Bremen Use case set up report

Pillar A+B+C

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SUMMARY SHEET

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Abstract	This document describes the implementation of the Bremen Use Case (Germany) in the framework of Pillar A+B+C. Furthermore the document identifies the contribution of involved partners, describes the context conditions (like economical, geographical and urban; public transport service; general information about the Use Cases), determines the objectives (like expected impacts and Use Cases KPIs), identifies the risks, constraints and monitoring criteria, and finally describes in detail the Use Cases and related work plan.
Keywords	Bremen Use Case, electric buses, energy storage, multimodal mobility
Critical risks	

DOCUMENT CHANGE LOG

Pillar A:

Version	Date	Main area of changes	Organisation	Comments
0.1	15/12/2015	Final Version	BSAG	
1	29/03/2016	Update Final Version	BSAG	Revision Final version

Pillar B:

Version	Date	Main area of changes	Organisation	Comments
0.1	22/01/2015		BSAG	First draft
0.2	16/02/2016	Review Pillar B leader	ASSTRA	Change Index
0.3	16/02/2016	Review PMT	RUPPRECHT	Commented draft, Delivery Review doc
0.4	25/02/2016	Update Draft version	BSAG	Final version
1	29/03/2016	Update Final Version	BSAG	Revision Final version

Pillar C:

Version	Date	Main area of changes	Organnisation	Comments
0.1	18/12/2015		BSAG	First draft
0.2	23/02/2016	Review Pillar C leader	VDV/Berends	Revised draft
1	25/02/2016	Update draft version	BSAG	Final version

CONTRIBUTING PARTNERS

Company	Names	Company Info
BSAG (P3)	BSAG – Bremer Straßenbahn AG	Public Transport Operator

Table of Contents

Overview Tables

Overview Figures

1. Executive Summary Pillar A

The present Deliverable D2.1.1A falls into the scope of WP2 'ELITPTIC Use Cases' which aims to implement eleven (11) ELIPTIC use cases (either live demonstrations in operation or feasibility studies) to successfully integrate electric bus systems into the existing public transport infrastructure.

In order to achieve this aim the ELIPTIC Use Cases are grouped in three (3) pillars:

- Pillar A: Safe integration of ebuses by using existing electric public transport infrastructure,
- Pillar B: Innovative energy storage systems to increase operational efficiency, and
- Pillar C: Multi-purpose use of electric public transport infrastructure.

This Deliverable relates to Pillar A and deals with operation-optimized system of opportunity charging at bus depots.

This setup report gives a complete overview of the Bremen Use Case and includes information about

- contribution of involved partners
- context conditions like economical, geographical, urban and public transport services,
- general information about the Use Cases,
- objectives like expected impacts and Use Cases KPIs,
- identified risks,
- constraints and monitoring criteria, and
- more detailed description of the Use Case features and its related work plan.

2. Partner Contribution Pillar A

Company	Sections	Description of the partner contribution
BSAG (P3)	All chapters	Compilation of the content (text, data, images, graphics) and preparation of the draft and final deliverable version
UITP	All chapters	Review of document
RC	All chapters	Review of document

3. Context conditions Pillar A

3.1. Economic, geographical and urban context of the Use Case

The Free Hanseatic City of Bremen has a strong political backing for the subject of sustainable urban transport. The Senate Department for Environment, Construction and Transport (SUBV) is the responsible authority for urban development and planning, for transport and for environment, climate protection and energy.

The City of Bremen (www.bremen.de) with its 548.000 inhabitants is a typical European city – undergoing a structural change from basic and traditional harbour industries to a modern city with a mix of old and new industry, research and services. Besides this structural transformation, significant parts of the town have developed into centres of technological competence and innovation.

Figure A 1 – Bremen location within Germany (source: Wikipedia)

Area size	~ 327 sqkm
Population	548,547 (31.12.2013)
More information	www.bremen.de

Table A 1 – Bremen's key figures

In terms of urban development, Bremen is undertaking a sensitive regeneration policy, with a strong focus on sustainability. The ambitious Bremen Climate and Energy Program sets a framework to reduce drastically the overall greenhouse gas emission, with an overall target of a 40% reduction (against the 1990 level).

Today's modal split of the Bremen citizens shows a good starting point – with a share of about 60% of all trips done by the sustainable modes (public transport, cycling and walking) – which shall be extended.

3.2. PT service context

Bremer Straßenbahn AG (BSAG) is the public transport operator offering mobility services within the Free Hanseatic City of Bremen and surrounding area and thus is leading partner in the regional Public Transport association VBN (Verkehrsverbund Bremen/Niedersachsen GmbH) with joint tariff system, seamless ticketing and joint passenger information.

The founding year of the company was in 1876 under the name of 'Actiengesellschaft Bremer Pferdebahn' starting with the operation of horse waggons. In 1891 the company name changed to 'Bremer Straßenbahn' as it is today. One year later the first electrified line stretch from the city centre (bourse) to the district Horn was put into operation. In 1911 the horse waggon operation was closed down.

BSAG offers mobility services on 7 tram lines (total length of about 106 km and 119 low floor vehicles) and 44 bus lines (bus network of about 506 km operated by 161 articulated and 49 standard buses). The tram and buses are parked in five garages, one for buses only (located at the north end of the city area).

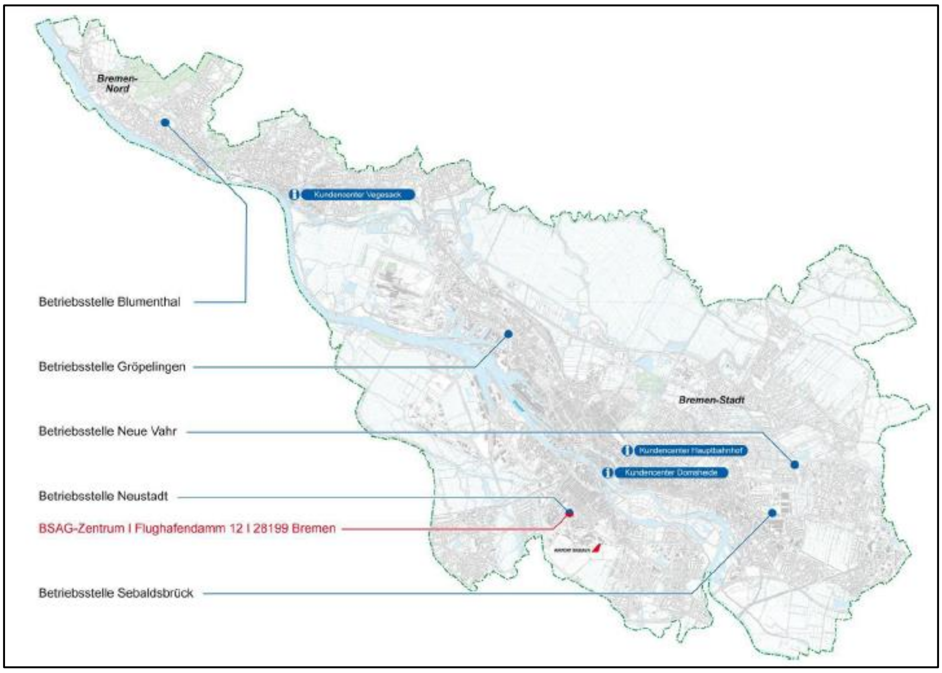

Figure A 2 – Location tram and bus depots in Bremen (source: BSAG)

Around 1,950 employees and 329 vehicles ensure that almost 300,000 people are using the comfortable, punctual and safe operation on a daily basis. Bremen travels 188 times a year by bus or tram. From this it can be estimated that around 104 million people will be moved every year.

