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FP7-SMARTCITIES-2013

STREETLIFE

Steering towards Green and Perceptive Mobility of the Future

WP8 – Impact Assessment & Simulations

Revised D8.2.1 – Achieved Impacts (initial)

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EXECUTIVE SUMMARY

In this revised version the following chapters have been adjusted with respect to the concerns expressed by the EC review report and further oral consultations:

- 2. Selected Generic Cities
  → 2.1 Large City – The Berlin Case
  Stronger focus on applied/available solutions and new additions, such as gamification.
- 3. Impact On User Behaviour
  → 3.2 Assessment of evaluation results
  Clearer derivation is given from local surveys (WP6), integration and benefit of gamification on changing users behaviour
- 4. Impact on Traffic Systems
  → 4.2.1 Simulation-based approach
  Clearer description of approaches and simulation, specification of applied assumptions
  → 4.3 Large city Impact Assessments
  Elaboration of results, derivations and improved tables and figures, information of baseline considerations
  → 4.3.1 Conclusion
  Outlook to be added how to properly define best possible user group sample, involve and engage more users in order to base 2nd iteration's simulation on field data
- 5. Impact on Carbon Emissions
  → 5.2 Research Approach
  Justification and description of simulation-based approach as in chapter 4
  → 5.3 Assessment of impacts for large cities
  Restructured (introduction, methods, results) and completely revised/enhanced, tables and figures to be improved
- 6. Conclusions revised

In this revision of D8.2.1 from the 25.02.2016, only the Berlin part of the report has been revised – in accordance with the EC expectations.

The core objective of WP8 is to deliver results on impact assessment of the proposed ICT solutions in terms in the transport related categories i) User behaviour ii) Mobility and iii) Environment in order to derive useful guidelines on mobility strategies for Smart Cities of the future. As representative cities Berlin, for a large city, Tampere for a medium-sized city and Rovereto for a small city were selected. The more generic approach was chosen in order to address a larger audience.

Based on the cities shortcomings, objectives were defined dealing with solutions coming from the ICT sector. These solutions were implemented and tested in a first iteration to finally assess the potential impacts in terms of the above mentioned impact categories. Therefore the present deliverable D8.2.1 – Achieved Impacts reflects the initial assessment on achieved impacts based on the results of the 1st iteration of field test trials conducted at three representative cities.

Due to the existing preconditions at the different pilot sites it was necessary to adopt different approaches, methods and tools to cover the relevant objectives.

With respect to the impact assessment of i) User behaviour it can be stated that people provided with an intermodal App are more willing to change mobility behaviour while changing their mode choice, as long as alternative “green” transport means are available. It could be observed independently from the App tested, that also different modes were combined more easily due to the information available.

The impact category ii) Mobility shows good results as well. In all cities the modal share could be changed in the envisaged way. In Berlin a simulation-based approach was used to calculate the effects. The results show that share of cycling can be increased by 5% if cycling becomes more attractive. Specifically people who are travelling mid-range trips (<7 km) are more willing to enhance their trip radius. At the same time it could be detected that the mode share for car decreased by 4%. In Tampere interviews were held with traffic managers in order to discuss the impact on the transport system. The discussion showed that STREETLIFE is heading into the right direction. The integration of multiple real-time information was assessed as very useful as these information´s feed into a single service and provide the End Users a great amount of information. The user will be enabled to plan their trip and adjust it depending on accidents or other unexpected events along the road. One of the next steps will be to make the App itself more attractive to accelerate the use of the system by a larger user group. Then, the impact on the traffic system and mobility behaviour can be much bigger. Focussing on the small city Rovereto, the STREETLIFE solutions provides the user a raising level of awareness and information about sustainable mobility service available in a small city. That results in clearly reduced impact on the city traffic system. The trials showed that gamification together with a policies framework about 25,000 car-driven Kilometre every day could be saved if all commuters would use the App for their trips.

With regard to the impact category iii) Environment the potential effects of STREETLIFE on carbon emissions have been assessed. The results receive provide a preliminary picture and underline the positive estimation. In a large city as Berlin about 500t out of 7.5mt could be saved per day for the overall transportation system. The carbon emission savings of a medium-sized city like Tampere are ranging in an area about 8t CO_2. For the small city Rovereto the results concerning carbon friendly trips illustrate similar results. Almost a reduction of 6% CO_2-emission compared to the baseline could be achieved. There was a constantly decreasing carbon emission by finally a saving of 4,4t of in a day.

The impact assessment shows that ICT solutions can have real impacts in the transport related categories i) User behaviour ii) Mobility and iii) Environment. STREETLIFE could demonstrate that a change in the mobility behaviour can be realized with direct effects on reduced car-kilometres and a decrease in carbon footprint of a user for certain origin-destination relations (OD).

The overall test setting for the city of Berlin included reliability of route request and data storage as well as testing the hypothesis. A first analysis of the acquired data will provide insights into possible changes in the trial setting and system improvements for the second iteration.

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D8.2.1 – Achieved Impacts (initial)

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ABBREVIATIONS

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	Graphical User Interface
IPR	Intellectual Property Rights
MGT	Management
MMIR	Mobile Multimodal Interaction and Rendering Framework
MiD	Mobilität in Deutschland
MS	Milestone
OS	Open Source
OSS	Open Source Software
OD	Origin Destination (relation)
P	Prototype
PT	Public Transport
PU	Public
PM	Person Month
R	Report
ROV	STREETLIFE Rovereto-Pilot
RTD	Research and Development
SL	STREETLIFE
TAM	Technology Acceptance Model
TAPAS	Travel-Activity PAttern Simulation
TIC	Traffic Information Center Berlin

TRE	STREETLIFE Tampere-Pilot
UI	User Interface
WP	Work Package
Y1,2,3	Year 1,2,3

PARTNER

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 Ingegneri - Urbanistica
Rovereto	Comune di Rovereto
TSB	Berlin Partner for Business and Technology
Tampere	City of Tampere
Logica	CGI Suomi Oy
VMZ	VMZ Berlin Betreibergesellschaft mbH

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1. INTRODUCTION

1.1. Intended audience

The intended audience of this deliverable are local stakeholders, like local authorities, traffic planner and manager with a special interest in the impact assessment of ITS solutions providing integrated urban mobility system enabling carbon reduction by managing different kinds of transport modes. In order to promote greener transport a soft approach to smart mobility is going to be developed by reusing existing mobility resources and exploiting advanced ICT solutions. Exemplary three cities have been selected which differ in their size and which have identified different shortcomings in terms of their transport system. These cities will be serve as representative were different ITS-based solution address the identified shortages. A comprehensive evaluation plan with related test activities will provide insight into potential benefit with regard to the set objectives.

1.2. Document structure

Chapter 1 - Introduction

In chapter 1, the core concept and the deliverable objectives are defined. The link between the Evaluation Plan and the city pilot's evaluation is given. In order to recap the activities and experiments conducted in the pilot´s an overview table is provided. Finally, the frame of the impact assessment and the constraints we had to deal with are summarized.

Chapter 2 - Selected Generic Cities

In chapter 2, we describe the representative cities by classifying them according to their sizes and certain mobility and transport statistics. In the framework of investigation criteria have been set up to better allow local authorities to compare their city with the research city. After describing the relevant transport statistics, the local shortcomings in terms of transport as well as the technology and services in place are described. Finally the identified solutions are discussed which are the basis for impact assessment.

Chapter 3 - Impact on the user behaviour

In chapter 3, the user behaviour impacts with regard to the STREETLIFE system are discussed and assessed. User behaviour assessment is one of the major aims as user acceptance and willingness to use the provided solution has a vital effect of other impact categories. Since the assessment is mainly based on the use of questionnaires, the method will be described in detail.

Chapter 4 -Impact on the traffic system

Chapter 4 discusses the impact of the STREETLIFE solution in terms of traffic. As passenger cars are still the most import transport mode, the major aim of this assessment is the analysis of potential effects of STREETLIFE in order to change the mobility behaviour. Demand shifts between transport modes can additionally have a strong effect on carbon emissions. Therefore, it is worthwhile to look at the effects on a transport system if alternative transport modes become more attractive as valuable information are always present.

Chapter 5 – Impact on the carbon emission

Chapter 5 provides an analysis and assessment of the important sustainability impact category Environment – addressed in STREETLIFE as impact on Carbon Emissions. Special focus is given on the reduction of carbon emissions through sustainable urban mobility solutions as implemented in STREETLIFE. Location specific answer is provided according to the potential extent of decreasing the carbon footprint of individuals and the carbon emissions within a city caused by land-based transport.

Chapter 6 – Conclusion

In chapter 6 a conclusion of the impact assessment is given. Based on the first iteration of the project field trials we provide a conclusion of the initial assessment of the STREETLIFE solutions in the impact categories: i) User behaviour ii) Traffic System and iii) Carbon emission. In order to assess the results we consider also the background and related limitations of the first iteration and impact assessment.

1.3. Concept and deliverable objective

The core objective of WP8 is to deliver results on impact assessment of the proposed solutions in terms of end-users behaviour, traffic and reduction of carbon emissions to derive useful guidelines on mobility strategies for smart cities of the future.

The assessment is based on the results of the first iteration of field test trials conducted at three pilot sites. Detailed information of the first field trial iteration can be consulted in D6.2.1 City pilots planning and evaluation results (initial) and D7.1 – City pilots' execution results (initial).

The entire evaluation and impact assessment approach is based on the STREETLIFE deliverable D8.1.1 'Evaluation Plan'. In close cooperation with the pilot evaluation manager the pre-conditions of the pilot sites were considered and the evaluation and assessment approach selected. Based on the objectives, the research questions, hypotheses and success criteria defined by the pilots, an assessment of the potential impacts has been conducted. Methods and tools are described in the relevant section. With regard to the affected impact categories for sustainability i) Society (impact on user behaviour), ii) Mobility (impact on traffic system) and iii) Environment (impact on carbon emission), impacts have been assessed. Different methods were applied to cover the relevant objectives. Due to the existing preconditions at the different pilot sites, it was necessary to adopt different approaches.

The table below summarizes the experiments and activities conducted at the three cities in order to evaluate the implemented system. These experiments are taken as basis data set for the impact assessment of STREETLIFE first iteration. A more detailed overview can be consulted in deliverable D6.2.1.

Table 1: Overview of experiments of STREETLIFE first iteration

Location/Experiment	Description
BER-EXP-1 Usability Test of Berlin App	
During iteration 1, within BER-EXP-1 the usability of the Berlin STREETLIFE App (SL App) has been assessed with usability experts. The experiment was separated into three parts. The first was dedicated to technical and usability aspects of the App; during the second a stronger focus was laid on qualitative applicability investigations, while in the third in-group discussions main results and feedback have been discussed and harmonised. The results of BER-EXP-1 have been taken into account for the deployment of the Berlin STREETLIFE App, which was intensively used during the BER-EXP-2. According to the work plan, during the second iteration the BER-Pilot extends the number of functionalities which involves a significantly higher number of public use	
BER-EXP-2 Berlin Field Trial – App Testing and User Acceptance Study	
Experiment BER-EXP-2 of iteration 1 consisted of two closely linked parts. 1st: GPS tracking of “friendly” users without using the SL App for the adaptation of the mode validation component of Siemens to suit the BER pilot conditions. 2nd: the usage of the SL App, including inter-modal routing with a new safe biking component, a completely newly developed gamification approach as well as GPS tracking. 12 users took part in this field trial, carried out as laboratory and usability tests and small scale field tests. This was accompanied by a user acceptance and take-up survey, which has been performed twice – at the end of the baseline (t0) and at the end of the treatment (t1) phase. In the preparation of iteration 2, the functions of the Berlin App have been tested additionally by approx. 50 users.	
ROV-EXP-1 Park & Ride for Commuters	
The first experiment involved 40 public users for 5 weeks between November and December 2014, and the technical solutions tested were the routing App “ViaggiaRovereto”, the Bike Sharing App “Rovereto Bike Sharing”, the implementation of the gamification engine in the Rovereto Green Game.	
ROV-EXP-2 Park & Ride for Special Events	
The second experiment involved an open field of tourists coming to town for the Christmas Markets, and took place in 8 days during December 2014. The STREETLIFE technical solutions tested were the same as in ROV-EXP-1 with the exception of the gamification engine. The feedback for evaluation in both experiments was collected through questionnaires to end users, log files from the routing app for mobility behaviour and log files from the Conta Parcheggi App for occupancy rates.	
TRE-EXP-1: Focus Test Group pilot (FTG), group of friendly users	
In this experiment the SL- system was integrated and set up on existing technologies and investments of the City of Tampere, which already has their Intelligent Transport Systems in place. The focus test group was set up by first selecting a suitable target group from the	

stakeholders. Many of the focus test group users came from the active public-private ITS Factory community in Tampere region.
TRE-EXP-2: Public Pilot, general public to also assess stability and scalability
Safe, personalized and real-time routing solution covering all modes of transport to achieve the best experience during the entire travel, thanks also to advanced user interfaces. The public pilot was engaged one month later by opening the STREETLIFE service to all users and by promoting the service in local magazines and internet channels, most notably in the official public transit service pages of Tampere city. During the first month, the public pilot got 3,381 users. Tampere Pilot experiments were evaluated using the following methods: Pre/post questionnaires, service monitoring and usage statistics, end user feedback and interviews with Tampere Traffic Planning authorities.

The impact assessment faces a complex task since various objectives are combined with the different implemented STREETLIFE components and systems. The challenge which the impact assessment faces is that there is not a unique stand-alone STREETLIFE system but rather different instantiations and deployments of the system exploiting and customizing STREETLIFE components according to pilot-specific needs and objectives. Therefore, the evaluation of the implemented systems had a different focus at each city. Practically, the Rovereto pilot focused on a Park&Ride information system with its impact on user behaviour, traffic impact and carbon emissions. In this regard, detailed data were acquired with different methods in order to evaluate the system in the mentioned impact categories.

As the Berlin pilot objective was mainly to enhance an existing system and bring a new user interface (STREETLIFE App) into play, the focus was on a proof-of-concept. Therefore, only a small number and only “friendly” users were taking part in the first iteration trials. In order to estimate the potentials of the new developments realized in STREETLIFE, a simulation has been carried out, comparing the Baseline Scenario with the STREETLIFE Scenario. For the second iteration, a number of measures have been put in place in order to significantly enhance the number of users and to collect data for a sample-based calculation of effects. During the functional tests of the App for iteration 2, approx. 50 users registered and provided feedback for optimization.

In addition to that, the pilot field trials were only running for a short time. That limits the assessment of the potential impacts as changes in the mobility behaviour or travel activity patterns are long-term changes.

In order to address a larger audience we defined generic cities of three different sizes, discuss the local situation, the identified transport shortcomings, and addressed solutions. City authorities from any city will be able to compare their city with the representative generic city and exploit the information presented in this document as valuable input for future decisions in this regard.

In the course of the report concepts of **mono-modality, multi-modality and inter-modality** will be used. **Mono-modality** means the usage of only one mode of transportation for a single trip. **Multi-modality** is referring to the usage of different modes of transportation in general, but no combination of transport modes within a single trip is considered. For **inter-modal** trips, different modes of transportation are being and combined. In the STREETLIFE Berlin pilot an inter-modal planning tool (SL App in combination with Siemens IMP) is being used which instantiated mono-modal routers in order to combine results for trip proposals integrating different modes for one single trip.

2. SELECTED GENERIC CITIES

2.1. Large City – The BERLIN Case

In order to adequately classify a large city certain mobility and transport statistics are required to describe the framework of investigation. The following statistics are based on the Berlin Senate Department of Urban Development and the Environment [SenStadtUm 2013]. About 3.4 million inhabitants are living in Berlin. They have about 1.2 Million cars, 500.000 bicycles, 90.000 motorbikes at their disposal to be used on about 5.300 kilometre public roads. On average each inhabitant makes three trips per day lasting about 70 minutes. The share of walk and cycling is almost as high as the share of car driven trips. Therefore, the political importance of no-motorized transport planning is high. In this regard walk and cycling specific transport strategies have been developed. Those results in more than 1.000 km cycling paths from which 662 km are constructional cycle paths and 174 km cycling paths marked on the road.

Several measures are continuously considered to allow incident free and sustainable in order to achieve a sustainable transport system. Aside from building up new roads during the past years, a number of regulating measures have been implemented, such as speed limit reduction to 30 km/h in selected sections on main roads during the night due to noise emissions. Another 372 km of main roads have also a speed limit of 30 km/h in the daytime due to safety reasons. Altogether about 17 % of the main road network in Berlin has at least a part time reduced speed limit. Additional an extension of the parking space management area has been continuously realized.

In terms of public transport Berlin possess of a well-organized network. Regional trains, City trains and Metro, light rails and busses have a network length of about 1.900 km. Altogether there are more than 3.100 stops used by yearly 937 Million passengers.

Regarding safety there are still 130.000 transport related accidents on Berlin roads with about 10% person injured. Although the number of injured caused by accidents has been reduced by 23% in the last 20 years, the accident risk by traveling with bicycle or walk is high. 30% of the accidents involved people were going by bike although only 13% of all trips are realized by bicycle.

2.1.1. Identification of local shortcomings in terms of transport

Although Berlin can be denoted as a car-oriented city it observes a growing demand in public transport (PT) and cycling. In this regard, the Berlin authority considers and supports the increasing number of bicycles within the city strategic infrastructure development plans and aim to further increase the usage of bicycles and public transport as green modes of transportation. Appropriate street infrastructure developments are foreseen to enable cycling and intermodal “Bike & Ride” mobility together with PT opportunities. On the other side, Berlin has an alarming accident statistics with about 1.752 badly injured and 27 cyclists killed in the three year period (2009- 2011) [Pol 2001]. This shows that broad activities are required to improve safety, enable, and promote cycling within the city. The traffic management with its monitoring and control activities affects currently the traffic situations mostly on a reactive level, such as providing warnings by radio or displaying updates on congested roads on information screens along the roads. Even rerouting suggestions are only general. Particularly, cycling specific information will not be provided like information for public transportation and private motorized vehicles like cars.

In this sense, new approaches are required to be able to sustainably change the mobility behaviour in terms of greener transport and safer traveling.

2.1.2. Identified solution

Following the Berlin policies, the following objectives have been defined for the BER STREETLIFE pilot:

i. Strengthen the modal shift to green modes of transportation and reduce carbon emissions

- By facilitating access to trip planning and execution
- By providing improved and easy to use intermodal information
- By enhancing the awareness of carbon footprints, related to each individual trip

ii. Strengthen in particular the usage of bicycles

- By providing safety related information
- By including gamification elements into intermodal routing in order to attract more users and
- By integration of bike sharing options into intermodal routing.

In order to realise these objectives, a valuable solution was developed and implemented in STREETLIFE, with the following functions:

1. Intermodal routing recommendations are provided to the traveller in Berlin by a completely newly developed STREETLIFE Berlin App. It provides routing recommendations for all modes of transport, i. E. Public Transport, safe cycling, bike sharing options, walking and car, for both, single-mode routes as well as intermodal routes, according to the selected user settings.

2. All route recommendations include related carbon footprints in order to enhance the awareness and convince the traveller to shift to green modes of traffic.

3. Routing for bicycles includes newly developed safety functions. Based on an in-depth evaluation of police accident statistics from the last years, the bicycle accident hotspots in Berlin have been identified. This geographic information has been included into the routing system and the user can request recommendations which avoid these cycling accident hotspots.

