UPPER

Unleashing the Potential of
Public Transport in Europe

D4.3 Public Transport services toolbox. System reliability and efficiency

WP4 Innovative solutions to increase the efficiency, reliability and attractiveness of PT

This project has received funding from the European Union's Horizon Europe research and innovation programme under Grant Agreement No 101095904

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Deliverable details

Project number	Project acronym	Project title
101095904	UPPER	Unleashing the potential of public transport in Europe

Title	WP	Version
D4.3 Public Transport services toolbox. System reliability and efficiency	4	1.0

Contractual delivery date	Actual delivery date	Delivery type*
31/08/2024	31/08/2024	DEM

*Delivery type: **R**: Document, report;
DEM: Demonstrator, pilot, prototype;
DEC: Websites, patent fillings, videos, etc;
OTHER;
ETHICS: Ethics requirement;
ORDP: Open Research Data Pilot.

Author(s)	Organisation
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Document history

Version	Date	Person	Action	Status*	Dissemination level**
V0.1	27/05/2024	Annie Kortsari, CERTH	ToC	Draft	CO
V0.2	02/08/2024	Demo sites, ETRA	Contributions	Draft	CO
V0.3	27/08/2024	FACTUAL	Contents and draft	Draft	CO
V0.4	28/08/2024	REDLAB, IBV	Peer review	Draft	CO

V0.5	29/08/2024	UITP, ETRA	Final review	Draft	CO
V1.0	31/08/2024	FACTUAL	Final version	Final	PU

*Status: Draft, Final, Approved, Submitted (to European Commission).

Dissemination Level: **PU: Public;
CO: Confidential, only for members of the consortium (including the Commission Services);
EU-RES: Classified Information - restraint UE;
EU-CON: Classified Information - confidential UE;
EU-SEC: Classified Information - secret UE

List of abbreviations and acronyms

Abbreviation/Acronym	Meaning
PT	Public Transport
WP	Work Package
EU	European Union
CINEA	European Climate, Infrastructure and Environment Executive Agency
DEM	Demonstrator, pilot, prototype
DEC	Websites, patent fillings, videos, etc
ORDP	Open Research Data Pilot
CO	Confidential, only for members of the consortium
PU	Public
LEV	Low-Emission Vehicle
ZEV	Zero-Emission Vehicle
BEB	Battery Electric Bus
UVAR	Urban Variable Area Regulation
EMDS	European Mobility Data Spaces
MVDS	Minimal Viable Data Spaces
KPIs	Key Performance Indicators
nuMIDAS	New Mobility Data and Solutions Toolkit
MSLG	Measures Support Leaders Group
D	Deliverable
MaaS	Mobility as a Service

MSLG	Measures Support Leaders Group
PTA(s)	Public Transport Authorities(s)
PTO(s)	Public Transport Operator(s)
WYD	World Youth Day
RRF	Recovery and Resilience Facility
OEM	Original Equipment Manufacturers
DRT	Demand Responsive Transit
HVAC	Heating, Ventilation, and Air Conditioni

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Abstract

This report details the activities undertaken within Task T4.3 of the UPPER project, focusing on improving efficiency in public transport (PT) operations. The goal of this task is to enhance the efficiency and reliability of PT systems by addressing specific needs and situations across different cities. The report examines various approaches to achieve this goal, including:

- Data-Driven Mobility Planning: This involves developing and implementing measures that leverage data to optimize PT planning and operations, encompassing the creation of mobility observatories, the enhancement of data management and processing capabilities, and the conduct of geospatial analyses of passenger flows.
- Fleet Electrification: The report explores the potential of transitioning public transport fleets to battery electric buses (BEBs), examining the feasibility of electrifying specific bus lines and developing comprehensive strategies for integrating and adapting these new vehicles into existing networks.
- User-Specific Solutions: The report investigates how to tailor PT offerings to meet the specific needs of different user groups, such as school students, individuals with mobility challenges, and other vulnerable populations. This includes exploring pilot programs, expanding existing services, and addressing challenges of accessibility and inclusion in PT systems.

The report highlights best practices, tools, and standards for enhancing PT operations, while also documenting the progress made by cities in preparing their mobility measures. It presents the outcomes of workshops that gathered valuable feedback from horizontal partners and identifies key points of attention for maximizing the measures' impact. The report concludes by summarizing the key findings and highlighting the overall impact of the activities carried out under Task T4.3.

Keywords

Public transport, Data sharing, Data-driven planning, Mobility observatory, Battery electric bus (BEB), Fleet electrification, Charging infrastructure

1.Introduction

1.1. Scope of the Document

Task 4.3 is a heterogeneous task focused on improving the efficiency and convenience of public transport by addressing specific needs and situations in different cities. The focus is on leveraging technology and innovative solutions to optimise public transport offerings and reduce reliance on private vehicles.

