D13.1
Gothenburg: Demo Description and Implementation Plan

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SUMMARY SHEET

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Abstract	The EBSF2 project aims to test, evaluate and validate innovative technological solutions and/or strategies for urban and sub-urban bus systems through demonstrations in real service. Six key research areas have been identified to have the highest potential to impact: Energy Strategy and Auxiliaries;; Green Driver Assistance Systems;; IT Standards introduction in existing fleet; Vehicle Design (capacity, accessibility, modularity); Intelligent Garage and predictive maintenance; and Interface between Bus and Urban infrastructure. These areas are to be further investigated in demonstrations in altogether 12 demonstration sites of which Gothenburg is one. The Gothenburg demonstration addresses three of the key research areas for innovation: New energy-efficient heating solution for electric buses (TIGot1); Attractiveness and efficiency of innovative external and internal design of electric buses (TIGot2); and Attractiveness of innovative bus stop designs (incl. indoor) and interaction between bus and bus stop designs (TIGot3).
Keywords	Public transport; bus system; electric bus; bus stop design; indoor bus stop; heating system; innovation

INTERNAL DISTRIBUTION

Participant N°	Participant organisation name	Country
1 Coordinator	Union Internationale des Transports Publics - UITP	Belgium
2	Régie Autonome des Transports Parisiens - RATP	France
3	Iveco France SA - IVECO	France
4	Fraunhofer-Gesellschaft zur Förderung der angewandten Forschung e.V. - FRAUNHOFER	Germany
5	Hübner Gummi- und Kunststoff GMBH - HUEBNER	Germany
6	DigiMobee SAS - DIGIMOBEE	France
7	Centro de Estudios e Investigaciones Técnicas - CEIT	Spain
8	Chalmers Tekniska Hoegskola AB - CHALMERS	Sweden
9	Compañía del Tranvía de San Sebastián, SA (CTSS) – DBUS	Spain
10	IRIZAR S Coop - IRIZAR	Spain
11	D'Appolonia S.p.A. - DAPP	Italy
12	EvoBus GmbH - EVOBUS	Germany
13	Volvo Bus Corporation - VBC	Sweden
14	Pluservice srl - PLUSERVICE	Italy
15	Universidad Politécnica de Madrid - UPM	Spain
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39	Union des Transports Publics - UTP	France
40	Västtrafik AB - VTAB	Sweden
41	Commissariat à l'Energie Atomique et aux Energies Alternatives - CEA	France
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ACRONYMS

HVAC – Heating Ventilation and Air-Conditioning
PT – Public Transport
VO – Validation Objectives

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1 Executive Summary

The European Bus Systems of the Future 2 (EBSF 2) is an Innovation Action co-funded by the European Union within the Horizon 2020 Research and Innovation programme. The project aims to test, evaluate and validate innovative technological solutions and/or strategies for urban and sub-urban bus systems through demonstrations in real service. Six key research areas have been identified to have the highest potential to impact:

- Energy Strategy and Auxiliaries;
- Green Driver Assistance Systems;
- IT Standards introduction in existing fleet;
- Vehicle Design (capacity, accessibility, modularity);
- Intelligent Garage and predictive maintenance; and
- Interface between Bus and Urban infrastructure

These areas are to be further investigated in demonstrations in altogether 12 demo sites of which Gothenburg is one. The Gothenburg demonstration addresses three of the key research areas for innovation:

- New energy-efficient heating solution for electric buses (TIGot1);
- Attractiveness and efficiency of innovative external and internal design of electric buses (TIGot2); and
- Attractiveness of innovative bus stop designs (incl. indoor) and interaction between bus and bus stop designs (TIGot3)

The deliverable, D13.1 - Gothenburg: Demo Description and Implementation Plan**,** provides a description of the innovations to be demonstrated, plans for implementation of the demonstrations, relevant validation objectives, and data to be collected.

2 Introduction

The European Bus Systems of the Future 2 (EBSF 2) is an Innovation Action co-funded by the European Union within the Horizon 2020 Research and Innovation programme and coordinated by UITP – the International Association of Public Transport. The project, which runs between May 2015 and April 2018, capitalizes on the results of the previous EBSF project (2008-2013) and, as the former, aims to develop a new generation of urban bus systems by means of new vehicle technologies and infrastructures in combination with operational best practices, and test them in operating scenarios within several European bus networks.

The need for more cost-effective and energy efficient bus systems has led to the identification of a set of technological innovations (TIs) and strategies with a strong potential to optimize mainly energy and thermal management of buses (in particular auxiliaries such as climate systems), green driver (eco driving) assistance systems, intelligent garage and maintenance processes, IT standard equipment and services. Moreover, to effectively address the need to move quickly from laboratory research to actual innovation of the bus fleets in operation in Europe, the technologies to be tested have been selected according to their technological maturity (and not only because of their potential) in order to ensure a short step to commercialisation once the project ends. The use of simulators and prototypes has been conceived as a preliminary step for the validation of the innovations in real operational scenarios, performed within the project as well, or as a necessary task to prove the potential of more futuristic solutions currently implemented at early stage of development (e.g. modular bus).

