery requirements, this use case provides assistance to define the daily delivery plan for goods delivery operators.
Primary actor	FEV delivery fleet operator, FEV, all infrastructure operators
Pre-conditions	• The fleet operator and FEV are subscribed to eCo-FEV system. • The fleet operator system is connected to the eCo-FEV system

Table 7.13: Use case description: Delivery planning

The use case diagram is as illustrated in Figure 7.7.

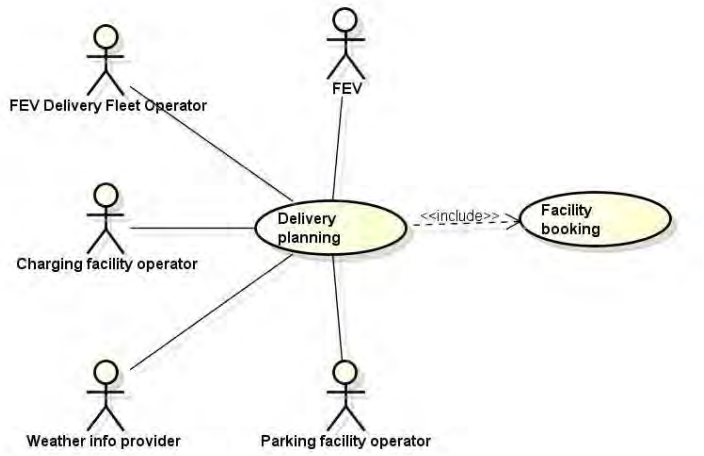

Figure 7.7: Use case diagram: Delivery planning

The functional and operational requirements of the use case are listed in Table 7.14.

Requirements	Description
	Functional requirements
FR108-1	The eCo-FEV system shall be able to receive a delivery plan from the fleet operator.
FR108-2	The eCo-FEV system shall be able to estimate the impact of traffic conditions and weather conditions on the delivery plan and informs this estimation to the fleet operator.
FR108-3	The charging plans and routes are elaborated for all participating FEVs.
FR108-4	The requirements for the initials SOCs for all participating FEVs have to be elaborated.
FR108-5	All final delivery plans shall be stored by the eCo-FEV system.
FR108-6	The eCo-FEV system should provide functionalities to authenticate FEV and/or eCo-FEV delivery driver.
FR108-7	Functional requirements of use case 104 (trip planning) should apply also to this use case.
	Operational requirements
FR108-1	Operational requirements of use case 104 (trip planning) should apply also to this use case.

Table 7.14: Requirements: Delivery planning

7.8. Delivery assistance

The fleet operator driver retrieves the delivery plan for his FEV and starts his round from the depot. The main objective of the assistance is to help the driver to follow the route and to return to the depot after delivering goods to all customers. During the entire trip the eCo-FEV system monitors the environment and the FEV to avoid or to manage autonomy issues traffic and weather perturbation or technical problems. Some preferences assure the assistance conformity with the specific context of the urban delivery fleet.

The use case is defined in Table 7.15.

Use case element	Description
Use case number	109
Use case name	Delivery assistance
Short description	This use case addresses the driver assistance during a planned route and schedule.
Primary actor	FEV, Fleet operator driver.
Pre-conditions	• The FEV is charged accordingly to the SOC elaborated by the global daily delivery planning. • The route and schedule has been planned. • The fleet operator driver shall be logged in to the eCo-FEV system.

Table 7.15: Use case description: Delivery assistance

The use case diagram is as illustrated in Figure 7.8

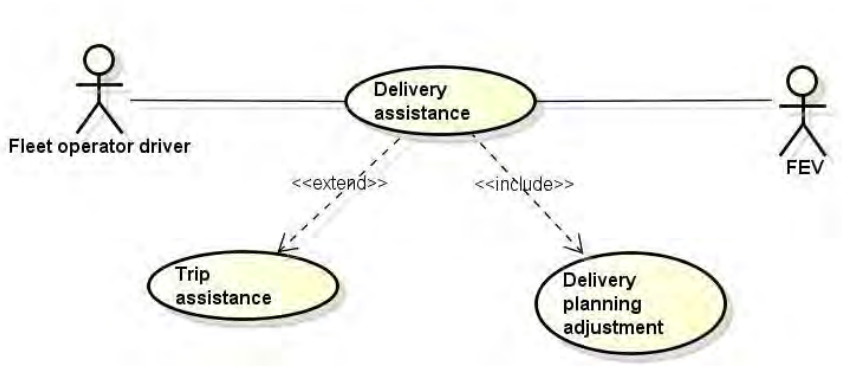

Figure 7.8: Use case diagram: Delivery assistance

The functional and operational requirements of the use case are listed in Table 7.16.