4. A gamification approach has been developed and integrated. A biking competition will be launched during three months of the second iteration field trial, starting at the beginning of March 2016. Hereby, gamification elements such as community building, competition and virtual/real incentives will be used in order to gain the participation of a significant number of public users. The gamification approach is based on several new

and further developed components and functions implemented in the framework of the STREETLIFE Berlin pilot, on both, backend side (CIP), such as

- Data base and data model extension, e. g. to include GPS tracking data
- User management
- Mode validation tailored to suite the Berlin pilot
- Gamification component including high score calculation, incentives management, winner management
- Interaction with the SL App, providing information on requests

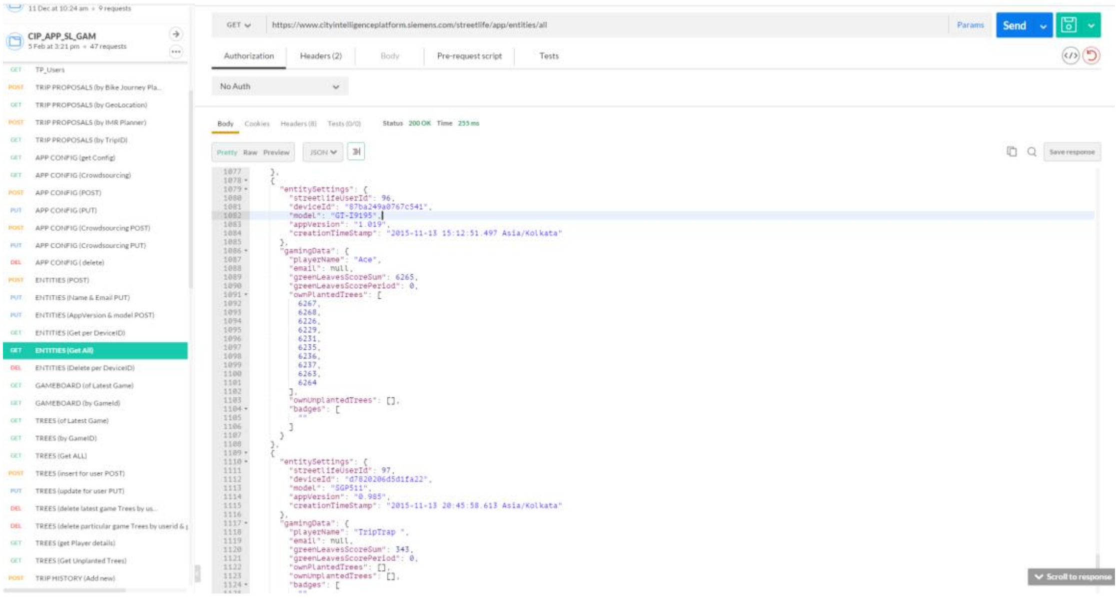

Figure 1: Example of CIP backend services for the gamification functions: user data management

As for the BER App, the following has been defined:

- Collection of tracking data with a new module
- Communication with CIP
- Visualisation of bicycle hot spots
- Visualization of high scores, current and previous game periods and gamification map
- Crowd sourced data collection in the framework of the gamification approach (user feedback)

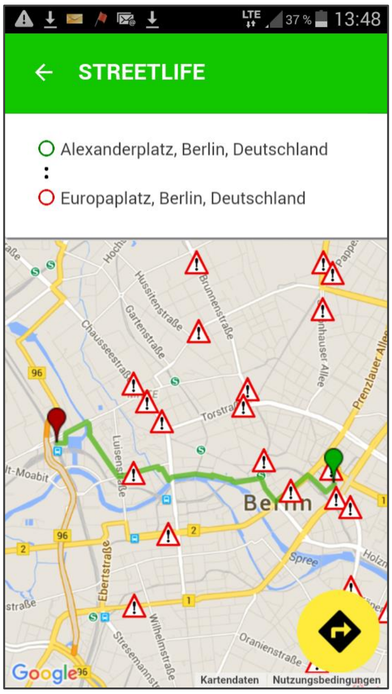

Figure 2: Safe Biking Map (accident hotspots warning) of Berlin shown on the App UI

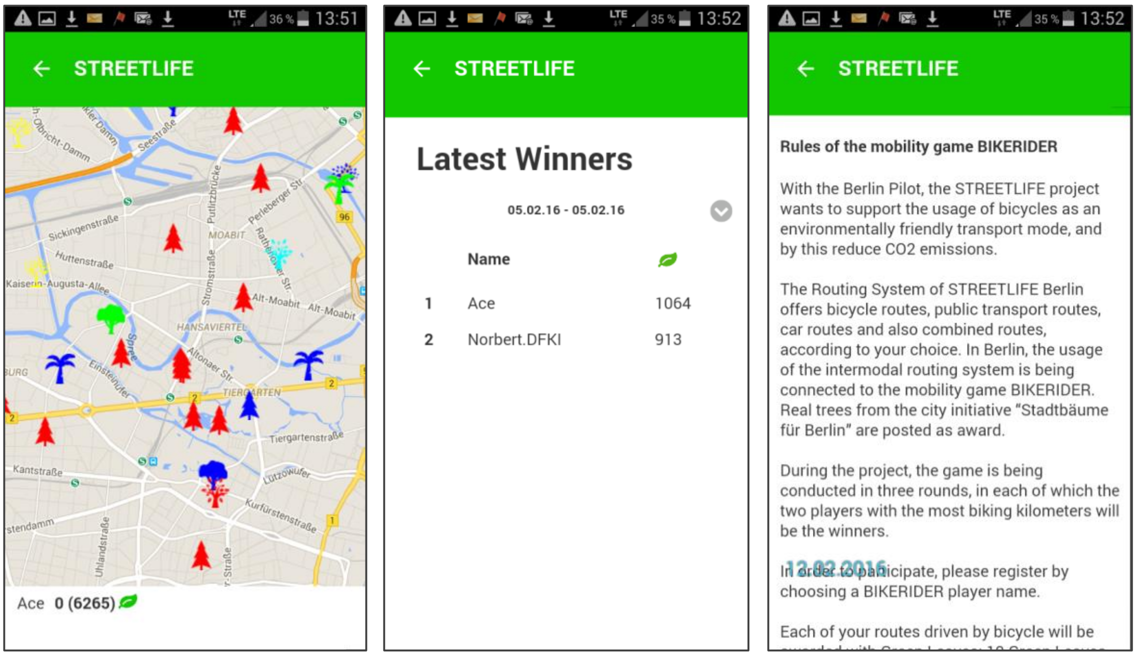

Figure 3: App UIs dedicated to gamification: virtual tree map, high score and rules

2.1.3. Technology and services in place

The BER Pilot involves components already available in Berlin as well as several new components/functions, developed in STREETLIFE. The system has been designed to be able to handle a large number of users.

The main actor for providing traffic information on behalf of the City of Berlin is the Berlin Traffic Information Centre (TIC Berlin), operated by Siemens VMZ. In regular operation, the TIC Berlin currently offers multi-modal routing services to the public. For this purpose, the TIC backend system integrates external as well as own routing services for public transport, biking, walking and car to a multi-modal router.
If – according to selected preferences - more than one modal route is possible, different suitable route recommendations are presented. The router also considers available real time traffic data that may have an impact on the trip results: Car routes take into account the current traffic situation (Level of Service - LOS[7]), as well as construction sites and road closures or similar events. Public transportation routes consider the real time departure times, including delays and further related information.

For STREETLIFE, the multimodal router has been further developed to provide safe biking routes based on accident statistics as well as bike sharing options.

In terms of frontend services, a completely new smartphone application for Android has been developed by DFKI. Under consideration of the findings from field tests, the generic end-user workshop and functional tests after iteration 1 tests with approx. 50 users who provided direct feedback to the developers, it has been further improved in terms of usability and functionality. The SL App enables the user

- To enter an intermodal route request
- To access different recommendations according to selected preferences
- To use the route companion mode with bike safety hotspots,
- To use gamification functions such as user data input, high score access, virtual incentives map and
- To provide feedback via crowd-sourced data collection.

The communication between the App and the intermodal routing is carried out via the City Intelligence Platform CIP, operated by Siemens. CIP is also in charge of

- Data storage for evaluation
- Data storage for the gamification
- Gamification backend services like user management, high score calculation and incentive management
- Mode validation based on real tracking data.

[7] Level of service divided into “no delay”, “moderate delay” and “severe delay”

The following figure shows the high-level architecture of the BER pilot with its technical components.

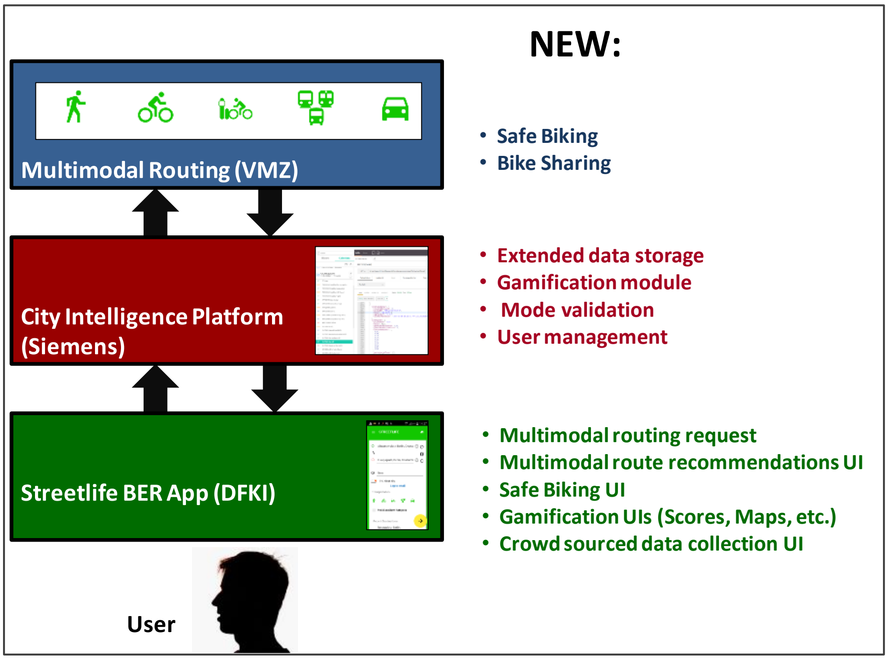

Figure 4: Components of the BER pilot STREETLIFE system

2.2. Medium City – The Tampere Case

2.2.1. Description of local situation by using statistics for the three cities

Tampere is a medium size city with 221,000 inhabitants (369,000 if the surrounding co-operating traffic region is included). The public transit system is well organised and heavily relies on bus traffic organized by the city. Tampere's local bus transportation includes over 60 main routes and 3,000 transit stops. It serves over 80,000 passengers per day on the average.

The general opinion about the public transit services is quite favourable: in a recent survey, citizens ranked it as 'reliable, friendly, pleasant, clean and environment friendly'. Nevertheless, there are plenty of challenges ahead. Historically, Finland is sparsely populated country and this can still be seen even in urban areas. In this context, a private car has been and still is a natural choice for transportation. About one-half of daily trips are currently made using private motorized vehicles; it is therefore fair to state that traffic in Tampere is clearly car oriented. The number of registered motor vehicles in the beginning of the year 2014 was:

- 98,038 total, of which 90,238 are cars
- 88,366 passenger cars
- 7,800 motorbikes
- 424 micro cars
- 1,448 other cars

Today, the city is systematically supporting development towards denser, more efficient urban population structure, which would in turn allow more efficient public transit services. However, this development will require long time before it has significant effect on transportation. As a medium size city, Tampere has a limited set of solutions available when planning new means of transportation. Subway is clearly out of scope, but tramway is currently under active planning and seems to be a plausible solution.

Tampere includes 700 km of road/street network. A considerable amount of main streets in the city centre are nowadays reserved for pedestrian, bicyclist and public transit use only. The city is aiming at reducing street parking, whereas underground parking arrangements are proceeding steadily. Currently there are about 4,000 parking places available in dedicated parking sites in the city centre; this can be considered to provide a fair, up-to-date parking capacity. But despite of relatively sparse population and good parking arrangements, private car traffic also faces problems. Tampere city is located on a narrow ridge between two lakes. This geographic fact inevitably creates some traffic bottlenecks especially during rush hours. Another factor which emphasizes the rush hour problems is concentration of working places into certain hot spots. These geographic issues naturally affect and challenge public transit services, too.

The city is nowadays strongly promoting bicycling and walking. Bicycling covers only 6 % of traffic, so there is certainly a good reason and chance to develop this means of transportation. There is about 850 km of km bicycling and walking paths inside the city area, and 186 bike parks. The current accident rate for walking and bicycling is 75.4 injured and 1.6 dead per year. Tampere is continuously improving the conditions for these lightest means of transportation, but the situation is still far from good: bicycling routes are not the best possible, there are connectivity problems, quality issues with route surfaces, poor safety in intersections with road traffic, and only part of routes are maintained continuously during the winter. Briefly: road network is designed for cars, and bicyclists are second-class citizens. Anyway, it is fair to note, that the climate in the north will set some natural limits and bias the traffic towards motorized vehicles.

2.2.2. Identification of local shortcomings in terms of transport

Traffic in Tampere is private car –centric and often congested during rush hours. The share of public transit – 19 % of all traffic – is low and should be increased, as well as the low rates of walking (25%) and bicycling (6%). The city aims at reducing private car traffic from the current 50% down to 46% by the end of 2016.

Public transportation has capacity problems during rush hours, especially in the morning. It is difficult to increase capacity and keep the cost efficiency high at the same time.

The available means to control and guide the traffic to distribute it more evenly, both spatially and in time dimension, and hence reduce congestion are limited and slow.

2.2.3. Identified solution

Generally speaking the following solutions will mitigate the shortcomings above.

- Long term policy to support bicycling and walking by improving the related infrastructure

- Improved public transit services will reduce private car traffic
- The new regional traffic system makes public transit more attractive, easier to use and suitable for a wider range of trips. More neighbour cities are joining to it. This will improve capacity and efficiency.
- More dedicated traffic lanes for public transportation are being planned
- New solutions for ticket faring are under consideration
- Integrated multi-modal routing service supports other developments of public transit services and helps in utilizing them efficiently
  - This service was the focus of STREETLIFE Tampere pilot phase I.
- New technologies such as real-time monitoring of utilization rate are becoming available; these can be integrated into the routing service to provide even more optimal user experience

To reach the overall objectives it was identified the need to encouraging commuters to shift more to public transport by providing passengers with better information: real-time and Park&Ride information which helps trip planning and execution. In addition, regional datasets were integrated to help regional travelling. People changing to public transport will reduce carbon footprint and help reducing the congestion.

2.2.4. Technology and services in place

Key objective for the STREETLIFE pilot in Tampere was that it integrates and builds on existing technologies and investments the City of Tampere already has made in their Intelligent Transport Systems. By better integration of existing systems, we can provide better information to end users.

Existing IT services integrated into the new STREETLIFE real-time routing service:

- Bus schedules
- Train schedules
- Multi-modal journey planner
- SIRI real-time bus tracking and estimates feed
- Datex II Parking places and their status
- Background map services
- Street / road network data sources
- Street address data

The STREETLIFE multi-modal journey planner included a mobile, easy to use front-end application, which is compatible with all HTML5 capable Internet devices. Through integrations it got real-time information, gives better information to passengers and covers the whole region. It maximized ease of use by offering a personalized set of route alternatives and by searching regular real-time based updates on presented itineraries automatically.

2.3. Small City – The Rovereto Case

2.3.1. Description of local situation by using statistics for the three cities

The small city case is based on Rovereto[8]. According to the last available statistics of 2013, the city counts about 40,000 inhabitants, almost 22,000 cars and 4,500 motorcycles. On average, each two inhabitants, one owns a car and one out of ten citizens has a motorcycle[9]. This rate in the last period (2007-2011) had decreased, thanks to population growth in the same time frame. Concerning the modal split, in 2011, the share of walking is about 4%, cycling is 14%, public transports reach 22%, while the percentage of trips travelled by private vehicles is 59%.

In terms of cycling infrastructure, now, the city is provided with more than 30 km of bicycle routes and in the future the total length of bicycle network is foreseen to be almost 75 km. In addition, in September 2014, Province of Trento together with city of Rovereto launched a new bike sharing system with more than 10 stations; the first data about utilization rate is good. The number of bike withdrawals passed from about 2,100 to 1,400 in January. This is a normal and expected variation related to the classic drop in temperature in the autumn season.

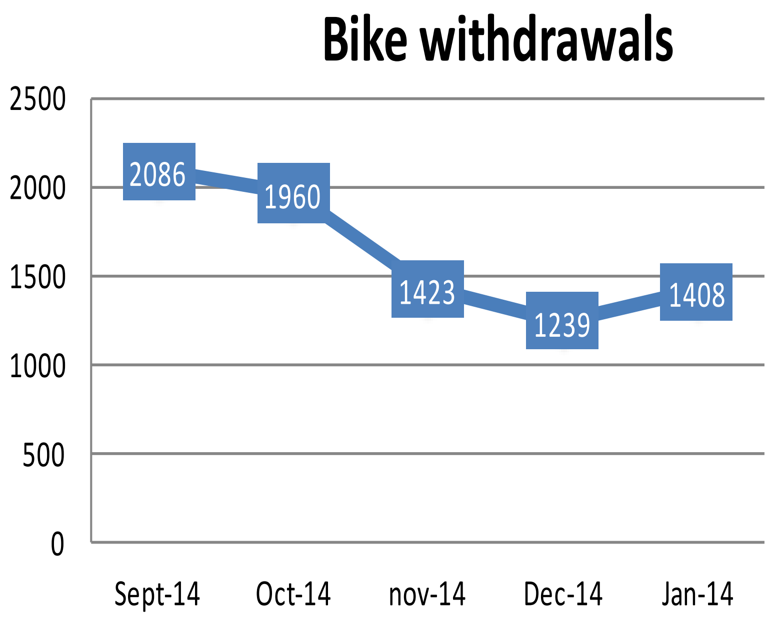

Figure 5: Number of bikes withdrawals from bike sharing service

[8] The following statistics are based on official public local and national authorities.

[9] Statistics about number of private bicycles in Rovereto are not available.

Concerning the traffic flow, vehicles circulating on road network had been detected from January to February 2011. Analysis shows two peaks, one in the morning (7.30-8.30) and one in the afternoon (17.30-18.30). From data collected, it was possible to develop a specific origin destination matrix for Rovereto. The total number of vehicles going in and out of municipal boundaries is 92,700 per day, split in half between vehicles leaving the city and vehicles entering it. If we consider the number of vehicles going in and out from the city centre, this number grows to 107,400 per day, showing a great traffic pressure. It has to be stressed that this area is affected by a great parking pressure as well. In fact, the amount of parking slots in the city centre is almost 5,600, but in the morning peak hour (from 10.00 until 12.00[10]) 84.30% of them are occupied.
Referring to heavy-duty vehicles, the percentage of trucks detected on the road network is about 5% and is uniform considering the incoming and exiting flows, but it considerably changes in relation to the section of the street, even reaching a maximum of 20% of total vehicles.

In order to ease the traffic burden on the city centre, the municipality, according to the Urban Mobility Plan, has pinpointed 22 areas that could be transformed in the so called "isole ambientali", that correspond to Zone 30 or "home zones" in other European countries. These areas are designed to meet needs of pedestrians, cyclists and residents and streets allow a maximum speed of 30 km/h. Apart from these projects, it has to be considered that the city already has a "zona a traffico limitato" (restricted traffic zone) where cars need a special authorization to enter and pedestrians and cyclists prevail over other vehicles; moreover in several streets maximum speed has already been reduced to 30 km/h.

These actions aim to increase safety conditions, but further improvements need still to be implemented. Indeed, if we examine the 2006-2010 period, previous to the described interventions, there were 1,575 accidents with 706 injured people and 2 died. The map of the accidents shows that many of them occur in the city centre. The involvement of pedestrians and cyclists implies high costs and reduce the impact of slow mobility policies, because the people are less inclined to walk and cycle in streets they do not feel as safe contexts.

In terms of public transport, from 2011 the bus service involves Rovereto and nearby municipalities as well. In 2012, 1.2 million km has been travelled (Source: Trentino Trasporti) and almost 4.6 million passengers used the service. The policy that extended the public transport coverage area beyond the municipality boundaries has led to a 5% increase in terms of passengers.

2.3.2. Identification of local shortcomings in terms of transport

Despite the small size of Rovereto in comparison to other European municipalities, the city is exposed to a significant traffic pressure especially in the city centre. Moreover, in this area parked cars occupy high valued space that could be used by pedestrian and cyclists. Indeed the occupancy rate of parking areas in the city centre in certain zones reached the 90%, and this condition generates additional traffic related to cars travelling and looking for a parking slot.

The municipality is taking actions to create strategic parking lots outside the city centre, but,

[10] The time band 10-12 a.m. is the default period usually considered to evaluate occupancy rate in parking areas in ROV.

now, the city lacks proper park and ride areas. In the southern part of the city there are no parking areas connected to the city centre, while in the northern part there is a large parking zone, but in order to transform it in a real park and ride area bike sharing and public transport services should be enhanced.

On the other side, mobility management policies should be strengthened to control and improve congestion during the peak hours. The municipality could plan and manage home-work and home-school trips, the two big components of traffic in a small city like Rovereto. For example, the use of car sharing and car-pooling services could be promoted or intermodal transport should be pushed among commuters who routinely travel to the city centre.

Another issue related specifically to Rovereto urban form is the concentration of congestion and pollutants on the traffic routes along the north-south axis. This particular configuration needs special actions; some infrastructural interventions have already been implemented (roundabouts, elimination of traffic lights, etc.), but other more expensive operations need still to be completed. In addition, the proximity of the city with a highway determines high values of carbon emissions along the north-south axis.

Lastly, the small dimension of the city implies more challenging efforts to make citizens change their habits. Indeed, a small city for its nature does not offer the same services, for example in terms of public transport that a medium-large city can guarantee to its inhabitants. Furthermore, in a small city, citizens are more reluctant to change their routines because it is likely that most of the people move in the same way and there are fewer opportunities to experiment new modes of transports.

In the frame of the R&D project activities new technologies and services based on ITS could have been developed and tested. The main objectives with regard to Rovereto are threefold:

i. Reduce traffic pressure and number of vehicles parking in city centre

ii. Push Park and Ride and greener transport solutions

iii. Improve mobility management policies

2.3.3. Identified solution

In order to achieve these objectives, during the first iteration both commuters and tourists were encouraged to choose greener transport solutions and to use park and ride service. Users were provided with information about different modes of transport and trip estimated duration, suggesting them, with diverse approaches, the option with less carbon emissions.

These efforts must be associated with measures, already defined in the Rovereto Urban Parking Plan, to discourage cars from parking in the city centre. First, the most expensive parking zone should be extended; then the city needs two park and ride areas with adequate level of services. One it is foreseen in the short-term in the north part of the city and another one in the long-term in the southern part. This plan implies a strong enhancement of public transport services, even if several actions have already been implemented.

Beyond a strategy about the parking system to free spaces in the city centre for bicycles and pedestrians, Rovereto municipality should continue on one hand to boost cycling and walking and on the other hand to strengthen mobility management policies, promoting sharing economy transport solutions as well. As this could not be implemented in the first iteration, no test trials have been addressed with respect to objective iii, but the second iteration will focus on this subject.

2.3.4. Technology and services in place

In Rovereto, the parking system is provided with technologies that allow a small city to partly manage and control the traffic situation in the most central zone. A signposting system specifying the real time data about the number of available parking spots in the main parking areas is installed on the major traffic routes. This system guides car drivers directly to the parking lots avoiding traffic related to vehicles looking for a parking space.

This technology is complementary to the access control system implemented in several parking areas. This component allows the municipality to have real time and historic data about occupancy rate and run analysis about profits. With this information, new policies and interventions can be carefully planned. In order to have a complete view of the parking system, during the first iteration, traffic aides were provided with an App to collect data about on-street parking.

Furthermore, police can already count on a web application to deal with municipality ordinances about mobility system, like a street closure for a working site, and events that happen in the road network, for example an accident. The system can send information to police officers operating in the city and be archived and used for analysis and statistics, for example about the location of accidents to identify the most dangerous intersections and streets.

Finally, the STREETLIFE experimentation process significantly contributes to raise the level of technologies available for Rovereto citizens. The ViaggiaRovereto android App was based on a multi-modal journey planner that provided users with information about the different modes of transport they can use, including buses and trains. The STREETLIFE version of the App in addition to give users more detailed information, like expected travel times and the amount of CO_2 produced for each trip option aim to have a real impact on users' mobility habits testing also a gamification process to evaluate its effect on city mobility system.

3. IMPACT ON THE USER BEHAVIOUR

The objective of this chapter is the discussion and assessment of the STREETLIFE system impacts towards user behaviour. It can be seen as the major aim to assess user acceptance and willingness to use the provided solution. In addition, we are going to answer the guiding question: How can STREETLIFE sustainably change the mobility behaviour of citizens into a more eco-friendly behaviour?

