FP7-SMARTCITIES-2013

# STREETLIFE

Steering towards Green and Perceptive Mobility of the Future

## WP5 – END-USER APPLICATIONS

# D5.1 – End-user applications requirements and specifications

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**Executive Summary:**

Work Package 5, End-user Applications aims at delivering applications for people on the move, featuring personalization, gamification and advanced graphical interfaces, to leverage low carbon ways of travel. We attend both the planning phase with pre-experiencing, and the contextual real-time situation on the road. As our applications are navigation aids, we discuss navigation in general to set the framework and to define overall goals. To reach our goals, we design these applications in this Deliverable via user-centred *Use Case*s that highlight our goals. We then expand the Use Cases, defining functional and qualitative *requirements*. These are mapped to ideas for implementation *specifications*. Finally, we set up *validation processes* for our end-user applications.

# D5.1 – End-user applications requirements and specifications

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## ABBREVIATIONS

| | |
|---|---|
| AR | Augmented Reality |
| CO | Confidential, only for members of the Consortium (including the Commission Services) |
| BER | STREETLIFE Berlin-Pilot |
| D | Deliverable |
| DoW | Description of Work |
| FP7 | Seventh Framework Programme |
| FLOSS | Free/Libre Open Source Software |
| GUI | Grafical user Interface |
| IPR | Intellectual Property Rights |
| MGT | Management |
| MS | Milestone |
| OS | Open Source |
| OSS | Open Source Software |
| O | Other |
| P | Prototype |
| PU | Public |
| PM | Person Month |
| R | Report |
| ROV | STREETLIFE Rovereto-Pilot |
| RTD | Research and Development |
| RTK | Real Time Kinematic |
| SIRI | Service Interface for Real-time Information |
| TAM | STREETLIFE Tampere-Pilot |
| WP | Work Package |
| VRML | Virtual Reality Modeling Language |
| Y1 | Year 1 |

## DEFINITIONS TO THE DELIVERABLE TEMPLATE

**Editor:** Individual responsible for the deliverable. This person should belong to the partner organization named responsible for the deliverable in the DoW.

**Contributors:** Individuals that are the co-authors of the document. But it does not necessarily mean that there is a joint foreground created by them.

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## PARTNER NAME CORRESPONDING TO ABBREVIATION IN STREETLIFE DOW

| | |
|---|---|
| Fraunhofer | Fraunhofer-Gesellschaft zur Förderung der angewandten Forschung e.V. |
| FBK | Fondazione Bruno Kessler |
| SIEMENS | Siemens AG |
| DFKI | Deutsches Forschungszentrum für Künstliche Intelligenz GmbH |
| AALTO | Aalto University |
| DLR | Deutsches Zentrum für Luft- und Raumfahrt |
| CAIRE | Cooperativa Architetti e Ingeneri - Urbanistica |
| Rovereto | Comune di Rovereto |
| TSB | Berlin Partner for Business and Technology |
| Tampere | City of Tampere |
| Logica | CGI Suomi Oy |

## LIST OF FIGURES

# 1. INTRODUCTION

Work Package 5 focuses in development of STREETLIFE end-user applications in a research-oriented and user-centred manner. Our end users are mainly individuals, ranging from local people, travelling daily between their home and work, to casual visitors, experiencing a new environment. We assume that our travellers have a variety of travelling means available to them, and require our applications to provide multimodal alternatives.

STREETLIFE end-user applications will aid end users in mobility planning, pre-experiencing routes and act as online travel assistants with real time features. The design and development of these applications will be driven by the key motivation of encouraging end-users participation and energy-efficient/carbon-low behaviours. To this extent, the work package will develop participation and gaming techniques that will be exploited within the mobile applications for engaging end-users in creating and sharing their mobility information and experiences, and to set-up and manage green mobility incentives and rewards.

STREETLIFE end-user applications are suited for the three main sites: **Berlin**, **Tampere** and **Rovereto**. Each city has its own specific features and available data, which affect the resulting end-user applications.

## 1.1. Goals and Concepts

This Deliverable presents the End-User Application *Use Cases* for each main *Feature*, drawing *Application Requirements* and *Specifications* from them. Each Use Case exemplifies a highlight of a STREETLIFE application feature, providing a pre-visualization of the foreseen situation. Use Cases are presented in narrative form. From these, user-centred requirements are drawn. These are then mapped, if applicable, to implementation ideas (high level *specifications*), naming for example formats, interfaces and technologies or explaining methods and processes.

The scale of user trials is defined within the Use Case specifications. They may vary from focused cognitive experimentation in laboratory conditions to large scale user trials. The targeted scale depends on the maturity level of the given feature: for a very advanced, beyond-state-of-the-art feature based on a previously untested hypothesis, laboratory experimentation or quasi-experimental field trial is a viable option for understanding the fundamental perceptual and behavioural phenomena. For a full application that is built on top of an existing widely used application, utilizing for example real-time traffic data as an added feature, large scale piloting is more appropriate.

## 1.2. Tasks

WP5 is divided to five Tasks, which set up the main technologies for the foreseen application features:

1. *Intermodal Personalised Travel Assistance and Routing* sets up a common toolset for personalized travel assistance and routing algorithms. This toolset is the basis for advanced context-aware real time assisting features supported with multimodal routing that can proactively aid the end user before and during a trip.

2. *Virtual Mobility* seeks to lower the threshold of using alternate and greener means of travel via visual pre-experiencing of the suggested routes.
3. *Citizen Participation and Gamification* provides development of engagement techniques that will a) facilitate end-users with tools for creating and sharing their mobility information and experiences, and b) increase enjoyment of greener means of travel via games, implemented with a customizable gamification engine.
4. *Advanced Graphical Interfaces* advances the visualization of traffic, routes and virtual mobility via mixed reality techniques, namely a) 3D virtual environments and b) augmented reality.
5. *Mobile App Development* integrates selected techniques, algorithms and engines from the four previous Tasks into actual applications, with advanced user interfaces and personalization features.

Tasks 1-4 form the basis for the actual integrated application as fundamental *features*. These featuers depend heavily on available static, real time and crowd sourced data (T3.1, T3.2, T3.3). This data dependency also leads to site dependency, for any localized data. For generally available data, such as OpenStreetMap, a routing solution can be a general feature. However, even in this case, data quality may vary, and lead to site specific differences in quality of service.

The last task (5), *Mobile App Development*, utilizes the developed enablers along with available data to form actual mobile apps.

## 1.3. Main User Categories

In our case descriptions, we will assume the following basic user types to be experimenting and trying out our end-user applications:

1. *Local people.* As STREETLIFE aims at reducing transport related carbon emissions with multimodal journeys offered for individuals, our main focus group is the local people, who could potentially alter their daily method of travel permanently. Locals know their environment, and have possibly accustomed to their habits, such as driving to work by car. If we could affect even a small fraction of people in this focus group, results would be visible.

2. *Visitors.* Easy access to transport in cities makes *visitors* our second focus group. With simple, straightforward and visually compelling mobile application, they might be more willing to try public transportation, for example, rather than a taxi.

As our work package is research oriented, we will perform focused studies for the effectiveness of the advanced interfaces. We will also assume that some of our end users would belong to the sub-group of *early adopters*, willing to try out leading edge applications.

## 1.4. Outline of the deliverable

The content of this document is organized based on the various technical and research tasks of WP5. We set up the framework with a discussion on navigation. Through a set of exemplary use cases, we describe the major innovative features that we want to research and introduce in the end-user application that STREETLIFE will deploy and evaluate during the project. In the remainder, the use cases we have defined are grouped by WP5 task.

## 2. NAVIGATION

STREETLIFE end-user apps are mobility tools, aiding people in navigating using available affordances, but with a twist toward environmentally friendly means. Navigation itself is complex action and requires observational skills, spatial comprehension, spatial inferring, decision making, manoeuvring and active use of efficient wayfinding strategies. In order to create a good navigation interface, to serve the *purpose* of the map [1], the interface should support and reflect the related processes. In the context of using transportation, such assistant should focus on all related issues.

### 2.1. Navigation models

**Darken** and **Peterson** define *navigation* as the aggregate task of *wayfinding* and *motion* [2]. Way-finding is the cognitive element of navigation, involving planning and observations, building up a *cognitive map*, an internal spatial model of the environment. Motion is the motoric element, the act of getting somewhere, namely travel. They describe *manoeuvring* as a subset of motion, consisting of "*smaller movements that may not necessarily be a part of getting from "here" to "there" but rather adjusting the orientation of perspective, as in rotating the body or sidestepping*". We also define *micro-maneuvering*, which takes place in a virtual environment if a single supporting maneuver, such as a view orientation, consists of a series of actions.

