Paper number ITS-EU-SP0100

STREETLIFE field trials – from pilot sites solutions to emission saving potentials

René Kelpin[1*](rene.kelpin@dlr.de), Dr. Flemming Giesel[1], Dr. Matthias Heinrichs[1]

1. German Aerospace Center, Institute for Transport Research, Germany

Abstract

The paper reports on the main results and achievements of the two individual, but closely connected pilot iterations in the FP7 project STREETLIFE. With two consecutive implementation and assessment cycles local challenges on supporting travellers' mobility by means of Intelligent Transport Systems (ITS) have been addressed in three individual city pilots. Based on that, on project level a common evaluation methodology is being applied to derive and compare general figures on the three main impact categories, namely i.) change of mobility behaviour, ii.) impact on transport system performances, and iii.) carbon emission reduction potentials. The paper will describe individual city pilots, its implementations and achieved impacts, starting from first iteration's results and its consideration for final pilot field trials. Special attention will be paid to the Berlin city pilot. With an App inter-modal mobility planning is being combined with innovative gamification approaches - which presage promising findings for the final evaluation.

Keywords:

Impact assessment, carbon emission savings methodology, gamification

Introduction

ITS (Intelligent Transport Systems) play an important role for informing travellers about mobility options – especially in dense urban contexts, where available mobility options may change rapidly by hardly predictable incidents and other interventions. The growing complexity of urban transport systems, including a variety of available mode options, possibilities for interchanging, ticketing and pricing options and all these components' interactions is hardly manageable even for insiders; for occasional users and tourists it is even more difficult to understand. Based on this, it is still to be proven to what extent ITS are able to support both transport system insiders and new-comers and how users' benefits and possible changes of mobility behaviour can be measured on the basis of quantitative indicators. To make it more concrete: Is it possible to translate changed mobility behaviour of users into an improved situation for the entire transportation system or into saved tons of emitted carbon and other transportation based emissions? And more important from a user perspective: What is the individual benefit an individual user can have from applying new ICT-based transportation services?

In this article the methodological approach and its application for quantifying impacts on transport's main performance indicators will be presented based on the results of the Berlin pilot.

Starting Situation and the Project

The FP7 project STREETLIFE (Oct 2013 – Sept 2016) sets a clear focus on supporting "greener" mode choices by means of Information and Communication Technologies (ICT). ICT are applied to establish Intelligent Transportation Systems (ITS), namely for provision of pre-trip and on-trip information about available trip and mode options and about impacts respective decisions may have on the overall traffic system performance and the environment. The project STREETLIFE in general is

- to understand why and under which conditions travellers opt for a specific mode of transportation,
- to use this knowledge to provide and highlight "green" alternatives when needed and appropriate, and
- to finally convince users to opt for more eco-friendly modes of transportation.

In STREETLIFE, this has been combined with innovative gamification approaches. With games travellers have been rewarded for making "greener" decisions, which have a positive impact on the overall transport system performance and – in consequence – on the carbon footprint. First data analyses had shown that applied gamification approaches have a significant impact on users' behaviour.

This general approach has been commonly applied to three individual city pilots. In Berlin the focus has been laid on an App based information provision for inter-modal routes including all modes of transport and – as the unique selling point of the App – paying particular attention to safer bicycle routes and a corresponding safety assessment. In Tampere (Finland) implementations have sought to improve the reliability and, thus, the usage of public transport under different circumstances (weather, time of the year, trip purpose, etc.) by means of advanced information provision and innovative augmented reality (AR) integration. The Rovereto (Italy) pilot has focussed on park-and-ride and company car sharing and pooling services for commuters as well as visitors, guests and tourists. These STREETLIFE pilot sites represent three different types of urban agglomerations. Local problems were to be resolved and evaluated by similar approaches and methods. Local achievements have been analysed, compared and finally provided as best practices for rolling-out individual services by further pilot cities and regions.

The STREETLIFE field trials (pilots) have been separated into two iterations, which comprised four phases, which are i.) Definition phase, ii.) Implementation phase, iii.) Consolidation phase, and iv.) Assessment & Proof of Concept phase. The two-step approach allowed assessing and adjusting first iterations' implementations to main achievements, revealed issues and stakeholders (transport management and end-users) verdicts collected with elaborated on-site surveys. Stakeholders' feedbacks and additional scenarios and use cases have been taken into account for defining second iteration's implementations and main research questions to be answered by the final field trials. Besides, second iterations' field trials have significantly exceeded initial trials in terms of duration and user group sizes. For instance, in Berlin's first iteration the App has been used and tested by a number of around 20 "friendly" users for a two weeks period only; in the second (large scale) field trial up to 400 users have constantly used the App and have taken part in the BER "Bike rider" game for a period of three months including three consecutive gaming periods.