2.1 Scope of deliverable

Thus, EBSF 2 aims to test, evaluate and validate innovative technological solutions and/or strategies for urban and sub urban bus systems through demonstrations in real service. The ultimate goal is to improve the efficiency of operations mainly in terms of costs and energy consumption but also to increase the modal share of bus services by improving the image of the bus for the users.

Six key research areas have been identified to have the highest potential to impact:

- Energy Strategy and Auxiliaries;
- Green Driver Assistance Systems;
- IT Standards introduction in existing fleet;
- Vehicle Design (capacity, accessibility, modularity);
- Intelligent Garage and predictive maintenance; and
- Interface between Bus and Urban infrastructure

These areas are to be further investigated in demonstrations in altogether 12 demonstration sites of which Gothenburg is one. The Gothenburg demonstration addresses three of the aforementioned key research areas for innovation, namely (i) energy strategies and auxiliaries, (ii) vehicle design, and (iii) interface between bus and urban infrastructure.

This deliverable, D13.1 - Gothenburg: Demo Description and Implementation Plan**,** provides a description of the innovations to be demonstrated, plans for implementation of the demonstrations, relevant validation objectives, and data to be collected.

2.2 Organisation of deliverable

The deliverable is organised as follows:

- Chapter 1 provides the Executive Summary;
- Chapter 2 introduces the EBSF_2 project; Chapter 3 presents a description of the context for the demonstrations;
- Chapter 4; describes the three innovations to be demonstrated in Gothenburg, plans for implementation of the demonstrations, relevant validation objectives, and preliminary overview of data to be collected;
- Chapter 5 presents the demo team; and finally
- Chapter 6 describes the contribution of the partners to the deliverable.

3 The Gothenburg Context

The city of Gothenburg is the second largest city in Sweden by population. The city is located in the cross roads of two major European routes: E6 between Malmö and Oslo, and E20 towards Stockholm. The southern and the northern parts of the city is divided by the Gothia River to be crossed by two bridges and one tunnel.

3.1 Socio-demographics

The city (see Figure 1) has a surface of approx. 2,400 km2 and approximately 540,000 inhabitants, however, if including the metropolitan area the number of inhabitants rises to around 900,000. The population is increasing by 1-1,5% each year. Sixty per cent of the inhabitants is aged between 20 and 64 while 15% is older than 65 (www4.goteborg.se). The income per inhabitant is on average 244,000 SEK or (approx.) 26,500 Euro.