**Downs** and **Stea** divide a navigation task to four main stages, 1) initial orientation, 2) manoeuvring, 3) maintaining orientation and 4) recognizing the target [1]. Navigation tasks that take place in virtual environments are further categorized by **Darken** and **Cevik** [3]. When a goal is marked on a map, a navigator performs a *targeted search*. When only the target's approximate location is known, a *primed search* is performed. When the location is unknown, the navigator performs an exhaustive, *naïve search* in the entire environment. Finally, the navigator can simply roam about, conducting *exploration*.

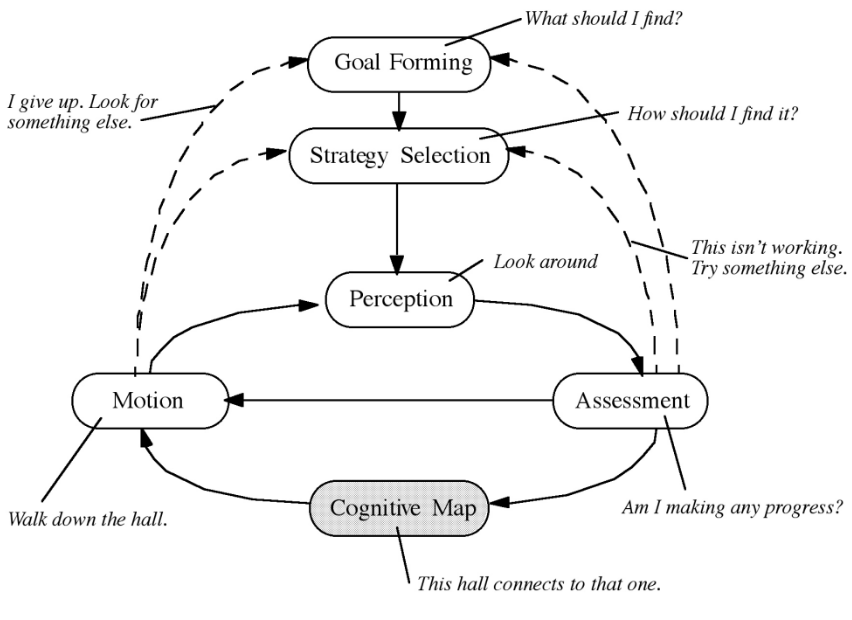


**Figure 1. A general framework for the navigation process (reproduced from [2], an adaptation from [4]).**

Figure 6.1 presents a model of the navigation process by **Jul** and **Furnas** [4], as modified by Darken and Peterson [2]. The process starts by goal forming, continues with strategy selection, and continues in the loop of perception (cue extraction), assessment of progress, and motion. This loop involves way-finding and develops the cognitive map as the navigator moves within the environment, observing it. We have further developed a variation of the presented navigation model involving two distinguished forms of actions, *pragmatic* and *epistemic* [5].

Navigation processes involve the use of spatial knowledge in problem solving. The classic hierarchical model builds on the concepts of *landmark knowledge*, *route knowledge* and *survey knowledge* [6]. The importance of *landmarks* and other *structural features* of urban environments was established in the seminal work by **Lynch** [7]. Use of a secondary source, such as a map, helps navigators to directly observe spatial relations and acquire survey knowledge [8]. However, map usage is a situated action, interactive and dynamic in nature, where the navigator, the current task and the environment constitute an integral whole [9]. The task dependency also poses the *scaling problem*, well known in both paper and electronic maps [10, 2]. For example, when navigating in a large virtual world, one needs a large scale view to maintain a sense of the overall environment, but a small-scale view is required for cue extraction, to identify details that are used to match the two worlds [11].

City planners can take into account known features that assist in navigation to create physical environments that are easy to navigate. Lynch's concept of *legibility* has had a profound influence on the fields of planning and architecture. Although the architecture itself, that is, the spatial configuration of a structure, may contain the information to generate a way-finding system, certain spaces lend themselves better to extracting and comprehending the relevant information. This quality is referred to as legibility. A place that facilitates obtaining and understanding of environmental information has a high legibility factor. Configurational complexity and the (high) number of choice points is the primary cause of way-finding difficulty [12].

The addition or deletion of certain architectural elements, for example *signage*, can manipulate legibility of a place. However, even the graphics of signage systems—the choice of lettering; the contrast created by black, white, and coloured elements; the size; the position; and illumination of a sign—all contribute to its comprehension, hence to the legibility of a space [13]. It is known that signage placed at *decision points* improves wayfinding performance, and can compensate for complexity of the environment [14].

Without access to physical manipulation of the environment, mobile aids can provide information and navigational guidance that is not otherwise directly available to the user. This information can be conveyed in various forms, suited for the task at hand. In the following, we set up requirements for mobile navigation aids.

## 2.2. Requirements for a mobile navigation aid

STREETLIFE end-user applications act as navigation aids for travellers who have a range of transportation modes available to them. These modes pose various restrictions and further requirements. For example, a car driver cannot spare much attention to tasks outside manoeuvring and navigating the vehicle. However, all travel modes are composed of the fundamental properties of navigation. In our development, we focus on conveying navigational guidance using methods of *visualization*. Here, our tools range from conventional maps to photographs, 360º photos, augmented reality and 3D virtual environments. Although the design of conventional maps is a science-art in itself, it has been well established and offer less interesting potential than more advanced techniques, which have become a technical feasibility very recently.

In the following, we set up requirements for the general navigation Use Case *[NAV-GEN]*.

A navigational aid must support all navigation phases:

| Req. Idea | Category | Description | Use case |
|---|---|---|---|
| NAV-GEN-1 | MUST | Navigational support for initial orientation | NAV-GEN |
| NAV-GEN-2 | MUST | Navigational support for manoeuvring | NAV-GEN |
| NAV-GEN-3 | MUST | Navigational support for maintaining orientation | NAV-GEN |
| NAV-GEN-4 | MUST | Navigational support for recognizing the target | NAV-GEN |

Furthermore, the aid must be able to manage and utilize the classical spatial knowledge types in *all relevant scales*:

| Req. Idea | Category | Description | Use case |
|---|---|---|---|
| NAV-KNOW-1 | MUST | Maintain and present landmark knowledge in navigation | NAV-GEN |
| NAV-KNOW-2 | MUST | Maintain and present route knowledge in navigation | NAV-GEN |
| NAV-KNOW-3 | MUST | Maintain and present configurational knowledge in navigation | NAV-GEN |

For the mobile interface, our goal is *transparency*, where a user would be embedded in performing a task to such extent that he would be unaware of the actual interface [15]. Therefore we wish to set up general guidelines for the interface itself:

| Req. Idea | Category | Description | Use case |
|---|---|---|---|
| NAV-UI-1 | SHOULD | Minimize cognitive load (as defined by working memory load, amount or duration of cognitive task processing, or complexity of mental computations) | NAV-GEN |
| NAV-UI-2 | SHOULD | Minimize motor effort and procedural complexity | NAV-GEN |
| NAV-UI-3 | SHOULD | Minimize use of time | NAV-GEN |

For navigation assistance, we also set up principal guidelines:

| Req. Idea | Category | Description | Use case |
|---|---|---|---|
| NAV-KNOW-4 | SHOULD | Maximize information that helps orientation | NAV-GEN |
| NAV-KNOW-5 | SHOULD | Maximize information that helps performing the current task | NAV-GEN |
| NAV-KNOW-6 | SHOULD | Maximize information that helps forming an accurate cognitive map | NAV-GEN |
| NAV-KNOW-7 | SHOULD | Minimize information that leads to disorientation | NAV-GEN |

Fulfilling these guidelines ensures that our principal navigational objectives are met:

| Req. Idea | Category | Description | Use case |
|---|---|---|---|
| NAV-OBJ-1 | SHOULD | User is able to find and travel through all places of interest | NAV-GEN |
| NAV-OBJ-2 | SHOULD | Use does not get lost | NAV-GEN |
| NAV-OBJ-3 | SHOULD | User is able to re-visit places with less effort | NAV-GEN |
| NAV-OBJ-4 | SHOULD | User feels familiar with the space | NAV-GEN |

STREETLIFE navigational aids need to support a range of travel modes. All modes can, however, be expressed with various representations. For example, large scale configurational knowledge can be expressed with maps. A route can be plotted on the map, to associate configurational context to it. The route can also be expressed along a topological network as a list of turns. These turns are decision points, which can then be presented individually. Again, going back up, one can provide these decision points within the context of a nearby landmark, and the entire route within the context of all relevant landmarks in the area.