The company takes responsibility for sustainable transport, as well as for responsible operation and internal procedures. It strongly supports the further extension of bus and tram network and initiates the development of new drive technologies. As tram operator, BSAG is experienced with electric powertrains. BSAG started testing hybrid buses already in 1998 and was already involved in several European projects (e.g. CIVITAS Vivaldi)

Most of the tram/ bus lines serve every 5 or 10 minutes. Only diesel buses (on an average not older than five years) are in service. The operation starts on weekdays (Monday to Friday) at about 4.00 am and ends at night at about 24.00 pm. At the weekend the operation starts a bit later but in return the service at night is non-stop service on 5 night lines.

All trams and buses operated by BSAG are low floor vehicles and equipped with air-condition and devices to get priority at almost all traffic lights. In addition physically separate right of ways for trams and buses as well as bus lanes at dedicated sections in the bus network and specific measurements at some traffic lights give priority to the trams and buses. Furthermore all transfer stations (e.g. connection tram/tram, tram/bus and tram/bus with railway) and all tram stops are equipped with real-time passenger information boards displaying the arrival time of each line stopping at that station.

The operation key figures of BSAG are (basis year 2014):

Total number of lines (tram / bus)	51 (7 / 44)
Total line length (tram / bus)	612 km (106 / 506)
Total number of stations (tram / bus / combined)	633 (90 / 470 / 73)
Total number of low floor trams	119
Total number of low floor buses (articulated / standard)	210 (161 / 49)
Total number of staff (incl. driver)	1,948 (1,040)
Total number of transported passengers per year / per day	104.051 Mio / 285,000

Table A 2 - Operation key figures 2014 BSAG

3.3. Information about the Use Case

The Bremer Straßenbahn AG (BSAG) as bus and tram operator is aiming to reduce fossil fuel consumption and targets a more efficient use of innovate vehicle technology through electrification of their bus fleet.

To achieve this forward-looking concept approach, BSAG will test in total three (3) electric low-floor buses in regular operation (two standard 12m and one articulated 18m) by own financial resources. To facilitate that, the infrastructure at one bus depots needs to be equipped with overnight charging stations (leased from the vehicle manufacturers).

Furthermore a logistical system needs to be developed (soft- and hardware) which can manage the electric bus charging by taking the operational as well as economic and technical aspects into account. This will be a starting point for the medium-term target of operating an entire electric bus fleet.

The technical requirements, specifications and configurations of the bus charging equipment, the vehicle technical specification and technological parameters were elaborated before the H2020 ELIPTIC project started in June 2015. This information was used by the middle of the year 2015 for an EU-wide procurement.

In this context a maintenance strategy for workshop and driver personnel training schemes will also be evaluated and elaborated. During the Use Case trial, a scientific monitoring of energy consumption, noise control, and the economic value of operating electric buses (12m/18m) will be carried out to evaluate potential impacts of operating new technology more widely.

Data will be collected from the operation with the new electric buses and charging infrastructure as well as from operating “conventional” reference technology.

4. Objectives Pillar A

4.1. Objectives of the Use Case

The main objective of the Bremen Use Case is to prove that electric buses with overnight charging at the depot can be already deployed for everyday operation and can be operated economically.

The tests during the day-to-day operation should not just deliver practical experience about the integration of electric buses in the operational and maintenance working processes, but also about charging technology and their suitability and reliability. Further the added value of an emission-free and low-noise vehicle and the integration of the charging technology into the urban environment shall be shown.

4.2. Expected impacts

The following preliminary list shows the expected impacts:

- Reduce the energy consumption
- Reduce the pollution and noise
- Simplify maintenance and repair work
- Increase the vehicle utilization (load factor, operating time)
- Increase the service reliability
- Improve the urban integration/ quality of life

4.3. Use Case KPIs

The performance of the Use Case lines 29 and 52 will be assessed by Key Performance Indicators (KPIs) as a part of WP3. The selected KPIs are both quantitative and qualitative and will be collected during two different periods ”No ELITPIC scenario” (before starting the Use Case testing phase) and “ELIPTIC scenario”(during the Use Case testing phase), in order to measure the impact of the measurements carried out. The period for data collection of both periods (“Before” and “During”) has been set as follows:

	No ELITPIC scenario (Before)	**ELITPIC scenario (During)**
Pillar A: Tram infrastructure for (re)charging e-buses	June 2015	May 2018

Table A 3 – KPI data collection periods (Before / During)

The KPIs to be collected for the Use Case Pillar A are listed as follows by grouping them by “KPI categories”:

<u>Staff</u>

- Driving staff

Supply
- Passenger capacity
- Daily supply

Maintenance
- Durability of charging infrastructure

Service
- Commercial speed
- Bus frequency
- Dwell time
- Bus punctuality
- Journey time
- Round trip time
- Operation time

Demand
- Passenger demand

Passenger
- Awareness
- Acceptance
- Noise perception

Drivers
- Driving comfort

5. Risks Pillar A

The main risks identified by the Use Case partner BSAG are as follows:

Description of risk	Proposed risk-mitigation measures
The installed charging infrastructure (leased by each of both vehicle manufacturers) won't fulfill the contracted requirements regarding functionality and operational readiness.	Communication with the manufacturer to find a solution.
The purchased vehicles won't fulfill the contracted requirements regarding operating range, availability and reliability.	Communication with the manufacturer to find a solution.

Table A 4 - Description of Pillar C risks and proposed mitigation measures

6. Detailed description of the Use Case Pillar A

6.1. Description of expected use case features, establishing the link among use case conditions, objectives and background

The Bremer Straßenbahn AG (BSAG) will test in total three (3) electric low-floor buses in regular operation (two standard 12m and one articulated 18m) on the bus line 29 and 52. The reason why these two lines were chosen are:

- They are closely linked in day-to-day operation.
- They pass the main bus and tram depot (located next to the airport).
- Hence in case technical problems the electric buses can be replaced easily by diesel buses.
- On these combined bus route already other electric and hybrid buses were tested and thus the test results can be compared with one another simply and traceable.

Operation key features of the bus route are:

- During day-to-day operation in total five (5) buses are running: two standard and three articulated buses.
- The circular route distance is 60km.
- The operation distance per day is minimum 200km for standard buses and minimum 300km for articulated buses.