First iteration's results and achievements

The first iteration was finished and internally reported in June 2015. STREETLIFE's second iteration's field trials partly started in October 2015 and will be concluded in May 2016. The large scale Berlin field trial took place from March to May 2016.

With respect to the main STREETLIFE evaluation criteria, from the first iteration the following results can be summarised (selection):

- Carbon emissions saving potential
  Based on analyses of data collected with the local field trials global emission savings have been estimated. For the pilots Berlin and Rovereto, simulation tools have been used to derive potential emission savings from field trial results. Scaling up identified changes of field trials user population to city levels, in Berlin 500 t (6.6%) and in Rovereto 4.4t (6%) of transport based CO_2 emissions could be saved.
- Impact of transport system
  The Berlin mode share of cycling could be increased from 15% to 20%, while car share decreased by 4% as longer trip distances have been reported for non-motorised modes. In Rovereto, applied city policies could save about 25.000 km car traffic every day, which decrease mode share of car by 4%. Under specific circumstances (in Finland mainly weather) in Tampere a modal shift of 0.5 to 1% from cars to public transport (busses) could be obtained; in a best case scenario about 75.000 km travelled by car could be substituted by public transport every day.
- Impact on users' behaviour
  It can be concluded even after the first iteration's trials that users are willing to change mobility behaviour when being reliably informed about the actual traffic situation, disturbances and alternatives. In Berlin users more often opt for combined (inter-modal) trips with a growing share of "greener" modes of transportation. The integration of gamification approaches in the Rovereto field trials caused a growing number of "green" itineraries; a continuously growing usage of local applications and services could be observed here. Especially for foreigners of the Tampere transportation system clear advantages and benefits have been provided and acknowledged by users of the systems. A better awareness of mobility habits have been reported by interviewed Tampere commuters.

Those promising results had to be proven with the second iteration's large scale field trial from March to May 2016. The following chapter is dedicated to the Berlin pilot field test.

From local pilots to carbon emissions

General methodological approach

The general methodological approach is depicted in Figure 1. Based on the research questions for the evaluation of the Berlin STREETLIFE pilot a targeted user group has been defined and recruited. The composition of this specific user group has been compared with official German mobility statistics, using the study Mobility in Germany 2008 [1]. The data of the study have been applied not only for this purpose, but also to calibrate the TAPAS model. Field test data have been analysed, and derived as input data for the TAPAS simulation for the entire Berlin population.