Requirements	Description
	Functional requirements
FR109-1	The eCo-FEV system shall be able to monitor the FEV autonomy and to estimate if the FEV is able to follow the planned delivery schedule. This estimation has to consider traffic and weather conditions and the observed FEV energy consumption.
FR109-2	The eCo-FEV system shall be able to transmit alert messages to fleet operators and fleet operator driver in case the battery autonomy is not sufficient to reach the final destination.
FR109-3	The eCo-FEV system shall be able to estimate the charging needs and the required energy to reach the next charging facility and the final destination.
FR109-4	If the previously elaborated trip plan is not feasible the eCo-FEV system shall be able to adjust the delivery planning.
FR109-5	The eCo-FEV system shall be able to update periodically the FEV‘s charging status to fleet operator.
FR109-6	The eCo-FEV system shall be able to update the delivery plan to fleet operator when adjusted.
FR109-7	The eCo-FEV system shall be able to record and store the charging historical information along the delivery itinerary and provide the information to fleet operators.
FR109-8	The eCo-FEV system should provide functionalities to authenticate FEV and/or eCo-FEV delivery fleet driver.
FR109-9	Functional requirements of use case 105 (trip planning) should apply also to this use case.
	Operational requirements
FR109-1	Operational requirements of use case 105 (trip planning) should apply also to this use case.

Table 7.16: Requirements: Delivery assistance

8. Use case synthesis

The figure below gives the synthesis of all eCo-FEV use cases.