In order to tackle the envisaged goal different sub-categories of user behaviour needs to be analysed and assessed, such as:

- User Acceptance
- Usability
- System Usefulness
- Functionality of the system
- Sustainability of achieved changes
- Applied motivators

In this regard, several research questions, hypothesis and indicators to measure these have been identified (see report D8.1.1 STREETLIFE Evaluation Plan) and are addressed in this chapter.

Overall, two iterations of development and testing are foreseen whereas the current assessment is focusing on the results gathered during the first iteration.

3.1. Research approach

In order to test the developed and implemented components and systems, site-specific planning documents were elaborated, given the specificity of each city, and the related research questions. Details with regard to the Pilot planning and evaluation process can be consulted in deliverable “D6.1 Specification of city pilots for the first STREETLIFE operation and evaluation” and “D6.2.1 – City pilots planning and evaluation results (initial)”.

With respect to gathering information in terms of user behaviour, two data sources have been used, while focusing mainly on the above-mentioned sub-categories. On one hand, a well-designed questionnaire has been approved as an adequate tool to provide valuable results. Although different services and user interfaces were tested at each single city a common questionnaire was used. This questionnaire addressed overall relevant items but was also supplemented by additional questions to meet the local requirements and objectives. According to the evaluation plan (D8.1.1) a baseline and treatment data acquisition was realised by using two slightly different questionnaires. It became clear at an early stage that gathering information from the test trial participants about their daily mobility behaviour and especially their expectation towards the promoted system would bring valuable results.

On the other hand, log files created by the STREETLIFE system provided additional benefits in terms of user behaviour evaluation. Valuable data sets could be gathered regarding the users interaction with the system and positioning data allowed to analyse trip details such as transport mode detection.

The test trials finally were conducted with two types of experiments:

- Controlled user group to focus on specific topics in detail and to realise controlled experiments, and
- Open field experiments with the general public which made use of the STREETLIFE systems via the Web or mobile Apps available at the Google Play Store

In the field trials, data has been collected both through the Apps and the related log data as well as through questionnaires. Questionnaires were filled in before actually starting the trials as baseline enquiry in order to collect information about users' travel activity habits and the end of the experiment as treatment enquiry. The goal was to evaluate the effectiveness of STREETLIFE and any changes on the users' responses as well as habits that can be attributed to STREETLIFE technologies. For example the issue of ViaggiaRovereto usability has been evaluated through questionnaires, while the mobility behaviour changes have been assessed using both data from log of the ViaggiaRovereto App and information from questionnaires.

The comparison between the similar questions of the two questionnaires has been considered only from users who answered both baseline and post-experiment questionnaire, in order to have a clearer picture of the variation.

For the BER pilot as well, usability tests were conducted and the evaluation was carried out through questionnaires, however with a smaller sample size. Further functional tests with approx. 50 users have been carried out in preparation of second iteration. A significantly larger sample size will be involved in the second iteration.

3.1.1. Questionnaire set-up

It is commonly known that the attitudes toward a technical system are dependent on the perceived ease of use and the perceived usefulness of this system. Those in turn are affected by external factors, which refer to the concrete implementation of the system for instance functionality and user interface (UI). A possible way to find out which product characteristics of a technical system can be perceived as useful or under which circumstances a system is perceived as being easy to use is to analyse user needs and requirements. This information has been gathered in a baseline and treatment questionnaire during the test trials. Thus, the participants of the different studies were asked to provide feedback on their expectations towards a STREETLIFE system and their made experiences. The questionnaire construction was based on the 'Technology Acceptance Model' (TAM) which has been applied successfully in multiple studies for evaluating the user acceptance of different technological systems [p. e. Davis et al., 1989, Davis, 1993, Bertrand & Bouchard, 2008]. It is an adaptation of the Theory of Reasoned Action (TRA) [Ajzen and Fishbein 1980; Fishbein and Ajzen 1975] specifically tailored for modelling user acceptance of information systems. TAM can serve the purpose of predicting user acceptance of a technology before the users get heavily involved with the technology, and thus is a cost-effective tool in showing potential candidate systems. TAM is not a specific questionnaire which can be used for the evaluation of different systems but more a procedure which leads the development of items in order to assess different technical systems. According to TAM the attitude towards using a system is a very important indicator for actual system use. Furthermore, TAM speculates that two particular beliefs, *perceived usefulness* (U) and *perceived ease of use* (EOU) are of primary relevance for the development of the *attitudes*. Perceived usefulness is defined as the prospective user's subjective probability that using a specific application system, i.e. STREETLIFE applications will increase his or her performance within an organisational context. Perceived ease of use refers to the degree to which the prospective user expects the target system to be free of effort.

The attitudes towards using a system are an important predictor of the behavioural intention to use this system. A set of different indicators were used, in order to measure the behavioural intention as a pre-condition for the actual system use. The questionnaire considered seven indicators, which were supposed to measure the actual system use as also to gather motives and expectations towards the STREETLIFE system.

The items which had to be rated were generated on a five-point-scale by the participants (1=strongly disagree; 2=disagree; 3=neutral; 4=agree; 5=strongly agree). The questionnaire used can be consulted in D6.2.1– City pilots planning and evaluation results (initial).

3.2. Assessment of evaluation results

The assessment of the user acceptance is strongly dependent on the design and functionality itself and the available transport alternatives. All pilot mobility Apps were described within “D5.2.1-End User Applications Techniques and Tools (initial)”. A detailed analysis and evaluation of the pilot specific user behaviour has been provided in D6.2.1 City pilots planning and evaluation results (initial).

The small number of test trial participants especially in the Berlin[11] and Tampere pilot does not provide a reliable basis for a quantitative assessment of each pilot. Therefore the present assessment is a short overview of addressed research questions and a synopsis of the results within the sub-categories.

In order to assess the implemented system a number of research questions have been defined in the Evaluation Plan. Therefore the assessment is going to answer these questions based on the evaluation data available. The research questions addressing the mode choice are:

RQ-BER-1 **RQ-ROV-1**	**Is there a significant change in the mode choice?**
RQ-BER-2 **RQ-ROV-2**	Which mode benefits most of the change?

[11] The small number of trial participants in Berlin refers to the users who tested the system and provided feedback via questionnaires, whereas in the functional tests a higher number of users were involved, as stated before.

3.2.1. Changes in mode choice

The analysis in BER and ROV proved that people provided with an intermodal App are attracted to change the mode choice, in case alternative transportation means are available. It could be observed independently from the App tested, that an increased usage of green transport modes such as walking (less than 500m), public transportation and cycling has been reported for the majority of trip purposes. Meanwhile, a decrease of car usage for private trips is indicated with the given data. Regarding car-usage, a slight decrease of usage in general is reported. Here, especially cycling and walking benefits most from this change. In addition, a slight but significant change towards an intermodal mobility can be detected. As for the combination of different modes of transport, the test trial participants stated to combine different modes of transportation for their trips due to the information available.

When analysing the different means of transport specifically towards the changes in mode choice, following changes can be observed:

<u>Car</u>

There is a slight trend in decreased car usage perceptible. This affects both: the number of paths and for the percentage of kilometres travelled. In certain trials, a reduction of even 50% of kilometres travelled by car could be observed.

<u>Public Transport</u>

In terms of public transport usage, a growing tendency is perceivable in the number of trips and the kilometres travelled. In some cases, even a strong growth could be observed.

<u>Cycling</u>

The results obtained for bicycle usage have been very positive as the percentage of trips increases during the test timeframe. Above that, an increase in the percentage of kilometres travelled by bike over the total kilometres was detectable.

<u>Walk</u>

The analysis shows, that also walking benefits from an intermodal route planer. The number of trips and the amount of kilometres walked increased. This is evident in the percentage of kilometres walked, but not in the percentage of trips which remains constant.

Summing up, there is an increased use of alternative modes. A clear statement about which mode benefits most cannot be given at this stage, as the data available are not sufficient to provide a significant indication.

3.2.2. Ease of use

The ease of use of the different Apps is a crucial requirement, as it is the relevant user interface. Overall, the feedback received was very good. The given design in all Apps was assessed as valuable as it enables the user to use the App intuitively. To navigate through the different functionality was easy to learn for most of the participants. However, also negative statements arose. In BER for example the navigation through the App was rated very well but, due to the system set up, responding time for multimodal route requests - which require the calculation of various combinations - were assessed as taking too long. Also critical remarks were given with regard to the TRE-App as the users were comparing the App with existing polished Apps from Google Play or App Store. Hereby, it has to be considered that the objectives of the trials of the first iteration focused on technical questions in BER and TRE and in the meantime, a number of improvements have been realized for the second iteration in order to enhance user acceptance.

3.2.3. Usefulness

Overall, the Apps were considered as useful in all test trials. The test trial participants rated the information provided as detailed enough. In some cases, the user expected more and better comparable information with regard to environmental and economical traveling. However, most of the participants increased their awareness of sustainable mobility options.

Above that, different planning criteria have been requested. It became clear that most participants favour “duration” as the most important trip planning criteria.

3.2.4. Compliance

In order to assess ‘Compliance’, data has been acquired by questionnaire, as in the first iteration tracking was not considered for compliance purposes. The trial participants indicated their compliance to the statement "I predominately follow the recommend route". Although the different routes were calculated regarding the user preferences less than half of the user stated that they followed the proposed route. However, more than 50% of users involved in STREETLIFE field trials of the first iteration found it easy to follow the suggestions given by the Apps. A possible explanation would be that user inserted certain route request for testing purposes only. Another option to be discussed addresses the usability and functionality of the App. Discrepancies between expectations and experiences might occur and need to be validated in the second iteration.

3.2.5. Benefit of gamification

In the first iteration, a small-scale test of a gamification approach was tested in the City of Rovereto. The results provided show a continuously growing usage of the App during the timeframe of test trials. There was a strong growing of App usage after launching the gamification functionality within the App. The concept behind was about to incentivise the user to use the App in order to plan their trip, and to use the App in order to plan greener transport options. It can be concluded that the results of these tests are consistent with the two hypotheses: in fact the *GreenGame with ViaggiaRovereto* reached both its goals, since there was an increase in the level of App usage and there was growth in the number of green itineraries chosen.

3.2.6. Conclusion

With respect to impact assessment of the user behaviour it can be stated that people provided with an intermodal App are more willing to change mobility behaviour while changing their mode choice, as long as alternative “green” transport means are available. It could be observed independently from the App tested, that also different modes were combined more easily due to the information available.

Ease of use – as a precondition for using the App and reaching a valuable user rate - needs to be addressed carefully. An intuitive navigation through the functionality allows the user to get familiar with the system, which is crucial for further use. Another important criterion in terms of using the system is usefulness. The routes proposed need to be aligned with the routing preferences set by the user. That is true for environmental and economic route proposals but also for number of changes between transport modes. Due to the variety of intermodal routes long timeframes for calculating these routes may occur. These and further disadvantages have to be considered for further development work in iteration two.

In Berlin, a gamification concept has been developed, implemented and tested in its functions. The concept considers lessons learned from a STREETLIFE end-user workshop, carried out by SIEMENS. This concept has been developed from the scratch, thus no public users have been involved so far.

The functional tests conducted between the first iteration and the second iteration involved the full data chain of the Berlin pilot

- Routing request from App via CIP to the intermodal router
- Recommendations from intermodal router via CIP to App
- User management
- Tracking data collection
- Mode detection
- Gamification including score calculation and
- Crowd sourced data collection.

In total 50 users registered to test the system with the new App and the new backend services. Promising feedback has been obtained from internal test persons but also from discussions and demonstrations to external mobility experts. In the meantime the SL BER App is available via Google Play Store (since mid of February 2016). The first game period will start on March 1st 2016.

Various publicity actions have been launched to address potential users. Thus, it is expected that a large number public users will use the new Berlin SL-App, and a good sample can be provided to assess the impacts of STREETLIFE Berlin Pilot.

4. IMPACT ON THE TRAFFIC SYSTEM

4.1. Objectives

Passenger cars accounted for 83.3% of inland passenger transport in the EU-28 in 2012 [EUROSTAT 2012]. STREETLIFE addresses two main topics: In order to change the mobility behaviour in terms of car usage, STREETLIFE follows the idea of providing better information on alternative "green" transport modes to the end-user by using new tools. The assumption of the STREETLIFE applications is, that there will be an impact on the attractiveness of "green" transport modes and thus on the overall road traffic demand as well as carbon emissions. Second, STREETLIFE will provide valuable information to the transport planner by gathering relevant data from the system user. Therefore, it is worthwhile to look at the effects on a transport system if alternative transport modes become more attractive as valuable information are always present.

4.2. Research approach

There were three research approaches used in order to assess the potential impact of STREETLIFE to the traffic system. For the large city, a quantitative approach based on a microscopic network simulation was selected as described in chapter 4.2.1. For the small and medium cities the transport simulation network was not available, thus, alternative approaches have been selected. In Rovereto, (see chapter 4.2.2) a very detailed data set of log files from the STREETLIFE system has been used for analysis. That was not the case for the medium city Tampere, as the available log files from the STREETLIFE system were not sufficient for analysis. In Tampere, the method of expert-interviews has been selected in order to reveal impacts on the transport system as well on carbon emissions.

4.2.1. Simulation-based approach

4.2.1.1. First iteration setup and results

According to the work plan of the BER pilot, the first iteration demonstrations have been considered and designed as 'small scale' piloting activities. In the BER pilot, a new multi-modal mobility-planning tool (APP) has been designed and developed from scratch and instantiated to the requirements of the STREETLIFE BER pilot. Requirements have been collected and defined in the first iteration's definition phase. For this reasons, WP6 experiments have had a clear focus on testing App usability and general feasibility/acceptance for the targeted tool and its technical integration. For such an immature App development status a larger scale test have not been considered reasonable.

However, to test the App two 'small scale' experiments have been designed and performed, which are elaborately described in D6.2.1 (City pilots planning and evaluation results – initial) - chapter 3.1.2. A usability test has been performed as a laboratory study in the premises of DFKI, and has been followed by a four-week field study. This field study was by design to test the App in the field with the same users applied in the laboratory study. For this purpose, two specific approaches were to be tested individually for a further deployment in the second iteration, namely i.) The App as a multi-modal mobility planning companion and ii.) A stand-alone GPS tracking routine for collecting ground-truth data from users. The main goal of this combined laboratory/field test has been to reveal the best-fitting system for final 'large scale' BER pilot implementations, but also to test qualitative survey methods.

No enhanced user recruitment campaigns have been planned for this field trial. Users/testers have mainly been recruited from the BER pilot partners and its networks.

As main results of these two experiments the following can be concluded (find more details and elaborated information at D6.2.1 - chapters 4.2.4 and 4.2.5):

- The overall methodology for pilot oriented experiments, its backend services and data flows have been successfully set up and tested with first iteration tests.
- Users stated a clear need for more reliable information on mobility options and indicated impacts of mobility decisions and agreed that this would have an impact on their mobility behaviour and mode choice decisions.
- Time and costs are still the most important planning criteria for daily mobility, while environmental impacts have been assessed as rather unimportant. But, the latter has been slightly changed during the field test.
- When using the App for daily trip planning purposes, a higher degree of combining different modes of transport could be observed.
- As for the App, even in this early stage of development, its clarity of information and usefulness for targeted STREETLIFE purposes have been assessed positively.
- The majority of users do not consider GPS tracking a personal issue for using the App.
- As it is hardly possible to entice users away from other commercial Apps available in Berlin for trip and mobility planning, it was decided to set a stronger focus on cycling safety and gamification with the further BER pilot and App deployment.

Aforementioned results, trends and interpretation are to be proved by the second project iteration with stronger user involvement supported mainly by means of public user recruitment and the integration of an interesting BER STREETLIFE game.

4.2.1.2. Scale-up - From field tests to city level

In general, the planned evaluation methodology for both BER pilot iterations follows the same approach: WP6 pilot experiments addresses defined research questions, tries to answer hypotheses and collect data to quantify performance indicators. In WP8 evaluation this data is thoroughly analysed with respect to rather general (WP8) impact categories and used as input for elaborated simulations of impacts for the entire BER transport system – as depicted in Figure 6: BER pilot simulation scheme. With the BER pilot specific scenarios are defined which are composed of use cases. To facilitate those use cases experiments are carried out collecting metrics (data) on a pilot level. Some of these metrics directly addresses performance indicators, which have been defined in WP8 from given impact categories, respective research questions and hypotheses. For some other WP8 indicators, but also main evaluation WP8 impact categories, namely impact on transport system performance and carbon emissions and for scaling up pilot findings to a city level the simulation has been used. (Subjective survey methods are not shown with this figure.)

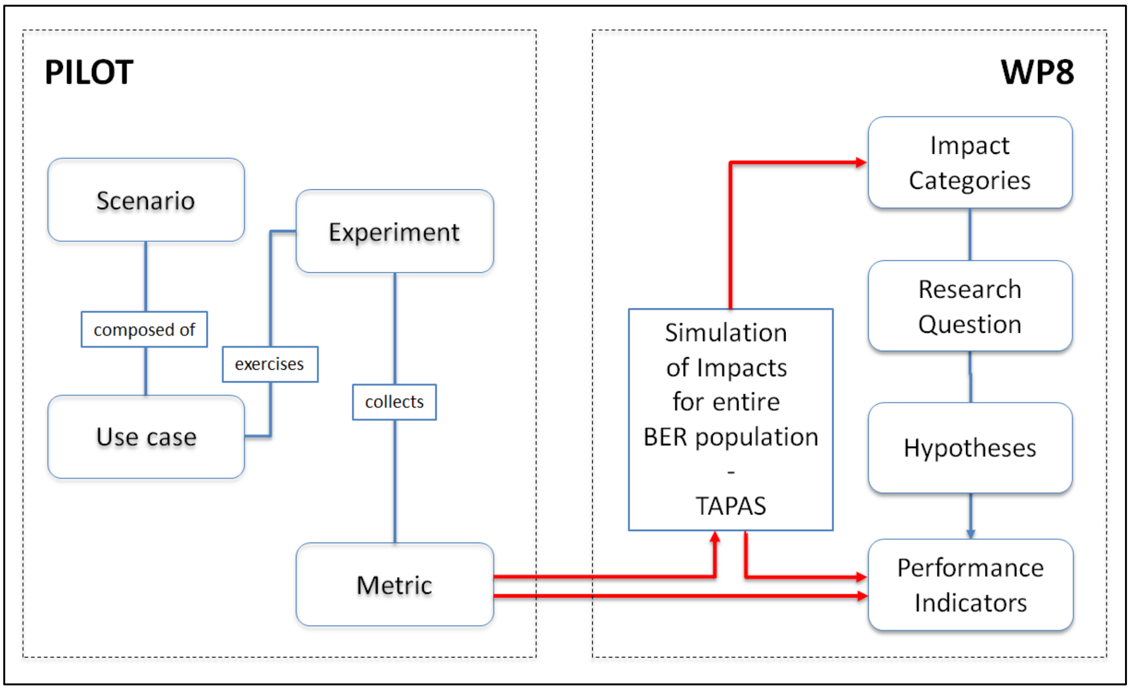

Figure 6: BER pilot simulation scheme

This simulation approach and its feasibility have been tested in the first iteration, too. But, for the first iteration it has been assumed from the beginning of the project that data collected in 'small scale' usability and field tests -as described before- cannot be reliably used for this purpose. Thus, an assumption-based scenario approach has been selected and well attuned to the specificity of BER pilot goals. Scenario assumptions have only been partly derived from feedback users gave during the field test; more reliable assumptions on how a targeted STREETLIFE BER system could impact on the overall performance of the BER transportation system and on the Carbon emission reduction potential have been derived from literature and corresponding initiatives (e.g. AMITRAN[12]).

The simulation described in chapter 4.2.1.3 is calibrated with mobility data of the German household mobility survey "Mobilität in Deutschland 2008", which is representative for the German and Berlin population. The non-treated simulation output is, thus, to be understood as the baseline - the "normal" mobility behaviour of Berlin population. With this baseline, the scenario based simulation output will be compared. This comparison allows detailed analyses on modal split, travel time and user group specifics, but also on emissions and further derivations of simulation outputs.

[12] The *Amitran* project defined a reference methodology to assess the impact of intelligent transport systems on CO2-emissions. see: www.**amitran**.eu

The STREETLIFE Evaluation plan (D8.1.1) discusses the research questions addressed in BER in terms of transport impacts. The outcome of the simulation has been applied to answer the research questions and hypotheses and quantified performance indicators in Table **2**:

Table 2: Research Questions addressed

RESEARCH QUESTIONS	HYPOTHESIS	Performance Indicator
RQ-BER-1: Is there a significant change in mode choice?	HY-205: STREETLIFE significantly leads to a change in mode choice.	Number of Trips Trips length, mode
RQ-BER-2: Which mode benefits most of the change?	HY-204 STREETLIFE does increase the use of "green" transport modes	Average modal split – user, Average modal split – trips, Number of mode transfers, Change in trip length
RQ-BER-3: Which type of commuters is most willing to change their mobility habits?		Average modal split – user, Average modal split – trips, Type of trip

In order to analyse these questions and to provide feedback to the hypothesis, the analysis was conducted by using the agent-based traffic simulation TAPAS (**T**ravel-**A**ctivity **PA**ttern **S**imulation) [Hertkorn 2005] which is operated at the DLR Institute for Transport Research. In TAPAS, so-called agents were created which reflect a synthetic person of the population. A synthetic person combines several data sources and attributes. Finally, the agent decides for a given trip about the transport mode. The effect of mode choice on traffic generation was analysed. In chapter 4.2.1.3 the simulation tool TAPAS is introduced and insight into the simulation methodology is given. In chapter 4.2.1.5 the main assumptions and hypotheses are explained and discussed. Chapter 4.3 concludes this chapter, with the results of the traffic demand simulation.

4.2.1.3. TAPAS simulation tool

The effects of the App's usage at a city level were determined by simulating the daily mobility of Berlin's population using the agent-based travel demand model "Travel Activity Pattern Simulation" (TAPAS). TAPAS models the travel behaviour of all or a sample of the inhabitants of the modelled region given the population itself, travel time matrices, activity (work, school, shopping…) locations within the region, and several further parameters. The major results of this simulation are daily activity plans for every simulated individual person including the visited locations and the respectively used mode of transport to reach this location. Figure 7 shows the workflow of a TAPAS simulation that will be described in-depth in the following.