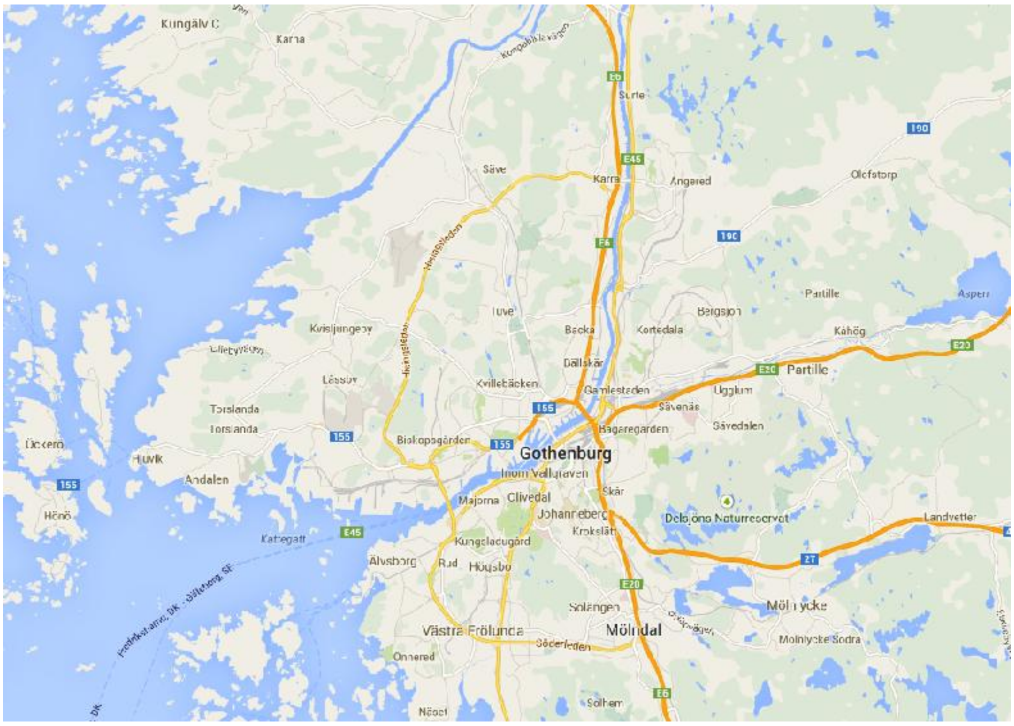

Figure 1 - Map of the Gothenburg area

3.2 Modal split

Public transport covers 29% of all trips, 48% are done by private car, 14% by motorcycles and non-motorized vehicles such as bicycles, while 9% are accomplished walking.

3.3 Public transport

Västtrafik is the second largest public transport (PT) company in Sweden, and responsible for public transport in Gothenburg as well as the region. The PT system includes 2,700 buses, trains, trams and ferries; 22,000 stops; and 390,000 kilometres driven every day.

Almost 940,000 trips are made each day by PT in the region and the number of passengers is increasing. Approximately 65% of passenger kilometres are operated using renewable energy.

The public transport system in Gothenburg city area consists of trams (263 trams and 12 lines stretching from 10 to 25 km), a light version of bus rapid transit (BRT) routes called 'stombusslinjer' (8 lines stretching between 25 and 40 km) and other bus services including Express buses (12 lines stretching between 15 and 55 km). There is also a ferry service across the river and to/from main islands in the Gothenburg archipelago.

Approximately 1.6 million trips are completed every year with the Gothenburg PT system and the number is increasing every year (for example by approximately 4% from 2011 to 2014). Most PT journeys are made by tramway (60%). The total number of bus trips is almost half the number of tram trips but the BRT system is gaining in popularity and carries around 15% of the passengers of all public transport trips in the city. The trams run with a frequency of between 4-6 departures per hour, the "stombuss" line system runs with on average 6-12 departures per hour (weekdays between 0600-1800) while the ordinary buses has a frequency of between 2-4 departures per hour.

Depending on the size of the bus/tram stop, the stop is indicated by a sign or equipped with one or two shelters. The static information provided includes printed time tables and route maps, information on ticketing, etc. Real-time information at bus stops and on the Internet was introduced in Gothenburg already in the 1990s and today a large number of bus and tram stops is equipped with real-time information displays providing information on minutes left until the next departure as well as information on delays and disturbances. Web services include a corresponding real-time information as well as a travel planner. Travellers can download a simplified travel planner for smartphones, iPhone as well as Android. There is a another app called "Var är bussen?" (Where is the bus?) which shows the position of closest bus/tram/ferry stops as well as the exact position of vehicles on a chosen line.

The ticketing system is an electronic smart card system. 65% of PT passengers use monthly tickets. It is possible to buy a card from Västtrafik's service shops, as well as from a number of local shops. It is however not possible to purchase tickets on board. It is also possible to buy individual tickets via SMS just before the trip valid for 90 minutes. All trams are equipped with ticket vending machines accepting coins and credit cards.

Västtrafik has been and is involved in several research and innovation project, both international and national. One of the most recent is ElectriCity (www.goteborgelectricity.se), a project where industry, research, and society collanorate in order to develop and test new solutions for a sustainable and attractive public transport. One of these new solutions is an electric bus line, running from one university campus to another (Chalmers and Lindholmen) and from one science park to another. The project is also a demo arena for new products and services including new bus stop solutions, information and communication solutions for seamless travel, and energy technology.

4 Demo Description

The Gothenburg demonstration team is committed to implement and test three (3) technological innovations (TIs); listed below according to the name and coding agreed with the EBSF_2 evaluation team and described in the following sections, namely:

- New energy-efficient heating solution for electric buses (TIGot1)
- Attractiveness and efficiency of innovative external and internal design of electric buses (TIGot2)
- Attractiveness of innovative bus stop designs (incl. indoor) and interaction between bus and bus stop designs (TIGot3)

4.1 A new energy-efficient heating solution for electric buses (TI-1)

In an electric driven vehicle the on-board energy consumption for heating is substantially higher compared to a diesel or hybrid driven vehicle. The technical innovation concerns the innovation topic Energy Strategy and Auxiliaries. More specifically it involves *a new energy-efficient heating solution for electric buses* that is driven by electricity and biofuels instead of diesel. The heating system will consist of a new heat pump and integrated air conditioner on the roof of the vehicle. In addition the coolant liquid is to be heated with a heater combining 16kW heating capacity from bio-fuel with 7kW electrical heating while driving and 9.2kW electrical heating in depot. A key to the improved performance is that the bus is pre-heated while standing in depot, either by hot coolant water or by electric power. In addition, in simulations and laboratory tests, the impact of vehicle designs on energy use will be investigated by taking into consideration the number and type of windows, insulation, and heated surfaces rather than heated air in compartment, as well as the effects of the number of passengers onboard. Comparisons will be made between different solutions to assess the possibilities for storing and distributing heat, for combining heat and cold storage as well as test solutions to achieve a distribution of temperature which is perceived as comfortable by passengers and drivers.

