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Use cases for supporting evaluation of e-mobility services

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Abstract

The introduction of light electric vehicles forms one of the emerging solutions for tackling air pollution and congestion in cities. In the STEVE project under the H2020 framework, electric mobility services with electric quadricycles and electric bicycles are tested at four demonstration cities in Europe. To prepare a way for describing and evaluating the services from the end users' point of view, three user centric use cases were defined and are presented in this paper: eMaaS, eco-driving and delivery. The potential of the services and use cases in addressing travel behaviour and road transport emissions will be assessed with mesoscopic and microscopic simulations.

Keywords: electric mobility; use cases; MaaS; light electric vehicles

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1. Introduction

Electric mobility is one of the emerging solutions tackling the growing problems of air pollution and congestion in cities. The STEVE project (*Smart-Tailored L-category Electric Vehicle demonstration in hEterogeneous urban use cases*, 2017–2020) deploys light electric vehicles in four cities to help accelerate the uptake of sustainable mobility options. The aim of STEVE is to function as a stepping-stone towards a vision of future mobility that provides sustainable, seamless and personalised travel on demand. Services are being implemented in four demonstration cities: Villach in Austria, Calvià in Spain, and Torino and Venaria in Italy. The vehicles deployed are electric bicycles and electric quadricycles.

Although pursuing the same goal of enabling sustainable user-friendly services, the demo cities differ in their implementation approach, reflecting the local conditions and preferences. In addition to the difference between the demo cities, the diversity inside the project consortium demanded effective communication. The use case approach has been successfully utilised in prior electric mobility related EU-projects, such as ASSURED [1] and regarding ZeEUS in [2] and [3], to describe objectives and provide a common platform for the multi-national and multidisciplinary consortia to work on. The good experiences in these projects, which had similarities in scope and working group diversity, bolstered the adaptation of the use cases in STEVE.

The emergence of use case modelling in software design was already reported in the mid-1990s [4], [5], [6] and several applications are still around [7], [8], [9], also in mobility related studies, for example [10] and [11]. The use cases have provided a powerful tool for illustrating the needs and functions of the services and software from the end users' point of view. This way, possible gaps in the descriptions and processes are made visible and actions can be taken to come across the possible shortcomings. On a general level, the use cases simplify and summarise what the services are about in a form of tangible illustration or textual representation. No strict form exists for use cases and the layout varies between each modelled system. For example, [5] formalises use case modelling and specifies restrictions on what can be expressed with use cases and how the use cases should be constructed. Additionally, the FESTA handbook [12], a handbook for setting up, carrying out and analysing field operational tests, describes use cases: "*Use cases provide a tool for people with different backgrounds (e.g. software developers and non-technology oriented people) to communicate with each other. A use case is a textual presentation or a story about the usage of the system told from an end user's perspective. Use cases are technology-independent and the implementation of the system is not described*."

Therefore, in order to group the different services and highlight the users' point of view, common user centric use cases were defined for each demo city in STEVE. The STEVE use cases define each step the user is required to perform in order to complete one round of STEVE service usage.

2. Use cases for sustainable electric mobility

In accordance with different possible usage patterns, the STEVE services were divided into three categories of use cases: STEVE eMaaS, STEVE eco-driving and STEVE delivery (table 1). The use case descriptions provide a general overview of the steps taken by the users for each service.

Table 1. Use cases implemented at demo sites.

Use case	Villach	Torino & Venaria	Calvià
eMaaS	✓	✓	✓
Eco-driving	✓		
Delivery		✓	✓

2.1. STEVE eMaaS use case

eMaaS refers to "electric mobility as a service", describing an integrated offering of sustainable forms of transportation, easily available to the user. The STEVE project implements the concept of eMaaS through mobile booking platforms and two electric transportation modes: eBikes and eQuadricycles. Fig. 1. describes the main use case for STEVE eMaaS from the users' point of view. The use case diagram outlines all the necessary steps the user is required to perform in chronological order, while using the service.