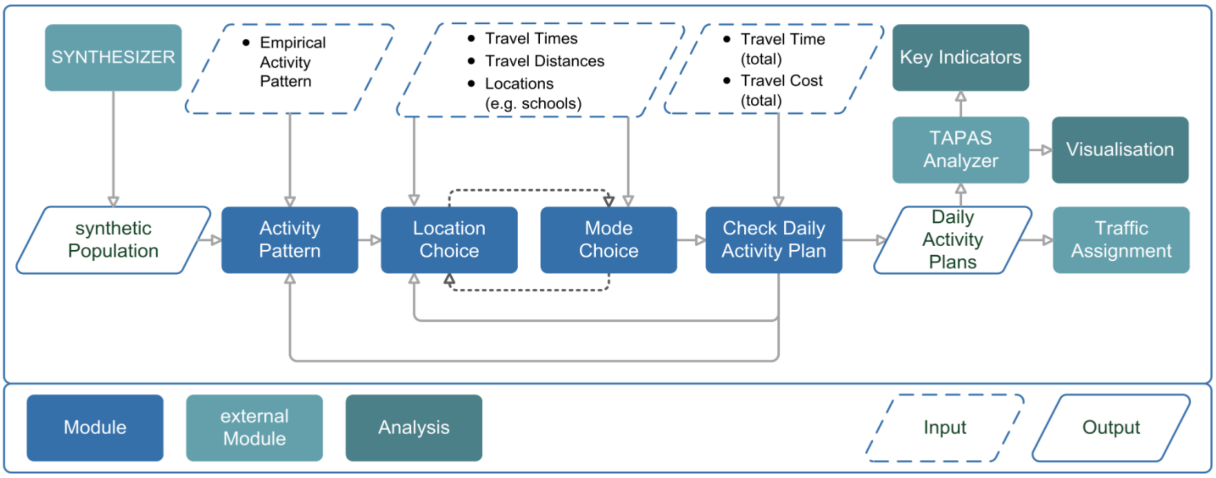

Figure 7: TAPAS workflow

The major input to TAPAS is a disaggregated, per-person model of the population within the modelled region. Every individual simulated in TAPAS is described by a set of attributes, mainly its age, sex, employment state, as well as driving licence, public transport ticket, and bicycle availability. Additionally, persons are group into households, which contain additional attributes such as owned cars or the monthly mobility budget. Such a disaggregated representation of a region's population is computed using the SYNTHESIZER tool that obtains available socio-demographic data from different sources, usually aggregated by traffic assignment zones, and reproduces the disaggregated distribution.

TAPAS distinguishes between walking, bicycling, driving an own car, joining a car ride, public transport, and taking a taxi as travel modes. The inclusion of car sharing services is under development. For each of these modes, the travel time matrices (implicitly describing their availability in the region) and their respective prices must be given. In addition, besides other parameters, TAPAS needs the individual locations of activity places in the modelled area. Figure 8 shows some selected examples of activity types as given in Berlin and used for the simulations in STREETLIFE.

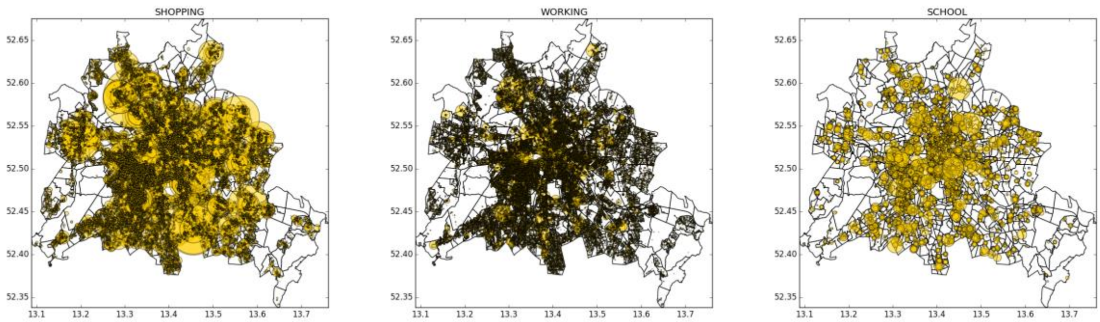

Figure 8: Examples for disaggregated activity locations from Berlin

TAPAS determines the population's mobility starting at a household level. For every person that belongs to the currently processed household, a daily activity plan is selected, first. The used activity plans were determined by clustering data from the German National Household survey "Mobilität in Deutschland" (MiD) as described above. After being clustered for obtaining a set of common daily activity types, probabilities to choose one of them by a certain person group given this group's characteristics were determined. The sample size consisted of nearly 80.000 households and is representative for the German population. A typical activity pattern is pictured in the following figure. The simulation for STREETLIFE has been run for a representative weekday in Berlin. The travel behaviour of Tuesday, Wednesday and Thursday travel pattern for the whole year is averaged in TAPAS simulations. Travel patterns for Monday and Friday are not included as the travel behaviour on these days differs significantly.

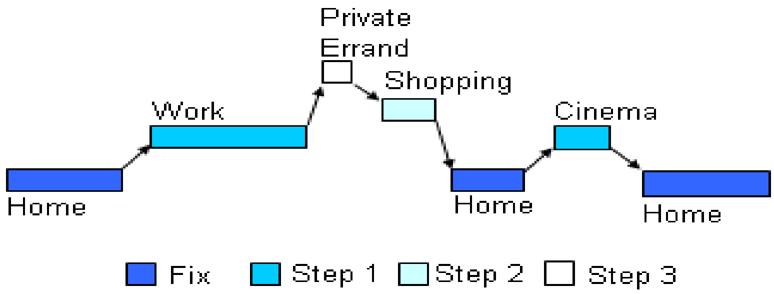

Figure 9: TAPAS activity patterns and day plan with time spans for activities

When processing a single person in TAPAS, one daily trip pattern is selected first, given this person's characteristics. As shown in Figure 9, a daily plan has a hierarchic structure; some actions are more important than others. In the example given in Figure 9, being at home and going to work are more important than shopping, e.g. the daily plan is traversed along the actions' hierarchy, first, then along the time. For every not yet allocated place to visit for performing the action, one possible location and the mode of transport to use to reach the location are computed.

The location choice is influenced by the previous and next location (if given from higher hierarchy layers), the person's transport mode preferences, accessibility of the location, travel time and the location's attractiveness computed using the location's remaining capacity. The person's choice for the mode of transport to use is influenced by the number of not yet scheduled cars in the household, distance of the trip, status as well as further attributes, among them the age and the sex of the individual. Further factors which have an impact are the household income or the purpose of the trip. The TAPAS calculation is based on these factors and uses a choice probability for each mode determined using a multinomial logit model of real-world mobility data.

After determining the activity location and used transport mode, the travel time is assigned to the day plan using the loaded travel time matrices. After this, the day plan's feasibility in terms of time and costs is validated. The sum of mobility costs consist of all expenses when using a certain transport mode. These costs are compared to the individual's mobility budget which is a part of the household income. It is possible that an individual rejects an assigned day plan if it shows to be unfeasible given the transport mode costs and travel times. In this case a new day plan is assigned and the requirements are tested again.

The results of the simulation are disaggregated daily plans for every simulated person. Every plan consists of a list of single trips to the next activity. Every trip includes a start and end location, the trip's purpose, distances from the start and the end locations and the chosen transport mode. For passenger cars, the occupation rate is tracked.

The resulting day plans can be used to determine a large scale of traffic indicators, among them:

- The average frequency of trips (by trip purpose, socio-economic person groups)
- The average trip length and distribution of trip lengths (by socio-economic person groups and trip purposes)
- Transport mode shares (by person groups and trip purposes)
- Occupation rate of vehicles (by trip purpose)

Some exemplary visual evaluations are shown in Figure 10.

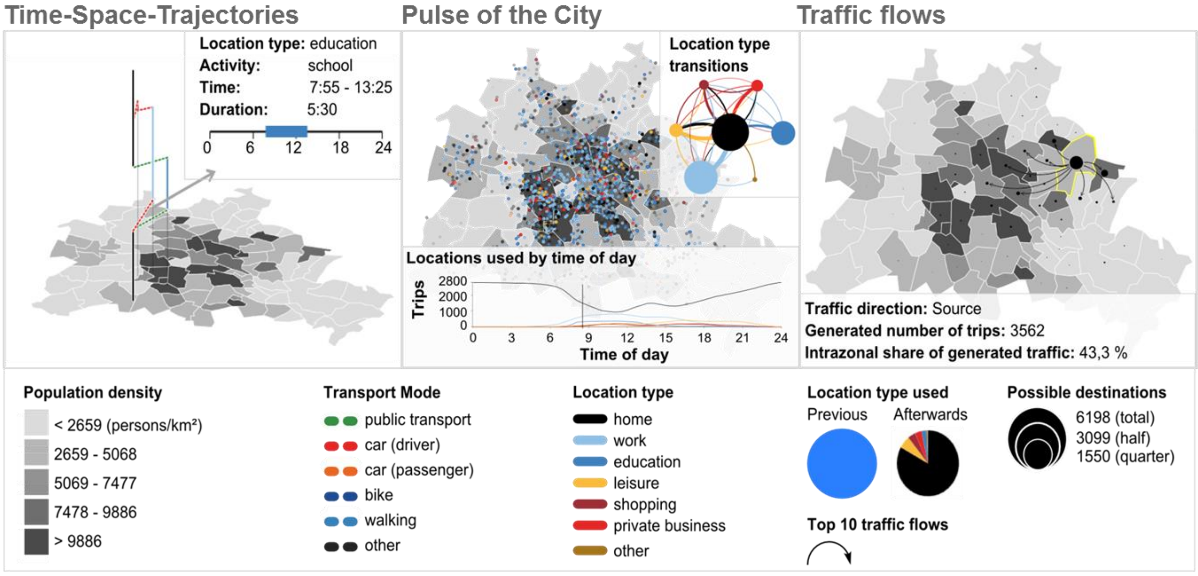

Figure 10: Sample evaluations of disaggregated daily trips from the Berlin simulation [Cyganski, von Schmidt, Teske 2015]

4.2.1.4. The Berlin base case

The base case simulation of the city of Berlin resembles the mobility within the city on a usual work day (Tuesday-Thursday) in the year 2010. Different data sources have been used for replicating the population's socio-demographic attributes and for distributing this population within the area. The total synthetic population of the city area includes 1.8 million households. Figure 11 shows some of the basic statistics for the obtained population.

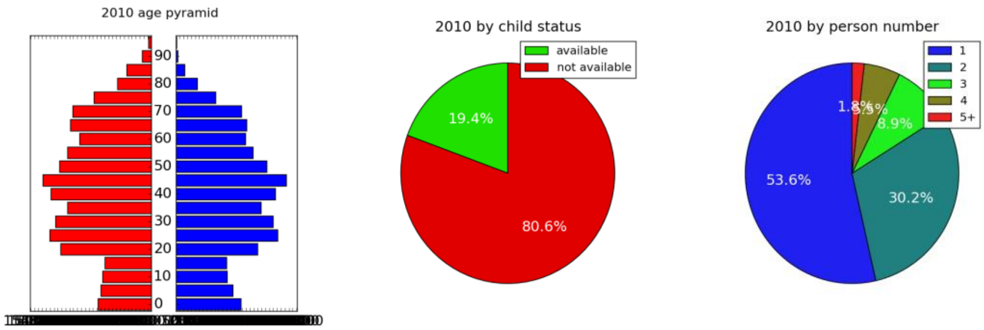

Figure 11: Sample statistics of the modelled population: age distribution, child status, person numbers per household

According to statistics, the Berlin network consists of around 1.4 million cars. In TAPAS each car is identified by the vehicle type, fuel type, private or business ownership, costs per km and emission class. Vehicle ownership has been applied to the generated households. Car availability and other mobility options of the modelled population are shown in Figure 12.

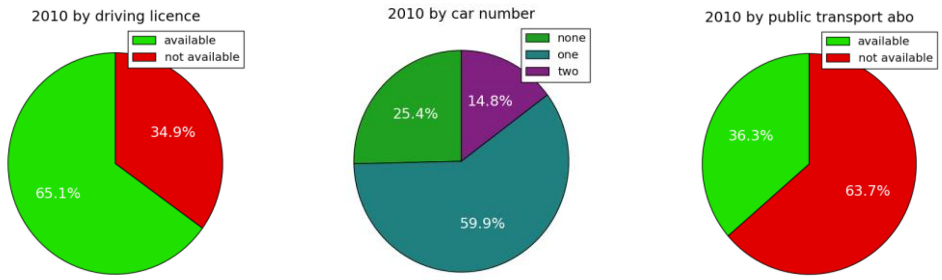

Figure 12: Mobility options' distributions

TAPAS uses road network data for Berlin to simulate the demand changes in an urban environment. The simulation was carried out on the Berlin city network for estimating the traffic impact and the related carbon emission in the frame of the STREETLIFE project.

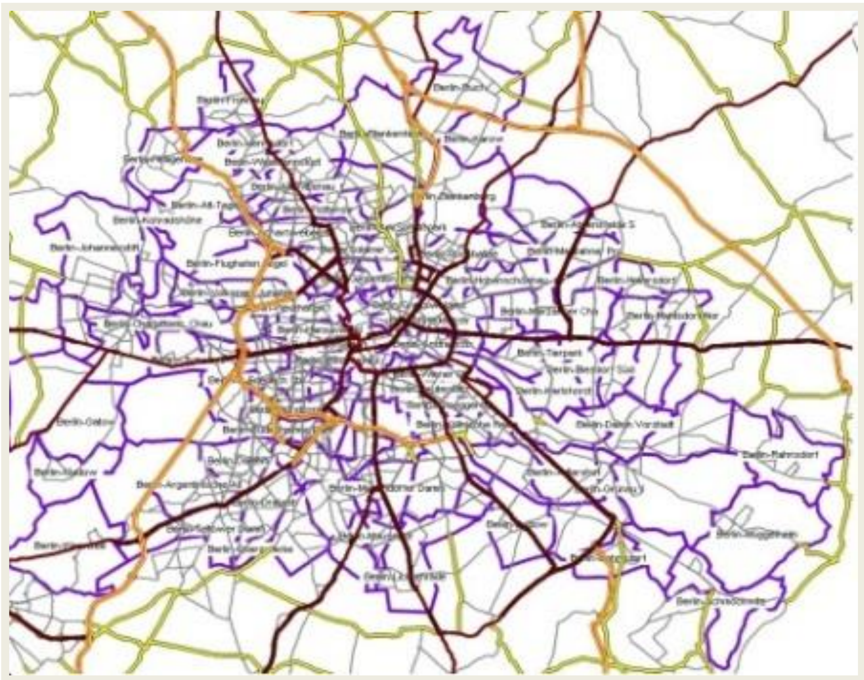

Figure 13: Berlin city network

A sample simulation with TAPAS delivers the following statistics:

- Berlin has 3,005,904 mobile inhabitants (2008)
- 14,21 million trips are made per day
- 3.38 million trips are made by car
- The average trip length in Berlin is 5.14 km
- Most trip purposes which are not ending at home are shopping/private errands (21%), leisure (20%) and work (10%).

By considering the modal share of the Berlin city transport mode it can be seen that car usage is, besides walking, the most frequented transport mode. Public transport follows third and bike usage as fourth most often used mode. Others include trips as passengers of cars or taxis and trips made by train.

4.2.1.5. Simulation settings

Due to the limited field trials in terms of user participation and related trip generation in the first iteration a literature review has been conducted to identify possible changes in the mode share based on STREETLIFE similar measures. Based on this literature review [Ahrens 2010; Bickelbacher 2002; Pucher 2010; UBA 2010; Martens 2007] the following changes have been applied to the base case for resembling the assumed effects of the city-wide introduction of the STREETLIFE App:

- Trips up to 1km: a decrease of car usage incl. co-driver by 60% has been realised by substituting the mode of according trips by walk and cycling while keeping the activity locations
- Trips between 1-2km: decrease of car usage by 50% by substituting car usage by cycling and public transport while keeping the activity locations
- Trips between 2-5km_ decrease of car usage by 40% by substituting car usage by cycling and public transport while keeping the activity locations
- Trips between above 5km: increased public transport usage by 20% motivated by Bike & Ride for educational and business trips

This synthesises most likely impacts of BER STREETLIFE interventions. Smaller trips are to be mostly affected by mode choice changing; with the gamification approach especially cycling will be rewarded. However, for the second iteration it is expected to derive these simulation settings from data of the large-scale field test directly. Another aspect to be further elaborated with the larger field test is a special attention to most affected groups of users. Who is most willing to take part in games like the Berlin “BikeRider”? Who is changing his/her behaviour most? How can this knowledge be used to further specialise similar Apps, urban games and incentive models?

Based on the above-mentioned assumptions the TAPAS simulation tool used a 10% sample of the Berlin population to retrieve valuable and comparable results in the STREETLIFE context. With a standard deviation of 0.25% the settings show to be stable. The sample was then compared with the baseline simulation run for which a sensitivity analysis has been done.

4.2.1.6. Simulation output

For each single person of the BER population all trips of this simulated day is given. For all trips further parameters are calculated and stored for evaluation purposes. For the targeted evaluation of impacts on modal split (performance of BER transport system) and carbon, emissions the following parameters are provided as outcome of the simulation:

- Trip duration
- Trip length
- Mode of transportation

These parameters have been used to quantify WP8 specific impacts for the complete BER population. Its interpretation is given with chapter 4.3.

4.2.2. Distance-saved approach

In the cases of the medium and the small city, the approach has been different. Since a simulation model for travel demand estimations was not available, this methodology aims to identify from the data collected a measure of the reduction of traffic achieved thanks to the STREETLIFE solutions.

This value has been identified as the amount of kilometres not travelled by car thanks to the STREETLIFE trial process. In effect, the goal of both pilots was to reduce car traffic by increasing public transport use and other, non-motorized modes of transport. In the medium city, the approach was entirely qualitative. Since the first iteration in Tampere focused more on technical evaluation of the solutions deployed, the STREETLIFE impact on the traffic system has been evaluated using a qualitative procedure that required the usage and submission of questionnaires.

The questionnaires used for evaluation purposes in the medium city case were of two types: The first one was submitted to users (see the Appendix to D6.2.1. for details) in a two-step approach. In this case the End Users received a Pre-test and Post-test in order reveal their mobility habits and if STREETLIFE changed them, in which way. This approach has been conducted in each Pilot City.

The second type of interview has been submitted to local Mobility managers after the end of first iteration with the goal of getting feedback towards the traffic impact and the impact on CO_2-emissions. In addition to that, the mobility manager was posed questions regarding potential benefits of the virtual mobility solution, the mixed reality and incentives.

The feedback received to both kind of questionnaires form the knowledge base necessary to evaluate the STREETLIFE impact on traffic system in a medium city.

In the small city case the approach was both quantitative and qualitative. The trial process tested the effect on traffic with two separate experiments, one related to commuting, and another one related to influx of visitors for special events. The purpose of both experiments was to reduce traffic congestion in the city centre with a twofold approach. Users coming from outside the city were pushed to use Park & Ride and reach their final destination not with a private motorized vehicle, but with a greener mode of transport. At the same time, users travelling within the city were incentivized to move in a sustainable way, for example using bike sharing and public transport.

Data collected in the experiments are both quantitative and qualitative and derived from questionnaires and log data of routing Apps. In the commuter experiment was used quantitative information about users' trips collected through the App, while in the experiment set up for special occasions data derived from questionnaires.

4.2.2.1. Data requirements

In this chapter, we will recap which research questions will be answered specific for the medium and small city pilot. These research questions focus on the traffic system and are additional to the general ones about the entire project.

TAMPERE PILOT SITE		
RESEARCH QUESTIONS	HYPOTHESIS	KPI
RQ-TRE-1 Is there a significant change in mode choice?	HY-203 HY-204 STREETLIFE significantly leads to a change in mode choice	PI-101 #Trips PI-120 #users PI-201 Trips length, mode
RQ-TRE-4 How an increased amount of information and specification brought by STREETLIFE can improve Park & Ride utilization	HY-TRE02 Park & Ride utilization increases	PI-312 #trips, #users, trips length, mode, P&R usage

ROVERETO PILOT SITE		
RESEARCH QUESTION	**HYPOTHESIS**	**KEY PERFORMANCE INDICATOR**
RQ-ROV16 Will STREETLIFE reduce time spent in traffic?	HY-201 STREETLIFE does not increase total travel time (individual), of a trip (OD)	PI-307 Journey time
RQ-ROV6 How STREETLIFE can improve the utilization rate of bike sharing service on the end user's side?	HY – ROV5 The efficiency of bike sharing system will be higher	PI-123 bike sharing trips with P&R

RQ-ROV1 Is there a significant change in the mode choice?	HY-204 STREETLIFE does increase the use of "green" transport modes.	PI-203 # of carbon friendly trips PI-204 km of carbon friendly trips
RQ-ROV2 Which mode benefits most of the change?	HY – ROV3 The utilization rate of the bike sharing system will rise HY – ROV16 The utilization rate of buses will grow	PI-120 Bike sharing distance (km) PI- 112 Turnover of bikes (%) PI-122 bike sharing km with P&R PI-126 Public Transports trips with P&R
RQ-ROV6 How STREETLIFE can improve the utilization rate of bike sharing service on the end user's side?	HY – ROV5 How STREETLIFE can improve the utilization rate of bike sharing service on the end user's side? HY – ROV19 Users choose trip options that include bike sharing	PI-112 Turnover of bikes (%) PI-124 bike sharing trips
RQ-ROV8 Is there a change in the utilization rate of parking slots available?	HY – ROV4 The utilization rate of outer parking slots will grow	PI-118 Park & Ride usage [%] PI-125 Park & Ride trips [#]

In the small city case, all the research questions listed find an answer in the experiment for commuters, since it was possible to collect baseline data during the first week of the experiment when no suggestions were given to users. In the experiment set up for special events, baseline should have been referred to data about tourists' mobility behaviour of previous years, but this information was not available. Thus, the research questions that have found an answer also in the second experiment are the following:

- RQ-ROV1: Is there a significant change in the mode choice?
- RQ-ROV2: Which mode benefits most of the change

In conclusion, for both types of city the principal types of data necessary to assess the STREETLIFE impact on traffic system are the following:

- modal split achieved as a result of STREETLIFE trial process;
- Average distance travelled by car in the city per day.

Modal splits have been determined either from questionnaires or from log of the journey planner; in both cases a baseline have been defined in order to evaluate the modal shift achieved during STREETLIFE experiments.