4.1.1 Goals

The goal is to improve the efficiency of heating by 30% in fully electric buses. This will be achieved through theoretical evaluations/simulations, controlled laboratory experiments, and field trials. The simulations will include comparisons of different design solutions to assess the possibilities for storing and distributing heat as well as for combining heat and cold storage; comparisons of different solutions to achieve a distribution of temperature, and assessments of the effects of different vehicle designs (e.g. type and number of windows) on energy use. The controlled laboratory experiments will encompass investigations and simulations of the actual impact of vehicle designs in terms of number and type of windows, insulation, heated surfaces rather than heated air in compartment, and effects of the number of passengers onboard. In the field trial, a feasible (part) solution (for heating pump/cooler) will be implemented in one electric bus in operation on the new bus line 55 in Gothenburg.

4.1.2 Validations objectives

The validation objectives (VO) (as of 2016-03-29) of the demonstration are listed in Table 1.

Table 1- Validation objectives of TI-1 demonstration.

Number	Description
VO1	Improving the overall energy efficiency of vehicle fleets
VO2	Improving the overall energy efficiency of specific components (HVAC)
VO17	Minimizing operating and maintenance costs
VO18	Improving onboard travel comfort

4.1.3 Test scenarios

The demonstration includes i) simulations, ii) tests in controlled environment, and iii) test under real operational conditions. The overall design is choosen to be able to, as much as possible, negate the effects of passengers and weather to the climate in the bus. Simulations will include a comparison between energy use in a vehicle with the innovation implemented compared to without. For the tests in controlled environment, a comparison will be made between a vehicle equipped with the existing heating system and a vehicle equipped with the new heating system. These tests will be done on instrumented vehicles in a controlled environment and withouth any people in the bus. For the test under real operational conditions, the same approach will be applied, hence the evaluation will compare energy use in a vehicle equipped with the existing heating system and a vehicle equipped with the new heating system. The field trial will involve two electric buses, operating the new electric bus line in Gothenburg, line 55. At first the buses will be run without passengers to be able to get reliaable data on tempeatures etc., and in a later stage with passengers to be able to measure the passengers perception of climate comfort.

4.1.4 Description of the no "EBSF_2 scenario vs "EBSF_2 scenario"

Existing heating systems are mainly drawing the heat from the buses' diesel engines. Since the engine is only operating intermittently, there is sometimes a need for more heat than is available from the engine cooling system. The buses are therefore equipped with a diesel fuelled additional 16 kW heater. The heat is transported by coolant fluid to convectors, in some places supported by fans.

The innovation will include new technical solutions that are expected to improve the efficiency of heating by 30%. The new system will be driven by electricity and biofuels. The heart of the system is a new REVO-E air to liquid heat pump and integrated air conditioner on the roof. In addition the coolant liquid is heated with a Spheros Thermo-H heater combining 16kW heating capacity from bio-fuel (BtL or HVO) with 7kW electrical heating while driving and 9.2kW electrical heating in depot. A key to the improved performance is that the bus is pre-heated while standing in depot, either by hot coolant water or by electric power. As in current buses heat is transported by coolant fluid and emitted to the environment by convectors, supplemented by fans. The new solution could also include adding insulation to different surfaces: in floor and ceiling, as well as new ways of controlling the fans.

4.1.5 Preliminary data collection plan

Data to be collected in the TI-1 demonstrator is described in Table 2. Energy use will be calculated and/or measured during simulations, controlled laboratory tests and field trial. Drivers' and passengers' assessment of comfort onboard will be collected at least twice during the field trial, once on buses with existing solution and once on the bus equipped with the new system. This data will be collected as an integrated part of the evaluation of the new electric bus (see TI-2), i.e. an expected response of 2 x100 passengers.

Table 2 - Overview of data to be collected and data collection method of TI-1 demonstration.

Data	Unit	Data collection method
Energy use	kW	Estimations and measurements
Cost	SEK	Calculation
Comfort	Rating scale	Questionnaires distributed to drivers and passengers onboard the bus during field trial.