Representations may focus on mode specific details. For a bus passenger, bus stops form main targets. During a ride, the decision point is the moment when the passenger starts the action to leave the vehicle, for example by pushing the stop button. A related landmark could be provided as a visual cue well before the bus stop.

Our advanced visualization methods focus on various ways to represent the environment with realistic expression. In this case, direct manipulation of the visualization, as is the case of conventional maps, is not applicable. The methods will rely on visual emphasis and signage.

While the creation and placement of physical signage is out of scope of STREETLIFE, a mobile navigational aid can, in principle, reproduce them. For example, in augmented reality, *virtual signage* can be overlaid over the physical world, providing the same functionality. Similar virtual signage can be placed in all our visual modes: photos, 360º photos, augmented reality and 3D maps. Guidelines from physical annotations apply for our cases:

| **Req. Idea** | **Category** | **Description** | **Use case** |
|---|---|---|---|
| NAV-ANN-1 | SHOULD | Virtual signage should be placed at *decision points* | NAV -GEN |
| NAV-ANN-2 | SHOULD | Virtual signage should be *legible* | NAV -GEN |
| NAV-ANN-3 | SHOULD | Virtual signage should utilize the presence of *landmarks* | NAV -GEN |

## 3. INTERMODAL PERSONALISED TRAVEL ASSISTANCE AND ROUTING (T5.1)

Intermodal personalised travel assistance and routing is at the core of most use-cases for the end-users who “consume” STREETLIFE. The majority of the use cases in D 6.1. need some sort of routing as their basis as well as personalization (see section *4 Requirements Ideas from Pilot Scenarios* of the deliverable for all requirement ideas).

### 3.1. Multimodal routing service

For all pilot sites (BER, ROV, TRE) we will use routing solutions that are available at the three sites. They will be adapted and expanded according to the needs.

#### *3.1.1. Use Case*

*User category*: *Local person*

*Trial level*: *Large scale pilot*

Below, we show a routing solution based on the Berlin Pre-trip planning (BER-CP1) use case:

> *After finishing work later this day, Silke is using the App connected to the STREETLIFE system again for planning the trip from work to the city center. For possible mode options criteria (costs, duration, $CO_2$ Footprint, etc.) are calculated and listed with the App. Amongst other, the App is offering to book an electric car sharing vehicle in a very close walking distance. Both, an acceptable travel time at this particular time of the day and the chance to win some “green leave” credits for choosing the most environmentally friendly option convince Silke to go for the car sharing option.*


**Figure 2. UI for a routing aid (mock-up).**

We investigated some currently existing apps for car sharing and travel planning in Berlin to explore how a possible UI could look like. The three mock-up screens (Figure 2) show left the profile information that is used in calculating the route, results from the routing, taking into account preferences and the current travel situation (middle screen) , and the navigation details for the selected result.

### *3.1.2. Requirements*

From D 6.1, we extracted the requirement ideas wrt. routing (sometimes also personalization, which influences the routing) :

| Req. Idea | Category | Description | Use case |
|---|---|---|---|
| BER-RI-1 | MUST | an app MUST be able to support multi-modal route planning | BER-PTP/1 |
| BER-RI-9 | SHOULD | The computation of actual necessary mode of transport SHOULD consider the user preferences. These user preferences MAY be predefined or given by the user directly. For example a user MAY be able to define not to use the bike on rainy days. | BER-PTP/3 |
| ROV-RI-43 | MUST | The STREETLIFE routing service MUST be able to provide the multi-modal P+R route even if the user has not original specified public transport or alternative transport means among the preferences for the trip | ROV-PR/1 |
| ROV-RI-44 | MUST | The STREETLIFE system MUST record the choice taken by the user about the trip with destination in the city center | ROV-PR/1 |
| ROV-RI-45 | MUST | The STREETLIFE system MUST be able to send notifications about events that are relevant to the car driver’s trip | ROV-PR/2 |
| TRE-RI-2 | MUST | Take real-time data into account in journey planning | TRE-2/1 |
| TRE-RI-3 | MUST | Remember user preferences in journey planning | TRE-2/1, TRE-4/ |
| TRE-RI-4 | SHOULD | User location awareness in journey planning (suggest current location as the route start point) | TRE-2/1, TRE-4/1 |
| TRE-RI-6 | MUST | Park & ride journey planning: citizens can plan a journey which combines private and public transportation. | TRE-4/1 |
| TRE-RI-9 | MUST | Publish an Open API for journey planner, to boost development of new third party applications. | TRE-2/1 |

### *3.1.3. Specification (implementation ideas)*

As we use already existing (multimodal) route planners for the three pilots, the core functionalities are already in place. Next steps will be to evaluate the requirements from the use case and the necessary extensions to the route planners. Note: the journey planner interface for Tampere pilot may only be partially useful for the advanced interfaces developed in WP5, and additional work for a lightweight client-side OpenStreetmap data based multimodal routing are required.

## 3.2. Personalisation

### *3.2.1. Use Case*

*User category*: *Local person*

*Trial level*: *Large scale pilot*

Personalisation is at the core of the end user's STREETLIFE experience. The App must be personal to a user, record all her preferences and use it in all functionalities. Again, we use a Berlin use cases (BER-PTP) to demonstrate the importance of the personalisation:

> *At this particular day Silke has to go to work and has an appointment at the evening in Berlin-Charlottenburg (close to downtown West). Having access to Silke's STREETLIFE user profile, the App is proposing to take the public transport (PT). The App is taking into account actual and forecasted weather and traffic situation. As rain is forecasted for the morning and the traffic situation between the city center and Adlershof is bad due to various construction sites and a heavy traffic load, modes "bike" and "car" were disregarded.*

For this use case, we show some examples from the Berlin mock-ups we use *Max Mustermann* – a common German placeholder name – for the profile) (Figure 3). The user must be identified/registered in order to use personal preference (screens one and two). Using the "my profile" in the main menu, he can scroll through the personal information. (second row, left). In the final screen (already used in the routing example above), we see, how information from his profile is used in the routing interaction flow.


**Figure 3. A personalization user interface (mock-up).**

### *3.2.2. Requirements*

From D 6.1, we extracted the requirement ideas wrt. personalization in the following table:

| Req. Idea | Category | Description | Use case |
|---|---|---|---|
| BER-RI-9 | SHOULD | The computation of actual necessary mode of transport SHOULD consider the user preferences. These user preferences MAY be predefined or given by the user directly. For example a user MAY be able to define not to use the bike on rainy days. | BER-PTP/3 |
| BER-RI-11 | MAY | A user MAY create and edit several profiles each with a different set of preferences. For example predefined preference templates like stay dry, low (to zero) carbon footprint, fastest connection, low cost and safety | BER-PTP/5 |
| BER-RI-12 | MAY | A user MAY be able to save the preferences under different names. | BER-PTP/5 |
| BER-RI-13 | MAY | The STREETLIFE system MAY be able to reason and self-learning from previous user-behaviour and preferences when suggesting route trips. | BER-PTP/5 |
| BER-RI-14 | SHOULD | The STREETLIFE system SHOULD have a centralised Identity Management System for end-user. | BER-PTP/6 |
| BER-RI-15 | MUST | A corresponding App and a STREETLIFE connected website MUST share the same Identity Management System. | BER-PTP/6 |
| BER-RI-23 | SHOULD | The user SHOULD be able to add other STREETLIFE user as friends to his profile. | BER-CPI/2 |
| BER-RI-24 | SHOULD | A STREETLIFE App SHOULD act in behalf of the user's STREELIFE system identity. | BER-CPI/4 |
| ROV-RI-9 | MUST | be able to register a user with her personal profile to the car pooling service | ROV-CP/1 |
| ROV-RI-10 | MUST | be able to define contact preferences for the car pooling service | ROV-CP/1 |
| ROV-RI-11 | MUST | be able to specify the itinerary for her ride request | ROV-CP/1 |
| ROV-RI-16 | SHOULD | interface with the user's calendar for such reminders | ROV-CP/1 |
| ROV-RI-22 | MUST | be able to mark ride requests with other (personal) tags | ROV-CP/2 |
| ROV-RI-27 | MUST | be able to input into the system the features needed for identification | ROV-CP/5 |

| | | | |
|---|---|---|---|
| ROV-RI-28 | SHOULD | be able to input into the system his/her recurrent starting place of a trip | ROV-CP/5 |
| ROV-RI-29 | SHOULD | be able to input into the system his/her recurrent ending place of a trip | ROV-CP/5 |
| ROV-RI-30 | SHOULD | be able to input into the system his/her recurrent time of a trip | ROV-CP/5 |
| ROV-RI-31 | SHOULD | be able to give inputs to the system about his/her workplace and/or other recurrent destinations | ROV-CP/5 |
| ROV-RI-32 | SHOULD | be able to input infos to the system about his/her common routes | ROV-CP/5 |
| ROV-RI-33 | SHOULD | be able to mark a trip into the system as a very frequent one | ROV-CP/5 |
| ROV-RI-34 | MUST | be able to read into the system the updated standings of the gamification system | ROV-CP/6 |
| ROV-RI-35 | MUST | be able to know the basic personal informations of the users in order to contact them when the game end | ROV-CP/6 |
| ROV-RI-44 | MUST | The STREETLIFE system MUST record the choice taken by the user about the trip with destination in the city center | ROV-PR/1 |
| ROV-RI-45 | MUST | The STREETLIFE system MUST be able to send notifications about events that are relevant to the car driver’s trip | ROV-PR/2 |
| TRE-RI-3 | MUST | Remember user preferences in journey planning | TRE-2/1, TRE-4/ |
| TRE-RI-4 | SHOULD | User location awareness in journey planning (suggest current location as the route start point) | TRE-2/1, TRE-4/1 |