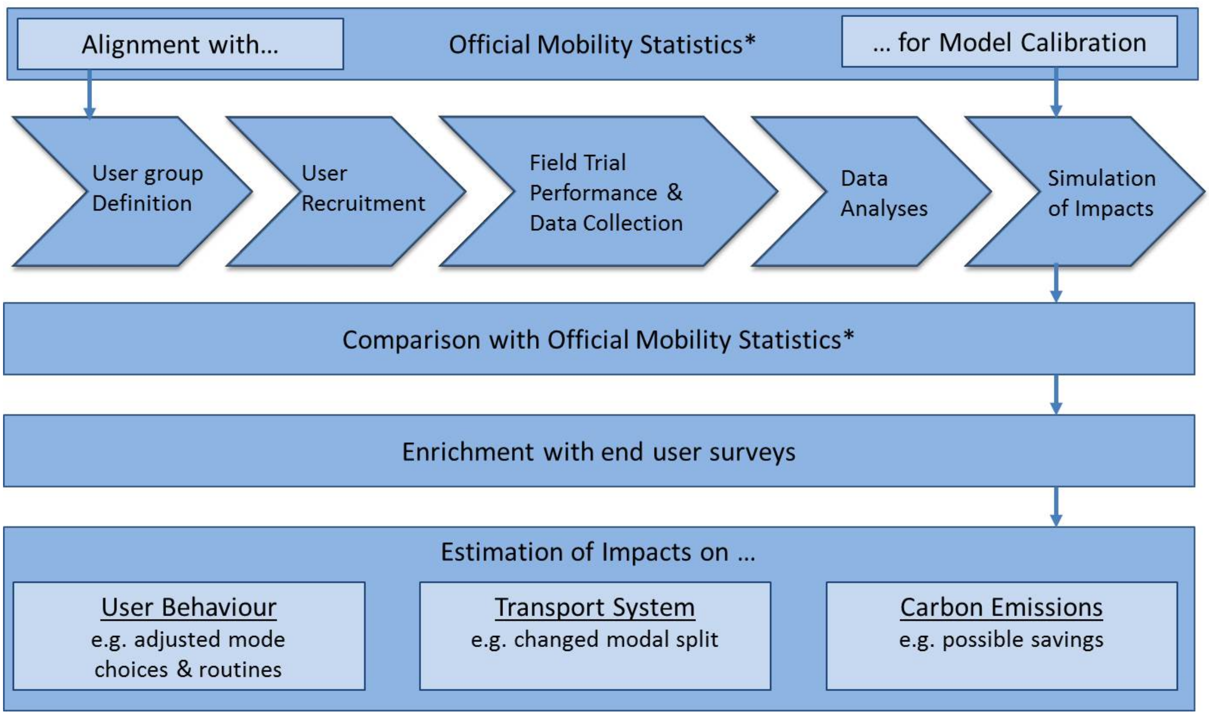

Figure 1: STREETLIFE Berlin methodological approach, * Survey Mobility in Germany 2008 [1]

After the TAPAS simulation was performed traffic demand data has been compared with official statistics and enriched with an end user survey focusing on end users' acceptance and uptake. Based on these main data sources impacts on the three main impact categories have been estimated and evaluated.

With the following paragraphs the three main steps, namely i.) user group definition and recruitment, ii.) field test execution, data collection and aggregation, and iii.) simulation of impacts, will be described in more detail.

User group definition, recruitment and investigation of mobility habits

For the user recruitment different criteria have been considered. Regarding travel behaviour, only a selected population in Berlin has been in focus of the STREETLIFE project. In order to address STREETLIFE research questions multimodal persons (i.e. regular use of at least 2 means of transport) have been of special interest because these persons are more prone to use an ICT-based transportation service for the planning of intermodal trips. In Figure 2, based on the representative study Mobility in Germany 2008 [1], the share of "mobility types" in Berlin – build on the regular use of private car, bicycle and public transport – is illustrated differentiated to age. Overall it can be seen that a high share of each age group uses regularly more than one means of transport. The share of multimodal persons decreases only in the older age groups. Nevertheless, private cars are used very often even by the younger age groups. That means that there is still a high potential for the reduction of private car use. According to this, especially all people aged 18-64 have been in focus of the STREETLIFE berlin pilot. Paying special attention to these assumptions and criteria the user recruitment was correspondingly carried out at the beginning of 2016.