4.1.6 Implementation plan

Preparations for the demonstration on energy strategies and auxiliaries include comparisons between different design solutions to assess the possibilities for storing and distributing heat as well as for combining heat and cold storage. It also includes comparisons of different solutions to achieve a distribution of temperature which is perceived as comfortable by passengers, and assessments of the effects of different vehicle designs (e.g. type and number of windows) on energy use. The controlled laboratory experiments will encompass investigations and simulations of the actual impact of vehicle designs in terms of number and type of windows, insulation, heated surfaces rather than heated air in compartment, and effects of the number of passengers onboard. The third step is the field trial, where a feasible (part) solution (for heating pump/cooler) will be implemented in one electric/electric hybrid bus in operation. The time plan is provided in Table 3.

Table 3 - Gantt chart of TI-1 demonstration.

	2016			2017					2018		
Preparations for simulations	■	■									
Execution of simulations			■	■	■	■	■	■	■		
Preparations for laboratory tests				■	■	■	■				
Execution of laboratory tests					■	■	■	■			
Preparations for field trial				■				■			
Execution of field trial					■				■		
Data collection					■				■		
Analysis					■	■			■	■	

4.1.7 Risk assessment

An assessment of the risk associated with the demontration of TI-1 is provided in Table 4.

Table 4 - Risk identification and assessment of TI-1 demonstration.

Risk	Probability assessment	Consequences	Comment
Delays due to technical problems	Moderate	Moderate	
The solution cannot be implemented on a bus in operation.	Low	Moderate-High	The assessment will have to rely on simulations and/or controlled laboratory data. However, data on drivers' and passengers' comfort assessment cannot be provided.
Delays due to lack of staff resources	Moderate	High	
Field trial: The data collection period will not include true winter conditions (i.e. - 5ºC)	Moderate	Moderate	The risk is associated with possible delays. If the field trial is delayed so that it cannot run for winter months, the assessment will have to rely on simulations and/or controlled laboratory data.
Loss of data during simulations, laboratory tests, and/or field trial	Low	High	

4.2 Attractiveness and efficiency of innovative external and internal design of electric buses (TI-2)

A new driveline means a possibility to create new vehicle designs. The technical innovation concerns the innovation topic Vehicle Design. More specifically it involves the attractiveness and efficiency of innovative external and internal design of electric buses.

The new vehicles to be demonstrated and evaluated include three fully electric buses and seven plug-in hybrid buses (for comparison) that operate the new bus line, line 55. The electric buses have a total length of 10,5 m (compared to 12 m), low floor, a large double doors in the middle of the vehicle to facilitate access/exit, an open layout with an extended number of folding seats to increase flexibility during peak hours, a modern colour scheme and WiFi onboard.

4.2.1 Goals

The objective is to demonstrate a new, more efficient and flexible solution (fully electric buses) and compare this with a more traditional design (hybrid buses). The overall aim of the technical innovation is to increase the attractiveness of public transport, increase passengers' perceived quality of the service, and improve passengers' satisfaction with PT in general and bus systems in particular. Related goals are to speed up boarding/alighting operations and hence reduce dwell times; improve flexibility; improve onboard travel comfort; and reduce noise and air emissions. Speeding up boarding/alighting is partly a consequence of the new bus design, partly the interplay between bus design and bus stop design (see also TI-3).

The goals are to be achieved by the particulars of an electric bus (i.e. lack of noise from engine and lack of emissions) as well as the particular design of the specific electric buses introduced on line 55 in Gothenburg (the large double doors, the open layout, the folding seats, the modern colour scheme).

4.2.2 Validation objectives

The validation objectives for the TI-2 demonstration (as of 2016-03-29) are provided in Table 5.

Table 5 - Validation objectives of TI-2 demonstration.

Number	Description
VO4	Increasing the uptake of fully electric and hybrid options
VO9	Speeding up boarding/alighting operations
VO18	Improving onboard travel comfort
VO10	Increasing accessibility for all
VO22	Reducing noise and air emissions
VO23	Increasing attractiveness of the service
VO25	Increasing passengers' perceived quality of service
VO29	Increasing demand
VO33	Improving urban interface with the bus. *Note: In the specific case Improving the interface between bus and urban interface.*
VOXX	Improving interior design of vehicle

4.2.3 Test scenarios

The new electric buses (test) are tested under real operational conditions on one a bus line in Gothenburg, line 55. This line is a completely new line between two university campus: Chalmers Lindholmen and Chalmers Gibraltar with three electric buses and seven electric hybrids. The buses run with a frequency of six departures per hour between 06:00 and 19:00, Monday to Friday.

The evaluation will first compare the fully electric buses with the electric hybrids (control). This comparison will allow a focus on the effect of the bus design specifically. A second comparison concern the impact of the new buses and the new bus line with a well established line in Gothenburg (control). This line 16 runs in part parallel with line 55 with a frequency of 6-12 departures per hour on average and 24 departures per hour during rush hours.