This task involves developing and implementing various measures across the pilot cities. These measures target a wide range of challenges and opportunities, encompassing data-driven approaches, fleet electrification, and user-specific solutions.

- Data-driven approaches are exemplified by measures like IDF_06, MAN_03, VAL_03 and BUD_01. IDF_06 aims to create a mobility observatory, providing a platform that collects, aggregates, and returns mobility-related information. MAN_03, implemented by RNV, seeks to enhance data quality and processing capabilities to leverage its data resources more effectively for planning and operational purposes. Similarly, VAL_03 utilizes data to carry out a geospatial analysis of passenger and traveller flows to determine the optimal transport offer for specific city situations. BUD_01 has launched a survey to collect data for a similar purpose – updating their Unified Transport Model to incorporate current travel patterns and improve the reliability of their public transport planning.
- Electrification of bus fleets is addressed by TES_09 and ROM_05, showcasing similarities and differences. Both cities are exploring the potential of electrifying their bus fleets to reduce CO2 emissions and improve sustainability. However, TES_09 focuses specifically on analysing the feasibility of electrifying specific bus lines and assessing the potential CO2 savings, while ROM_05 is implementing a broader strategy to integrate LEV and ZEV buses into their fleet and adapt their network to accommodate these new vehicles.
- User-specific solutions are explored in LIS_04 and OSL_03, demonstrating how public transport offerings can be tailored to the needs of specific user groups. LIS_04 focuses on improving PT offerings for school students through the "Amarelo Pilot Project" and the expansion of the "Navegante Escola PT ticket card". OSL_03 aims to improve the use and accessibility of public transport in conjunction with alternative mobility to reduce private car ownership, focusing on addressing the friction between different functions within a dense urban environment. While these measures target different user groups, they both highlight the importance of tailoring public transport services to specific needs and addressing the unique challenges of different urban environments.

This document presents the activities carried out in task 4.3, such as monitoring measures and animating workshops, and the cities' preparation process of these measures. During the monitoring phase of the measures, the task leaders were able to collaborate periodically within the Measures Support Leaders Group led by CERTH. In addition, leaders of T4.2 and T4.3 collaborated for the animation of Workshop 1: PT service: Exploiting data for better planning and operation in Rome. Appraisal exercise was conducted in April-May 2024, followed by a second workshop with the cities, which gathered valuable feedback from horizontal partners in the consortium.

1.2. Intended audience

This document is intended for professionals involved in public transport (PT) enhancement, including mobility managers in municipalities, public and private sector companies, transport technicians, and regulators. It outlines various innovative methods for capturing and sharing data in PT operations, as defined and developed within the UPPER initiative by different European cities. These examples can serve as valuable case studies for mobility experts in other cities.

Additionally, the document provides a curated collection of reference materials, guides, and EU city mobility initiatives that promote the development of new services based on both static and dynamic data sources, making it a recommended resource for professionals focused on advancing sustainable urban mobility.

1.3. Structure of the document

The document is structured in six sections, starting with a brief introduction. The second section of the document presents the methodology followed to perform the different activities comprehended in task 4.2. The third section presents the results generated in the task related to generate a collection of reference projects and initiatives, to support cities in the development of their mobility measures within UPPER project.

The fourth section of the document presents the results generated in the workshops participated by the cities, the horizontal partners, and in general all the partners involved in the task. Two workshops are described: a first one focused on sharing experiences and good practices among cities involved in T4.2 and T4.3 (and WP4 in general), and a second one aimed to produce *points of attention* to be considered by the cities' teams when developing their measures. The second workshop preparation included the mobility measures' appraisal (definition of points of attention), which are also reported within this section.

The following section (fifth) is focused on describing the process followed to support the cities in the mobility measures development. This section reports the results generated along the monitoring process performed jointly by mobility measures' contact person and the task team.

The last section of the report comprehends a collection of conclusions related to the main activities performed in this task.

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1.4. Measures included under task 4.3

As already mentioned before, the mobility measures linked to Task 4.3 are:

Measures	Title
ROM_05	New LEV and ZEV bus fleet – network adaptation.
OSL_03	Improve use and accessibility of public transport in conjunction with alternative mobility to reduce private car ownership
TES_09	To raise environmental awareness and trigger behavioural change towards PT
IDF_06	Advanced technology to optimize the PT offer in line with users' needs
MAN_03	Data-driven platform for supporting PT planning and operations based on the concept of Mobility as a Right
VAL_03	To optimise public transport offer based on advanced technology
LIS_04	To improve PT offer, adapted to school students
BUD_01	To improve the efficiency and convenience of PT service

2. Methodology

2.1. Supporting resources: A systematic review

A systematic review of reference projects and best practices in Europe related to implementing innovative methods of capturing and sharing data for public transport (PT) operations was conducted. This review covered relevant projects, their outcomes, and tools that can be adopted by cities to implement similar measures. Then, it focused on public transport data-sharing standards systems and transport simulation platforms. An effort was made to identify and summarise the most relevant resources for task T4.3. However, the resources presented in this document are not exhaustive.