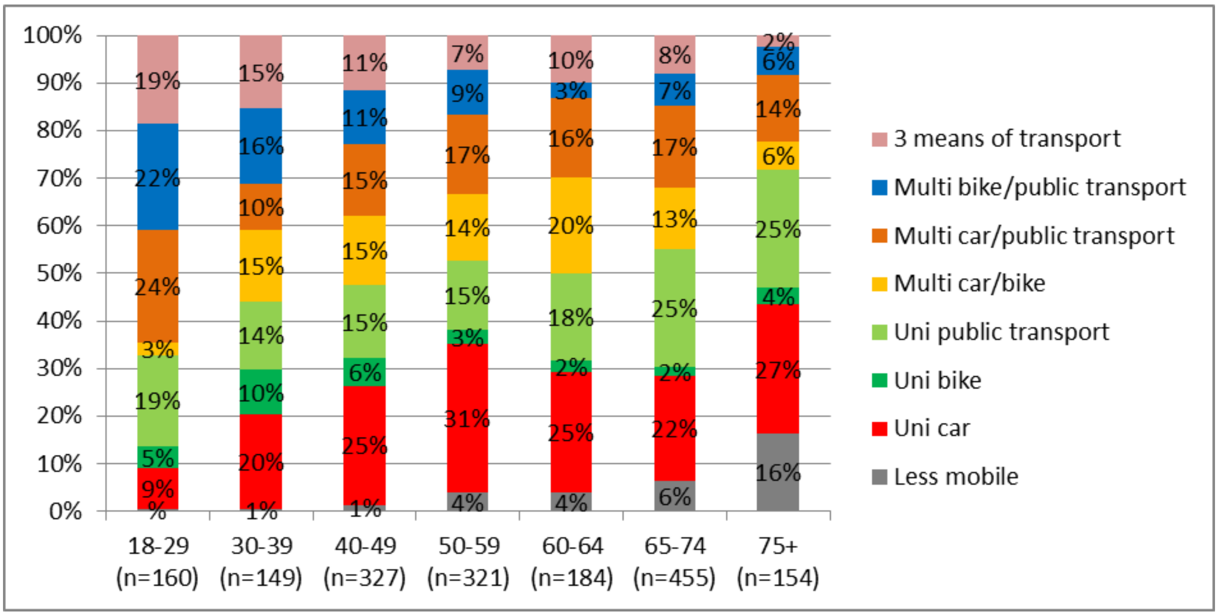

Figure 2: Mobility types in Berlin differentiated to age. Authors' own analysis, based on data from the study Mobility in Germany 2008 [1]

At the time of editing this article 168 persons were acquired to the field trial in total. During the execution of the field trial, a series of further public user recruitment activities has been carried out. For users recruited at these events and by public advertisement campaigns no influence on user selection has been possible. In Table 1 the age structure of the current sample is shown. It can be seen that especially younger age groups could be addressed with the first user recruitment. The reason for this could be a higher ICT affinity of this group and thus a higher degree of application of modern ICT trends. Due to this fact, the 18-29 and the 30-39 age groups have been in the focus of the Berlin pilot evaluations. In the next step, these groups will be described in more detail regarding socio-demographic and mobility specifics in comparison to the basic population.

Table 1: Age structure of the sample. Authors' own analysis, based on STREETLIFE data.

	n	share
under 18	0	0%
18-29	101	60%
30-39	42	25%
40-49	13	8%
50-59	8	5%
60-64	4	2%
over 65	0	0%
total	**168**	**100%**

Table 2 shows that there are some differences between the sample and the Berlin reference group. Regarding the age group 18-29 only a small proportion of men and people with a full time employment could be recruited. In contrast, many people with a high school degree and many students belong to the sample. Accordingly, the share of bicycles in the household and the share of public transport season ticket holder are very high. The differences regarding the age group 30-39 are much smaller and correspond largely to the basic population.

Table 2: Characteristics of the sample compared to the Berlin population. Authors' own analysis, based on STREETLIFE data and study Mobility in Germany 2008 [1].

	18-29		**30-39**	
	Sample	**Berlin**	**Sample**	**Berlin**
Men (n=101/251/42/189)	37%	51%	48%	50%
High school degree (n=101/161/42/149)	88%	66%	83%	74%
Full time employment (n=101/251/42/188)	12%	27%	38%	62%
Students (n=101/251/42/188)	70%	32%	33%	6%
Car in the household (n=101/251/42/189)	35%	59%	60%	60%
Bicycle in the household (n=101/161/42/150)	94%	74%	95%	91%

Public transport season ticket holder (n=101/158/42/145)	79%	61%	48%	32%

Some differences become also clear by comparing the mobility types (see Figure 3). In the age group 18-29 there are more multimodal bike/public transport users and unimodal bike users compared to the corresponding age group in Berlin. Again, the age group 30-39 is really close to the basic population.