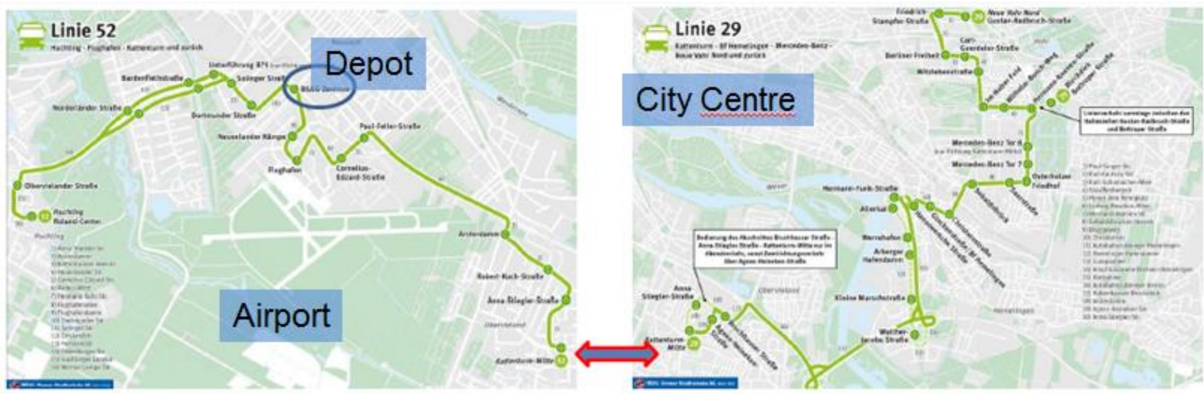

Figure A 3 – Use Case Bus Line 29 and 52 (source: BSAG)

The deployed electric vehicles – two standard 12m buses (Ebusco, SILEO) and one articulated 18m bus (SILEO) - are equipped with low-floor technology, ticket vending machines and air conditioning systems to maintain the usual standard for urban buses operated by BSAG.

The charging infrastructure is made available (leased) by both vehicle manufacturer companies and can used only for their own vehicle. The energy will be supplied with power from the medium-voltage network of the local energy supplier. Hence no energy from the existing DC tram infrastructure at the depot is used.

The following table shows the assigned tasks for the involved partners in the Use case Pillar A:

Involved Parties	Assigned Task
BSAG (Bremer Straßenbahn AG)	Public transport operator, Use Case coordinatior
Ebusco/ SILEO	Bus vehicle manufacturer
Swb	Local energy supplier
Berends-Consult	Technical coordination and planning support
University of Applied Science Landshut	Scientific monitoring of the operating electric buses
Engineering consultancy company	Analysis of the existing flywheel energy storage system
Transport consultancy company	Analysis of implementation of multimodal mobility hub stations

Table A 5 - Assigned Tasks for Involved Parties (Pillar A)

6.2. Use Case constraints

The Use Case constraints can be summarized as follows:

- Pre-instruction and briefing of trainers, drivers, technical experts and maintenance staff by the bus manufacturer (in this case Ebusco and SILEO) about specifics of the electric vehicle types and related leased charging station (at the depot) are needed beforehand.
- The aim is to train all 250 drivers and 30 workshop workers (mechanical and electric staff) in the operation and maintenance of the electric vehicles and charging stations.

6.3. Use Case monitoring criteria

Data loggers will be installed by both vehicle manufacturers on their vehicle. The data loggers will from July 2016 continuously monitor the buses on miscellaneous parameters (see KPIs described in chapter 4.3). The logged data will be analyzed by the Use Case leader and vehicle manufacturer.

In addition, scientific research and analysis of the energy consumption, noise control, economic value of the operating e-buses for the 12m and 18m buses will be carried out by the University of Applied Sciences Landshut

7. Use case work plan Pillar A

7.1. Use Case development logic

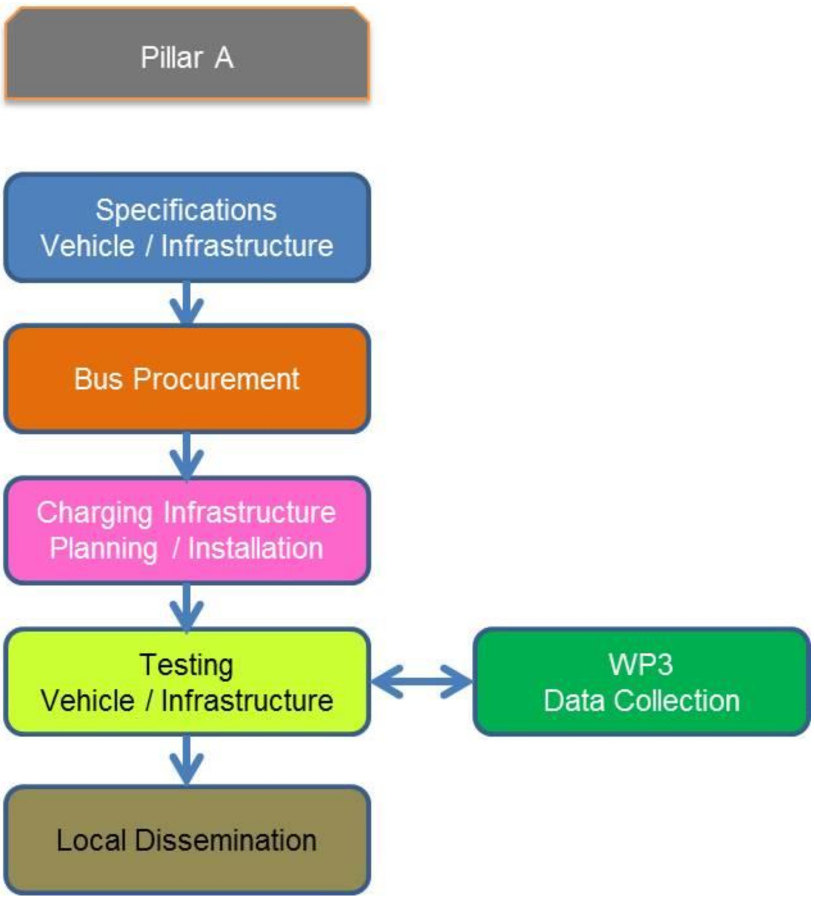

Figure A 4 – Use Case Development Logic (Pillar A)

7.2. Work plan

Pillar A: Use of tram infrastructure (catenary and substation) for (re)charging e-buses

The following work plan contains the main Use Case Pillar A activities:

No	Action	Total PMs	Staff 1	Staff 2	External	Start-month	End-month
1	Specification vehicle and infrastructure parameters/ performances		Staff from Technical and Operational Units	Staff from Transport Planning Unit		Already executed (May 15)	
2	Execution electric bus procurement	0.5	Staff from Administrative Unit	Staff from Transport Planning Unit		1 (Jun 15)	2 (Ju6 15)

3	Planning and installation charging infrastructure	0.5	Staff from Technical Unit	Staff from Transport Planning Unit		1 (Jun 15)	8 (Jan16)
4	Test vehicles and charging infrastructure	8.0	Staff from Technical and Operational Unit	Staff from Transport Planning Unit	Vehicle manufacturer incl. charging infrastructure (Ebusco, SILEO)	9 (Feb 16)	36 (May18)
5	Close monitoring of daily vehicle operation & data collection	2.5	Staff from Technical and Operational Units	Staff from Transport Planning Unit	Vehicle manufacturer (Ebusco, SILEO)	13 (Jun 16)	36 (May18)
6	Local dissemination	0.5	Staff from Administrative Units (Marketing, Planning)	Staff from Administrative Units (Marketing, Planning)	Vehicle manufacturer (Solaris), charging infrastructure (Siemens)	1 (Jun 15)	36 (May18)
	In total	**12.0**					

Table A 6 – Work Plan (Pillar A)

7.3. Detailed timeline

Use Case Bremen (Pillar A)
Work Plan Schedule and GANTT (15/12/2015)

No	Action	Start Month	End Month
1	Delivery D2.1.1B 'UC Set-up Report' (Draft Version)	5	7
2	Delivery D2.1.1B 'UC Set-up Report' (Final Version)	7	7
3	Execution electric bus procurement	1	2
4	Planning and installation charging infrastructure	1	8
5	Test vehicles and charging infrastructure	9	36
6	Collection evaluation data	13	36
7	Local dissemination	1	36
8	Delivery D2.1.2B 'UC Set-up Report' (Final Version)	29	32
9	Delivery D2.1.2B 'UC Set-up Report' (Final Version)	29	32

Project Month

2015					>>		2016	>>												2017	>>											2018	>>			
J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36

Table A 7 – Work Plan and Schedule (GANTT Chart) for Pillar A

The above work plan contains the schedule for tasks/ activities for the Bremen Use Case (Pillar A).