Distance travelled by car has been derived from local (regional or national) database in both the quantitative and qualitative approach.

4.3. Large city impact assessment

4.3.1. Simulation data analyses

Some of the research questions addressed in chapter 4 have already been anticipated by the analysis of potential changes in user behaviour in chapter 3. In addition to that, a scenario-based approach has been selected to quantify the expected impact of STREETLIFE service implementations in Berlin.

In order to specify the expected changes of modes' mileage, simulation output data has been analysed accordingly.

For the entire BER population of 3.4 million inhabitants for one-day improvements could be achieved as shown in Table 3.

Table 3: Impact on traffic system from simulation

	Baseline		Scenario	
Mode	Trips per day	mileage in km	Trips per day	mileage in km
Walk	3,103,980	5,570,065	3,096,970	5,532,222
Bicycle	2,063,230	8,119,605	2,695,930	10,174,876
Car	4,283,120	31,536,338	3,666,940	29,099,749
Car_Passenger	969,340	7,873,306	716,440	6,506,378
Public Transport	3,303,770	25,811,737	3,480,570	26,822,241
Total	13,723,440	78,911,051	13,656,850	78,135,467

Based on simulated output, the daily mileage could be reduced from 78.91 million to 78.13 million kilometres, which is approximately 1% of overall transport performance. Almost the same amount of km is still being travelled, but the modal split has significantly changed (see Figure 14).

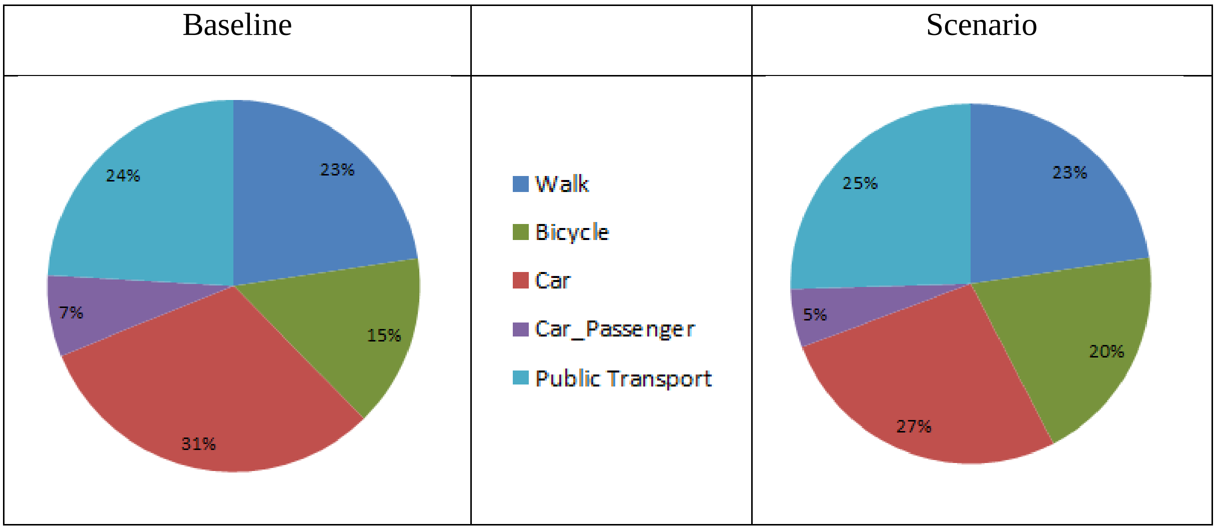

Figure 14: BER Modal split simulated

The following modal share changes can be seen:

- Modes share increase: Bicycle (5%) and Public Transport (1%)
- Modes share decrease: Car (4%) and CarAsPassenger (2%)
- As for the average trip lengths, the following can be concluded (see
- Table 4)
- Average trip length decreased for mode *bicycle*, as very short car trips have been replaced by cycling trips.
- Average trip length did not significantly change for modes *public transport* and *walking*, which shows that STREETLIFE Berlin interventions did not substitute public transport and walking trips.

Table 4: TAPAS simulation average trip lengths

	Average trip length in Kilometre for	
Mode	**Baseline**	**Scenario**
Walking	1.8	1.8
Bicycle	3.9	3.7
Car	7.4	7.9
Car Passenger	8.1	9.0
Public Transport	7.8	7.7

4.3.2. Qualitative investigations

As a common cross-pilot evaluation activity for all STREETLIFE pilots, test users of the first iteration field trial have been approached by a user acceptance questionnaire. This questionnaire also included some questions on how BER STREETLIFE implementations could impact on aspects relevant for the overall transport performance. This common questionnaire has been attuned to the needs and peculiarities of all pilots.

The BER questionnaire and its results are comprehensively described in WP6 report D6.2.1 chapter 4.2.4.3.

As for expected impacts on the traffic system, the following can be summarised:

- Different modes of transportation have more often been combined when using the App for trip planning purposes.

- Using the App, an increase of modes “walking (less than 500m)”, “public transportation” and the “car (as driver)” has been reported for the majority of trip purposes. However, for private trips a significant decrease of car usage is indicated with the given data. For the mode car sharing and rental car, a slight decrease of usage in general is reported.

- A remarkable increase of modes “walk” and “public transport” has been reported by the users after being provided with better information on route options.

4.3.3. Conclusion and outlook

In order to assess the impact of the implemented STREETLIFE solution the microscopic network simulation TAPAS has been used. The simulation has been run for a representative weekday in Berlin with a 10% sample of the Berlin population to retrieve valuable and comparable results in the STREETLIFE context. The sample simulation includes 14 million trips per day and is based on assumptions of STREETLIFE affected trips. Due to the fact that STREETLIFE enables user to plan and find an alternative route, the bicycle mode benefits the most, whereas the mode share for cars decreases. In this regard short trips normally conducted by car will be substituted by bicycle. Overall, the average trip length of public transport and walking did not significantly change.

With respect to the research question addressed the following can be concluded from first iterations simulations, user surveys and interviews.

Research Question	Main Result of First Iteration
RQ-BER-1: Is there a significant change in mode choice?	Simulation could show a small but relevant change of mode choices; relevant for the goals of BER STREETLIFE implementations, but also for the expectations and transport development plans of Berlin stakeholders

RQ-BER-2: Which mode benefits most of the change?	By design of the first iteration experiments and simulation, greener modes of transportation benefit most of STREETLIFE interventions into the transport system. Modes bike and public transport are more often used, while mode car suffers most of these changes.
RQ-BER-3: Which type of commuters is most willing to change their mobility habits?	To be further elaborated in second iteration. With the limited number of users no reliable conclusion could be made – and proved with field test data and respective surveys.

With the first iteration test setup reasonable trends and changes could be achieved. These trends and results are to be proven with the large-scale field tests of the second iteration. This can only be accomplished with larger groups of well-selected users. Therefore, strong efforts have been applied between the first and the second field test period to engage more users.

A two-fold user engaging approach will be used. For a reliable recruitment of a base group of users the BER pilot will have access to a mobility user panel operated by a research partner of DLR. A group (N = 80) of users recruited from this panel will intensively use the BER services for the entire field test period of three month. This panel user group will be complemented by a larger group of users freely recruited by means of public advertisement and social networks. It cannot be assured that second group's users will use the App for the entire field test period, but with the integration of a gamification approach and real incentives a longer and more active engagement of those "voluntary" users is targeted.

Thus, with the second iteration evaluation it is also planned to assess how gamification can contribute to a reliable user engagement in order to positively impact on traffic system performance.

4.4. Medium city impact assessment

The medium city impact assessment uses the following data as source for evaluation:

- Data collected during the pilot by the multi-modal journey planner;

- Questionnaires submitted to user to gather data about mobility habits have been submitted during period with different weather conditions. Indeed, a pre-study was carried out before there was snow in Tampere, while the post-study was made in the winter period when both private car usage and public transport usage increase and cycling decreases. The weather plays a big role on modal choice and this makes comparison of pre and post-study pilot data evaluation difficult and unreliable;

- Questionnaires submitted to traffic managers in a qualitative ex-post survey

The first research question from the evaluation plan with respect to the medium city case is the following: Is there a significant change in mode choice?

According to the interviews held with traffic managers, STREETLIFE is heading into the right direction. The integration of multiple real-time information feeds into a single service and provides the End Users a great amount of information to plan their trip and adjust it depending on accidents or other unexpected events along the road. Obviously the impact on traffic can be bigger if the group of users expands.

The second research question is about the change in modal choice: while the first question wants to know if STREETLIFE has been able to change mobility behaviour, the second one aims for the mode choice (even 1%-point change in modal split is very big, because of number of trips per day. It´s difficult to calculate variations in modal split and uncertainty of calculations is quite high).

According to the answers received from mobility managers in the context of the medium-sized city, the impact of STREETLIFE has been rated positive also with respect to the commuters demand: compared to other trip planners available in TRE, the STREETLIFE solution includes in the available journey options also trains and buses used mainly from commuters outside of the city, and this is a great advantage and a step forward towards multimodal integration.

Unfortunately data from end-users were not usable for evaluation purposes: weather conditions changed completely between pre-questionnaire and post-questionnaires. In Tampere weather plays a big role on modal choice, since winters are really cold and car is more comfortable than waiting outside for a bus. Car usage grew from 9% to 23% between pre and post treatment, but for the aforementioned reasons no conclusions can be extracted from this data. Car usage grew because of weather, not because of STREETLIFE.

Regarding research question #3 “Which type of commuters is most willing to change their mobility habits” and question #4 “How an increased amount of information and specification brought by STREETLIFE can improve Park & Ride utilization”, unfortunately at this stage of technical development is not possible to give a clear response about the impact of STREETLIFE on the usage of Park & Ride solutions in a mid-size city. Traffic managers believe that ICT solutions like STREETLIFE will have a positive impact on the congested zones of the city. Traffic managers also say STREETLIFE Apps Park & Ride mode reduces the time for looking parking place and leads to overall reduction of private vehicles on the streets, as people can more comfortably switch to public transport. Park & Ride is foreseen as a technical evolution of the multi-modal journey planner implemented in the second iteration in the middle city case, so the evaluation for the two questions quoted above is postponed to the second cycle.

The next research question coming from the middle city that involves the impact on the traffic system is question #8: Will STREETLIFE reduce time spent in traffic?

According to the answers given from the mobility manager operating in the medium city, STREETLIFE solutions have a positive impact on traffic: the STREETLIFE system is useful especially in circumstances where the End Users need to reach a place they are not familiar with. In those circumstances giving the users a clear set of indications to follow will reduce time and length of their trip. Traffic managers say as STREETLIFE enables people to choose best travel mode and they get real time information about traffic situation, this leads to overall time spent in traffic is reduced.

Research Question #11 in the medium city case is specific for the medium-city case: Will STREETLIFE enable traffic managers to manage passenger flows by varying stop goodness values?

Traffic managers said that this is a very interesting idea. Similarly, to the implementation of Park &Ride scenarios, this specific case will be tested in the second iteration, but preliminary feedback on topic has been positive, since quality values associated to bus stops could help citizens to avoid congested stops and generate an equal distribution of traffic flows.

Another hypothesis tested in the medium city involves the trip length, and the impact that more mobility information available can have on the kilometres travelled in a usual trip. In this specific case there are available data regarding their average trip length coming from end users questionnaires:

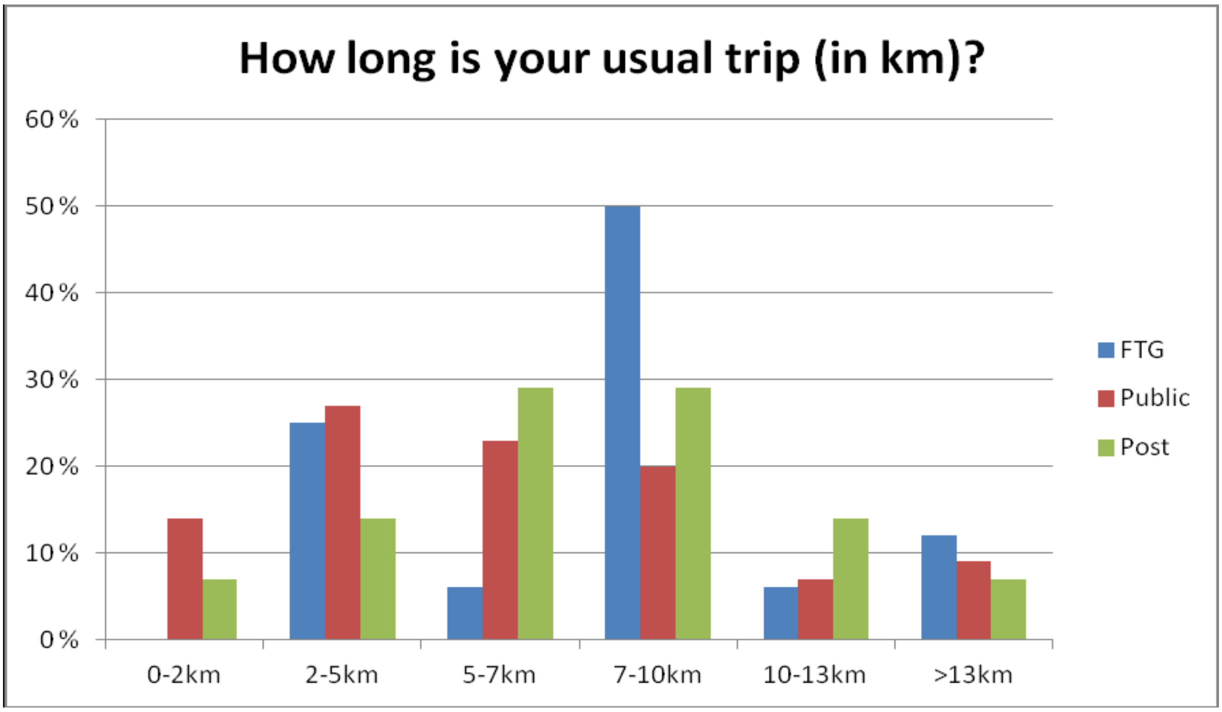

Figure 15: Average trip length from End Users in the Medium City
(FTG=Focus Test Group, Public is the pre-test questionnaire, Post is the ex-post questionnaire)

According to the answers given to pre and post questionnaires, the average length of trips for medium city End Users became longer between the two aforementioned phases. Longer trips taken from STREETLIFE users in the medium city case have also the meaning of more time spent on public means of transportation, since private car does not appear among the routing options of the journey planner. This is another piece of information that adds to the answers given from mobility manager, towards the direction of a positive impact on traffic.

SCALING UP

These considerations lead Tampere mobility manager to evaluate the effect of STREETLIFE at a city level. This evaluation has been quantified in a range between 0.5 and 1% modal shift. In fact, winter period usually causes 3% increase of private car usage and 3% increase in public transport usage due to reduction of cycling usage. In the best case STREETLIFE scenario, with accurate and real time information, waiting time at bus stops will be minimized and the 3% increase of private car usage use in winter could be halved leading to further increase the public transport usage in winter.

The new modal shift takes into consideration that the potential STREETLIFE web App users could be 12,000 and over 20% of commuters in Tampere use ICT to plan their trips several time per day, according to STREETLIFE pre-study questionnaire.

Since the pilot was focused only on public transport, the new modal spilt achieved in the best-case scenario was calculated, increasing bus trips by 1% and reducing car usage by the same value. From the latest official data about traffic in Tampere we extrapolated these key figures:

- Modal split: car 45%, public transport 17%
- Daily trips: 6,200,000 in Tampere, 84% have origin and destination within Tampere municipality;
- Average length of car trips: 9.2 km.

Table 5: Km saved in a medium city thanks to STREETLIFE

	Car	Walk	Bicycle	Bus	Other
MODAL SHARE 2012	45%	27%	10%	17%	1%
TRIPS BASELINE	279,000	167,400	62,000	105,400	6,200
STREETLIFE MODAL SHARE	44%	27%	10%	18%	1%
STREETLIFE TRIPS	272,800	167,400	62,000	111,600	6,200
AVERAGE LENGHT PER TRIP	9.2	1.2	2.90	7.00	-
KM SAVED	-57,040	0	0	43,400	-

Combining together these data, it was possible to achieve the key indicator able to assess the STREETLIFE impact on medium city traffic system. Results are very good; in the best case scenario described above, thanks to STREETLIFE web App in a medium city more than 57,000 km would have not been travelled by car, but by public transport, reducing traffic congestion in Winter, precisely when car usage considerably increase and traffic congestion reaches its peak.

Traffic managers commented that during winter streets can be narrow at times as there can be lot of snow which also causes increase of badly parked cars, therefore even relatively small modal shift to public transport can have big impact in overall traffic situation.

4.4.1. Conclusion

In the environment of the medium city the qualitative evaluation of the STREETLIFE system has given a positive response. The STREETLIFE trip planner provides a multimodal approach to the routing problem, and the suggested routes are more comprehensive and clear about all the possible solutions, thus providing advantages for tourists, people planning new routes and for commuters on long trips in and out of the city.

The first iteration of the STREETLIFE pilot has raised the environmental awareness and provided better information to Pilot users about public transport. While there is general consensus on the fact that STREETLIFE has managed to change mobility habits of its users, the second iteration will be useful in order to determine how this changes occur in a more detailed way.

Nevertheless, even in the first iteration, it was possible to state that in the best case scenario in a medium city, 57,000 km could have not been travelled by cars, but by public transport, thus having a real reduction of car traffic congestion.

In the second iteration more specific cases traffic-related will be tested, like Park & Ride or stop goodness values that will make available more data regarding the impact on private car users and bus users.

4.5. Small city impact assessment

The assessment for the small city case will be developed in three steps. First of all, since a quantitative research approach has been used, the KPIs linked to traffic impact and listed in paragraph 4.2.2.1 will be analysed. The following tables show the variation of each indicator during the trial process. The baseline was considered the first week, when the App did not suggest any sustainable behaviour, while the post-experiment result is referred to the last week, when all incentives to push green transport solutions had been adopted. In the second experiment, results have been compared to the neutral scenario. The indicators that have not been discussed in D.6.2.1 will be fully investigated, whereas the others will be shortly summarized in order to have a complete vision of the trial process performance. In a second step, the amount of kilometres not travelled by car in both experiments will be calculated. Finally, the results achieved the focus group of users in the first experiment will be scaled up to the whole city of Rovereto, while results referring to the experiment for special events do not need any scale-up procedure, because it was an open-field test.

COMMUTERS EXPERIMENT			
KPI	**BASELINE**	**POST-EXPERIMENT**	**DELTA**
PI-307 Journey time	22 minutes	24 minutes	+2 minutes
PI-203 # of carbon friendly	122 per week	309 per week	+187 trips per week
PI-204 Km of carbon friendly trips	499 km per week	1168 per week	+ 669 km per week
PI-120 Bike sharing distance	25 km per week	97 km per week	+72 km per week
PI-112 bike withdrawals	37	42	+ 5 per week
PI-124 bike sharing trips	12 per week	49 per week	+67 trips per week
PI-118 Park & Ride usage			
P&R “Stadio” facility	22%	45%	+23%
P&R “Ex-Manifattura” facility	72%	90%	+18%
PI-125 - Park & Ride trips [#]	0	3 per week	+3 trips per weeks

SPCIAL EVENTS EXPERIMENT	
KPI	**EXPERIMENT RESULTS**
PI-203 # of carbon friendly trips	196
PI-204 Km of carbon friendly trips	784 km

PI-307 Journey time:

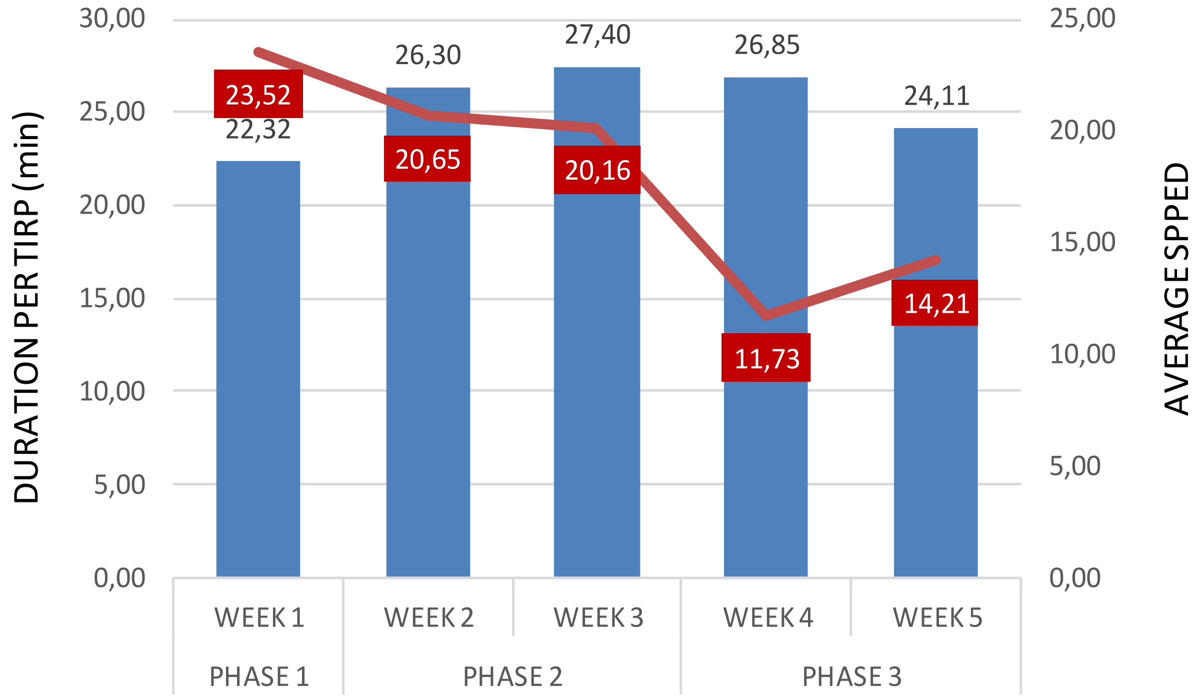

Figure 16 Trip duration during ROV-EXP1

Results about trip duration are slightly different from expectations from the evaluation plan. Indeed, it was supposed that STREETLIFE would have not increased the total travel time (individual), of a trip (HY-201). Actually, journey time rose from 22 minutes per trip to 24, reaching a peak of 27 minutes in the third week. This variation is correlated to the reduction of average speed that slowed down to 14.21 km/h, while at the beginning it was 23.5 km/h.