### *3.2.3. Specification (implementation ideas)*

According to the requirements list above, personalisation must, first of all, provide means to record and store information about the users personal travel preferences, common start and end locations, but also information related to the usage of the STREETLIFE app, like gaming information. This can be collected in data structures as defined in Deliverable D3.1, section *3.2.1 User Model*. It has to be determined, which exact information is used and useful for the three pilots, however the core information must be used. It is also to be determined, whether the user model (or user profile) model will reside locally on the user’s device, or centrally, on a STREETLIFE server. Some of the use requirements in the table above call for a central storage mechanism. However, processing requirements may call for at least a local copy. The data protection requirements in the different countries have to be examined, too, to find a viable solution.

The profile data is the basis for the user adaptive multimodal routing (see 2.1 above). As can be seen, some of the personal preferences like *no bike when rain* require the inclusion of external services in the process of personalizing a route for the user.

The data collected from the user's interactions, are stored in the UserHistory. This history can be used to create suggestion, increase the quality of the routing, and to advise users about her CO2 footprint.

# 4. Virtual Mobility (T5.2)

Virtual Mobility refers to the use of the new Information and Communications technologies (ICT) as an alternative to physical mobility. In our context of personalized mobility, virtual mobility allows users to pre-experience their travel plan. The task creates a set of key points for the personalized route, which are expressed using a multitude of visualizations. Advanced graphical interfaces (T5.4) present features based on 3D virtual environments and augmented reality, which can be applied to Virtual Mobility, and are described in Section 6.

## 4.1. Image based decision point visualization

As the basic visual off-line and on-line aid for a traveler, we provide image-based guidance. The goal is to show the key points of an itinerary with images, where the targets and key landmarks are marked or highlighted. Bus or tram stops are shown to ensure certainty of the correct stop. An image of the environment, potentially with an identifiable landmark, is shown prior to a bus or tram stop during a ride.

### *4.1.1. Use Case [VM-IMG] – Image based guidance*

*User category*: *Visitor*

*Trial level*: *Small scale research experiment*

> *Richard is a backpacker from England on a tour around Europe. He's just arrived in Helsinki and staying at the apartment of a friend living in Pikku Huopalahti. His friend is working the following day and Richard wants to go to a flea market in the morning to find some unconventional souvenirs. He doesn't know yet what the city center looks like or how tram stops are marked so he fires up the STREETLIFE application to familiarize himself with the route. In the application Richard sees an interesting theatre building on the way just before the flea market and he decides to walk by it.*

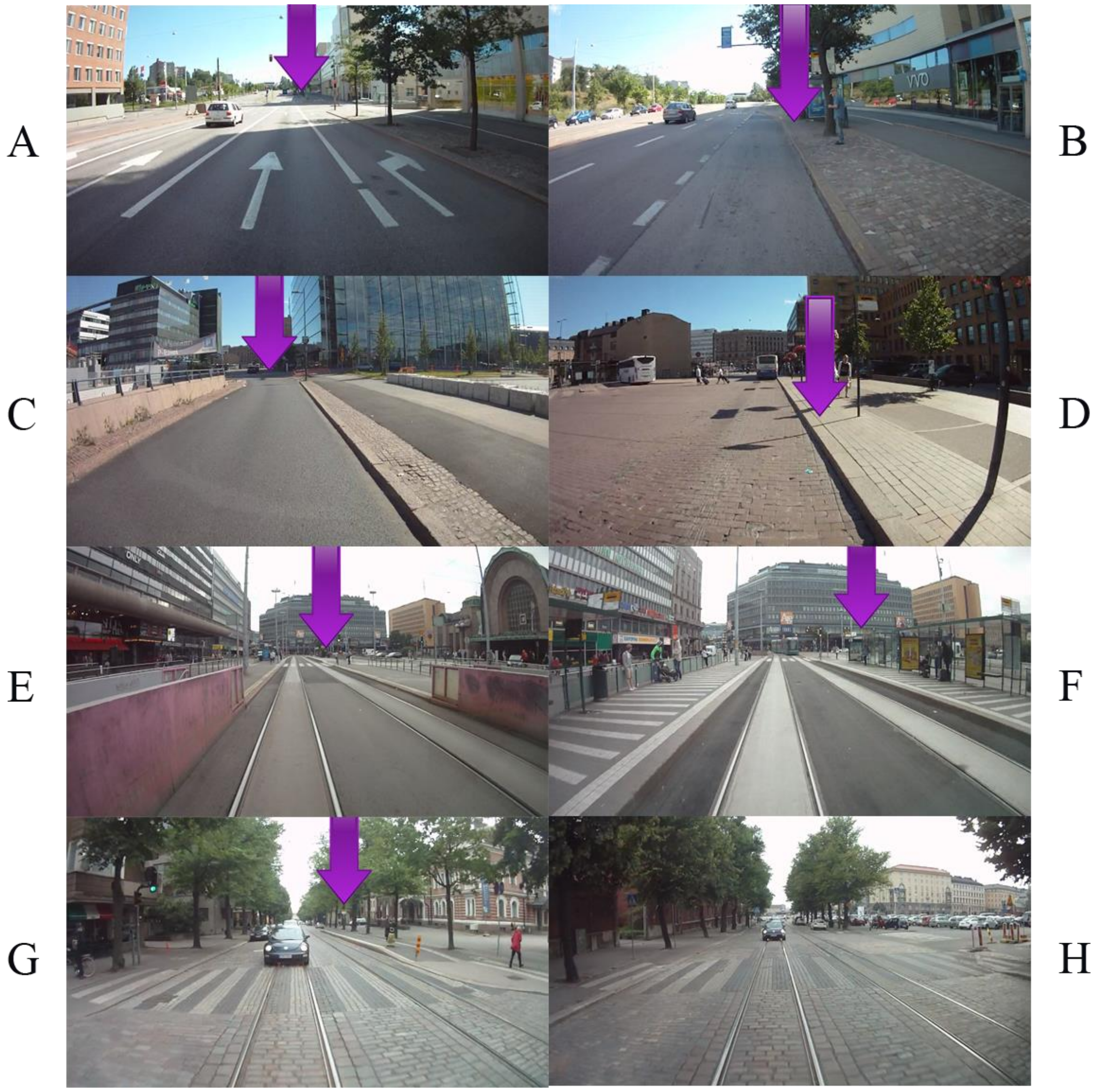


**Figure 4. Photos along a public transport route with one change of vehicles (mock-up).**

Figure 4 shows key locations along the route:

A: Large intersection where the first bus stop can be seen, easy to find by walking.

B: Stop of the bus 63 headed to city center.

C: Large landmark buildings before stop to get off the bus.

D: The stop where to exit the bus.

E: Surroundings of the next stop. Most buildings from the previous picture are visible.

F: The stop where to get into tram 6 is seen on the right.

G: An old decorative theatre building just before the flea market is on the right.

H: The flea market is on the right.

Important landmarks along the way are shown, especially along public transport routes just before the correct stop to get off the vehicle, so it's easier to pay attention at the correct time.