4.2.4 Description of the no “EBSF_2 scenario vs “EBSF_2 scenario

The bus fleet in Gothenburg consist primarily of diesel fuelled buses. In an earlier project, however, HyperBus (2011-2014) plug-in hybrid buses were tested on line 60.

Line 16 (the control line), one of the “stombuss” lines, are run with 20 diesel fuelled buses. All are double articulated buses with a comfort capacity of 120 passengers. Otherwise they have traditional, standard design, externally and internally regarding the design of doors, the interior layout and overall interior design (see Figure 2 and Figure 3)

Figure 2 - An example of the buses along line 16.

Figure 3 - Interior design of the standard bus.

The new fully electric buses come with new features (see Figure 4). The fully electric bus has a total length of approx. 10,5 m with a total capacity of maximum 85 passengers, two large double doors, low-floor, and flexible/folding seats to increase accessibility, as well as new and light interior design and WiFi onboard. The electric hybrid (See Figure 5) with a total capacity of 71 passengers has a similar colour scheme but is fiited with three doors (one in the front, one in the middle, and one in the rear part of the bus) and a more traditional interior layout.

Figure 4 - The exterior design of the new electric bus.

Figure 5 - The interior design of the new electric bus.

4.2.5 Preliminary data collection plan

The data to be collected is summarised in Table 6.

Data on passengers' perception of the respective buses will be collected on a regular basis along the field trial (one each every three months). Data will be collected onboard buses on line 16 and onboard buses on line 55. A target value is completion of 100 questionnaires/ on line 16 bus stops (the control) and 100 on line 55 buses (test) for each wave of data collection

Complementary and more in-depth information will be collected in so called 'co-trips' (Swe: medresor) during which a researcher follows a traveller onboard the bus for a trip during which topics of relevance are addressed. This will be accomplished with a more limited number of passengers, approximately 20, repeated twice during the trial. In addition will the behaviour of passengers on board be studied, for instance choice of seat and flow through the vehicle, according to the methodology developed in the EBSF project (Andersson et al. 2010). In this case, data collection will take place on repeated occasions during the field trial.

Data re drivers' perception of the new bus, in particular the electric bus, will be collected by means of personal interviews. The number of interviews will be decided at a later stage, based on the total number of drivers who drive the new buses and the accessibility to staff. The intention is to repeat these interviews minimum twice during the field trial.

Table 6 - Summary of data to be collected and data collection method of TI-2 demonstration.

Data	Unit	Data collection method
Passenger's assessment of the new bus (interior design, exterior design, accessibility, noise level, and comfort)	Ratings	Questionnaires
Passengers' explanations, suggestion for changes and improvements		Interviews during co-trips
Passengers' use of bus (choice of		Observations

seat, flow, etc)		
Drivers’ assessment of the new bus (driver’s position, design of cabin, visibility, etc.)		Interviews
Dwell time	Seconds per bus stop	Measurement
Commercial speed	Km per hour	Measurement
Occupancy	No of travellers entering/exiting per bus stop	Measurement/Registration

4.2.6 Implementation Plan

Regarding vehicle design, preparations for the demonstration should, accordling to the DoW, include the realisation of three fully electric buses with new features: a total length approx. 10,5 m (compared to 12 m) with corresponding passenger capacity, flexible/folding seats, central location of the driver, increased wheelbase, and two large double doors in the middle of the vehicle. The demonstration is however an integrated part of the ElectriCity project. As a consequence of deadlines within the ElectriCity project Volvo Bus Corporation has proceeded the realisation of the electric bus prototypes and introduced them on the new line 55 in June 2015. The field trial is hence ongoing. In order to capture initial impressions of the new bus evaluations will start already during the Autumn and Winter 2015.

Table 7 - Gantt chart. for TI-2 demonstration. (Data collection began at the time of the introduction of line 55, i.e. June 2015.)

		2016				2017				2018	
Field trial	■	■	■	■	■	■	■	■	■		
Data collection (questionnaire, in-depth interviews, observations)	■	■	■	■	■	■	■	■	■		
Analysis			■	■	■	■	■	■	■	■	

4.2.7 Risk assessment

An assessment of the risks associated with the demontration of TI-2 is provided in Table 8.

Table 8 - Risk identification and assessment of TI-2 demonstration.