The trip duration increased because commuters chose to move with sustainable modes of transport; those are typically slower than cars. Moreover, the number of users involved in the experiment was not sufficient to actually reduce traffic congestion and achieve a speed-up effect of public transport vehicles, which remain not fast enough to be competitive in comparison with private motorized vehicles in terms of journey time.

It has to be stressed that the increment is limited to 2 minutes, that corresponds to a +7% in relation to the baseline week value. This variation is minimal, especially if compared to the greater benefit that the mobility system has from the reduction of car usage in the city.

PI-203 - # of carbon-friendly trips and PI-204 - km of carbon friendly trips

The definition of carbon-friendly trip used in this case is a trip without car. Trips with bus and train are included in this category is derived by the fact that, considering a constant supply, these vehicles would travel (and consequently emit pollutant agents) independently by any external consideration including the impact of the STREETLIFE solutions. In the experiment focused on commuters, since a single trip usually involved more than one mode of transport, these indicators refer to parts of a single trip, called legs.

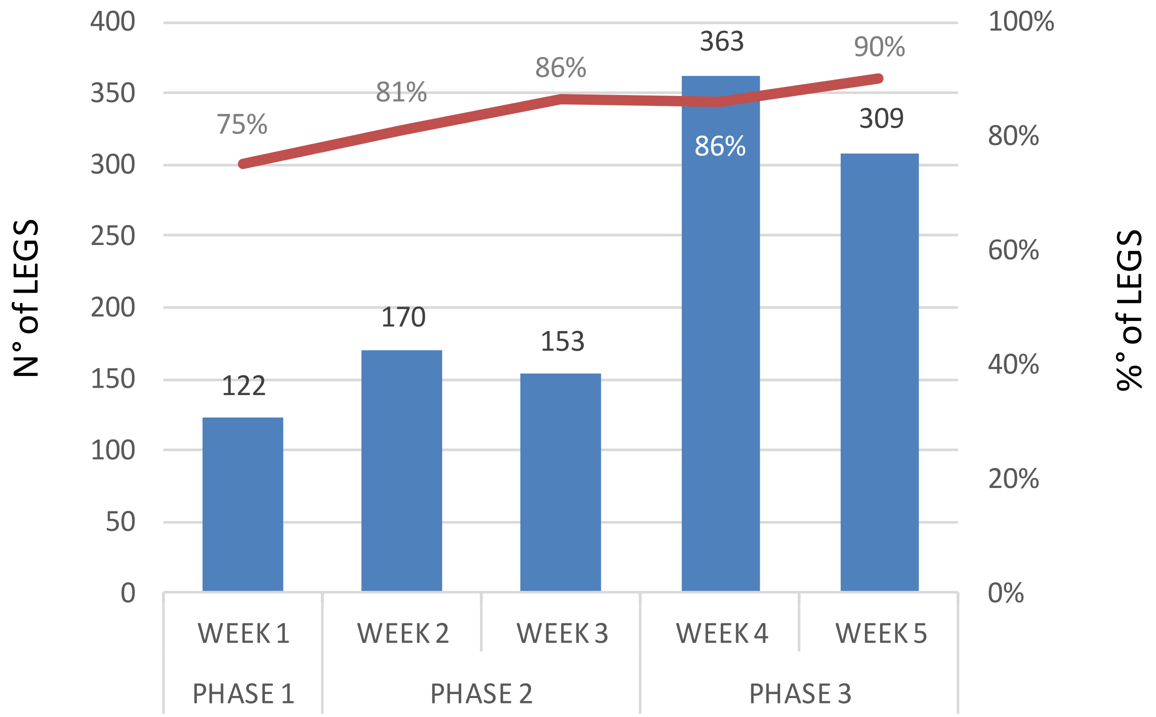

Figure 17: Number of legs travelled by carbon friendly modes of transport in each week and its percentage in relation to the total amount of legs.

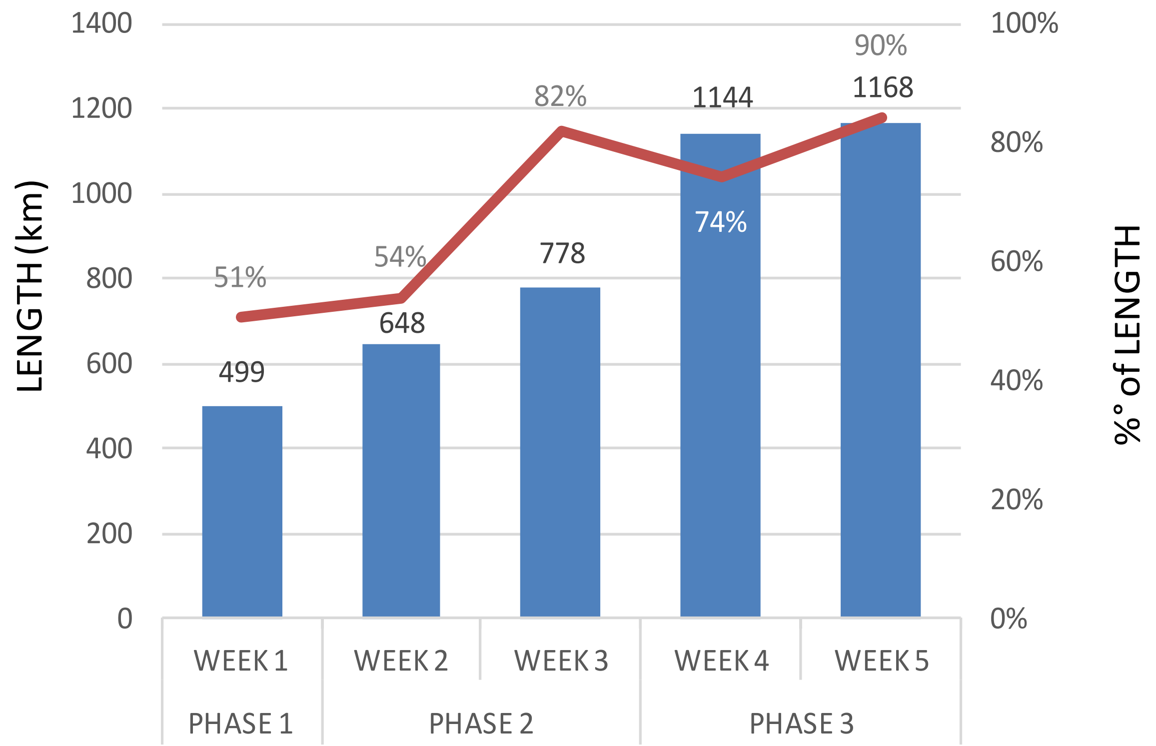

Figure 18: Length travelled by carbon friendly modes of transport in each week and its percentage in relation to the total amount of km.

The achieved results are positive, since the percentage of carbon-friendly trip legs constantly grows, even if the starting point is already high. There is a significant increase from phase 1 to phase 2, when the App started to suggest users how to travel in a more sustainable way. The gamification process in week 4 and 5 had continued to rise up the length of kilometres travelled by carbon friendly modes of transport, although there was a modest decrease from week 3 to week 4.

For the special events experiment, the definition of carbon-friendly trips had to be adjusted. The aim of the experiment was to push tourists to park outside the city in a P&R area, where a shuttle bus service was specifically set up to move them from the parking lot to the event location. Thus, carbon-friendly trips have been identified as those that used the Park&Ride area and reached their final destination not using private vehicles, but by bus or on foot. Specifically, PI-203 corresponds to the number of all the interviewed drivers who parked at the P&R area, while PI-204 has been calculated considering the distance between the event location and the P&R area (2 km to reach the event location from the parking lot added to 2 km to return back to the parking lot, in total 4 km for each carbon friendly trip).

DAY	CARBON FRIENDLY TRIPS	CARBON FRIENDLY DISTANCE [km]
06/12/14	114	456
13/12/14	21	84
20/12/14	18	72
21/12/14	19	76
22/12/14	6	24
23/12/14	2	8
24/12/14	9	36
27/12/14	7	28
TOTAL	**196**	**784**

Figure 19: Trips and length travelled by carbon-friendly modes of transport in each experiment day during ROV-EXP2.

In 8 days, almost 200 carbon-friendly trips had been carried out and nearly 800 km have not been travelled by car. Considering together the effect of both experiments, the trial process produced more than 1,300 carbon friendly trips, and more than 4,500 km were travelled by carbon friendly modes of transport.
In conclusion, findings proved that STREETLIFE increased the use of "green" transport modes (HY-204) both for commuter and occasional (visitors') trips.

PI- 112 Bike withdrawals

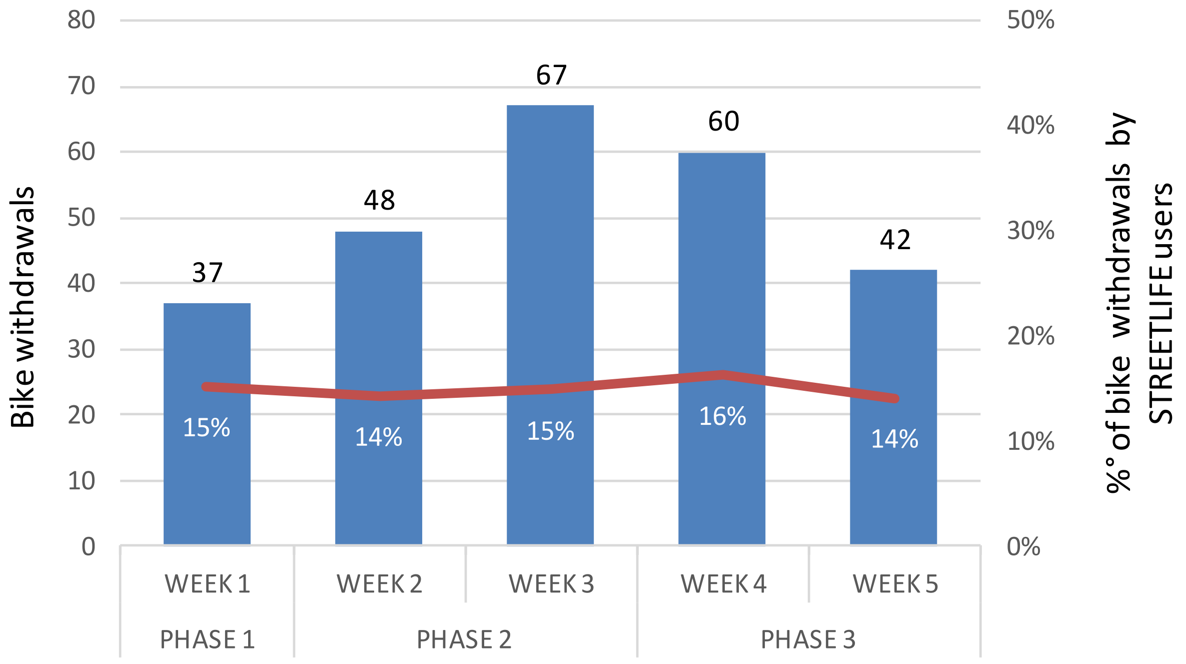

Figure 20: Bike withdrawals made by STREETLIFE users and its percentage in relation to the total bike withdrawals.

Findings for commuters show in the experiment an increase of bike withdrawals from week 1 to week 3 when it was reached a peak of 67 withdrawals. After phase 2, there was a reduction but this trend is perfectly aligned to the total withdrawals made by all bike-sharing users in the city in the same week. Indeed, the percentage of withdrawals made by STREETLIFE users compared to all users remains quite steady, close to 15%.

This indicator that must be related to PI-120 (bike sharing distance) and PI-124 (bike sharing trips), reveals a good answer to the related RQ. Nevertheless, it has to be highlighted that these results are not sufficient to assess the impact of bike sharing service, since it was launched only in September 2014. For this reason, a correct evaluation needs a more extended period of time, even if first findings are promising.

During the experiment for special events, as already described in D.6.2.1, none used the bike sharing service, probably because the registration procedure needed to access to the bike sharing service in Rovereto is not friendly for visitors or occasional users, and is instead oriented to servicing residents and regular users. In fact, completing the registration procedure takes one or more days.

PI- 120 PI-124 PI-118 PI-125

The remaining indicators, which had already been analysed in the context of D.6.2.1, show good results according to the hypothesis formulated in the evaluation plan. Concerning the bike sharing service, the percentage of legs travelled by bike sharing doubles from week 1 to week

5, and there is a significant increase also in the percentage of kilometres travelled. Regarding the P&R trips, even though the result in both experiments is minimal and below expectations, an important fact is that most of the P&R trips were carried out during the third phase of ROV-EXP-1, while none was taken during the first phase; this result suggests a potential of ViaggiaRovereto, together with gamification, to direct users to the P&R facilities. This preliminary result will need to be confirmed and, if confirmed, potentiated with the help of the city Mobility Management.

These indicators describe how the STREETLIFE trial process impacted on the several components of Rovereto traffic system, but do not give a direct measure of the reduction of congestion. For these reasons, the assessment focuses on the estimation of the amount of kilometres not travelled by car thanks to STREETLIFE solutions.

				N° of KMs					
PHASE	WEEK	TRIPS	KM	CAR	BUS	TRAIN	BIKE SHARING	BIKE	WALK
PHASE 1	WEEK 1	113	985	486	188	234	25	5	47
PHASE 2	WEEK 2	133	1199	551	154	313	65	21	95
	WEEK 3	103	946	168	116	492	61	39	70
PHASE 3	WEEK 4	295	1537	393	253	519	105	73	195
	WEEK 5	245	1388	220	273	538	97	100	160

Figure 21: Length travelled for each mode of transport during ROV-EXP-1

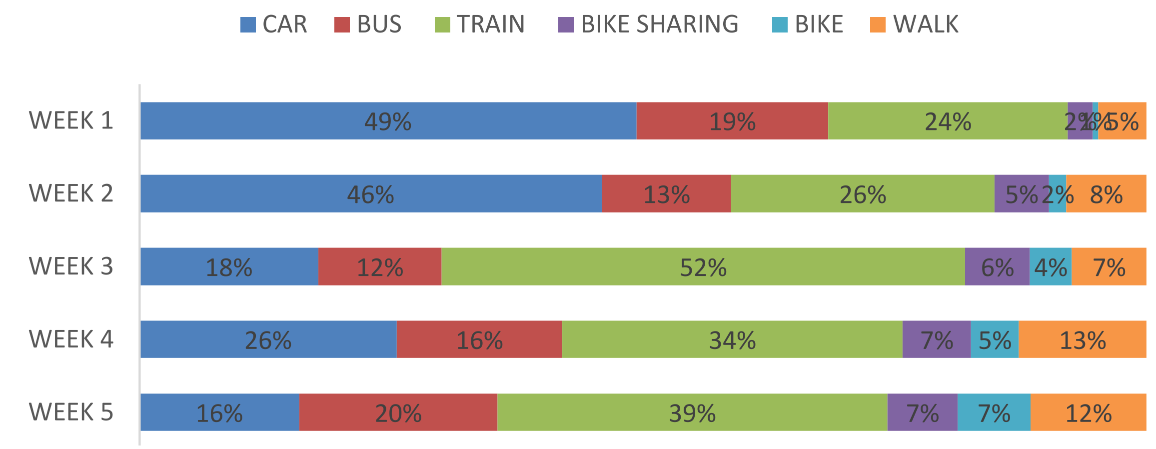

Figure 22: Percentage of length travelled for each mode of transport during ROV-EXP-1

In the experiment for commuters distance travelled increased from 985 to 1388, probably because as explained in D.6.2.1, users became more and more confident and use the App for all their daily trips. Thus, it is not sufficient comparing the distance not travelled by car in each week, but a normalisation is needed. The total distance travelled in the baseline period (week

1) had been considered fixed, and the normalized distance covered by car has been calculated considering the percentage of length travelled by car in each week.

PHASE	WEEK	TOTAL KM TRAVELLED	KM TRAVELLED BY CAR	LENGTH TRAVELLED BY CAR	KM SAVED	KM SAVED NORMALIZED
PHASE 1	WEEK 1	985	486	49%	--	--
PHASE 2	WEEK 2	1,199	551	46%	64	-34
	WEEK 3	946	168	18%	-318	-311
PHASE 3	WEEK 4	1,537	393	26%	-94	-235
	WEEK 5	1,388	220	16%	-266	-330

Figure 23: Kilometres saved for each week during ROV-EXP1

The results are very good. The amount of kilometres saved increased from 34 to 330 per week. This indicator shows the benefit of STREETLIFE on traffic generated by commuters in Rovereto. Moreover, the results must be related to the findings concerning the use of long-stay parking areas, illustrated in D.6.2.1. The experiment succeeded also to reduce the pressure of on-street parking areas and divert car drivers to long-stay parking lots outside city centre.

Concerning the impact of STREETLIFE on traffic system during special events, we must take into account that a bus shuttle service was specifically set up. Thus, if tourists did not travel part of their trip by car, an additional vehicle would have been circulating in the traffic network. The shuttle bus service run about 25 trips per day, according to the timetable set up with the municipality, travelling 4 km per trip. Therefore, the actual distance saved thanks to ROV-EXP2 is the difference between length not travelled by cars and distance travelled by shuttle-bus.

DAY	CARBON FRIENDLY TRIPS	CARBON FRIENDLY DISTANCE [km]	DISTANCE TRAVELLED BY SHUTTLE BUS [km]	ACTUAL DISTANCE SAVED [km]
06/12/14	114	456	100	356
13/12/14	21	84	100	-16
20/12/14	18	72	100	-28
21/12/14	19	76	100	-24
22/12/14	6	24	100	-76
23/12/14	2	8	100	-92
24/12/14	9	36	100	-64
27/12/14	7	28	100	-72
TOTAL	**196**	**784**	**800**	**-16**

Figure 24: Kilometres saved for each day during ROV-EXP2

Results are very good in the first day of the experiment, when more than 350 km have been saved. In the other days, findings are below expectations. The bus-shuttle has successfully operated during peak-hours, while in the off-peak hours it was used by a low number of tourists. This was caused by the need to guarantee a high-frequency service and a clear message for tourists. Furthermore, Rovereto is a small city and the P&R area was just outside the city centre. In fact, as reported in D.6.2.1, more than 50 people parked in the P&R area and walked to reach the event location. Finally, it has to be stressed that this event was family-oriented and car occupancy rate was quite high, about three people per car. For these reasons, in other type of events the P&R service could have offered more significant traffic benefits.

SCALING-UP

Once assessed the impact of the experiment, the evaluation process concentrates on the scaling-up procedure, in order to estimate the STREETLIFE impact on the entire city if all citizen would have used STREETLIFE solutions. The first step was the calculation of the modal split achieved by commuters involved in the experiment according to Italian National Institute of Statistics standards [Istat, 2014] in order to have a clear comparison between the modal share of STREETLIFE users and the total modal split in Rovereto. For this reason, the modal share considers only the prevalent mode of transport, defined has the mode responsible for the most kilometres in each trip. Saved trips with the app have been divided in two categories: the first includes users moving within the city, while the second counts commuters coming from other municipalities. This specification is necessary because users moving within a small city have more mobility option than people coming from outside, also because of different distances that they have to travel. Thus, it is fundamental to keep separated these two categories. Modal shares refer to second week since it is the first week where the App included green-advertised routes.

	BIKE	BUS	CAR	TRAIN	WALK	total
inside city	51%	12%	12%	2%	23%	100%
outside city	8%	28%	43%	20%	1%	100%

Figure 25: Modal share of STREETLIFE users during second week

The second steps deals with the estimation of a new modal split of the entire city. The new modal split considers the variation only of those users that had actually changed their behaviour from the first week and assigns this variation to the modal share provided by the survey of Italian National Institute of Statistics, which is the last available official data.

For each week of the experiment, has been calculated the modal share reached as a result of the pilot.

	BIKE	BUS	CAR	TRAIN	WALK	TOTAL
inside city	14%	3%	61%	0%	21%	100%
outside city	2%	4%	92%	2%	1%	100%

Figure 26: Rovereto modal share according to ROV-EXP1 effects in the second week

The third step concerns the analysis of the total commuter trips towards Rovereto according to the last data published by Italian National Institute of Statistics referring to 2011 [Istat, 2014]. Commuter trips within Rovereto boundaries are 9,491 and 9,150 come from outside the city.

	BIKE	BUS	CAR	TRAIN	WALK	TOTAL
inside city	1,131	331	5,849	31	2,150	9,491
outside city	152	368	8,415	158	57	9,150

Figure 27: Total commuter trips towards Rovereto per day. Source: Italian National Institute of Statistics (ISTAT)

These data do not consider commuter trips that have origin within Rovereto and destination in other municipalities, because the target of the experiments was commuters moving towards Rovereto.

To continue, these internal and external trips have been multiplied by the new Rovereto modal share in order to obtain the number of trips for each mode of transport. At this point, it was possible to calculate the difference of trips carried out towards Rovereto and within its boundaries between the first week and the following four ones.

	BIKE	BUS	CAR	TRAIN	WALK	TOTAL
inside city	81	-18	-107	0	44	0
outside city	26	-44	-130	118	30	0

Figure 28: Variation of trips between Rovereto incoming commuter trips and the relative ones that consider STREETLIFE effects during the third week of ROV-EXP1.

In order to achieve the final results, we need to consider the average number of trips per day per person and the average travel distance. In northern Italy, as reported by Higher Institute for Transport Research and Education (ISFORT) [Isfort 2013], a person carries out 2.9 trips per day and in Rovereto, according to the App logs, the average distance travelled within the city are 5 km, which increases to 15 km for people coming from other municipalities.

This data lead to the quantification of the amount of kilometres that would have not been travelled by car, if all car commuters moving towards Rovereto had used the STREETLIFE solutions. Figure 22 describes the variation in percentage of kilometres travelled by car, where the reference point is distances travelled by car according to Rovereto official modal split.

	km travelled by Rovereto car commuters	WEEK 2	WEEK 3	WEEK 4	WEEK 5
inside city	50,884	-2%	-3%	-13%	-18%
outside city	366,059	0%	-2%	-2%	-4%
Total	**416,943**	**-1%**	**-2%**	**-3%**	**-6%**

Figure 29*:* Variation of distance travelled by cars in Rovereto thanks to STREETLIFE

The results are very good. If all commuters in a small city would have used STREETLIFE, the reduction of traffic congestion would have constantly grown, reaching the 6% during the last week. If we examine the two categories pinpointed, the best results would have been achieved for trips within the city, probably because the nearby municipalities do not offer competitive car alternative services to reach Rovereto.