### *4.1.2. Requirements*

| Req. Idea | Category | Description | Use case |
|---|---|---|---|
| NAV-IMG-R-1 | MUST | Annotated georeferenced and oriented photos of public transportation stops and of recognizable landmarks in the vicinity | TRE-IMG |

### *4.1.3. Specification (implementation ideas)*

| Impl.Idea | Category | Description | Use case |
|---|---|---|---|
| NAV-IMG-S-1 | MUST | A routing capability that is associated with a visualization database | TRE-IMG |
| NAV-IMG-S-2 | MUST | GPS and orientation tagged photo database of transportation stops and recognizable landmarks supporting JPG and PNG formats | TRE-IMG |
| NAV-IMG-S-3 | MUST | Annotations with associated contextual data (bus stop numbers etc) extracted from for example GTFS or Kalkati.net data | TRE-IMG |
| NAV-IMG-S-4 | MAY | Potentially crowd-sourcing content and annotation tools for image database creation | TRE-IMG |
| NAV-IMG-S-4 | MUST | A user interface binding journey planning functionality to photo visualization using geotagging or road segment identifiers for association | TRE-IMG |

## 4.2. 360º Image based decision point visualization

Full spherical photos are images, which have been photographed in a spherical fashion to all directions from a single point (Figure 5). They are familiar from QuickTime VR™ and Google StreetView. They are sometimes called "*360º photos*", although they could be called more appropriately as "*4π photos*". Such photos are typically constructed from multiple individual photos by *stitching* them together. This can be automated for fixed set-ups where multiple cameras with wide angle lenses have been combined to a single instrument, or one can create them manually using individual photos and suitable software, such as *Hugin*.

By layering these photos over a virtual sphere, the environment can be observed from this single viewpoint using suitable viewing software. Such a view can then be used to localize landmark and other points of interest, for example. Given a high resolution original image, one can also zoom in to certain extent for details. In a 3D environment, implementation can utilize standardize 3D APIs such as OpenGL, OpenGL ES or higher level libraries.

**Figure 5. A 360 panorama image (mock-up).**

### *4.2.1. Use Case [VM-360IMG] – 360º image based guidance*

*User category: Visitor*

*Trial level: Small scale research experiment*

> *Richard's friend Peter took him today for a tour in Otaniemi, Espoo, to see how Aalto University site looks like. They got off at the library, walked around the campus and entered the Computer Science building, where Peter works. Now Peter has to continue with his deadlines and Richard wants to go and visit Tapiola, one of the first post-war "new town" projects in Continental Europe, designed to be a garden city. A number of buses go through Otaniemi, and Peter is a bit unsure of which stop he should go.*
>
> *Peter takes out his STREETLIFE app, which provides him with an itinerary. He selects the 360º photo option and views the photo closest to his recommended bus stop. He looks around inside the bubble (*Figure 6*), recognizing the Computer Science building and the Main Building. There are two bus stops nearby, but only one is marked. He zooms on that*

**Figure 6. Zooming inside a 360º image toward a target bus stop (mock-up).**

### *4.2.2. Requirements*

| Req. Idea | Category | Description | Use case |
|---|---|---|---|
| NAV-360-R-1 | MUST | Ability to view and zoom annotated 360º photos | TRE-360 |

### *4.2.3. Specification (implementation ideas)*

| Impl. Idea | Category | Description | Use case |
|---|---|---|---|
| NAV-360-S-1 | MUST | 360º photo viewer within the mobile application, OpenGL ES and C/C++ based implementation for AR/3D compatibility | TRE-360 |
| NAV-360-S-2 | MUST | 360º photo database of key navigational points: bus stops, landmarks; geotagged or associated to road segment identifiers | TRE-360 |
| NAV-360-S-3 | MUST | A user interface binding journey planning functionality to 360º photo visualization; Java UI feasible for Android for AR/3D compatibility | TRE-360 |

# 5. CITIZEN PARTICIPATION AND GAMIFICATION (T5.3)

To facilitate and motivate citizens to adopt the sustainable urban mobility solutions supported by the STREETLIFE project, we will introduce in the end user applications that STREETLIFE will deploy and evaluate some features, which implement incentive mechanisms, based upon the concept of *gamification*.

Gamification is a general term that indicates the *"use of game design elements in non-game contexts"* [16]. The non-game contexts can be very varied, ranging from user interaction with an information system, interactions between multiple users, completion of tasks at work, or in a volunteer community or other social settings, etc. Typically, these interactions occur through – and with the support of - an ICT system that implements some form of game-like logic on top of its core business logic, and directs the end users in their gamified interactions.

Mechanisms of many different types are collected under this wide umbrella, ranging (to name a few) from simple "leader board" reputation schemes that assign some "points" and a ranking to regular user interactions with and through the gamified system, to mechanisms that associate virtual as well as actual awards and rewards to certain interactions, or for the achievement of certain levels within those point schemes, to more complex designs where most (or all) of the activity by the user within the gamified ICT system is organized in a way that resembles the set up and logic that are typical of some kinds of digital games (for example, adventure games).

In the context of STREETLIFE, the objective of gamification is twofold: as a principal goal, we want to create personal and social incentives for users of STREETLIFE, which will strengthen their commitment to take advantage regularly and consistently of the advanced mobility solutions made available by the STREETLIFE end user applications; at the same time, we want to ensure that using those solutions is fun and rewarding, which is likely to increase usage and at the same reinforce sustainable mobility behaviours in the end users population.

A gamification initiative aimed at promoting end user participation in STREETLIFE must include several technological components. We distinguish here between a *gamification engine*, which provides the server-side functionality to define, deploy and run games, including rules, activities and point schemes, based on the various services implemented in the STREETLIFE mobility information system; and the front end-facing presentation of the gamified functionality that is delivered to the end user, as she interacts with the STREETLIFE information system through the mobile apps. In the remainder of this Section, we concentrate on the latter, whereas the analysis and design of the former is largely an architectural issue that is one of the foci of the analysis and design activity of the overall STREETLIFE system architecture in WP2.

To discuss the end user features, we leverage the use cases that we present below. These use cases are not exhaustive at this early stage, and others are going to be developed to guide the design of both the backend and frontend functionality of the gamification facilities; however, we consider these two use cases as representative of the kind of end user experience and participation incentives that can be provided via the gamification of the STREETLIFE services and applications. The first use case, identified with GAM-PBA, deals with computing and assigning points, badges and awards to the end user, based on the mobility choices taken during trip planning, thus influencing those choices. The second use case, identified with GAM-VMC, includes proactive guidance by a virtual assistant, a “mobility coach”, which motivates the end user to leverage specific mobility services, in order to further improve the “player’s status” within the STREETLIFE community.

*5.1.1. Use Case [GAM-PBA] – earning points, badges and awards*

*User category: local person*

*Trial level: large scale pilot*

> *Davide is a habitual STREETLIFE end user, and he is trying to reach the MART museum in the city of Rovereto. As usual, he leverages the STREETLIFE mobile app to help planning his trip. The mobile app provides Davide with multiple options for reaching his destination. Some of those options, according to the rules of the STREETLIFE mobility game deployed in Rovereto, will provide Davide with a number of “green leaves”, i.e. game points.*
>
> *Davide decides to choose the option that allots the most green leaves, since he is engaged in a competition with some of his friends to see who will earn the highest rank in the STREETLIFE leader board of Rovereto. By choosing that option, Davide (whose STREETLIFE game ID is “Davidator” does not only climbs up a few places in the ranking, but reaches a point level that qualifies him as a “green hero – level 2”, which awards him a badge that is reported in his STREETLIFE game profile and on the leader board. Davide has earned several badges already, and he has to earn at least one more, to complete a collection of badges that will earn him an award, in this case a weekly pass for the Rovereto mobile transportation system.*

In Figure 7, we show the UI mock-up of an end user application that supports trip planning, and shows multiple options for the same itinerary. Some traveling options are decorated with icons, which show to the user the potential of earning green leaves.

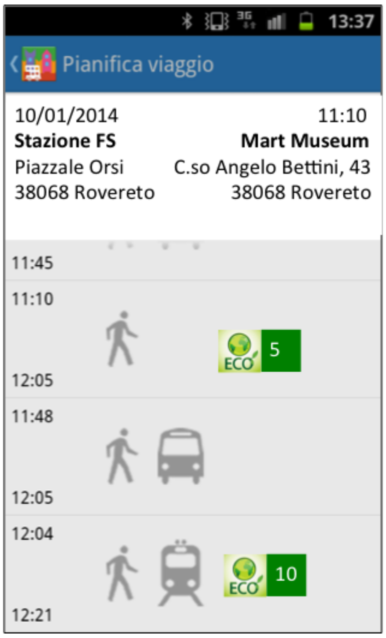


**Figure 7. Earning "green leaves" when planning a trip (mock-up).**

Accumulation of points leads to reputation and recognition, as shown in the leader board mock-up below. Players ID are associated to their green leaves total, and to a game profile that can be examined and shows more information, like the badges they have collected so far.