8. Expected results Pillar A

The expected results for both Bremen Use Cases (Pillar A) are described as follows:

- Gain experience of the operational reliability and availability of the three e-buses
- Gain skills and knowledge about the specific energy requirement (battery, auxiliaries) for the e-buses
- Gain experience of the operational reliability and availability of the charging infrastructure.

9. Executive Summary Pillar B

The present Deliverable D2.1.1B falls into the scope of WP2 'ELITPTIC Use Cases' which aims to implement eleven (11) ELIPTIC use cases (either live demonstrations in operation or feasibility studies) to successfully integrate electric bus systems into the existing public transport infrastructure.

In order to achieve this aim the ELIPTIC Use Cases are grouped in three (3) pillars:

- Pillar A: Safe integration of ebuses by using existing electric public transport infrastructure,
- Pillar B: Innovative energy storage systems to increase operational efficiency, and
- Pillar C: Multi-purpose use of electric public transport infrastructure:

This Deliverable relates to Pillar B and deals with refurbishment of a flywheel energy storage system to assure the recuperation of braking energy from trams.

This setup report gives a complete overview of the Bremen Use Case and includes information about

- contribution of involved partners
- context conditions like economical, geographical, urban and public transport services,
- general information about the Use Cases,
- objectives like expected impacts and Use Cases KPIs,
- Identified risks,
- constraints and monitoring criteria, and
- more detailed description of the Use Case features and its related work plan.

10. Partner Contribution Pillar B

Company	Sections	Description of the partner contribution
BSAG (P3)	All chapters	Compilation of the content (text, data, images, graphics) and preparation of the draft and final deliverable version

11. Context conditions Pillar B

11.1. Economic, geographical and urban context of the Use Case

The Free Hanseatic City of Bremen has a strong political backing for the subject of sustainable urban transport. The Senate Department for Environment, Construction and Transport (SUBV) is the responsible authority for urban development and planning, for transport and for environment, climate protection and energy.

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Figure B 5 – Bremen location within Germany (source: Wikipedia)

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Table B 8 – Bremen's key figures

In terms of urban development, Bremen is undertaking a sensitive regeneration policy, with a strong focus on sustainability. The ambitious Bremen Climate and Energy Program sets a framework to reduce drastically the overall greenhouse gas emission, with an overall target of a 40% reduction (against the 1990 level).

Today's modal split of the Bremen citizens shows a good starting point – with a share of about 60% of all trips done by the sustainable modes (public transport, cycling and walking) – which shall be extended.

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Bremer Straßenbahn AG (BSAG) is the public transport operator offering mobility services within the Free Hanseatic City of Bremen and surrounding area and thus is leading partner in the regional Public Transport association VBN (Verkehrsverbund Bremen/Niedersachsen GmbH) with joint tariff system, seamless ticketing and joint passenger information.

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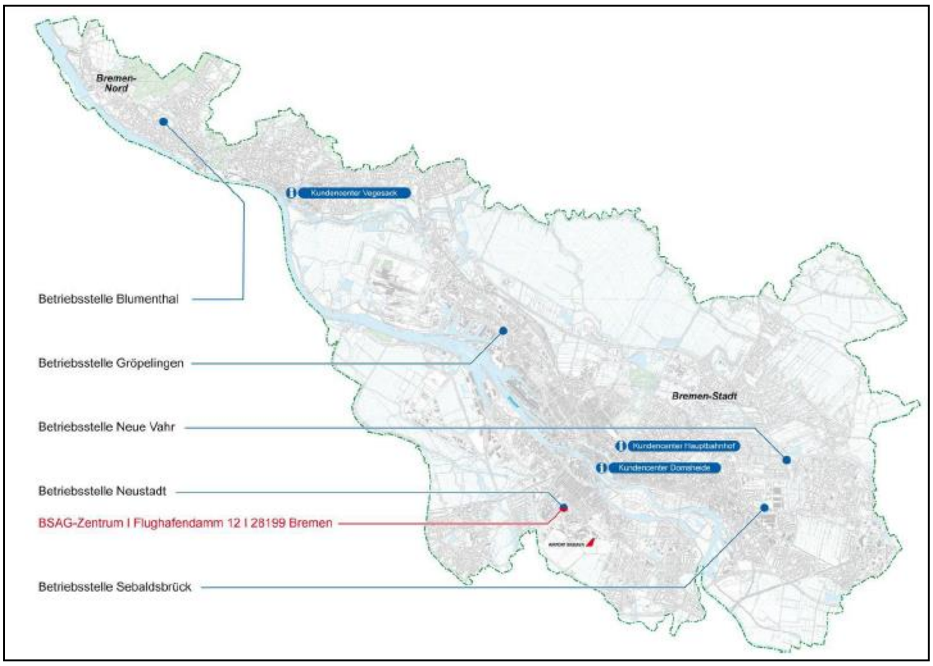

Figure B 6 – Location tram and bus depots in Bremen (source: BSAG)

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The company takes responsibility for sustainable transport, as well as for the operation and internal procedures. It strongly supports the further extension of bus and tram networks and initiates the development of new drive technologies. As tram operator, BSAG is experienced with electric powertrains. BSAG started testing hybrid buses already in 1998 and was already involved in several European projects (e.g. CIVITAS Vivaldi)

Most of the tram/ bus lines serve every 5 or 10 minutes. Only diesel buses (on an average not older than five years) are in service. The operation starts on weekdays (Monday to Friday) at about 04.00 am and ends at night at about 24:00 am. At the weekend the operation starts a bit later but in return the service at night is non-stop service on 5 night lines.

All trams and buses operated by BSAG are low floor vehicles and equipped with air-condition and devices to get priority at almost all traffic lights. In addition physically separate right of ways for trams and buses as well as bus lanes at dedicated sections in the bus network and specific measurements at some traffic lights give priority to the trams and buses. Furthermore all transfer stations (e.g. connection tram/tram, tram/bus and tram/bus with railway) and all tram stops are equipped with real-time passenger information boards displaying the arrival time of each line stopping at that station.

The operation key figures of BSAG are (basis year 2014):

Total number of lines (tram / bus)	51 (7 / 44)
Total line length (tram / bus)	612 km (106 / 506)
Total number of stations (tram / bus / combined)	633 (90 / 470 / 73)
Total number of low floor trams	119
Total number of low floor buses (articulated / standard)	210 (161 / 49)
Total number of staff (incl. driver)	1,948 (1,040)
Total number of transported passengers per year / per day	104.051 Mio / 285,000

Table B 9 - Operation key figures 2014 BSAG

11.3. Information about the Use Case

A flywheel is a rotating wheel spinning around an axis, used for storing energy mechanically in the form of kinetic energy. The flywheel works by accelerating a rotor to a very high speed and maintaining the energy in the system as rotational energy. Flywheels can be used to produce high power peaks.