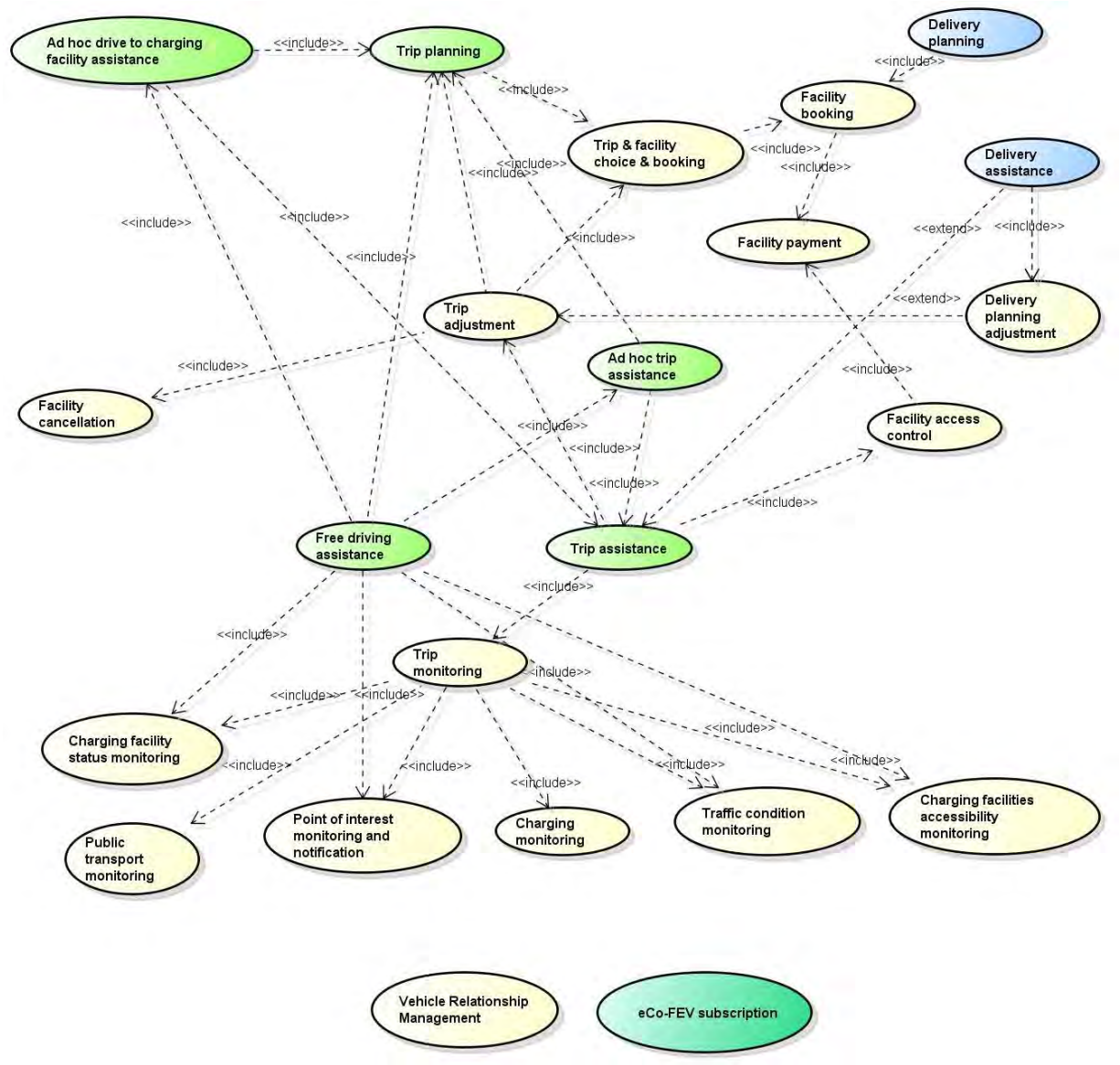

Figure 8.1: Use case synthesis

The items in green represent the primary individual traveler use cases, the items in blue the urban delivery primary use case, yellow all secondary use cases.

Two use cases are shown as isolated: “Vehicle Relationship Management” and “eCo-FEV subscription”. The second is in charge of the preliminary process necessary to join the eCo-FEV community and the first is in charge of the permanent data collect from all eCo-FEV vehicles and used by the data mining backend activities evaluating behavioral models of cars and drivers.

9. Conclusions

The objective of eCo-FEV project is to provide a set of user services (applications) to FEV users and to infrastructure operators, in order to improve the FEV mobility and the infrastructure management efficiency. These services are provided by a back end system that will be designed at the upcoming phases of system architecture and system specifications. Different actors have been identified and described in this document, including FEV users, FEVs and infrastructure operators.

Additional operators may be required to operate the eCo-FEV system in order to enable new business. Nevertheless, in the current document, these operators are not considered in the use case definition. Some of these potential new operators are:

- Back-end platform provider
- Telematics service provider
- Data integrators
- etc.

The current deliverable defines a set of potential use cases that may be provided by eCo-FEV system as well as high level requirements of the use cases. The proposed list of use cases is based on consensus reached among the eCo-FEV consortium partners. However, the use case is not only limited to the partners specific needs. Other potential business models need to be considered, in order to keep the flexibility of the eCo-FEV system for potential exploitation beyond the eCo-FEV project.

The foreseen eCo-FEV services have been described as set of use cases and linked with identified actors. Primary use case describes the services that may be provided by the eCo-FEV system to external actors, e.g. users and multiple infrastructure operators. Therefore, this work is essential to scope the perimeter of the eCo-FEV system to be designed and developed by the project. At this point in time, the eCo-FEV system is seen as a black box where the project does not make assumptions on any specific eCo-FEV system architecture.

Nevertheless, given the scope of the project, i.e. eCo-FEV system targets at providing user services from back end, a set of secondary use cases are further defined. These secondary use cases do not necessarily provide direct services to eCo-FEV system user, but provide essential

functions that would be needed, either for the realization of the user services' use case (e.g. monitoring user case), or for the business operation of the service (e.g. subscription use case).

Furthermore, for each described use case, functional and operational requirements have been listed in the current deliverable. The requirements define the functionalities and operating conditions of the eCo-FEV system and are useful, not only in the following phases to guide the architecture design of the eCo-FEV system and the system specifications, but also in the case evaluation phase to define the test scope and test purposes of the use cases. At this stage, no quantitative requirements are defined because the setting of quantitative testing requirements is normally limited by the test sites conditions. Therefore, these quantitative requirements may be defined later on during the test case definition phase.

References

[1]. ETSI EN 302 637 – 2: Intelligent Transport Systems (ITS); Vehicular Communications; Basic Set of Applications; Part 2: Specification of Cooperative Awareness Basic Service.

[2]. ETSI EN 302 637 – 3: Intelligent Transport Systems (ITS); Vehicular Communications; Basic Set of Applications; Part 3: Decentralized Environmental Notification Basic Service.

[3]. DATEX II V2.0 USER GUIDE, available at http://www.datex2.eu/sites/www.datex2.eu/files/DATEXIIv2.0-UserGuide.pdf

Acronyms

CAM	Cooperative Awareness Message
C2X	Car to Car and Car to Infrastructure
C/S	Charging Station
CWD	Charging While Driving
DENM	Decentralized Environmental Notification Message
EV	Electrical Vehicle
FEV	Full Electrical Vehicle
FOT	Field Operational Test
G5	Telecommunication technology of C2X
HMI	Human Machine Interface
ITS	Intelligent Transportation System
OBU	On Board Unit
PoI	Point of Interest
RSU	Road Side Unit
SAM	Service announcement message
SoC	State of Charge
SoH	State of Health
VRM	Vehicle Relationship Management