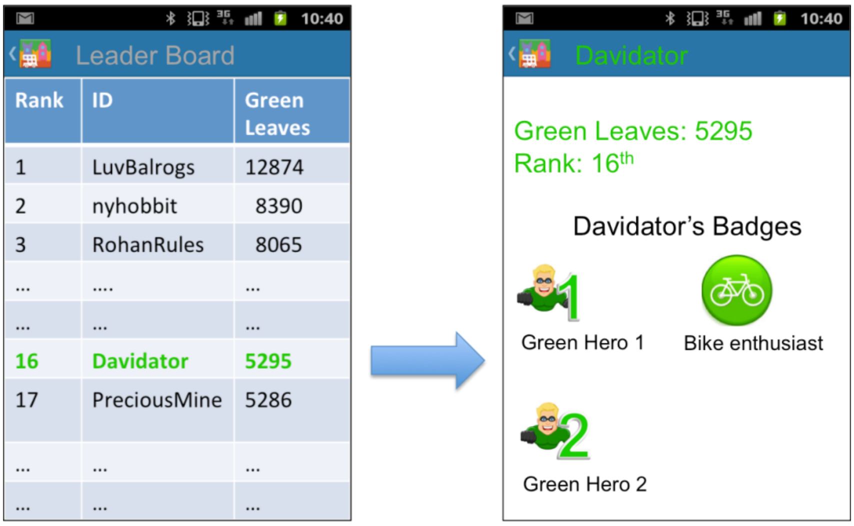


**Figure 8. Leader Board for the STREETLIFE mobility game (mock-up).**

*5.1.2. Use Case [GAM-VMC] – virtual mobility coach*

*User category: local person*

*Trial level: large scale pilot*

> *Davide is currently too busy to check his status in the STREETLIFE mobility game often. However, the mobility management office of the Rovereto municipality has just launched a promotion, to encourage citizens to try out the Park&Ride (P+R) service, which is supported through the STREETLIFE mobility information system. The incentive is that an end user who tries the P+R service twice within the same week when traveling into the city center, he will earn automatically the badge "Mobility Explorer – level 1". That badge is missing from Davide's collection, and would satisfy his requirements for winning an award in the mobility game.*
>
> *The STREETLIFE gamified end user application includes a "virtual mobility coach", a proactive notification mechanism that is designed to monitor the end user / player profile and to inform the player of opportunities, bonuses and special activities or initiatives that can help that player to get ahead in the mobility game, especially if the user has been inactive in the game system for some extended period. A couple of days after the beginning of the P+R promotion, Davide's own virtual mobility coach notifies Davide of it, pointing out the opportunity to earn the new badge and achieve his award. This prompts Davide to check out on his mobile the Rovereto P+R service, through the user interface provided for that service within the STREETLIFE end user application, and to set up a P+R itinerary for his next trip to the city center, which is planned later that day.*

Below, we show a UI mock-up of the virtual mobility coach notification system. There are several options with respect the in-app delivery of the coach notifications, as well as other game-related notifications, which we will consider and analyse during the design of the frontend presentation of the gamification features. For instance, the app could simply show an unobtrusive pop-up message on the screen and perhaps play a sound; or, at the other end of the spectrum in terms of interactivity and attention-focusing, the virtual mobility coach could be represented by a synthetic character with an avatar, who engages the end user and guides him in his interactions with the application. In the mock-up, we propose an avatar for the virtual mobility coach.

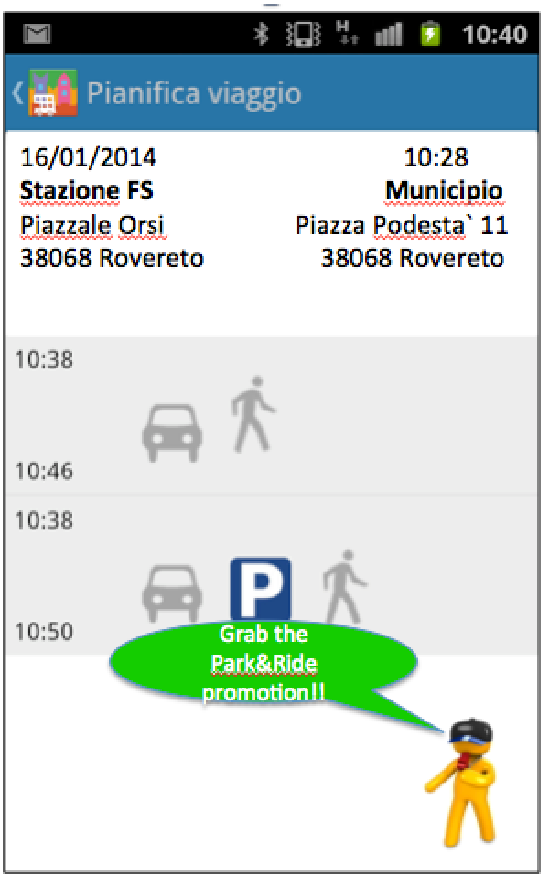


**Figure 9. The Virtual Mobility Coach in action (mock-up).**

### *5.1.3. Requirements*

The list of requirements below is derived from the use cases above and their narrative. It is not intended as an exhaustive list, and focuses on the front end of the gamification facility, and on the user-facing features.

| Req. Idea | Category | Description | Use case |
|---|---|---|---|
| GAM-R-1 | MUST | Store and display gamer profile of the user | GAM-PBA |
| GAM-R-2 | MUST | Allow end user to join with her profile and leave one (or multiple) mobility games | GAM-PBA |
| GAM-R-3 | MUST | Associate a number of green leaves point to specific user actions and choices within the end user application | GAM-PBA |

| | | | |
|---|---|---|---|
| GAM-R-4 | MUST | Present to the number of points associated to the various actions and choices that are available to the user, based on the current usage context of the end user application | GAM-PBA |
| GAM-R-5 | MUST | Update green leaves point earned by the player, based on actions taken by the player within the end user application | GAM-PBA |
| GAM-R-5 | MUST | Update badge collection of end user based on end user achievements | GAM-PBA |
| GAM-R-6 | SHOULD | Assign awards (prizes) to end user based on end user achievements | GAM-PBA |
| GAM-R-7 | MUST | Show the leader board of the game(s) in which the user participates and the ranking of the user in it | GAM-PBA |
| GAM-R-8 | SHOULD | Show a filtered leader board that includes only a subset of players indicated by this player | GAM-PBA |
| GAM-R-9 | MUST | Log all game-related user activity for history and audit purposes | GAM-PBA<br><br>GAM-VMC |
| GAM-R-10 | MUST | Monitor periodically the state, profile, progress and game log of the player | GAM-VMC |
| GAM-R-11 | MUST | Reason on the player’s state vis-à-vis reachable objective in terms of points, badges and awards | GAM-VMC |
| GAM-R-12 | MUST | Trigger proactive (“coaching”) notifications to the end user, suggesting ways to reach objectives in terms of points, badges and awards | GAM-VMC |
| GAM-R-13 | SHOULD | Deliver coaching notifications in a way that is compelling and attention-focusing, yet unobtrusive | GAM-VMC |
| GAM-R-14 | SHOULD | Have multiple options for the mode of delivery of notifications by the virtual mobility coach | GAM-VMC |
| GAM-R-15 | MUST | Allow end user to enable/disable the coaching system of notification | GAM-VMC |
| GAM-R-16 | SHOULD | Allow end user to customize the coaching notification system, in terms of notification filtering as well as mode of delivery | GAM-VMC |
| GAMR-17 | SHOULD | Show and guide the end user in acting upon the coaching notification in the correct way (that it, the way that will get the player to the objective described in the notification) | GAM-VMC |

### *5.1.4. Specification (implementation ideas)*

The gamification of the end user applications of STREETLIFE will occur by means of the development of an ensemble of design-time tools and run-time components, which include (at a high level of abstraction):

1. A gamification engine, where the game logic resides and is executed server-side
2. A game designer environment, which supports developers in defining the game logic, the points, badges and awards schemes, and how they are associated to the end user’s interactions with the various pieces of functionality of the STREETLIFE mobility information system
3. A framework for capturing at run time the user actions and decisions taken from within the STREETLIFE end user applications, and invoke game functionality within the gamification engine
4. A persistence layer where all the entities relevant to the game state are stored
5. An extension of the STREETLIFE user model that specifies and stores an extension of the user profile, that is, the *player profile* with all the personal information of the end user as a participant to the STREETLIFE mobility game(s).

Among the elements above, only #3 is directly part of the end user applications. However, the gamification system as a whole requires all of those elements. Below, we describe some major ideas and choices about the enabling technologies with which we plan to develop the suite above, considering that the selected target development and runtime environment is Java technology.