4.5.1. Conclusion

In the environment of a small city, the overall effect of STREETLIFE on traffic system could be an important step towards greener mobility habits. The designed STREETLIFE solutions, besides raising the level of awareness and information about sustainable mobility service available in a small city like Rovereto, proved that they could have a real impact on the city traffic system. ViaggiaRovereto and its gamification together with policies that Rovereto municipality chose to promote in the context of the project, which are automated and pushed via the STREETLIFE solution, would have saved almost 25,000 km every day, if all commuters to Rovereto used the App for planning their trips. This result refers to the difference between the kilometres usually travelled by car commuters and those one that would have been travelled in the fifth week if STREETLIFE have involved the whole city.

	km travelled by Rovereto car commuters	**WEEK 2**	**WEEK 3**	**WEEK 4**	**WEEK 5**
inside city	50,884	49,906	49,331	442,88	41,567
outside city	366,059	364,597	360,422	359,989	350,466
Total	**416,943**	**414,503**	**409,753**	**404,277**	**392,033**

Figure 30: Distance travelled by car every day in a small city considering commuters as all Android users

This estimation imagines that all Rovereto commuters use ViaggiaRovereto. In fact, the rate of Italian people owning a smartphone is 68% with respect to the whole population, and this figure is constantly growing.

	km travelled by Rovereto car commuters	**WEEK 2**	**WEEK 3**	**WEEK 4**	**WEEK 5**
inside city	**50,884**	**-1%**	**-2%**	**-9%**	**-12%**
outside city	**366,059**	**0%**	**-1%**	**-1%**	**-3%**
Total	**416,943**	**0%**	**-1%**	**-2%**	**-4%**

Figure 31: Distance travelled by car every day in a small city considering smartphone penetration

Estimating a 75% of penetration of smartphone in European population in a few years, the distance travelled by car thanks to STREETLIFE will decrease by 4% that corresponds to a reduction of more than 16,600 km every day.

This is an important outcome for a small city, because it was reached acting only on the ICT facet of the mobility system. In a small city, however, these kinds of solutions have necessarily a limited impact, if not supported by adequate infrastructure. This was evident in the P&R

scenario, where result was below expectation, because the selected areas for P&R lack some key characteristics to be effective P&R facilities for a small city.

Another aspect that is essential for a small city is mobility management. Despite the limited size of the city, mobility management is crucial because it strongly contributes to change commuters' modal split and consequently reduce critical situations during peak hours. Mobility management also in a small city is important because it can orient mobility demand towards sustainable mode of transports and reduce traffic congestion exploiting ICT solutions. This will be tested during the second iteration, when Rovereto mobility manager will be provided with a dashboard monitoring different component of the traffic system.

Finally, it has to be stressed that the solutions implemented in Rovereto must be adjusted if used in other small cities. If the ideas can be adopted in other contexts, the same scenario cannot be simply replicated *as is* in other small cities. For example, bike sharing may not be suitable in a very low density city, where it may be more appropriate investing in a specific scenario about public transport.

In conclusion, STREETLIFE proved to have a real effect on traffic system both for commuter and occasional trips. However, these solutions must be adjusted according to key characteristics of the city and should be combined with infrastructural and mobility management interventions in order to have a higher impact.

5. IMPACT ON CARBON EMISSION

5.1. Objectives

One main objective of STREETLIFE is the reduction of carbon emissions through sustainable urban mobility solutions based on Information and Communication Technologies (ICT). Therefore the guiding question of the impact assessment in terms of carbon emission is: To what extent STREETLIFE can decrease the carbon footprint of individuals and the carbon emissions within a city caused by land-based transport? Therefore the estimation of CO_2-effects on a small scale, distinguished for different situations (e.g. traffic state, transport mode etc.) and taking situational variables into account (e.g. time of day, and weather, etc.).

RQ–ROV-7 RQ-BER-8	If there is a change in the mode choice, what impact does it have on CO_2-emissions?	HY – 102; HY – 104; HY-106
RQ–ROV-17 RQ-TRE-6	If there is a change in the mode choice, what impact does it have on fuel consumption?	HY – 101; HY – 103; HY-105

5.2. Research approach

Based on literature review a number of general effects of routing and travel information systems may influence CO_2-emissions. The effects can be distinguished between direct, short term and long-term effects. According to the system design and functionality, the following direct or short-term effects can be expected:

- Departure time choice: positive effect, since congestion can be avoided using the system by departing earlier or later [Cham 2006].
- Route choice: positive effect, since congestion can be avoided using the system by choosing a route with no or less congestion [Dziekan 2007].
- Mode choice: positive effect, one may decide to switch to public transport (pre-trip and on-trip) when the system indicates heavy congestion on the road such that travel times with public transport may become shorter than by passenger car [Roider 2011].

Long-term effects expected of routing and travel information systems are changes in mobility behaviour and following transport demand. “Greener” transport modes such as public transport or cycling might then be selected for a trip. Certain changes in the mobility behaviour have in turn an effect on carbon emissions. Finally, the public transport scheduling might change when the system would increase the use of public transport structurally.

In order to better understand the mechanisms by which ITS exert their influence the impact of ITS-based routing and travel information systems, a short excurse might be gain benefit. As the system can have a direct or indirect influence on driver or mobility behaviour, these can be described by factors and parameters. By separating the direct and indirect effects of ITS into four groups, the following overview can be detected:

- Parameters describing traffic demand
- Parameters describing travel behaviour and vehicle
- Indirect factors (influences on transport processes)
- Long-term effects of ITS.

These parameters have an effect on the type of modelling that is used for the assessment.

- Individual level: Compare ex-ante/ex-post travel behaviour of pilot participants
- Network: Analyse results of the traffic simulation with focus on CO_2 emission reduction

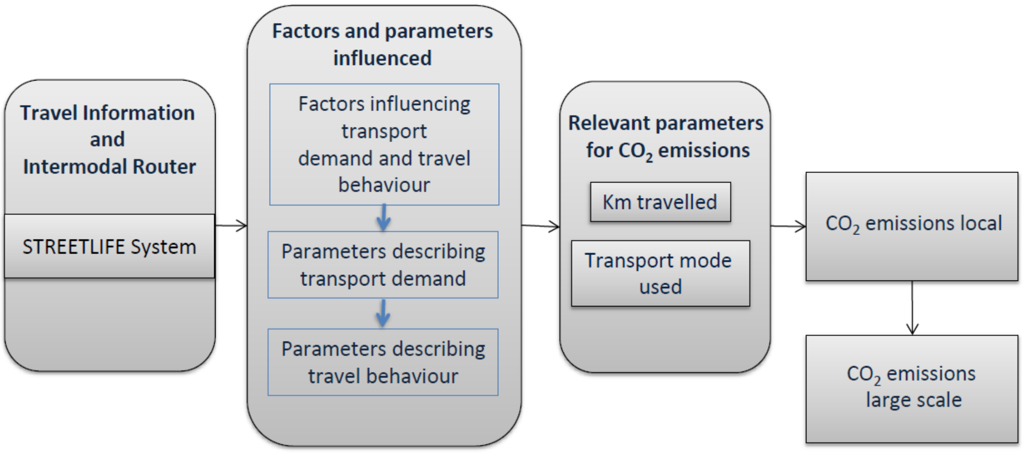

Figure 32: Schema of CO_2 assessment of ITS (adopted by AMITRAN)

In STREETLIFE, the schema above (Figure 32) is used to calculate the carbon emission saved due to routing and travel information systems. For the calculation and estimation of traffic impacts different methods have been used as it is shown in chapter 4. The calculation of local CO_2-emission is based on these results whereas different methods were used.

Simulation-based approach

As the BER pilot is following the simulation-based approach in order to quantify carbon emission savings, the corresponding research question for the BER pilot is given with the following table.

BERLIN PILOT SITE		
RESEARCH QUESTIONS	HYPOTHESIS	KPI
RQ-BER-8 If there is a change in the mode choice, what impact it has on CO_2-emissions?	HY-104 STREETLIFE does increase the use of "green" transport modes.	PI-101 #trips PI-106 Trips length mode

The approach applied is manly based on results described in Chapter 4. This approach uses the TAPAS microscopic traffic network simulation results in order to quantify the kilometre travelled and the transport mode used. In addition, the CO_2-values for the different transport modes have been considered for calculation. The emission factor is an average value considering the different vehicle categories (mini-luxury cars) and both power units (Gasoline and Diesel).

In order to calculate carbon emission E the following formula will be applied:

$$E = \sum_{i=0}^{n} c_i * B_i$$

where i = trip, c = trip distance and B = emission factor for applied mode of transportation. This will be calculated for the baseline (investigation described in chapter 4.2.1.2) and the scenario situation as derived from literature studies or – in case of the second iteration large scale field trial – field test data collection.

Quantitative approach

This approach is manly based on results described in Chapter 4, because all the key indicators necessary to assess the impact of STREETLIFE in terms of CO_2-emissions derive from the amount of kilometre not travelled by car thanks to STREETLIFE pilot.

Similarly to the research approach used in the traffic impact section, for the medium city case the methodology is purely qualitative because the first iteration was more focused on testing technical evaluation deployed. In fact, the journey planner provided users with information of CO_2-emissions per each trip option, but it was not possible to gather data about the actual trip chosen by users. Moreover, weather played a big role in the pilot and we could not compare data collected in pre and post study questionnaires, because they were submitted with different weather conditions that strongly influence users' mobility behaviour.

For these reasons, the evaluation of the medium city case is mainly based on answers given by the mobility managers who estimated the modal shift achieved through STREETLIFE solutions.

In the small city case, the approach has been both quantitative and qualitative. In fact, the evaluation of the effects on commuter's mobility was based on data collected by the routing App, while the impact on mobility system in case of special events was assessed through questionnaires.

In order to quantify the CO_2-savings, it was necessary to multiply the kilometres saved by an emission factor. In the medium city, this value has been derived from national statistics, while in the small city case it has been calculated for the specific selected city through CORINAIR, a methodology developed by European Environment Agency (EEA) that provides an emission inventory for every category of vehicles.

In the small city case, the analysis was focused on emission produced by exactly Rovereto car fleet. The procedure used CORINAIR methodology developed by European Environment Agency (EEA) that provides an emission inventory of every category of vehicle. In detail, CO_2-estimation is derived from fuel consumption that, like other pollutant agents, is determined with this algorithm:

$$E_{i,j}(t) = \sum_k \left(N_{j,k} * M_{j,k}(t) * EF_{i,j,k}\right)$$

where

$M_{j,k}$ = distance driven by all vehicles of category j and technology k in period t in [vehicles/km]

$EF_{i,j,k}$ = technology-specific emission factor of pollutant i for vehicle category j and technology k in [g/(vehicle-kilometres)]

$N_{j,k}$ = number of vehicles in city's fleet of category j and technology k

Once the fuel consumption has been obtained, another algorithm is needed for CO_2 estimation:

$$E_{CO2,k,m} = 44.011 * \frac{FC_{k,m}}{12.001 + 1.008 * r_{H:C,m} + 16.008 * r_{O:C,m}}$$

where

$FC_{k,m}$ = fuel consumption of those vehicles for the time period considered and
$r_{H:C,m}$, $r_{O:C,m}$ = hydrogen:carbon and oxygen:varbon ratios for different fuel types.

5.2.1. Data requirements, analysis

The following table recap the research questions, hypothesis and KPIs concerning CO_2-emissions.

TAMPERE PILOT SITE		
RESEARCH QUESTIONS	HYPOTHESIS	KPI
RQ-TRE-1 Is there a significant change in the mode choice?	HY-203 HY-204 STREETLIFE significantly leads to a change in mode choice	PI-101 #Trips PI-120 #users PI-201 Trips length, mode

RQ-TRE-5 If there is a change in the mode choice, what impact it has on CO_2-emissions?	HY-102 STREETLIFE does not increase the total travel time (network) HY-104 STREETLIFE does increase the use of "green" transport modes.	PI-101 #trips PI-102 #users PI-106 Trips length mode

ROVERETO PILOT SITE		
RESEARCH QUESTION	**HYPOTHESIS**	**KEY PERFORMANCE INDICATOR**
RQ-ROV1 Is there a significant change in the mode choice?	HY-204 STREETLIFE does increase the use of "green" transport modes.	PI-203 # of carbon friendly trips PI-204 [km] km of carbon friendly trips
RQ-ROV17 If there is a change in the mode choice, what impact it has on fuel consumption?	HY-101 STREETLIFE will reduce the fuel consumption of a trip for a certain OD. HY-103 STREETLIFE will reduce the fuel consumption of the daily trip chain.	PI-205 Fuel consumption [l]
RQ-ROV7 If there is a change in the mode choice, what impact it has on CO_2-emissions?	HY-102 STREETLIFE will reduce the carbon footprint of a user for a certain OD. HY-104	PI-201 Carbon emissions [kg CO_2]

	STREETLIFE system will reduce the CO_2-emissions of the daily trip chain.	

In addition to the amount of km not travelled by car estimated in chapter 4, the piece of information necessary to calculate these indicators is the emission factor related to private motorized vehicles. In the medium city case these values was obtained from national calculation system for traffic exhaust emissions and energy consumption (LIPASTO) developed by VTT Technical Research Centre of Finland (http://lipasto.vtt.fi/yksikkopaastot/indexe.htm). This factor corresponds to 171 g CO_2/km, while in the small city case the emission factor CO_2 have been calculated through CORINAIR methodology, considering Rovereto car fleet composition.

Data about vehicle fleet divided in the categories specified by CORINAIR methodology derive from ACI database (Italian Automobile Club). The following table show the composition of Rovereto car fleet.

FUEL SUPPLY SYSTEM	HORSE POWER	EURO 0	EURO 1	EURO 2	EURO 3	EURO 4	EURO 5	EURO 6	NOT DEFINED	TOTAL
GASOLINE	up to 1400	2.47%	1.02%	5.32%	4.85%	11.45%	5.23%	0.32%	0.01%	30.68%
	1401 - 2000	0.96%	0.61%	1.93%	1.19%	2.72%	0.79%	0.04%	0.00%	8.24%
	over 2000	0.17%	0.05%	0.10%	0.10%	0.30%	0.09%	0.00%	0.00%	0.82%
GASOLINE AND LIQUEFIED GAS	up to 1400	0.09%	0.02%	0.09%	0.09%	1.48%	0.55%	0.02%	0.00%	2.34%
	1401 - 2000	0.14%	0.07%	0.20%	0.13%	0.65%	0.12%	0.01%	0.00%	1.31%
	over 2000	0.01%	0.01%	0.02%	0.03%	0.06%	0.01%	0.00%	0.00%	0.14%
GASOLINE AND NATURAL GAS	up to 1400	0.01%	0.00%	0.01%	0.01%	0.20%	0.26%	0.01%	0.00%	0.51%
	1401 - 2000	0.01%	0.01%	0.02%	0.03%	0.13%	0.03%	0.00%	0.00%	0.23%
	over 2000	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.01%
DIESEL	up to 1400	0.04%	0.00%	0.00%	0.76%	2.95%	3.40%	0.20%	0.00%	7.35%
	1401 - 2000	0.30%	0.11%	1.84%	6.25%	9.23%	19.15%	3.08%	0.00%	39.95%
	over 2000	0.26%	0.17%	1.03%	2.05%	2.10%	2.22%	0.39%	0.00%	8.21%
ELECTRIC-HYBRID	up to 1400	0.00%	0.00%	0.00%	0.00%	0.00%	0.01%	0.00%	0.00%	0.01%
	1401 - 2000	0.00%	0.00%	0.00%	0.00%	0.01%	0.13%	0.04%	0.00%	0.18%
	over 2000	0.00%	0.00%	0.00%	0.00%	0.01%	0.01%	0.00%	0.00%	0.02%

Figure 33: Rovereto car fleet composition

Using the algorithm explained in paragraph 5.2.1, an emission factor for each type of vehicle has been calculated.

FUEL SUPPLY SYSTEM	HORSE POWER	EURO 0	EURO 1	EURO 2	EURO 3	EURO 4	EURO 5	EURO 6	NOT DEFINED	TOTAL
GASOLINE	up to 1400	2022,8	719,0	3757,5	3425,4	8087,3	3696,0	228,5	10,6	21947,1
	1401 - 2000	931,4	505,1	1610,4	991,7	2262,2	653,4	36,3	2,7	6993,2
	over 2000	199,6	57,5	112,0	113,1	320,0	102,1	4,9	0,3	909,5
GASOLINE AND LIQUEFIED GAS	up to 1400	59,2	14,9	61,5	60,1	1029,6	385,7	16,2	0,0	1627,1
	1401 - 2000	96,1	47,1	142,1	89,3	450,0	85,7	3,5	0,2	914,0
	over 2000	9,7	5,4	14,8	18,8	43,7	4,0	0,0	0,0	96,5
GASOLINE AND NATURAL GAS	up to 1400	4,7	2,8	9,1	8,3	140,9	181,3	4,9	0,0	352,1
	1401 - 2000	4,6	5,4	14,9	23,0	87,7	22,8	1,9	0,4	160,8
	over 2000	0,2	0,2	0,0	1,1	2,8	0,2	0,0	0,0	4,4
DIESEL	up to 1400	19,3	1,1	1,9	357,6	1392,1	1605,7	93,5	0,0	3471,1
	1401 - 2000	231,9	73,2	1256,5	4273,5	6312,0	13091,1	2106,4	0,2	27344,7
	over 2000	239,3	153,0	935,9	1861,7	1901,5	2011,9	350,0	0,7	7454,0
ELECTRIC-HYBRID	up to 1400	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
	1401 - 2000	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
	over 2000	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0

Figure 34: Rovereto car fleet CO_2-emissions [kg/km]

The sum of these factors divided by the number of cars in Rovereto produced the average emission factor that corresponds to 179.91 g CO_2/km. The value added of this procedure is its specificity Indeed; the emission factor refers exactly to a small city.

5.3. Assessment of impacts for large cities

5.3.1. Introduction

According to plan, for the STREETLIFE large city pilot a simulation-based approach has been applied for the first iteration. This simulation is based on assumptions described in chapter 4.2.1.5. The simulation has been calibrated (baseline) with official mobility statistics, namely the household mobility study "Mobilität in Deutschland 2008". Applied emission factors have been investigated in 2014 in the FP7 research project MOLECULES – not distinguishing between different car engine types. Factors of public transport modes are provided by BER public transport operators.

5.3.2. Results

Based on simulated output, the following tables could be derived.

Baseline				
Mode	Trips per day	Mileage in km	Emission factors	Emissions in kg CO_2
Walk	3,103,980	5,570,065	0	0
Bicycle	2,063,230	8,119,605	0	0
Car	4,283,120	31,536,338	176	5,550,395
Car_Passenger	969,340	7,873,306	88	692,851
Public Transport	3,303,770	25,811,737	49	1,264,775
Total				**7,508,022**

Scenario				
Mode	Trips per day	Mileage in km	Emission factors	Emissions in kg CO_2
Walk	3,096,970	5,532,222	0	0
Bicycle	2695,930	10,174,876	0	0
Car	3,666,940	29,099,749	176	5,121,556
Car_Passenger	716,440	6,506,378	88	572,561
Public Transport	3,480,570	26,822,241	49	1,314,290
Total				**7,008,407**

With the applied simulation scenario carbon emissions of **499,615 kg = 500 tons** could be saved per day for the overall Berlin transportation system. That would equate for about 6.5% of the road based transport emission (without logistics, busses). In fact, the potential of carbon emission reduction for a large city is very high when realizing a comprehensive cycling approach.

This calculation incorporates the following emission factors: Car = 178g/km, CarAsPassenger = 88g/km. It further assumes that the modal split for public transport modes bus, metro, train and tram are equally distributed. Corresponding mode specific emission factors (bus = 118g/km, metro, train and tram = 26g/km) are averaged to 49g/km.

With respect to the research question addressed, the following can be concluded from first iterations simulations, user surveys and interviews.

Research Question	Main Result of First Iteration
RQ-BER-8: If there's a change in the mode choice, what impact it has on CO_2-emissions?	With the change of modal split an impact on carbon emissions can directly be derived. When a change of modal split can be achieved, it will have an impact on emissions. Thus, a close relation between those impact categories exists and described methodologies (TAPAS simulation) will be used also for quantifying changes of the second iteration. For the second iteration a clear focus is set on simulation settings derived from field test results.

5.3.3. Qualitative investigations

During the small-scale pilot users have been asked for their assessment on how targeted STREETLIFE solution could contribute to carbon emission savings (see report D6.2.1 chapter 4.2.4.3).

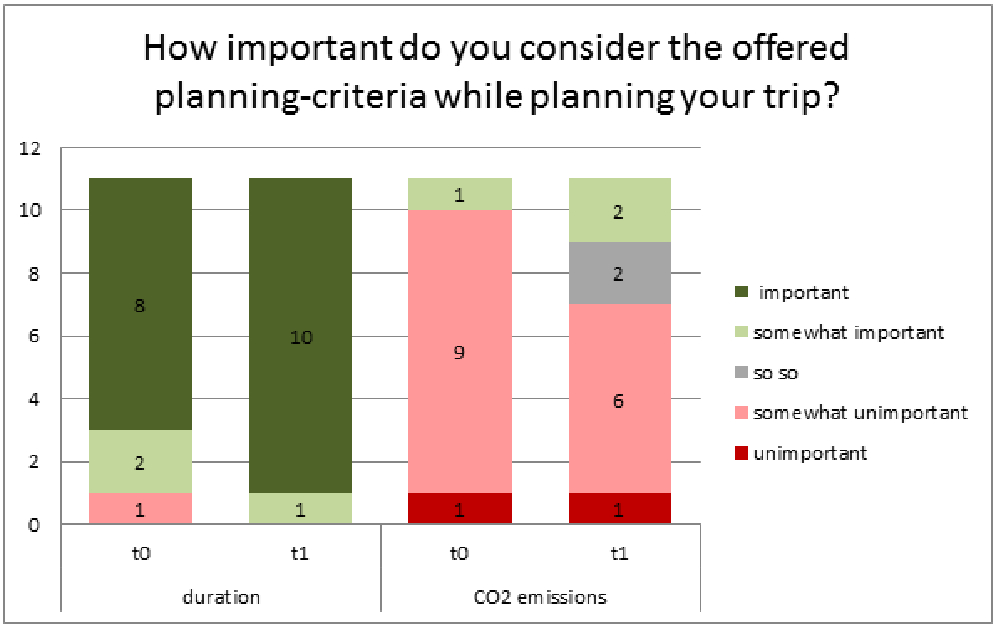

Figure 35: Importance of planning criteria

In Figure 35, it is obvious – also from a variety of European and national research projects – that duration (or costs) is the most important trip planning criteria; it even increases with using the App for trip planning. On the other hand, emissions were reported at the beginning of the trials as the least important planning criteria. This fact is still valid after the App has been integrated into planning, this has slightly changed in the meantime. An explanation could be that the provisioning of information of environmental impacts of individual mode choices supports greener mobility decisions.