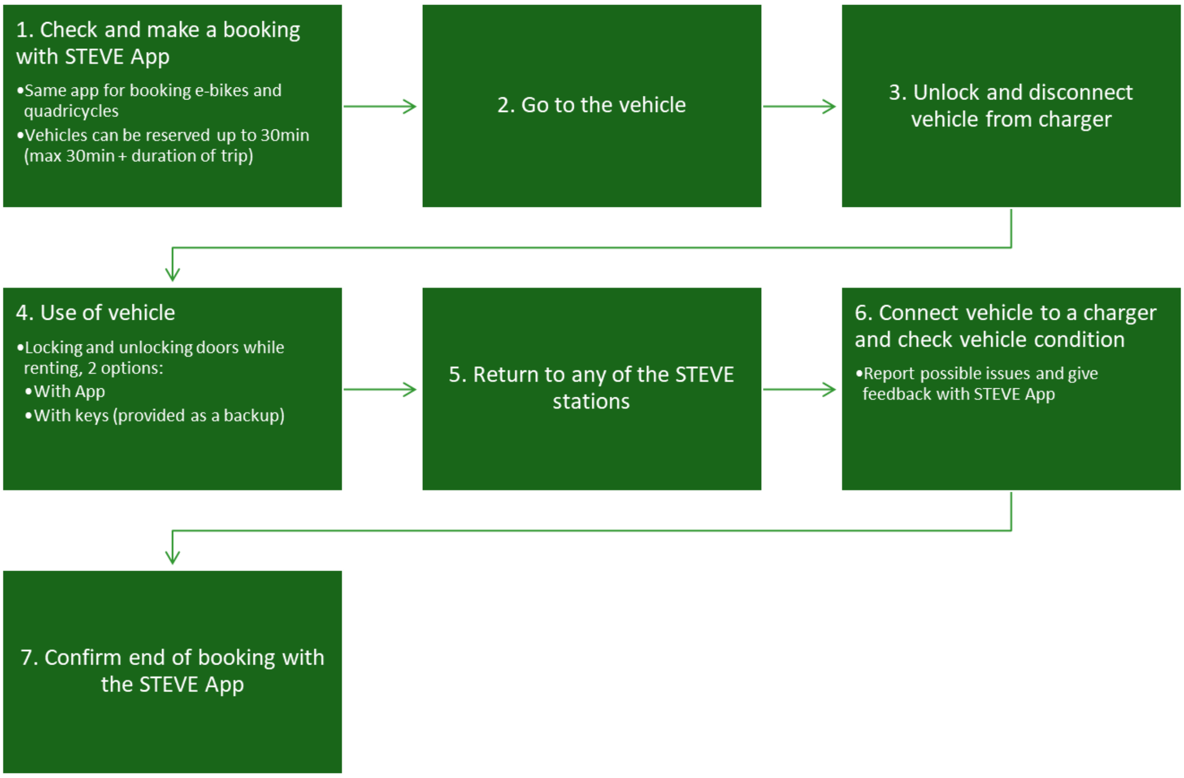

Fig 1. User-centric process diagram of STEVE eMaaS use cases.

Before the first usage, the user is asked to download an application and register. Once everything is set up, the user checks for available vehicles on the application, chooses a vehicle and reserves it through the same application. Locations of the vehicles are shown in the app, which helps the user to locate the vehicle. The user has access to the locks of the vehicle and is responsible for operating the charging cable.

After the vehicle is unlocked and disconnected, the user can drive the eQuadricycle or ride the eBike to desired destination(s). The usage ends by returning the vehicle to a STEVE charging station, where the user connects the vehicle back to a charger, locks the vehicle and confirms the end of the booking with the STEVE application.

The demonstration cities have distinct objectives and circumstances regarding the STEVE eMaaS. In Villach, a novel eMaaS mobile application is piloted, in which both eQuadricycles and eBikes are implemented in a common platform, whereas in Turin and Venaria (referred as the Italian cluster) only eQuadricycles are utilised and the demonstration focuses on gamification and EL-V operation. The use case description provides a generalised view on the STEVE eMaaS concept, which is common to the applicable partner cities. Further demo-specific details are elaborated by user-centric process diagrams.

The use case processes in Villach are concentrated on piloting the eMaaS concept with eBikes and eQuadricycles. In principle, one user-centric process diagram can be used to address the activities within the Villach demonstration. The process starts with the user making a reservation of a vehicle with the mobile STEVE application. If the user is eligible to drive an eQuadricycle, both available eBikes and eQuadricycles are visible in the application and the user can pick either one through the same interface. A driving licence is required to use the eQuadricycles, and it is checked during the registration procedure. The vehicle has to be booked up to 30 minutes beforehand. After successful booking, the user goes to the vehicle and checks its condition. In case of eQuadricycle, the operator may require photos to be taken of the vehicle and uploaded to the operator via the STEVE application. The locks of the doors and charger cable of the eQuadricycle as well as the lock of the STEVE bike stand are operated with the same application. A physical key is also provided in the eQuadricycles as a backup. At the end of the drive, the vehicle can be returned to any of the local STEVE stations. The user connects the vehicle to the charging station and locks it with the STEVE application. Possible issues regarding the vehicle, such as flat tires, can also be reported with the app.