The **gamification engine** will be developed on top of the Drools 6.0 rule engine, augmented with a custom layer that facilitates writing game-specific styles of rules, as well as a tool providing high-level means for the specification of those rules.

The **game designer environment** is a Web-based IDE that interacts with the gamification engine, and is used at design time to specify all the game entities and logic; this environment will be developed on top of the Spring framework, and its GUI will be developed with Tiles technology. The Spring framework will be also employed to implement the **runtime framework that captures the user actions** within the end user application and enables the interaction between the end user application and the gamification engine as the game is in progress.

The **persistence layer** for the game state will be implemented on top of Hibernate ; moreover, REST services will be developed to expose such game state to the end user application. The game state will be stored in an SQL database. The **player profile** will be similarly stored, and its schema will be linked to the generic STREETLIFE user profile. The player profile schema will thus constitute an extension of the STREETLIFE user information, exclusively for game purposes

# 6. ADVANCED GRAPHICAL INTERFACES (T5.4)

Modern mobile platforms provide 3D graphics hardware and spatial sensing as standard features along with the common wireless networking capabilities. This task exploits these properties and creates two complementary visualizations of traffic, routes and virtual mobility in general: 1) 3D virtual environments and 2) augmented reality. Together they are called *mixed reality interfaces*, where the real and virtual components are combined [17].

***3D maps*** are 3D virtual environments that represent the real world. Three-dimensional maps represent reality with their naturally three-dimensional components. However, due to common display technologies, an internally three-dimensional representation is viewed on a two-dimensional surface, such as the computer screen. Indeed, a 3D map has been defined to be "*a two-dimensional visualization of a three-dimensional representation of a physical environment, emphasizing the three-dimensional characteristics of this environment*" [18].

The usefulness of a 3D map depends on context: for example, in urban environments, buildings dominate the landscape, with a wealth of visual cues in the form of architectural features, company logos etc. In such an environment, local orientation or spotting an exact target may be challenging with an abstracted or otherwise simplified visualization, such as a flattened 2D street map. The representation type that drives to preserve these visual cues that are present in the physical environment is called *realistic*. There are many levels of realism, which can be adapted according to the design goal of the representation.

Other features that might be available to a 3D representation include *dynamic* content; a 3D map carried with a user, for example as an interactive application, is *mobile*; using a display that fully engulfs the user's view in the environment can be called *immersive*, especially if the environment is portrayed with the so-called *first person view* and with *stereoscopic vision*, where a separate image is provided for each eye.

***Augmented Reality*** (AR) is a technology that aims at enhancing the real-world by overlaying computer-generated data on top of it and in such a way provides new means to define user interfaces. AR blurs the distinction between the user interface and the real world combining them in a natural way and allows the creation of simple and intuitive user interfaces even for complex applications.

In general, an AR system has three key characteristics: (a) it mixes real and virtual imagery, (b) registers the digital data to the real world and (c) provides interactivity in real-time [19]. While in the first years of AR applications users were required to wear bulky head mounted displays, nowadays the availability of mobile phones and tablet PCs enables "anywhere" augmented reality applications.

To overlay computer-generated data on the real world, the system has to track the pose of the camera in order to register it with respect to the real world. The level of realism of the augmentations is mainly defined by the accuracy of this pose estimation. The estimation has to run in real-time and is mainly based on advanced methods from the field of computer vision. To be able to derive the camera pose in real world coordinates, we assume that some known entities like 3D geometry or natural and fiduciary markers are present in the scene, and this knowledge then allows for overlaying computer generated data accurately at desired locations.

  

## 6.1. 3D Virtual environments

As part of T5.4, we are building virtual environments based on Tampere 3D models, where we embed real time tracked public transportation. The goal in visualization is realism, where both the environment and the moving entities such as buses would visually match with the real world.

The presented visualization (Figure 10) is indicative. It shows a 3D city model, a bus appearing from behind a corner and occluded buses (occlusion is here depicted with red colour). Also the bus line number is shown. Multiple visualizations will be tested, with varying information depending on available data. For example, if we knew whether or not the bus is on schedule, we could provide a visual indicator. Also contextual indicators will be tested, such as highlighting the bus that our user has his/her interest in.

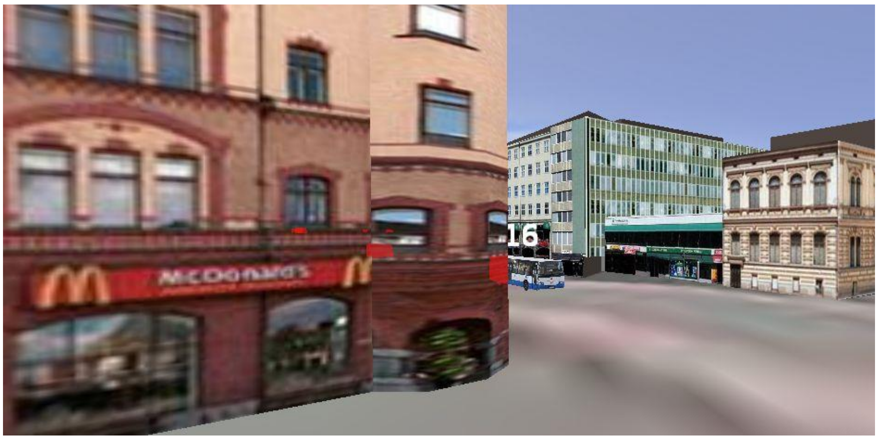


**Figure 10. Possible 3D Tampere presenting real time tracked public transportation.**

### *6.1.1. Use Case [AGI-3DMAP] – 3D Map*

*User category: Visitor*

*Trial level: Small scale research experiment*

> *Matti, a guy from Helsinki, Finland, is visiting Tampere for a quick meeting. He has just finished his lunch and planned a route to the meeting with the STREETLIFE app running on his tablet.*
>
> *Still running the app, Matti goes out, switching the app to 3D mode. The app, aware of his current position and orientation, shows a realistic 3D visualization of the city from his viewpoint, pointing out the bus stop he needs to go to (Figure 11). The stop is just outside the restaurant.*
>
> *Matti sees his bus number on the display with an arrow to the left. He chooses the 3D mode, which raises a bit as he lowers the screen, turning to the left. The 3D view, too, turns along with his bodily rotation. There he sees his bus, still behind buildings, depicted with just a red box and the number.*

*Matti moves to the bus stop and glimpses back toward the incoming bus, raising the tablet in front of him. The view is now lower, near street level. His bus is just emerging from behind the corner.*


**Figure 11. A possible use case of a 3D app pointing a bus stop (left) and visualizing an approaching real time tracked bus (middle and right).**

### *6.1.2. Requirements*

| Req. Idea | Category | Description | Use case |
|---|---|---|---|
| NAV-3D-R-1 | MUST | A sufficiently detailed, realistic 3D model of target area | TRE-3D |
| NAV-3D-R-2 | MUST | Real-time rendered visualization of the 3D city model on mobile devices (20fps or better) | TRE-3D |
| NAV-3D-R-3 | MUST | Free viewpoint for the virtual environment (i.e., not bound to ground level) | TRE-3D |
| NAV-3D-R-4 | MUST | Visualization of public transportation with realistic vehicles in their current position in the 3D city model | TRE-3D |
| NAV-3D-R-5 | MUST | Gesture and touch screen based interaction for the 3D view | TRE-3D |
| NAV-3D-R-6 | MUST | User positioning | TRE-3D |
| NAV-3D-R-7 | MUST | Attention management and visual emphasis for essential navigational entities: bus stops, buses | TRE-3D |

### *6.1.3. Specification (implementation ideas)*

| Impl. Idea | Category | Description | Use case |
|---|---|---|---|
| NAV-3D-S-1 | SHOULD | SIRI public transportation real time tracking network service | TRE-3D |
| NAV-3D-S-2 | MUST | Realistic 3D model of Tampere in VRML format with JPEG or PNG texture files | TRE-3D |

| | | | |
|---|---|---|---|
| NAV-3D-S-3 | MUST | Bus route and bus stop data (GTFS, Kalkati.net) | TRE-3D |
| NAV-3D-S-4 | MUST | Routing engine (integrating GTFS/Kalkati.net and OpenStreetMap) | TRE-3D |
| NAV-3D-S-5 | SHOULD | 3D engine capable of viewing large scale 3D urban environments and large numbers of dynamic content and entities. Implementation with C/C++ and OpenGL ES to allow case specific optimizations. | TRE-3D |
| NAV-3D-S-6 | MUST | Mobile platform capable of real time 3D graphics and networking; NVidia Tegra 3 or newer for CPU/GPU with OpenGL ES/OpenGL support; 3G/4G or Wi-Fi with TCP/IP using `sockets`. | TRE-3D |
| NAV-3D-S-7 | MUST | Mobile platform with spatial sensing capability (GPS/RTK; internal or external inertia sensor, magnetometer and accelometer). Android `SensorManager`. | TRE-3D |
| NAV-3D-S-7 | MUST | A user interface binding journey planning functionality to dynamic 3D visualization. Java UI on Android. | TRE-3D |