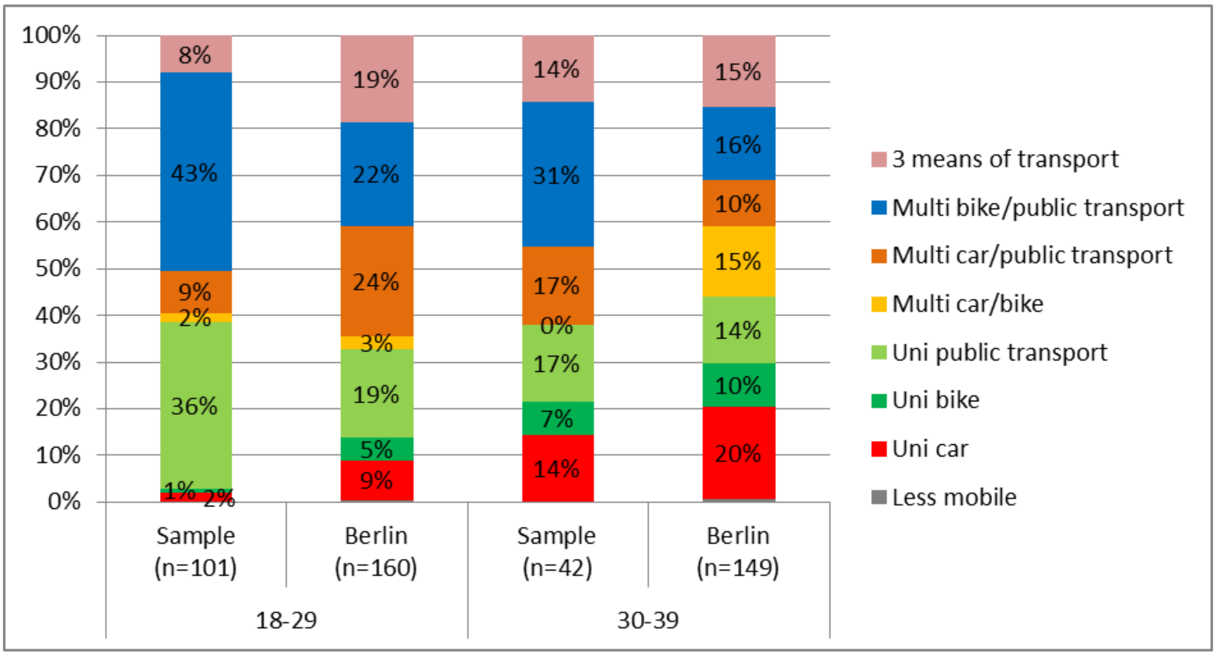

Figure 3: Mobility types of the sample compared to the Berlin population. Authors' own analysis, based on STREETLIFE data and study Mobility in Germany 2008 [1].

Compared to the basic population in Berlin (as described with the study Mobility in Germany [1]) there are some differences regarding socio-demographic and travel-related. This fact is to be re-assessed when the user recruitment campaigns concluded. However, the evaluation of impacts of the STREETLIFE-App on the travel behaviour will be elaborately investigated for the groups of user aged 18-29 and 30-39.

Field test execution, data collection and aggregation

To compare the mobility behaviour tracked in the field test with the participant general mobility behaviour, users have been asked to fill out a questionnaire when registering for field test participation. The questionnaire on general mobility habits has also been applied for further user recruitment at bike fairs in Berlin. Furthermore, the information of user mobility routines and attitudes has also been used when scaling up the behaviour of the user group on the total population of Berlin by comparing the reported mobility habits with the results of the study Mobility of Germany.

The large scale field trial of the second project iteration took place from March to May 2016. Up to 400 end users used the Berlin STREETLIFE App to plan, execute and evaluate daily mobility. More than 5.000 trips have been executed, tracked and evaluated in terms of convenience of cycling stretches or public transport interchanges. The field trial period has been segregated into three phases of the Berlin STREETLFIE game "BikeRider". With the game "greener" mobility decisions, namely the usage of bicycles for daily mobility purposes, have been rewarded with game points – "green leaves" that enabled users to take part in a virtual competition. In this three months' competition more than 150.000 leaves have been collected, which stands for more than 15.000 kilometres travelled by bicycle.

For each individual trip the following set of information has been stored:

- Trip request properties
- Proposed trip options (incl. mode of transport, duration, length, costs, carbon emissions)
- Selected trip (incl. mode of transport, duration, length, costs, carbon emissions)
- GPS track of performed trip

For cycling trips, trips with cycling stretches or public transport trips with interchanges, a safety and convenience assessment of this trip has been stored additionally. In case a trip has been assessed as rather unsafety, also GPS coordinates of specific dangerous points could be specified in a map and stored.

At the end of each game period a short online survey on App usability was conducted. In addition, at the end of the field trial period (end of June 2016) a large user acceptance and uptake survey was carried out, in order to gain detailed insights on how the participation in the STREETLIFE field trial could influence on individual mobility routines and habits.

Finally, a thorough analysis of the aforementioned data sources – a variety of direct measurements from field trials, survey results on subjective system assessments and evaluation – in combination with further assumptions from earlier projects and literature studies defined specific input variables for the simulation of impacts on the Berlin transportation system. As the final field test data was not available at the time of final editing of this paper, the following list shows a first selection of assumptions taken from a tentative data assessment. This is to illustrate how aggregated results from field studies have been taken into account by the simulation.