In general, the role a STREETLIFE App or, more generally, information provision could play for emission saving has been assessed from neutral to rather good by users.

In addition, these aspects and first trends will be thoroughly re-assessed in the second field trial with larger user groups and better data from the field.

5.3.4. Outlook

A direct allocation of savings to STREETLIFE could not be achieved due to the small scale field trials of the first iteration. This will be analysed in detail within second iteration based on in-situ field data.

With the first iteration test setup reasonable trends for carbon emission reduction potentials could be achieved. This trend is to be proven with the large-scale field tests of the second iteration. This can only be accomplished with larger groups of well-selected users. As mentioned before, strong efforts have been applied between the first and the second field test period to engage more users.

As described in chapter 4.3.3 the user engagement will address panel user as well as a free user recruitment on-field in order to reach the highest possible number of test users.

Taking into account findings of the first iteration, the second iteration evaluation will pay special attention on how gamification can contribute to reliably save carbon emission for daily mobility as an additional driver complementing information provision. Assessment of impacts for medium cities

5.4. Assessment of impacts for medium cities

The evaluation process for the medium city case is based on results achieved in terms of traffic impact, as already described in the research approach. For the reasons described in paragraph 5.2.2, the evaluation is based mainly on the answers given by Tampere mobility managers. As reported in these interviews, multiple real time information feed integrated into a single, easy to use and reliable service has impact on people travels, and consequently on CO_2-emissions. Furthermore, mixed reality interface makes learning the use of public transport network easier both for tourists, who are not familiar with city public transport system, and for citizens. Indeed, if they already know how the network works, in case of changes in the main routes, they could re-plan their trips thanks to STREETLIFE web app.

Raising levels of information is the prerequisite for informed decisions. Indeed, sustainability issues (carbon footprint) might not be direct enough for end users to make them change their mobility habits and chose greener mode of transports. STREETLIFE will probably have long-term effects on CO_2-emissions, but IT system and new traffic infrastructure investments must be combined to have a stronger effect on sustainable mobility. Moreover, co-operation with big companies in Tampere region might bring additional effect.

Other available data collected during the experiment deal with users of the web App. In three months 4,280 people used the App and 63% use it more than once. These data combined to traffic manager questionnaires show the effort to achieve a positive impact in terms of CO_2 emission.

<u>SCALING UP</u>

The scale up procedure is based on the amount of kilometres not travelled by cars in the best case scenario. The mobility manager estimated a 1% modal shift considering that STREETLIFE web App could reach 12000 users and that over 20% of commuters in Tampere usually plan their trips with ICT.

The distance that would not have been travelled by car thanks to STREETLIFE in the best-case scenario have been multiplied by the emission factor of cars in Finland (171 g/km).

	CAR	ON FOOT	BYCICLE	BUS	OTHER
MODAL SHARE	45%	27%	10%	17%	1%
STREETLIFE MODAL SHARE	44%	27%	10%	18%	1%
TAMPERE DAILY TRIPS	272,800	167,400	62,000	111,600	620,000
AVERAGE LENGTH PER TRIP [km]	9.2	1.2	2.90	7.00	-
KM SAVED	-57,040	0	0	43,400	-
CO_2 SAVED [t]	-9,75				

Figure 36: Tons CO_2 saved in the best case STREETLIFE scenario in a medium city

Results are very good. The amount of CO_2 that would have been saved in the best-case scenario is 9.75 t CO_2. Tampere's CO_2 project estimates that total emissions in a year due to road traffic amount to slightly less than 300.000 tons, so the amount of STREETLIFE-based savings would be of 1,2% of total emissions. This outcome shows that ICT solutions could have a real environmental impact in a medium city. It has to be highlighted that these results have been achieved acting only on one mode of transport and without infrastructural interventions.

5.5. Assessment of impacts for small cities

This chapter will describe the results achieved in terms of environmental impact in a small city. Firstly describing the KPI linked to CO_2-emissions, defined in the evaluation plan will be analysed for trips related to commuters and special events. Afterwards results about commuters will be scaled up at city level in order to assess the impact of STREETLIFE in a small city similar to Rovereto.

The method to calculate the variation of the KPIs is equivalent to the procedure already described in paragraph 5.2.1. The baseline for the experiment focused on commuters was considered the first week and the post experiment results refer to the last week. Since the total distance travelled increased during this trial process, the same normalisation implemented in the traffic impact chapter has been used.

Concerning the experiment about special events, results have been compared to the do-nothing scenario.

EXPERIMENT FOR COMMUTERS		
KPI	**BASELINE**	**POST-EXPERIMENT**
PI-203 - # of carbon friendly	122 per week	309 per week
PI-204 Km of carbon friendly trips	499 km per week	1168 per week
PI-205 - Fuel consumption [kg]	27.87	12.62
PI-201 - Carbon emissions [kgCO_2]	87.48	39.63

Since all the assessment approach is based on the evaluation about traffic impact, indicators related to carbon friendly trips have been already described in paragraph 5.2.1.

PI-205 Fuel consumption

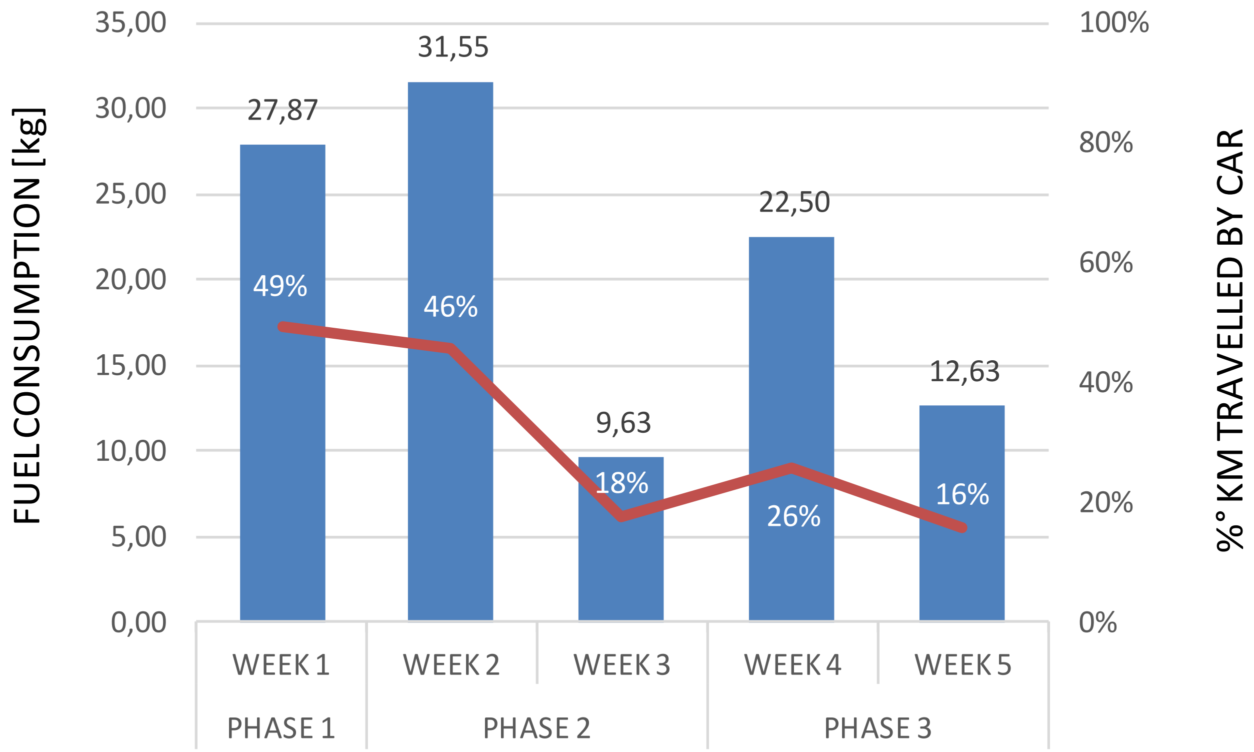

Figure 37: Fuel consumption of cars during ROV-EXP1 and percentage of km travelled by car

Results achieved during the experiment focused on commuters show a positive trend. In week 3, the fuel consumption reached its minimum. These results must be evaluated considering that the amount of kilometres travelled is not constant during every week.

PHASE	WEEK	KM	CAR KM	% CAR KM	FUEL CONSUMPTION [kg]	NORMALIZED CAR DISTANCE	FUEL CONSUMPTION NORMALIZED [kg]	FUEL SAVED [kg]
PHASE 1	WEEK 1	985	486	49%	27,87	486	27,87	-
PHASE 2	WEEK 2	1199	551	46%	31,55	452	25,93	1,94
	WEEK 3	946	168	18%	9,63	175	10,02	17,84
PHASE 3	WEEK 4	1537	393	26%	22,50	252	14,42	13,44
	WEEK 5	1388	220	16%	12,63	156	8,96	18,91

Figure 38: Fuel consumption savings during ROV-EXP1

Adopting the normalisation described in paragraph 4.5, results become clearer. Fuel savings due to experiment on commuters' trips grew during the trial process. This figure proved that

STREETLIFE reduced the fuel consumption of a trip for a certain OD (HY-102) and that fuel consumption of the daily trip chain (HY-103). In fact, the experiment made Rovereto save almost 19 kg of fuel.

DAY	FUEL SAVED BY CARS[kg]	FUEL CONSUMED BY BUS SHUTTLE[kg]	ACTUAL FUEL SAVINGS [kg]
06/12/14	26,13	7,80	+18,33
13/12/14	4,81	7,80	-2,99
20/12/14	4,13	7,80	-3,67
21/12/14	4,36	7,80	-3,44
22/12/14	1,38	7,80	-6,42
23/12/14	0,46	7,80	-7,34
24/12/14	2,06	7,80	-5,74
27/12/14	1,60	7,80	-6,20
TOTAL	**44,93**	**62,40**	**-17,47**

Figure 39: Fuel consumption savings during ROV-EXP2

Concerning the experiment about special events, the same considerations described in paragraph 4.5 affects these findings. The real results are the difference between the fuel saved by cars using P&R area and fuel consumed by shuttle bus, specifically set up for the event. Results, similarly to the kilometres saved, are very good in the first day, but for the other days results are below expectations.

<u>*PI-201* CO_2-emissions</u>

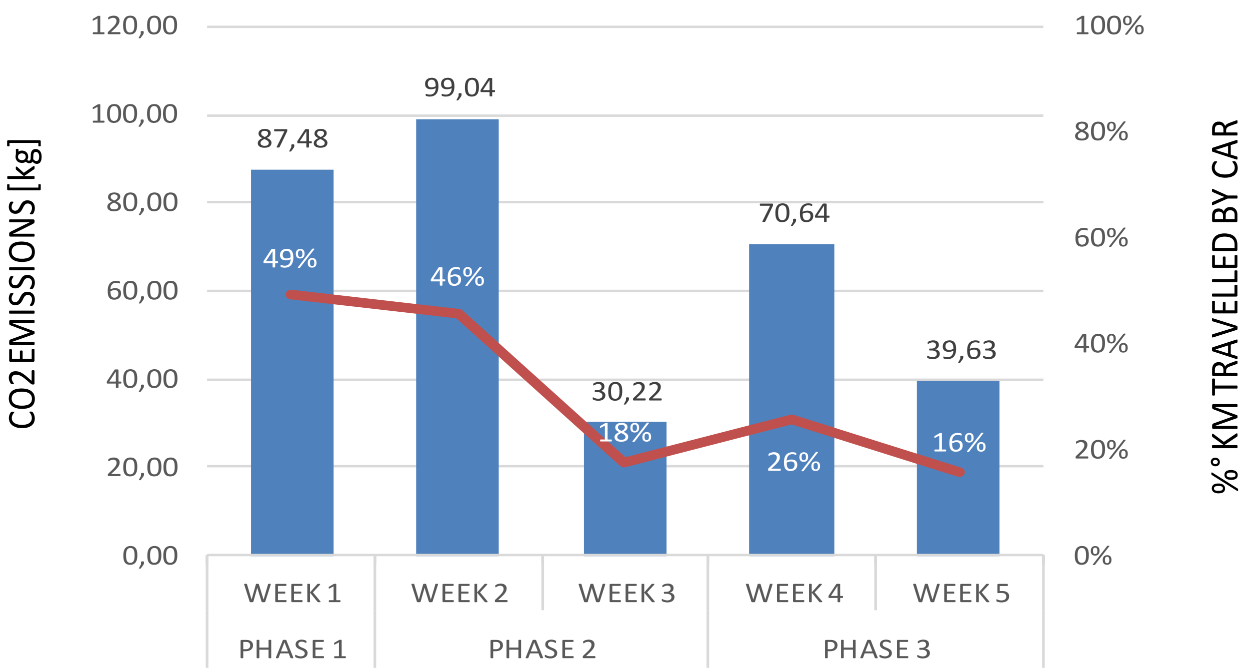

Figure 40: CO_2 car emissions during ROV-EXP1 and percentage of km travelled by car

CO_2-emissions decrease during the experiment about commuter trips. In order to evaluate the actual saving, results have been normalised in the following table.

PHASE	WEEK	KM	CAR KM	% CAR KM	CO_2 EMISSIONS [kg]	CO_2 EMISSIONS NORMALIZED [kg]	CO_2 SAVINGS [kg]
PHASE 1	WEEK 1	985	486	49%	87.48	87.48	--
PHASE 2	WEEK 2	1,199	551	46%	99.04	81.40	6.08
	WEEK 3	946	168	18%	30.22	31.47	56.01
PHASE 3	WEEK 4	1,537	393	26%	70.64	45.28	42.20
	WEEK 5	1,388	220	16%	39.63	28.12	59.36

Figure 41: CO_2-savings during ROV-EXP1

During the experiment, CO_2-savings constantly grew, comparing the fifth week to the first one, almost 60 kg of CO_2 were not emitted every day thanks to STREETLIFE. These results are very good and demonstrate that STREETLIFE could actually reduce the carbon footprint of a user for a certain OD (HY-102) and the carbon footprint of a user for a certain OD (HY-104).

DAY	CO_2 SAVED BY CARS [kg]	CO_2 BUS SHUTTLE EMISSIONS [kg]	ACTUAL CO_2 SAVINGS [kg]
06/12/14	82.04	23.60	58.44
13/12/14	15.11	23.60	-8.49
20/12/14	12.95	23.60	-10.65
21/12/14	13.67	23.60	-9.93
22/12/14	4.32	23.60	-19.28
23/12/14	1.44	23.60	-22.16
24/12/14	6.48	23.60	-17.12
27/12/14	5.04	23.60	-18.56
TOTAL	**141.05**	**188.80**	**-47.75**

Figure 42: CO_2 savings during ROV-EXP2

Similarly, to findings related to PI-205, in ROV-EXP2 it should be considered that an additional bus was producing CO_2. Thus, the difference between CO_2 saved by cars using P&R area and CO_2 produced by the bus shuttle was calculated. Results are very good in the first day, when almost 60 CO_2 kg were saved, but for the same reasons already explained in paragraph 4.5, for the rest of the experiment the ratio was negative.

Scaling up

Once assessed the environmental impact of the experiment carried out in Rovereto, the evaluation scaled up results derived from the commuters' experiment in order to estimate the STREETLIFE impact on a small city similar to the one selected for the case study.

Since the estimation is based on the amount of kilometres not travelled by car, part of the methodology has been described in paragraph 4.5

	km not travelled by Rovereto car commuters	WEEK 2	WEEK 3	WEEK 4	WEEK 5
inside city	50,884	-977	-1,553	-6,595	-9,317
outside city	366,059	-1,462	-5,637	-6,070	-15,593
Total	416,943	-2,439	-7,190	-12,665	-24,909

Figure 43: Reduction of km not travelled by car every day in a small city thanks to STREETLIFE experiments

The emission factor calculated with, CORINAIR procedure has been applied to distances in Figure 39. Then the amount of CO_2-emissions was obtained that would have been saved in each week if all car commuters had used STREETLIFE App.

	CO_2-emissions by Rovereto car commuters [kg]	WEEK 2	WEEK 3	WEEK 4	WEEK 5
inside city	9,154	-176	-279	-1,187	-1,676
outside city	65,857	-263	-1,014	-1,092	-2,805
Total	75,012	-439	-1,294	-2,279	-4,481

Figure 44: Reduction of CO_2 in a small city thanks to STREETLIFE

Findings are very positive. CO_2-emissions would have constantly decreased during the trial process, reaching a reduction of 6% in the final week. Finally, if all commuter of a small city would use the STREETLIFE App 4.4 t of CO_2 could be saved a day. Considering that the total emissions produced from Rovereto car commuters are 71 t of CO_2 each day, the STREETLIFE solutions would have an impact estimated in a reduction of 6% on transport based emissions.

Similarly to traffic impact, this result does not take into account how many people can actually use the STREETLIFE App. Considering that in a few years, 75% of European population could own a smartphone, STREETLIFE could save 2.8 t of CO_2 every day in a small city. This result reveals that ICT solutions can have a real and measurable environmental impact even in a small city like Rovereto.

6. CONCLUSION

The core objective of WP8 is to deliver results on impact assessment of the proposed solutions in terms of end-users behaviour, traffic and reduction of carbon emissions to derive useful guidelines on mobility strategies for smart cities of the future. Therefore, the present deliverable D8.2.1 – Achieved Impacts reflects the initial assessment on achieved impacts.

The assessment is based on the results of the first iteration of field test trials conducted at three pilot sites: Berlin, Tampere and Rovereto.

Based on the objectives, the research questions, hypotheses and success criteria defined by the pilots, the assessment of the potential impacts has been conducted in accordance with the proposed work plan for the first project iteration. Methods and tools are described in respective chapters. With regard to the affected impact categories i) User behaviour, ii) Mobility (Traffic System) and iii) Environment (Emissions), preliminary impacts have been assessed. Respective trends and observations are to be proved with the second iteration field trials and its evaluation in a much larger scale. Due to the existing preconditions at the different pilot sites, it was necessary to adopt different approaches to cover the relevant objectives.

With respect to the impact assessment based on first iterations field data and assumptions, for i) User behaviour it can be stated that people provided with an intermodal App are more willing to change mobility behaviour while changing their mode choice, as long as alternative “green” transport means are available. It could be observed independently from the App tested, that also different modes were combined more easily due to the information available.

The impact category ii) Mobility shows very good results. In all cities the modal share could be changed in the envisaged way. In Berlin, a simulation-based approach was used to calculate possible effects. The results show a possibility that the share of cycling could be increased by 5% if cycling becomes safer and, thus, will be used for more trips and purposes. Specifically people who are regularly travelling mid-range trips (< 7 km) are more willing to enhance their trip radius. As a consequence, it could be detected that the mode share for car would decrease by 4%.

In Tampere interviews were held with traffic managers in order to discuss the impact on the transport system. The discussion showed that STREETLIFE is heading into the right direction. The integration of real-time information was assessed as very useful. Multiple information feeds into a single service and provide the users a great amount of added value for trip planning purposes. Users will be able to plan their trips and adjust it depending on traffic congestions, accidents or other unexpected events along the road. One of the next steps will be to make the App itself more attractive to accelerate the use of the system by a larger user group. Then, the impact on the traffic system and mobility behaviour can be much bigger.

Focusing on the small city Rovereto, the STREETLIFE solution provides the user a raising level of awareness and information about sustainable mobility service available in a small city. That results in clearly reduced impact on the city traffic system. The trials showed that thanks to gamification, properly combined with a policies framework, about 25,000 car-driven kilometres every day could be saved if all commuters would use the App for their trips.

With regard to the impact category iii) Environment the potential effects of STREETLIFE on carbon emissions have been assessed. The results provide a preliminary picture and underline the positive estimation.

Taking into account expected impacts of STREETLIFE interventions on the transport system, in a large city as Berlin about 500 t could be saved per day for the overall transportation system. The carbon emission savings of a medium-sized city like Tampere are ranging in an area about 8 t CO_2. For the small city Rovereto the results concerning carbon friendly trips are also very good. Almost a 6% reduction of CO_2-emissions compared to the baseline could be achieved. There was a constantly decreasing carbon emission by finally a saving of 4.4 t per day.

With respect to lessons learnt, the following key topics need to be addressed better within the 2nd iteration:

- Quantity and reliability of data to be improved

  → There is a need of trial-specific data which affects the system logs of the user interaction with the system as well as environmental data like weather.

- Enhancing pilot trial phase

  →A longer trial time frame allows better to identify changes in mobility behaviour.

- Adoption of a common methodology for CO_2-emissions

  → A comparable data availability of the carbon emission factors and the cities vehicle fleet is a requirement.

In conclusion, it can be stated that the impact assessment shows that ICT solutions can have real impact on the transport related categories i.) User behaviour ii.) Mobility and iii.) Environment. STREETLIFE could demonstrate that a change in the mobility behaviour can be realized with direct effects on reduced car-kilometres and a decrease in carbon footprint of a user for a certain origin-destination (OD).

Reflecting on lessons learnt from STREETLIFE first iteration's experiments, strong efforts will be spent in preparation to the experiments to enhance the scale of second iteration field trials significantly. Tools and methods have been put in place and intensively tested with experiments taken into account with this report's evaluation. With larger user groups and longer durations of coming field trials revealed trends and first promising findings need to be elaborated, proved or corrected.

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