2.2. STEVE Eco-driving use case

The second use case combines eco-routing and eco-driving in one service. Eco-routing means navigation with taking into account energy efficiency aspects of routing. In conventional routing, the application would usually show the fastest route to the destination, even if it means a higher energy consumption than other options. Contrary to that, eco-routing aims to balance the offered routes towards those with the lowest estimated energy consumption yet an acceptable duration. Eco-driving can thus help the driver reach the optimum speed profile leading to lowest energy consumption. In addition, gamification is implemented in the application by giving a score based on how well the route was followed and speed profiles with lowest energy consumption. In the STEVE project, Eco-Routing concept, depicted in Fig. 2, is piloted in the Calvià demonstration.

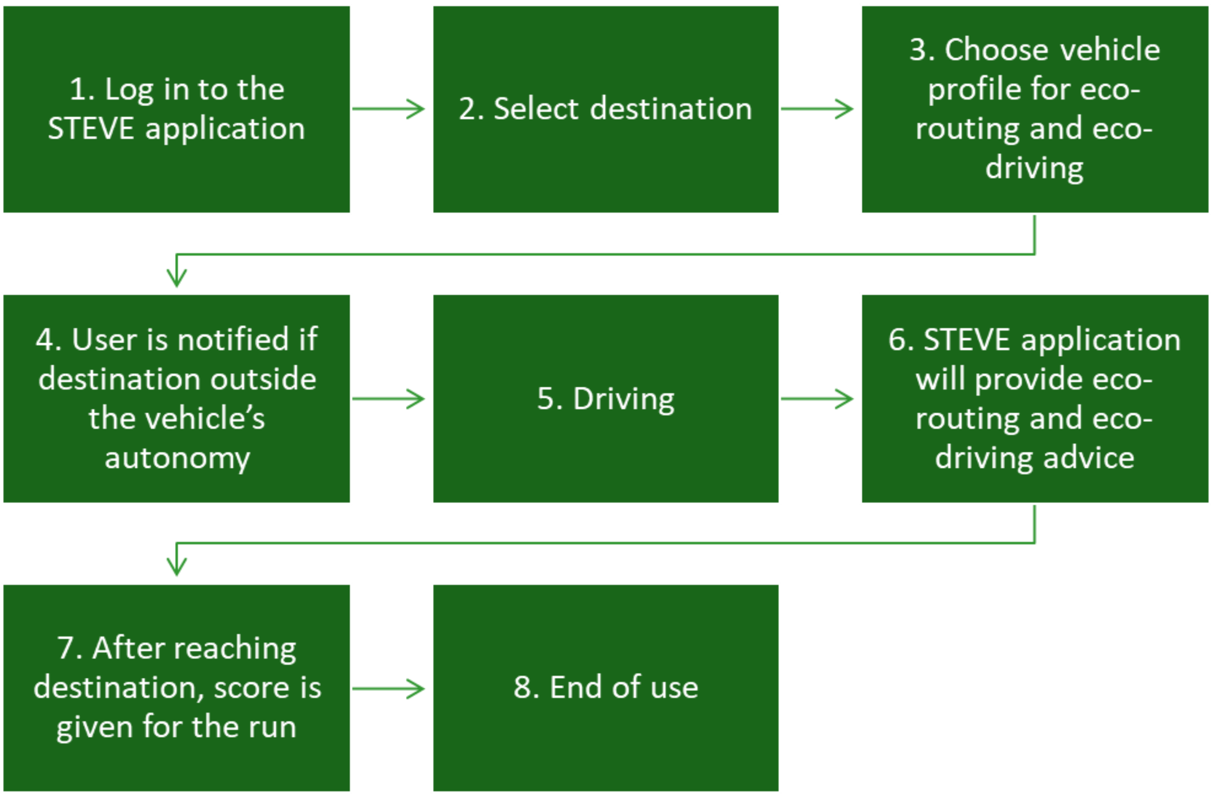

Fig 2. User-centric process diagram of STEVE Eco-driving use cases.

As before, the user needs to download the application and register as a user. However, no driving licence is required in the registration as the STEVE application in this case is supplementary to normal driving. The user then chooses a destination in the application as well as a vehicle profile, which is needed in order to provide the correct information for the eco features. The user is able to choose from a list of ready-made vehicle profiles or may provide custom specifications in case the vehicle cannot be found in the list.