Risk	Probability assessment	Consequences	Comment
Technical failures (the electric buses are prototypes)	Low	High	The TI-2 demonstration cannot be completed. However Volvo buses allocate substantial resources in order to keep the buses in best possible condition.
Marketing of the ElectriCity project will influence passengers’ and drivers’ impression of the new buses and bus line	High	Moderate to high	Repeated data collection over a longer period, i.e. with the intention to reach ‘steady state’

Introduction of new features/services on board the buses will not create a 'steady state' for evaluation why a strict comparison with the control line cannot be achieved.	High	Moderate to high	By collecting qualitative data the impact of new services/features can be separated from the core service.
Loss of data: registration of passengers entering/existing at bus stops cannot be accomplished why dwell time calculations cannot be obtained	Moderate	High	Complementary data collection by means of manual registration (counting) at key bus stops to ensure the availability of data

4.3 Attractiveness of innovative bus stop designs and interaction between bus and bus stop (TI-3)

Electrification offers new opportunities for creating innovative solutions for the interface between public transport and the urban environment, in terms of new types of bus stops. The innovation concerns the topic Interface Bus-Urban Infrastructure. More specifically it involves the attractiveness of innovative bus designs and interaction between bus and bus stop design including an indoor stop.

The new bus line 55 passes altogether 16 bus stops of which five will have a new design. One of these is an indoor bus stop, located at Lindholmen university campus. It forms an extension to an existing building in which is located e.g. a cafeteria and teaching facilities. Also other bus stops have a new design, including a shelter which is larger in size than the standard ones and which are equipped with new information features.

4.3.1 Goals

A main goal of the demonstration is to investigate how the interface between the urban infrastructure and the bus can be improved from different perspectives. The redesign of bus stops and the new buses are expected to contribute to more efficient boarding/alighting but there are also more overriding goals related to satisfaction and in the long run, demand.

A second goal is to demonstrate the feasibility of an 'indoor' bus stop for increased attractiveness of bus systems in particular while solving technical challenges including charging and climate. The demonstration will allow for a comparison between traditional bus stops and indoor bus stops, which provide improved shelter for travellers waiting fot the bus but more fundamentally the intention is to create a shared space for PT and other urban activities, reducing the distance between PT and for instance school or work and hereby changing the perception of a bus stop: from "bus stop" (a place where the bus stops) to a space for activities including travel.

4.3.2 Validation objectives

The validation objectives of TI-3 demonstration (as of 2016-03-29) is provided in Table 9.

Table 9 - Validation objectives of TI-3 demonstration

Number	Description
VO9	Speeding up boarding/alighting operations
VO10	Increasing accessibility for all
VO23	Increasing attractiveness of the service
VO25	Increasing passengers' perceived quality of service
VO29	Increasing demand
VO31	Improving passengers' satisfaction
VO33	Improving urban interface with the bus

4.3.3 Test scenarios

The overall approach is to compare existing designs (control) with new (test), i.e. traditional bus stops along line 16 will be compared with new bus stops partly along line 55 (of which some are common stops. More in particular the study design will include a comparison of a traditional bus stop, equipped with traditional shelters, and an indoor bus stop.

4.3.4 Description of the no "EBSF_2 scenario vs "EBSF_2 scenario"

The control is line 16 and its altogether 22 bus stops. These are equipped with one or two JC Decaux standard shelters equipped with information (including realtime information).

Figure 6 - Example of bus stop along line 16.

Figure 7 - Example of shelter provided along line 16.

The new electric bus line has altogether 16 bus stops. Five of these have or will have a new design including bus shelter, furniture, and information. The indoor bus stop is located at Lindholmen where it forms an extension to an existing building in which is located a cafeteria and teaching facilities. The building is situated in a context of university buildings, office buildings, a science park, and restaurants. Close by are also found new apartment buildings. Regarding the indoor bus stop the intention is to create a shared space for PT and other urban activities, reducing the distance between PT and e.g. school or work but also change the perception of a bus stop: from "bus stop" (a place where the bus stops) to a space for activities including travel. Charging of the electric buses takes place at the indoor stop at Lindhomen and at an outdoor stop close to Johanneberg Science Park.

4.3.5 Preliminary data collection plan

Data on passengers' perception of the new bus stops will be collected on a regular basis along the field trial (one each every three months). Data will be collected onboard buses on line 16 and onboard buses on line 55. A target value is completion of 100 questionnaires/ on line 16 bus stops (the control) and 100 on line 55 buses (test) for each wave of data collection.

Complementary and more in-depth information will be collected in so called 'co-trips' (Swe: medresor) during which a researcher follows a traveller onboard the bus for a trip during which topics of relevance are addressed. This will be accomplished with a more limited number of passengers, approximately 20, repeated twice during the trial. In this case, data collection will take place on repeated occasions during the field trial. In addition, information will be gathered by means of observations of passenger behaviour at bus stops of different designs. Data will also be collected on the number of participants entering and exiting at each bus stop in order to allow a comparison of the ‘fit’ between bus design and bus stop design.