The difference among flywheels and EDLCs (electric double-layer capacitor) is that flywheels have higher energy density while EDLCs have slightly better efficiency and suffer from lower self-discharge. Other aspects that have to be considered when dealing with flywheels are the gyroscopic forces and safety enclosures.

In case of Bremen the flywheel is located along the tram line 1 next to the tram stop 'Weserpark' (see figure below, marked with a red ring). It was installed in the year 2011 - but not in operation at present due to a few technical problems.

Figure B 7 – Flywheel location along tram line 1

12. Objectives Pillar B

12.1. Objectives of the Use Case

The main objective of the Use Case Bremen is to make an inventory of the existing flywheel and check the repair measures and investment costs whether and under which conditions it can be put back into service. The required technical and financial aspects and conditions will be examined by means of feasibility study.

If this feasibility study comes to the result that the restart is technically, economically and financially feasible then the Bremer Straßenbahn AG will start the necessary planning and engineering procedures. Otherwise the flywheel won't be restarted and probably dismantled (or alternative technical solutions will be investigated).

12.2. Expected impacts

Flywheel solution like in Bremen can avoid energy losses and reduce the overall energy consumption. By reducing the energy consumption, such systems can strongly impact the operational costs linked to the energy prices and substantially lower CO2 emissions as well as other harmful pollutants emissions if these are produced by energy plants are using primary energy sources.

It is worth mentioning that an assessment of the impacts of an energy storage system like a flywheel is difficult as it isn't easy to measure the effects of strong weather changes during a day operation and the mixture of different operated types of tram vehicles.

12.3. Use Case KPIs

Only when the feasibility study comes to the result that the restart is technically, economically and financially feasible then indicators can be collected. Those Key Performance Indicators (KPIs) which has been selected in advance are both quantitative and qualitative and will be collected during the "ELIPTIC scenario"(during the Use Case testing phase) only and will be assessed as part of WP3. The period for data collection has been set as follows:

	ELITPIC scenario (During) **Start month**	**ELITPIC scenario (During)** **End month**
Pillar B: Refurbishment of a flywheel energy storage system	January 2017	December 2017

Table B 10 – KPI data collection period (During)

The KPIs to be collected for the Use Case Pillar B are listed as follows by grouping them by "KPI categories":

Service
- Commercial speed
- Tram frequency
- Journey time
- Round trip time
- Operation time

Costs
- Operating costs (general)
- Investment for the network
- Maintenance operational costs
- Electricity costs for vehicles

Revenues
- Economic surplus

Consumption
- Electricity consumption

Emissions
- CO average emission
- NOx average emission

Other
- Operation Availability
- Standby energy loss
- Power density
- Energy density
- Recharge time

13. Risks Pillar B

The main risks identified by the Use Case partner BSAG are as follows:

Description of risk	Proposed risk-mitigation measures
The feasibility study comes to the result that the restart is technically, economically and financially feasible.	The Bremer Straßenbahn AG won't undertake the repair/ reconstruction of the flywheel and probably dismantled it.

Table B 11 - Description of Pillar C risks and proposed mitigation measures

14. Detailed description of the Use Case Pillar B

14.1. Description of expected use case features, establishing the link among use case conditions, objectives and background

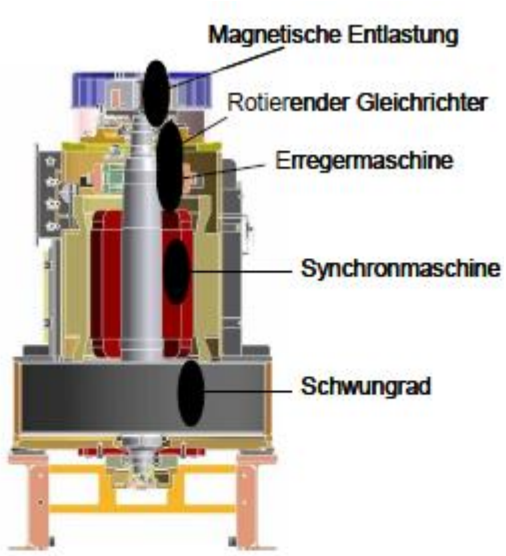
It is foreseen to tender the modelling & simulation in order to get solid, traceable, reproducible and authentic data for carrying out the planned reactivation study (see chapter 7.2). Main part of the tendered work will be a tool which takes into account all electrical components and operational conditions and

- calculates the energy usage,
- displays voltage flow in the catenary system,
- analyses the benefits of investments,
- shows energy usage of traction vehicles.

The tool having in mind is the so-called Energy Flow Simulation (EFS) tool developed by the Austrian engineering company KRUCH[1].

Technical data of the flywheel system are as follows:

- Effective energy: 2 kWh
- Maximum power: 250 kW
- speed range: 15000…25000/minute
- Maximum discharging current : 1,500A
- Efficiency rate: 80%
- Weight : 10 tons
- Noise : <45dB(A) (distance 45 m)



1 http://www.kruch.com/en/productsandservices/efssimulationsoftware/

Figure B 8 – Flywheel layout examples (cross-section and 3D view)

14.2. Use Case constraints

In case the feasibility study comes to the result that the restart is technically, economically and financially not feasible then further activities in relation to the originally planned Use Case wouldn’t be carried out anymore.

14.3. Use Case monitoring criteria

In case that feasibility study comes to a positive results any monitoring criteria will be defined according to the selected Key Performance Indicators (KPIs).

15. Use case work plan Pillar B

15.1. Use Case development logic

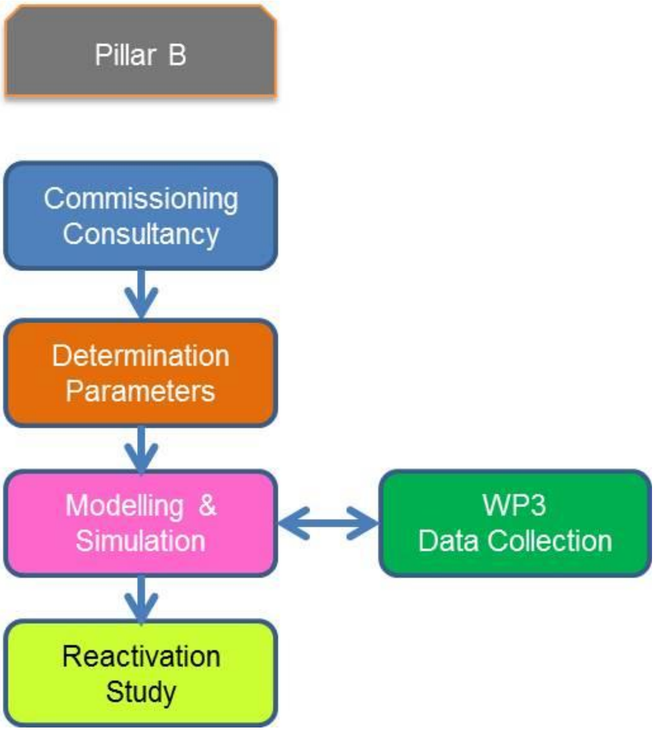


Figure B 9– Use Case Development Logic (Pillar B)