- Due to the participation in a competitive game, rewarded modes of transport (bicycle) have been selected more often in comparison to the general mobility habits. Trip length apparently did not play a major role in this respect. Thus, for the simulation the modal share of cycling has been increased generally, while mode share of cars has been decreased.
- Significant impacts on the mobility behavior could be investigated for highly mobile groups of users among the entire field trial population. In the simulation, for those user groups and for specific trip purposes (work/education, leisure, etc.) the modal split has been adjusted according to field trial and survey results.
- In simulation scenarios, different combinations of assumptions and input variables have been computed. When discussing the results of the STREETLIFE evaluation, this may help to play

with the options to, finally, better understand the flexibility and sensitivity of the transport systems with respect to applied STREETLIFE interventions and changes.

The presentation of this paper at the ITS conference in June 2016 will take into account final field trial data, as well as its analyses and interpretations.

The Simulation of transport impacts

The results of the Berlin STREETLIFE field trial can be extrapolated using simulations for determining effects on traffic and environment at a bigger scale. As the Berlin STREETLIFE system instantiation targets at changing the users' mode choice, a microscopic demand model that determines the activity locations and the traffic mode to access them for a modeled synthetic population has been used. Being microscopic, the used model "TAPAS" ("Travel-Activity PAttern Simulation", [2][3]) uses a model of Berlin's population which consists of single individuals grouped into households, travel time and distance matrices, and activity locations. Berlin's baseline simulation regards more than 3.4 million individual persons which are grouped into 1.8 million households.

In TAPAS, every person is described by a set of attributes, including age, sex and employment status. Furthermore, every person has a set of mobility attributes containing driving license, public transport ticket and a personal bicycle. These individuals are grouped into households with shared attributes, like income, cars, children and a monthly mobility budget. Many different data sources are used for describing the population, including the Mobility in Germany 2008 (MiD2008) survey as well as municipal data, business registers and commercial registers for describing the activity offers in the modelled region, such as places to work, shops, schools, doctors, playgrounds, cinemas and many other types of locations. TAPAS simulates each individual by choosing an activity pattern that statistically belongs to the individual's socio-demographic group, first [4]. Then, the locations of the activities are computed including the mode of transport used to reach them. The mode is determined using a MNL model fitted to the 290 000 reported trips for the city of Berlin in the SrV2008 [5][6]. Afterwards, the activity plan is rated based on estimated travel-time and budget because the activity locations and the mode of transport chosen by the individual may yield in too long travel times and higher transportation costs. In such cases, a different plan is computed. The finally generated feasible activity plan consists of trips between different activity locations including information relevant for STREETLIFE impact considerations, such as

- used mode,
- travel time,
- distance,
- purpose of the trip and
- destination.

The baseline simulation of the city of Berlin resembles the mobility within the city on a usual work day (Tuesday-Thursday) in the year 2010. Figure 4 shows the most important sociodemographic population data, like age, income and household size distribution for the modelled region.

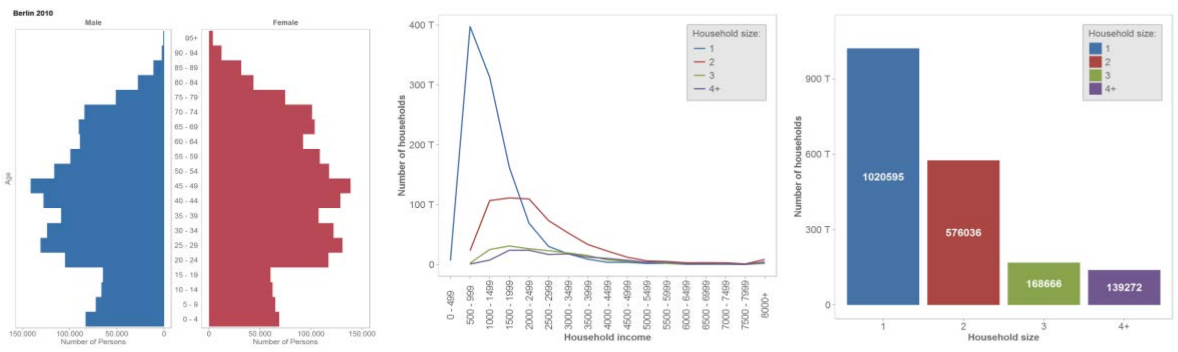

Figure 4: Sample statistics of the modelled population, showing distribution for age, income and household size

Based on the data from the first (small scale) field trial and an accompanying literature study, the influence of the Berlin pilot changes was set up for the simulation as follows:

- Trips up to 1km: a decrease of car usage incl. co-driver by 60% has been realized 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

A wider base of information about the changes in the users' behaviour will be available at the end of the field trials in May 2016, and will be reported with the paper presentation at the ITS conference in June 2016.