Virtual 3D environments pose further challenges for 3D interaction. We have earlier found out that manoeuvring in a 3D world is challenging, and there are several methods in aiding users. For this, one needs a suitable combination of metaphors, assisting functionalities and navigation constraints that match and support the navigation tasks. The following table specifies a required set of features.

| **Impl. Idea** | **Category** | **Description** | **Use case** |
|---|---|---|---|
| NAV-3DUI-S-1 | SHOULD | *Tracks* - Minimize micro-maneuvering. Restrict navigation space to a street network. Provide street names. | TRE-3D |
| NAV-3DUI-S-2 | SHOULD | *Orientation value* - Maximize view's orientation value. Orient downward when elevating, and upward when descending; when in tracks mode at street level, translate away from the opposing façade for a better view. | TRE-3D |
| NAV-3DUI-S-3 | SHOULD | *Speed adjustment* - Match motion with user's needs. Adjust speed automatically and smoothly based on elevation, being slower at street level and faster at sky. | TRE-3D |
| NAV-3DUI-S-4 | SHOULD | *View landmark* - Orientation aid. Trigger an animated view transition to present a landmark and the user's current position. | TRE-3D |
| NAV-3DUI-S-5 | SHOULD | *Change viewpoint* - Minimize micro-maneuvering. Scripted view level transition to three predetermined view levels (street level, rooftop level, sky) with automatic orientation. | TRE-3D |

| | | | |
|---|---|---|---|
| NAV-3DUI-S-6 | SHOULD | *Markers* - The main signage visualization method. Decrease cognitive load, enable targeted search instead of primed search. Marker arrows point at, for example, the start point and the target, releasing users from remembering the exact positions. | TRE-3D |
| NAV-3DUI-S-7 | SHOULD | *Fly-to-target* - A scripted action to fly to a target. If fast transition is needed, a smooth but fast fly is less disorienting than teleportation, and demands less from the user than manual maneuvering. Can be triggered with a double-click. | TRE-3D |
| NAV-3DUI-S-7 | SHOULD | *Orbit mode* - Aid for recognizing a target. View is locked towards a point, and controls are mapped to a cylindrical coordinate system, orbiting around the point. | TRE-3D |

## 6.2. Augmented reality with real time public transportation

Augmented reality is one mode of Advanced Graphical Interfaces being implemented in T5.4. In general, AR overlays graphics (virtual content) over the real world. In mobile AR, real world is presented by the camera feed of the mobile device, on top of which augmentations are placed. AR techniques depend highly on registration accuracy. Perceptual phenomena affect the experienced end result as well, with the known interposition effects being one of the most important (if the target is occluded, such as a bus being behind a building, the overlaid virtual content appears to be in front of the occluder, not the target)

In STREETLIFE, we utilize real time transport tracking interfaces, viewer positioning with GPS or RTK techniques, and viewer orientation with embedded or external orientation sensors. The success of the AR mode therefore depends highly on the accuracy of the available data. In the presented case here, the bus remains stationary on the end station, and is clearly in view, occluded only by two pedestrians.


**Figure 12. Augmented Reality with public transportation information (mock-up).**

### *6.2.1. Use Case [AGI-AR] – Augmented Reality*

*User category: local person*

*Trial level: Small scale research experiment*

*Ritva has left her car home today and is using public transportation. Her day at the office has ended, and she is returning home. She has checked the STREETLIFE planner for the return trip and is walking toward the central plaza where she got off her bus in the morning.*

*Ritva pulls out her tablet and points it at the plaza in the augmented reality mode, showing the camera feed of the device. There is a bus very close by, marked by the app. It is her bus, and she still has two minutes to get on board.*

### *6.2.2. Requirements*

| Req. Idea | Category | Description | Use case |
|---|---|---|---|
| NAV-AR-R-1 | MUST | Capability for public transportation routing | TRE-AR |
| NAV-AR-R-2 | MUST | Capability to mark navigational entities and journey instructions on the camera view of a mobile device | TRE-AR |

### *6.2.3. Specification (implementation ideas)*

| Impl. Idea | Category | Description | Use case |
|---|---|---|---|
| NAV-AR-S-1 | MUST | Bus route and bus stop data (GTFS, Kalkati.net) | TRE-AR |
| NAV-AR-S-2 | MUST | SIRI public transportation real time tracking network service | TRE-AR |
| NAV-AR-S-3 | MUST | Routing engine with real time tracking support (integrating OpenStreetMap and GTFS/Kalkati.net data) | TRE-AR |
| NAV-AR-S-4 | MUST | Mobile device with capability for augmented reality with networking connection. Android `Camera API`, 3G/4G or Wi-Fi with TCP/IP connectivity using or `Java.net.socket.` | TRE-AR |
| NAV-AR-S-5 | MUST | Mobile platform with spatial sensing capability (GPS/RTK; internal or external inertia sensor, magnetometer and accelometer). Android `SensorManager`. | TRE-AR |
| NAV-AR-S-6 | MUST | A user interface binding journey planning functionality to augmented reality. Java `UI.Fragments` on Android. | TRE-AR |

## 7. Mobile App Development (T5.5)

STREETLIFE mobile apps provide the fundamental tools and user interfaces for on-the-fly mobility management and assistance. Integrated back end services feed the mobile apps with full support for personalized, intermodal journey planning and on-the-fly situational awareness, where the app can alert the user on accidents with automatic re-routing suggestions. The app will also keep the users aware of their current level of 'greenness', guiding users constantly toward energy efficient mobility.

STREETLIFE apps will be developed on commonly available platforms such as Android phones and tablets. They combine features from tasks T5.1-5.4 into actual mobile apps, also utilizing components emerging from T3.2, T3.3, T3.4 and T3.5. Depending on available data on each site (Tampere, Rovereto, Berlin) and other site specific issues, these applications are localized to some extent. At the moment, we set up only very high level requirements for STREETLIFE apps.

| Req. Idea | Category | Description | Use case |
|---|---|---|---|
| APP-1 | MUST | Have support on a commonly available platform | ALL |
| APP-2 | MUST | Support at least one STREETLIFE Use Case or component as a standalone app | ANY |
| APP-3 | MUST | Be possible to be validated via either benchmarking or user experience | ALL |
| APP-4 | SHOULD | Follow the general STREETLIFE goal of leveraging green means of travel | ANY |

## 8. Validation

End-user applications or their limited features that are developed in this work package will be validated with two basic methods:

1. **Technical benchmarking**. The application or its limited feature, such as rendering speed or networking transmission efficiency, is benchmarked and analyzed for scalability, performance and technical feasibility.

2. **User experience**. The application or its limited feature is tested on users, measuring the feasibility or subjective acceptance. These tests may rely on quantitative or qualitative measures, depending on case.

STREETLIFE produces a range of applications and journey planners. Advanced research interfaces are present to investigate the possibilities of these new features in engaging users, leveraging greener means of travel and by simply making travel easier. There are fundamental open questions with these interfaces and features that need addressing in real world situations, such as depth perception of augmented reality view or spatial interaction with 3D worlds.

Several presented use cases have practical limitations. For example, annotating ordinary photos or 360º photos is not straightforward. To automatically place markers over navigational targets, both the accurate position and calibrated orientation of the 360º photo need to be available, along with accurate navigational target positions. In general, such information is not available, or is inaccurate, depending on the originating source.

Separate controlled experiments need to be conducted for selected features to better understand to which navigational tasks they are most suited for and what is their value to the travellers. In general, these selected advanced features will not be present in large scale pilots, but the results will be utilized by exploiting partners in their plans for advancing their products to new levels. For those features that are included in City Pilots, the pilots themselves act as main validation tools.

# 9. Conclusion and future

We have presented selected features for end-user applications that exceed the current state-of-the-art in commonly available journey planners and mobility apps. These features, along with components developed in T3.2, T3.3, T3.4 and T3.5 are combined to actual mobile apps in T5.5. Depending on the case and maturity of given technology, these apps will be tested in small scale experiments or in the City Pilots themselves.

Actual application logic and user interface designs will be defined and reported in D5.2.1, D5.2.2 and D5.2.3. These Deliverables will also provide validation results for the developed features and integrated end user apps.

## APPENDIX A: LITERATURE

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