15.2. Work plan

The following work plan contains the main Use Case Pillar B activities:

No	Action	Total PMs	Staff 1	Staff 2	External	Start-month	End-month
1	Commissioning engineering consultancy company	0.25	Staff from Power Supply Unit			1 (Jun 15)	6 (Nov 15)
2	Determination technological parameters	0.75	Staff from Power Supply Unit		Engineeering consultancy company	7 (Dec 15)	19 (Dec 16)
3	Modelling & simulation (incl. collection evaluation data)	1.5	Staff from Power Supply Unit		Engineeering consultancy company	20 (Jan 17)	31 (Dec17)
4	Reactivation study (financial feasibility, infrastructure design)	1.5	Staff from Power Supply Unit		Engineeering consultancy company	7 (Dec 15)	19 (Dec 16)
	In total	**4.00**					

Table B 12 – Work Plan (Pillar B - Flywheel)

15.3. Detailed timeline

Use Case Bremen (Pillar B)
Work Plan Schedule and GANTT (15/12/2015)

No	Action	Start Month	End Month
1	Delivery D2.1.1B 'UC Set-up Report' (Draft Version)	5	7
2	Delivery D2.1.1B 'UC Set-up Report' (Final Version)	7	7
3	Commissioning Engineering Consultancy Company	1	6
4	Determination Technological Parameters	7	19
5	Modelling & Simulation (incl. Evaluation Data Collection)	20	31
6	Reactivitation Study (Finances, Infrastructure Design)	7	19
8	Delivery D2.1.2B 'UC Set-up Report' (Final Version)	29	32
9	Delivery D2.1.2B 'UC Set-up Report' (Final Version)	29	32

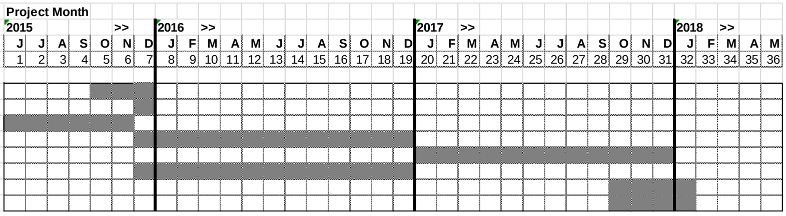


Figure B 10 – Work Plan and Schedule (GANTT Chart) for Pillar B

The above work plan contains the schedule for tasks/ activities for the Bremen Use Case Pillar B.

16. Expected results Pillar B

If restoration is feasible and cost-efficient then flywheel will be put into service again so that the expected results are:

- Gain information about operation, maintenance, reliability and availability.
- Check cost-effectiveness of the restart procedure.

17. References Pillar B

Engineering company KRUCH, Energy Flow Simulation
http://www.kruch.com/en/productsandservices/efssimulationsoftware/

INTERREG IVB North-West Europe project „Ticket to Kyoto“ http://www.tickettokyoto.eu/en

H2020 Smart Cities Call, Proposal U.R.Smart

18. Executive Summary Pillar C

The present Deliverable D2.1.1C falls into the scope of WP2 'ELITPTIC Use Cases' which aims to implement eleven (11) ELIPTIC use cases (either live demonstrations in operation or feasibility studies) to successfully integrate electric bus systems into the existing public transport infrastructure.

In order to achieve this aim the ELIPTIC Use Cases are grouped in three (3) pillars:
- Pillar A: Safe integration of ebuses by using existing electric public transport infrastructure,
- Pillar B: Innovative energy storage systems to increase operational efficiency, and
- Pillar C: Multi-purpose use of electric public transport infrastructure.

This Deliverable relates to Pillar C and deals with the extension of existing multimodal mobility hub station.

This setup report gives a complete overview of the Bremen Use Case and includes information about
- contribution of involved partners
- context conditions like economical, geographical, urban and public transport services,
- general information about the Use Cases,
- objectives like expected impacts and Use Cases KPIs,
- Identified risks,
- constraints and monitoring criteria, and
- more detailed description of the Use Case features and its related work plan.

19. Partner Contribution Pillar C

Company	Sections	Description of the partner contribution
BSAG (P3)	All chapters	Compilation of the content (text, data, images, graphics) and preparation of the draft and final deliverable version

20. Context conditions Pillar C

20.1. Economic, geographical and urban context of the Use Case

The Free Hanseatic City of Bremen has a strong political backing for the subject of sustainable urban transport. The Senate Department forEnvironment, Construction and Transport (SUBV) is the responsible authority for urban development and planning, for transport and for environment, climate protection and energy.

The City of Bremen (www.bremen.de) with its 548.000 inhabitants is a typical European city – undergoing a structural change from basic and traditional harbour industries to a modern city with a mix of old and new industry, research and services. Besides this structural transformation, significant parts of the town have developed into centres of technological competence and innovation.

Figure C 11 – Bremen location within Germany (source: Wikipedia)

Area size	~ 327 sqkm
Population	548,547 (31.12.2013)
More information	www.bremen.de

Table C 13 – Bremen's key figures

In terms of urban development, Bremen is undertaking a sensitive regeneration policy, with a strong focus on sustainability. The ambitious Bremen Climate and Energy Program sets a framework to reduce drastically the overall greenhouse gas emission, with an overall target of a 40% reduction (against the 1990 level).

Today's modal split of the Bremen citizens shows a good starting point – with a share of about 60% of all trips done by the sustainable modes (public transport, cycling and walking) – which shall be extended.

20.2. PT service context

Bremer Straßenbahn AG (BSAG) is the public transport operator offering mobility services within the Free Hanseatic City of Bremen and surrounding area and thus is leading partner in the regional Public Transport association VBN (Verkehrsverbund Bremen/Niedersachsen GmbH) with joint tariff system, seamless ticketing and joint passenger information.

The founding year of the company was in 1876 under the name of 'Actiengesellschaft Bremer Pferdebahn' starting with the operation of horse waggons. In 1891 the company name changed to 'Bremer Sraßenbahn' as it is today. One year later the first electrified line stretch from the city centre (bourse) to the district Horn was put into operation. In 1911 the horse waggon operation was closed down.

BSAG offers mobility services on 7 tram lines (total length of about 106 km and 119 low floor vehicles) and 44 bus lines (bus network of about 506 km operated by 161 articulated and 49 standard buses). The tram and buses are parked in five garages, one for buses only (located at the north end of the city area).