Results

At the time of final editing of this paper final data from the second iteration (large scale) field trial was not available. Thus, achievements of the first iteration (small scale) field trials are used to depict the simulation outcome and its interpretation for STREETLIFE evaluation purposes. With the final paper presentation at the ITS conference in June data from the large scale field trial (carried out from March to May 2016) will be applied.

Based on the data generated by the TAPAS simulation the following conclusions have been drawn. For the entire BER population of 3.4 million inhabitants for one normal working day improvements could be achieved as shown in Table 3.

Table 3: TAPAS simulation - Impact on traffic system

	Baseline		Scenario	
Mode	Trips per day	mileage in km	Trips per day	mileage in km
Walk	3103980	5570065	3096970	5532222
Bicycle	2063230	8119605	2695930	10174876
Car	4283120	31536338	3666940	29099749
Car Passenger	969340	7873306	716440	6506378
Public Transport	3303770	25811737	3480570	26822241
Total	13723440	789178951051	136578810051	78135467

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 5).

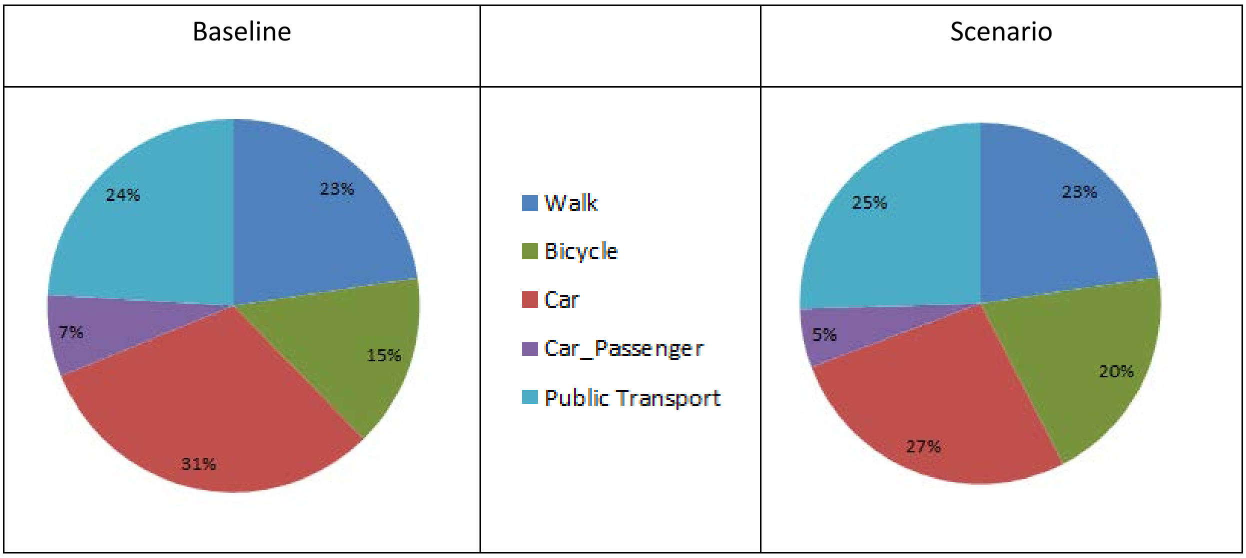

Figure 5: BER Modal split simulated

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 kilometers 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

When it comes to Carbon emission savings, values in Table 5 could be derived from the simulation output.