After setting the destination and vehicle profile, the application calculates an optimal route to the destination, taking energy consumption into account. In case the remaining range of the vehicle will not be sufficient to cover the journey to the destination, the application warns the user to take charging into consideration.

Once the user has embarked on the route, the application provides navigation advice along with eco-driving instructions. The suggested optimal speed is displayed in the speed indicator of the application. As soon as the user finishes the route, the application scores the drive based on how well the speed advice was followed. Awards are granted depending on the score. In addition, the application keeps a ranking list, where the users can check statistics and compare scores.

2.3. STEVE Delivery use case

The third use case considers electric delivery services within the STEVE project. Delivery services pose an alternative way to increase the usage of vehicles otherwise used for eMaaS. In addition, electrifying the city logistics would contribute to a reduction in local emissions. In the STEVE project, EL-V delivery service is demonstrated only in Turin.

The user-centric process diagram for the delivery use case is presented in Fig. 3. The process starts with the user making a booking with the STEVE application. The user has to define a destination already in the booking phase, which permits beforehand calculations for the route and duration of the trip. Keys to the vehicle are managed a separate key master operator that assigns the keys for the user. After the user has acquired keys, user disconnects the vehicle from the charger, delivers the goods to the pre-determined destination and returns to the origin. To end the use case, the user has to connect the vehicle back to the charger and return the keys to the key master. In addition to single delivery action case, the delivery use case can also be utilised to serve multiple deliveries during a reservation. In this case, the process follows the same pattern but the steps 3-6 of the diagram are repeated as many times as necessary. The process ends in the same last steps.

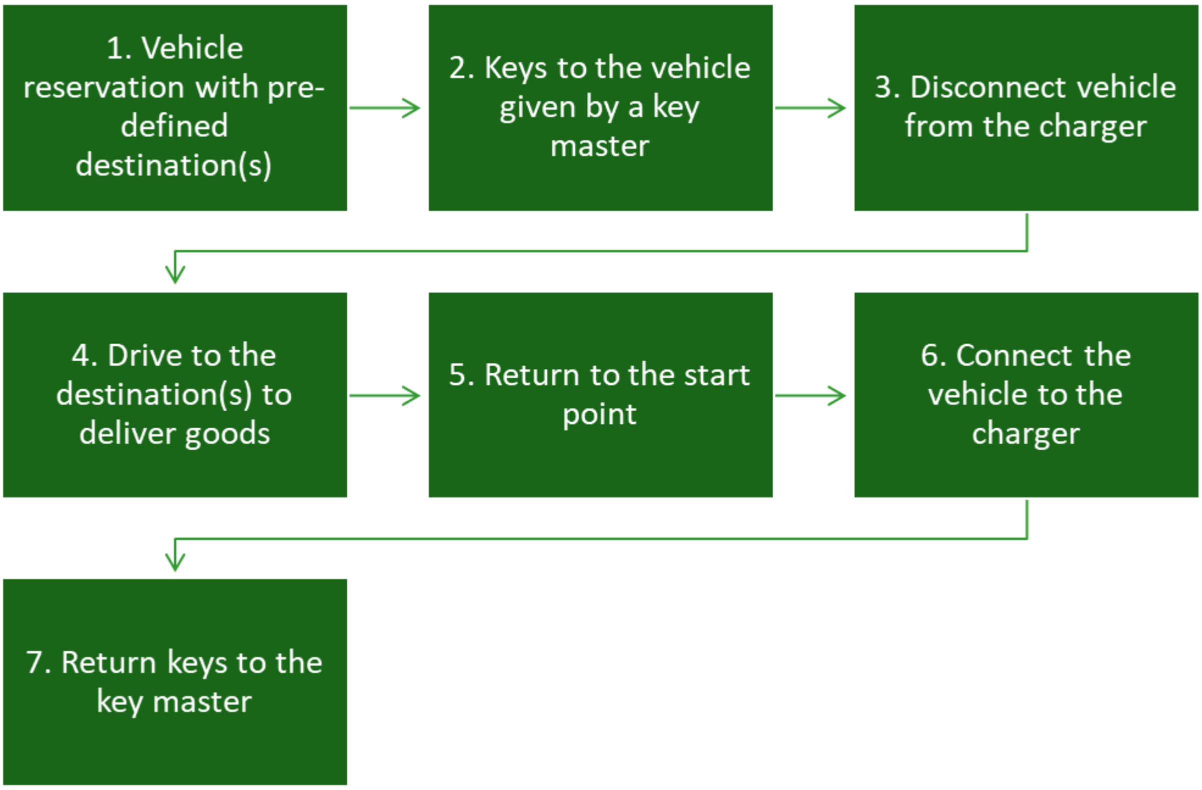

Fig 3. User-centric process diagram of STEVE Delivery use cases.