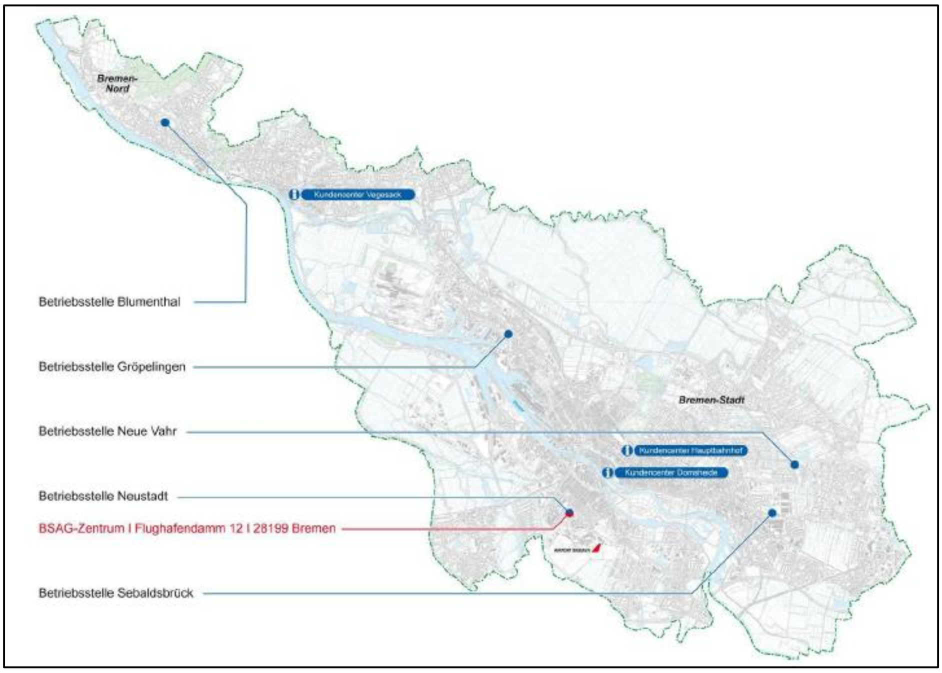


Figure C 12 – Location tram and bus depots in Bremen (source: BSAG)

Around 1,950 employees and 329 vehicles ensure that almost 300,000 people are using the comfortable, punctual and safe operation on a daily basis. Bremen travels 188 times a year by bus or tram. From this it can be estimated that around 104 million people will be moved every year.

The company takes responsibility for sustainable transport, as well as for responsible operation and internal procedures. It strongly supports the further extension of bus and tram network and initiates the development of new drive technologies. As tram operator, BSAG is experienced with electric powertrains. BSAG started testing hybrid buses already in 1998 and was already involved in several European projects (e.g. CIVITAS Vivaldi)

Most of the tram/ bus lines serve every 5 or 10 minutes. Only diesel buses (on an average not older than five years) are in service.The operation starts on weekdays (Monday to Friday) at about 4.00 am and ends at night at about 24.00 pm. At the weekend the operation starts a bit later but in return the service at night is non-stop service on 5 night lines.

All trams and buses operated by BSAG are low floor vehicles and equipped with air-condition and devices to get priority at almost all traffic lights. In addition physically separate right of ways for trams and buses as well as bus lanes at dedicated sections in the bus network and specific measurements at some traffic lights give priority to the trams and buses. Furthermore all transfer stations (e.g. connection tram/tram, tram/bus and tram/bus with railway) and all tram stops are equipped with real-time passenger information boards displaying the arrival time of each line stopping at that station.

The operation key figures of BSAG are (basis year 2014):

Total number of lines (tram / bus)	51 (7 / 44)
Total line length (tram / bus)	612 km (106 / 506)
Total number of stations (tram / bus / combined)	633 (90 / 470 / 73)
Total number of low floor trams	119
Total number of low floor buses (articulated / standard)	210 (161 / 49)
Total number of staff (incl. driver)	1,948 (1,040)
Total number of transported passengers per year / per day	104.051 Mio / 285,000

Table C 14 - Operation key figures 2014 BSAG

20.3. Information about the Use Case

Within an integrated mobility approach, car ownership will not play the same role as in the past. Increasing costs, dependence on oil, climate change and the fact that owning a car for young people continues to lose its attractiveness, make new solutions for sustainable mobility necessary.

For the City of Bremen the combination of car sharing with electric mobility services looked to have the potential to be the right way forward. Based on this concept approach a first multimodal mobility hub station at the tram and bus stop ‘Berliner Freiheit’ was put into operation in July 2014 under the title “VAHR vernünftig”. At central locations within the social housing area “Vahr” the existing public transport services (tram, bus) was complemented for the local residents by e-car sharing and e-bike rental services.

Special emphasis was put to the aspect to involve a wide range of various actors/stakeholders like the city council, public transport operator (Use case coordinator BSAG), mobility service provider (Move About) and social housing company (GEWOBA)).

The aim of this project is to extend the public transport services by a readily available and at the same time environmentally friendly mobility services. The existing mobility chain will be extended by additional e-mobility offerings. Because of the success of the first implemented mobility station, those stakeholders involved (see above) took the initiative to widen the services and develop further features (diversification strategy) like cargo-carrying and family pedelecs. Furthermore a second mobility station was inaugurated in autumn 2015 at the tram stop'Schweizer Eck'. Finally a feasibility study will be carried out to find more suitable locations within the entire city area and linked to the exisiting public transport network (tram and bus).

Figure C 13 – Mulitmodal mobility hub locations along tram line 1 (source: BSAG)

21. Objectives Pillar C

21.1. Objectives of the Use Case

The main objective of the Use Case Breemen is to extend the public transport services by environmentally friendly mobility services (e-car and e-bike rental services) and inter-institutional cooperation between the public transport operator, public/social housing company and mobility service provider.

21.2. Expected impacts

In general, the seamless multi-modality is expected to reduce GHG emissions of transport. Hence through the Use Case Bremen transport users are supported to use the vehicle that best suits their transport needs, which in many cases will be a small energy efficient vehicle instead of their own car or a combination of public transport with other modes like walking and cycling. That means the door-to-door mobility will be enhanced by environmental friendly means of transport.

The wider potential benefits for cities like Bremen include the following values by the solution proposed:

- Decrease "mobility poverty" especially for commuters who depend on cars via last/first mile mobility services.
- Decrease public space occupied by cars
- Foster transit services by quality of service
- Improve quality of life of citizens
- Improve acceptance of people with special needs
- Improve attractiveness to tourists
- Decrease sound levels
- Increase social cohesion
- Improve economic opportunities.

21.3. Use Case KPIs

For carrying out the Use Case selected Key Performance Indicators (KPIs) will be assessed as part of WP3. The selected KPIs are qualtitative (soft KPIs) only and will be collected during two different periods "No ELITPIC scenario" (before starting the Use Case testing phase) and "ELIPTIC scenario"(during the Use Case testing phase), in order to measure the impact of the measurements carried out. The period for data collection of both periods ("Before" and "During") has been set as follows:

	No ELITPIC scenario (Before) ELITPIC scenario (During)	
	Start month	**End month**
Pillar C: Multimodal mobility hub station	June 2016	May 2018

Table C 15 – KPI data collection period (Before / During)

The KPIs to be collected for the Use Case Pillar C are listed as follows by grouping them by "KPI categories":

Other

- Integration with surroundings
- Transfer connectivity
- Pedestrian accessibility
- Bike accessibility
- Implementation time
- Transit ridership
- Attractiveness

22. Risks Pillar C

There have been no risks identified by the Use Case partner BSAG.

23. Detailed description of the Use Case Pillar C

23.1. Description of expected use case features, establishing the link among use case conditions, objectives and background

The feasibility study carried out in the framework of Pillar C aims to find suitable locations where to combine high demand for environmental friendly mobility services with electric charging infrastructure.