Table 5: TAPAS simulation - Carbon emission savings calculations

Baseline				
Mode	Trips per day	Mileage in km	Emission factors	Emissions in kg CO2
Walk	3103980	5570065	0	0
Bicycle	2063230	8119605	0	0
Car	4283120	31536338	176	5550395
Car Passenger	969340	7873306	88	692851
Public Transport	3303770	25811737	49	1264775
Total				**7508022**
Scenario				
Mode	Trips per day	Mileage in km	Emission factors	Emissions in kg CO2
Walk	3096970	5532222	0	0
Bicycle	2695930	10174876	0	0
Car	3666940	29099749	176	5121556
Car Passenger	716440	6506378	88	572561
Public Transport	3480570	26822241	49	1314290
Total				**7008407**

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. Emission factors have been investigated in 2014 in the FP7 research project MOLECULES [7] – not distinguishing between different car engine types. Factors of public transport modes have been provided by BER public transport operators.

Conclusion & Outlook

The main goal of the final evaluation was to analyse the three impact categories, which are i.) impact on the overall transportation system, ii.) impact on user behaviour, and iii.) impact on Carbon emission saving. Furthermore, the results and preliminary trends of the small scale field trials in year 2015 were to be verified. The conditions for this are favourable as the large scale field trial in 2016 boldly exceeds the small one not only in duration, but also in the number of participating end users, considered use cases and research questions. The collected data promise a remarkable variety of analyses and aspects for evaluation and, in consequence, very interesting results.

It can be concluded that with the described methodology and the collected data a reliably derivation of the above mentioned impact categories is possible. As a starting point of the overall project evaluation, performance indicators have been defined at the very early pilot definition process in close coordination with the pilot planning and project evaluation – in order to meet stakeholders' expectations and to answer defined research questions. For these indicators field trial data collections have been tailored and designed for a dedicated project evaluation purpose. Direct data measurements have been combined and enriched with surveys and interviews. After the field trial, data has been thoroughly analysed and translated into input variables for the TAPAS simulation. TAPAS, finally, simulated a normal working day for the entire Berlin population. For each Berlin inhabitant on average 3.7 trips have been generated by the simulation. Based on an analysis of trip properties (e.g. mode of transportation, length, duration) impacts for the project evaluation could be deduced and evaluated.

The results presented in the preceding chapter have been derived from the small scale field trials of the first project iteration. In contrast, the presentation to be held at the ITS conference in June 2016 will be based on the final data and results of the large scale field trial (performed from March to May 2016).

References

1. Lenz, B. Nobis, C. Köhler, K. Mehlin, M. Follmer, R. Gruschwitz, D. Jesske, B. Quandt, S. *MiD - Mobilität in Deutschland 2008*. DLR Project Report, 2010, http://daten.clearingstelle-verkehr.de/223/ http://elib.dlr.de/68010/

2. Hertkorn, G. (2005). *TAPAS - Mikroskopische Modellierung von zeitabhängiger Verkehrsnachfrage und von Verkehrsflußmustern*. Dissertation, German Aerospace Centre, Institute of Transport Research, Germany.

3. Heinrichs, M., Krajzewicz, D., Cyganski, R., von Schmidt, A. *Disaggregated car fleets in microscopic travel demand modelling*. The 7th International Conference on Ambient Systems, Networks and Technologies (ANT 2016). (In print).

4. Varschen, C., Wagner, P. *Mikroskopische Modellierung der Personenverkehrsnachfrage auf Basis von Zeitverwendungstagebüchern. Integrierte Mikro-Simulation von Raum- und Verkehrsentwicklung*. Theorie, Konzepte, Modelle, Praxis, AMUS, 2006, pp 63-69.

5. Ahrens, G.-A. *Endbericht zur Verkehrserhebung „Mobilität in Städten - SrV 2008“ und Auswertungen zum SrV-Städtepegel*, Lehrstuhl für Verkehrs- und Infrastrukturplanung, TU Dresden. 2009, http://tu-dresden.de/die_tu_dresden/fakultaeten/vkw/ivs/srv/dateien/staedtepegel_srv2008.pdf

6. Ahrens, G.-A. *Tabellenbericht zum Forschungsprojekt „Mobilität in Städten – SrV 2013“ Berlin,* http://www.stadtentwicklung.berlin.de/verkehr/politik_planung/zahlen_fakten/download/SrV_2013_Berlin_Tabellen.pdf , 2014

7. Kelpin, R., Enrich, R. Schilling, T. Soufflet, S. *MOLECULES – D7.2 Evaluation of users, results and conclusions*, FP7 Project, 2014, http://www.molecules-project.eu/download/public-documents/