Table 10 - Summary of data to be collected and data collection method of TI-3 demonstration

Data	Unit	Data collection method
Travellers’ assessment of the new bus stops (exterior design, interior design, accessibility, comfort, etc.)	Ratings	Questionnaires
Passengers’ use of the respective bus stops (activities, use of furniture, etc.)		Observations
Interplay between bus and bus stop (accessibility, flow, etc.)		Observations
Dwell times	Time in sec	Measurement

4.3.6 Implementation plan

The demonstration is an integrated part of the ElectriCity project. As a consequence of deadlines within the ElectriCity project, Chalmers Fastigheter had to proceed with the plans to complete the construction of the bus stops at Chalmers Gibraltar and Chalmers Lindholmen (i.e. the indoor bus stop). Implementation activities to be performed on the recently built bus stop include;

- managing the indoor climate including an efficient use of energy. Problems were identified during the summer period as the indoor bus stop became warmer than what was perceived as comfortable. Approaching winter, CF is prepared to address an indoor climate that could be perceived as too cold. Too warm or too cold would have significant impact on how travellers’ perceive the bus stop and how the bus stop will be utilised.
- addressing the interior of the indoor bus stop. At the moment the facilities include a table and some chairs, a bookcase including some books on electromobility etc., and a screen visualising the charging process. In order for the indoor bus stop to be recognised and utilised as something more than a ’bus stop’, to be used for other activities than waiting (which has a negative impact on travellers’ experience of the bus journey), the design of the interior of the bus stop must be addressed in a way that support other activities.

Table 11 - Gantt chart of TI-3 demonstration

		2016				2017				2018	
Field trial	■	■	■	■	■	■	■	■	■		
Modifications of indoor bus stop					■	■					
Data collection (questionnaire, in-depth interviews, observations)	■	■	■	■	■	■	■	■	■		
Analysis	■	■	■	■	■	■	■	■	■	■	

4.3.7 Risk assessment

An assessment of the risk associated with the demontration of TI-3 is provided in Table 12.

Table 12 - Risk identification and assessment of TI-3 demonstration

Risk	Probability assessment	Consequences	Comment
Technical failures so that the indoor bus stop cannot be used as intended	Low	High	The impact of an indoor bus stop cannot be addressed in the project.
Marketing of the ElectriCity project will influence passengers' and drivers' impression of the new buses and bus line	High	Moderate to high	Repeated data collection over a longer period, i.e. with the intention to reach 'steady state'
Introduction of new features/services at bus stops will not create a 'steady state' for evaluation why a strict comparison with the control line cannot be achieved.	High	Moderate to high	By collecting qualitative data the impact of new services/features can be separated from the core service.
Loss of data: registration of passengers entering/existing at bus stops cannot be accomplished why dwell time calculations cannot be obtained	Moderate	High	Complementary data collection by means of manual registration (counting) at key bus stops to ensure the availability of data

5 Demo team

The Gothenburg demonstration team consists of the following:

- MariAnne Karlsson (MAK), Professor, Chalmers University of Technology. MAK and has overall responsibility according to the EBSF2 methodology.
- Oskar Rexfelt (OR), Associate Professor, Chalmers University of Technology. OR is involved in the detailed planning and execution of TI-2 and TI-3 demonstration evaluation.
- Pontus Wallgren (PW), Senior lecturer/Researcher, Chalmers University of Technology. PW is responsible for coordinating the demonstrations in Gothenburg and for the detailed planning and execution of the evaluations.
- Li Wikström (LiW), Senior lecturer/Researcher, Chalmers University of Technology. LiW is responsible for designing the observation studies to be performed in relation to TI-2 and TI-3.
- Anna Eckerstig (AE), Director of Projects and Development, Chalmers fastigheter. AE is responsible for the construction and maintenance of the indoor bus stop at Lindholmen as well as the new bus stops at Chalmers Gibraltar.
- Jennifer Elsren, Project manager, Västtrafik. JE is responsible at Västtrafik for the ElectriCity project and thus for line 55. JE is responsible for the surveys to be completed on line 16 and line 55.
- Håkan Jubell, Senior Project Manager, Volvo Bus Corporation. HJ is responsible for the TI-1 demonstration.

6 Partner Contribution

The following partners have contributed to completion of the deliverable as specified below.

Institution/Company	Sections	Description of the partner contribution
Chalmers University of Technology	All	A draft version of the deliverable, including all chapters and sections, as well as updates based on input from partners (below) as well as from the work on KPIs etc. within WP2.
Chalmers Fastigheter	TI-3	Contribution to content regarding TI-3. Review of content
Volvo Bus Corporation	TI-1	Contribution to content regarding TI-1. Review of content
Västtrafik	TI-2	Contribution to content regarding TI-2. Review of content
UITP	All	Review of content Quality check

References

Andersson, Torbjörn; Wikström, Li; Karlsson, MariAnne (2010): D2.1.2.a. Empirical Studies of Passenger Behaviour and the Creation of Personas. Appendix to D2.1.2. EBSF project, Chalmers, Göteborg

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