3. Applications of use cases for evaluation

Measuring impacts of the services directly in the real world is not feasible during the demonstrations due to restrictions posed by time and resources. In addition, many changes take a long time to show or require high usage rates. Such changes include changes in travel patterns – where, when and how people choose to travel.

Therefore, at a later stage, the potential impacts of the STEVE e-mobility services will be assessed with simulations. Here, the use cases describing the different e-mobility services of STEVE provide a natural basis for planning and structuring the simulations.

Simulations are an efficient way to complement measured data in order to provide answers to research questions. Specifically, they help in assessing potential long-term changes and wider effects, where real world measurements are not feasible. Two types of simulations are planned to be carried out in STEVE: mesoscopic simulations for assessing travel patterns and microscopic simulations for assessing potential impacts of STEVE services on traffic flow and emissions. Both models can be used in the city mobility analysis, however, slightly different inputs are needed for the models.

The first level is a mesoscopic, activity based model that entails complete urban environments, such as city and its outskirts. A similar activity based simulation approach will be utilised in STEVE as in [13], which elaborates the concept further. In short, the mesoscopic tool utilises agent models to describe daily activities of residents, and requires rather detailed data of the daily travel behaviour of inhabitants of a city region for calibration and validation. These can be obtained from different existing travel statistics and databases, supplemented by calculations where necessary. As a result from the activity based modelling, estimates on transport within a city or area can be obtained; for example, origins and destinations of trips, modal split and expected traffic volumes on the roads. The activity-based model is suitable for assessing several different scenarios, such as introduction of new mobility options (e.g. full-scale MaaS), regulations (travel mode restrictions) and changes in the transport network. Along with the statistics and survey reports, the STEVE use cases provide a general frame for the travel patterns in the activity based model. The use cases set constraints for the eMaaS modelling in the simulation, such as the usage should ultimately start and end at a charging station.

The second level is microscopic model that focuses on parts of the region, such as small networks, individual roads or vehicles. Once the movement of people between different areas of a city has been modelled with the mesoscopic model, microscopic traffic simulation can be used to examine the impacts of these movements on a more detailed level in order to obtain estimates on traffic flow, travel times and emissions. Microscopic traffic simulation models individual behaviour of single vehicles on the road network. Both types of models – mesoscopic activity based model and microscopic simulation – are used to address the effects of different policy aspects and to support measured data, in order to supplement the measurements of KPI. In STEVE, modelling provides a way to assess the potential impacts of the eMaaS, Eco-driving and Delivery use cases on a larger scale than the demonstrations, which are limited in scope and time.

Input for the simulations will be derived from various databases and statistics and complemented with data from the demonstration tests, e.g. through user surveys. Simulations can be carried out for one or several of the demo sites. Alternatively, a general environment without specifying a single location could also be useful for providing more generalised results.

4. Conclusions and next steps

The use cases created in STEVE – eMaaS, Eco-driving and Delivery – provide a helpful and simple tool for designing, implementing and analysing the demonstrations of STEVE light electric vehicles. In the designing phase, they provide a tool for people from different backgrounds to work together in planning and setting up the demonstrations, as well as a checklist to make sure that all important processes from the user point of view are taken into account. In addition, the use cases are utilised in the planning of the urban mobility and traffic-related simulation activities carried out in STEVE. They provide insight on the constraints and requirements for travel patterns.

For the demonstration phase, use cases are a convenient way to introduce and explain the services to the users, most of whom presumably are not well aware of these light electric vehicles or transport services. In the analysis phase, use cases provide a framework for structuring and presenting findings. Further, use cases are helpful in presenting the project and disseminating its results.

The assessment of the services in STEVE calls for further operational details. Data collection in form of surveys and real-world measurements provide key information but they tend to be difficult and expensive to obtain. Especially in pilot programs, such as STEVE, where the number of vehicles and users are relatively low. Concrete tests can be vastly expanded with computational simulations, which hence have great potential to elaborate the operational details and consequences of high volume electric transport. The simulations provide an efficient and flexible way to study how people may use shared electric vehicle services and how they would affect a city's transport network, which can aid in the planning of such systems. Further research is required to test out the STEVE use cases via activity based modelling and verify such analysis.

Acknowledgement

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