An important factor for consideration is that, depending on its location, the specifications of a certain mobility hub station will differ. Implementation of the diversification strategy will therefore require a detailed analysis of where to place such stations. A further aim of the strategy is to use the existing tram power supply infrastructure for charging the e-cars and e-bikes. Requirements of electric mobility (and e-car sharing in particular), their users and the use and long-term demand can be conclusions about finding the appropriate locations. Certainly it will become a challenge to develop standardised solutions.

Factors which will allow the selection of appropriate locations are among other things:

- Sozio-economic parameters like average age and annual income.
- Constructional-structural parameters like population density and land use.
- Transport related parameters like the transportation network and their use.
- Existing offers of e-car sharing and their effective use (catchment area).
- Existing power supply infrastructure provided by the local energy supplier and public transport operator (tram network).

In addition to the selection of a location on the urban macro level is the utilization of the mobility hub station by the design and integration of the site into the urban surrounding. Important criteria for a successful integration are among other things:

- Interfaces with the public transport
- Short walking distance between public transport (tram, bus) and additional mobility services.
- Good visibility of the mobility hub station.
- Context-oriented design/ layout of the mobility hub station and charging equipment.
- Well signposted signage to find the mobility hub station and markings to prevent e.g. parking offender and misuse of the facilities.

Planning of such mobility hub stations require a long-term implementation (roadmap) that clearly defines, in which periods of time which planning and investment measures are required. Such roadmap is largely determined by existing plans and prior knowledge of actor constellations and available resources. In case of Bremen the planning and implementation of such mobility hub stations will be divided into the following three phases:

Phase 1: Vision and strategy development

- Work out an overarching local authority strategy in order to integrate electromobility and e-car sharing into the city and transport development planning.
- Develop action-orientated goals comprising the energy supply, urban space and transport planning.

- Check of suitable business models to be implemented (opportunities might be direct financing by the public and private sector as well by public private partnerships (PPP)).

Phase 2: Customized planning
- Carry out an empirically backed site analysis and site selection comprising a prioritization and phasing just as.
- Record quantity structure of facilities and equipment infrastructure for each location.

Phase 3: Realisation of the infrastructure
- Detailed review the suitability of a site taking into account stakeholder interests (e.g. local energy supplier, property owner).
- Carry out a site-specific planning according to the design recommendations
- Initiate the application procedure.
- Installation and operation of new mobility hub stations.

For the Bremen Use Case the phases 1 and 2 apply in the context of the feasibility study carried out by a subcontracted transport consultancy company.

23.2. Use Case constraints

There have been no constraints identified by the Use Case partner BSAG.

23.3. Use Case monitoring criteria

Due to the fact that modelling and a feasibility study will be executed and no real operation test will be carried out no monitoring criteria will be available.

24. Use case work plan Pillar C

24.1. Use Case development logic

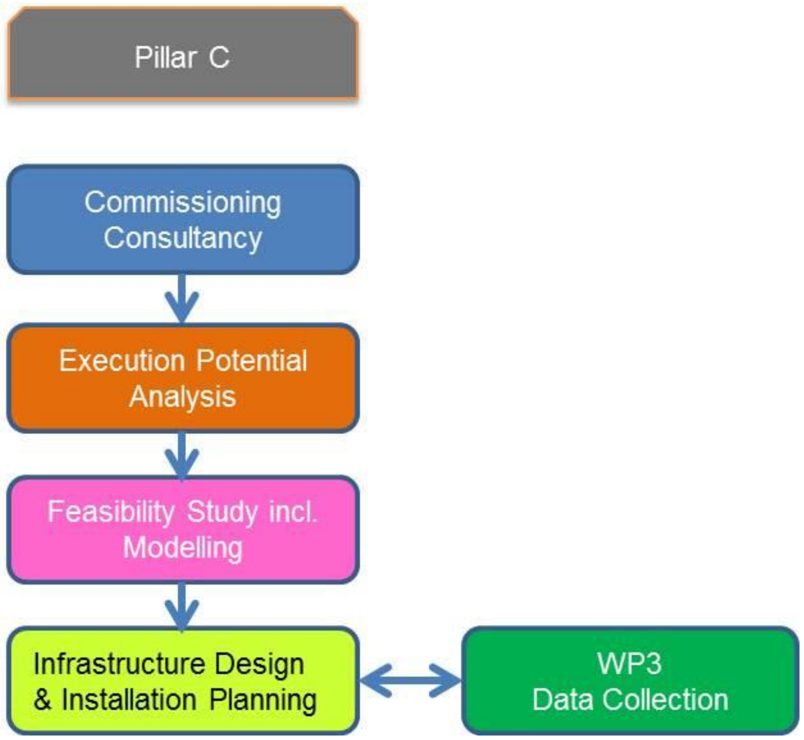


Figure C 14– Use Case Development Logic (Pillar C)

24.2. Work plan Pillar C

The following work plan contains the main Use Case Pillar C activities:

No	Action	Total PMs	Staff 1	Staff 2	External	Start-month	End-month
1	Commissioning transport consultancy company	0.25	Staff from Transport Planning Unit			4 (Sep 15)	7 (Dec 15)
2	Execution potential analysis	0.25	Staff from Transport Planning Unit		Transport consultancy company	6 (Nov 15)	12 (May 16)
3	Feasibility study (legal,finances) incl. modelling	1.25	Staff from Transport Planning Unit		Transport consultancy company	6 (Nov 15)	12 (May 16)
4	Infrastructure design and installation planning	1.0	Staff from Transport Planning Unit		Transport consultancy company	13 (Jun 16)	36 (May 18)
5	Collection evaluation data	0.5	Staff from Transport Planning Unit		Transport consultancy company	13 (Jun 16)	36 (May 18)
	In total	**3.00**					

Table C 16 – Work Plan (Pillar C - Multimodal Mobility Hub Station)

24.3. Detailed timeline

Use Case Bremen (Pillar C)				Project Month																																			
Work Plan Schedule and GANTT (15/12/2015)				2015					>>		2016		>>										2017		>>										2018		>>		
		Start	End	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M
No	Action	Month		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
1	Delivery D2.1.1B 'UC Set-up Report' (Draft Version)	5	7																																				
2	Delivery D2.1.1B 'UC Set-up Report' (Final Version)	7	7																																				
3	Commissioning transport consultancy company	4	7																																				
4	Execution potential analysis	6	12																																				
5	Feasibility study (legal,finances) incl. modelling	6	12																																				
6	Infrastructure design and installation planning	13	36																																				
7	Collection evaluation data	13	32																																				
8	Delivery D2.1.2B 'UC Set-up Report' (Final Version)	29	32																																				
9	Delivery D2.1.2B 'UC Set-up Report' (Final Version)	29	32																																				

Table C 17 – Work Plan and Schedule (GANTT Chart) for Pillar C

The above work plan contains the schedule for tasks/ activities for the Bremen Use Case Pillar C.

25. Expected results Pillar C

The expected results gained from the feasibility study are:

- Selection and evaluation of further suitable mobility hub station locations
- Indication of potential users
- Concrete proposals for business and financing models

26. References Pillar C

Smart cities & communities, Smart Cities Stakeholder Forum , Key to Innovation Integrated Solution – Multimodal personal mobility, December 2013

ELIPTIC WP4 workshop at Bremer Straßenbahn AG (BSAG) premise on 6th November 2015, Presentation BSAG

Charging the City – A guide for integrated charging infrastructure, Modellregionen elektromobility, BeMobility (Berlin), October 2014