2.2. Measures support workshop series

2.2.1. Workshop 1: Barriers, challenges and good practices in the measures' preparation process

The Rome GA assembly, held in January 2024 as part of the UPPER project, served as a platform for cities to exchange insights on their evolving mobility measure development processes. The D2.2 deliverable, released in July 2023, involved a comprehensive review and refinement of measure descriptions. This process revealed varying levels of maturity, with some measures nearing completion while others remained conceptual.

Recognizing the opportunity for cross-learning, the consortium agreed to organize a workshop during the Rome GA to facilitate knowledge sharing. This workshop, jointly moderated by Factual and IFPEN (coordinators of T4.2), focused on public transport services, data-driven planning, and operations. Participants were presented with case studies of both advanced and less developed measures, followed by open discussions and question-and-answer sessions. This interactive format encouraged collaboration and the exchange of best practices among cities and project partners.

2.2.2. Workshop 2: Points of attention for maximizing measures' impact

The process defined to support and to accompany cities in the development of mobility measures resulted in a monitoring process guided by the leaders of those tasks including mobility measures (i.e. T3.4, T3.5, T4.2, T4.3, T4.4, T4.5, T5.2, T5.3, T5.4). In this monitoring process, the cities had the support of task leaders, but the knowledge and know-how of horizontal partners participating in the tasks was missing. In order to correct this situation, and to get benefit of the mobility knowledge of PTAs and associations, including users, associations, cities associations and PTOs associations, the consortium proposed to organize an assessment process of the mobility measures, and a workshop to discuss on the results generated by the assessment. The aim of the workshop is to support cities in their tasks of developing UPPER measures, by challenging and improving their initial measure description (as presented in UPPER Deliverable 2.2 Annex) The process is structured around several steps that are common across all the UPPER tasks where measures are developed.

In the WP4 online workshop focus on data-driven mobility planning (duration 1,30h) horizontal partners presented the points of attention previously identified, together with potential recommendations or best practices of how these can be addressed. Representatives from the UPPER partners responsible for the development and subsequent measures actively reacted and participated.

CERTH, as WP4 leader, was the overall coordinator of the WP4 workshop. CERTH defined the main structure and contents of the workshop and, with the support from EMTA, EIT Urban Mobility Foundation and ICLEI, distributed the responsibilities for the workshop among the horizontal partners with resources in tasks T4.2, T4.3 and T4.5. EMTA led the event organization, including the preparation of the required material, set-up of the agenda and moderation of the plenary sessions. EIT Urban Mobility Foundation coordinated the appraisal of the measures and follow up with reviewers (IFP, IFPEN, FACTUAL, ECF, UITP, EMTA, EITUMF, EPF, ICLEI) to ensure timely and adequate identification of points of attention. All the points of attention, grouped by city, are set out in Annex 1.

The assessment was organized by collecting *points of attention* linked to the measures, basically issues to be considered by cities' teams when developing their mobility measures. These *points of attention* were organized around topics (categories) relevant to the development process, some of them generic, like *stakeholder involvement*, some of them specific for mobility, like *Mobility as a Right*. The collected *points of attention* were analysed, and discussed in a participated workshops with cities and horizontal partners.

2.3. The Measures Support Leaders Group

WPs 3,4 and 5 share common goals; to develop the UPPER tools and to make sure that all the necessary steps have been taken in order to get the 84 measures ready for implementation, in the framework of WP6. Having identified from the very beginning his common goal, the participating horizontal partners (WP and Task leaders) decided from the very beginning to join forces. More specifically, aiming to ensure that all partners involved in the development of the measures, including cities and horizontal partners, are aware of their responsibilities and the corresponding timeline, they decided to formulate a group, entitled "Measures Support Leaders Group" (MSLG) which was created at the beginning of the duration of these Tasks, in M8.

CERTH being the leader of WP4, under which most of the measures are prepared, was appointed leader of the MSLG. The group consisted of the leaders of the tasks under which the measures are developed (T3.4, T3.5, T4.2, T4.3, T4.4, T4.5, T5.2, T5.3, T5.4), while meetings were held in a monthly basis. The table below presents the UPPER partners forming the MSLG.

Table 1: Members of the Measures Support Leaders Group.

Task	Leader
T3.4 “Re-design the urban mobility space to promote the use of PT”	ETRA
T3.5 “Definition of new operational and policy-based measures and solutions regarding zonal and network-based UVAR and parking”	POLIS
T4.2 “New services for users and PT operators based on the existing mobility data collection and sharing”	IFPEN
T4.3 “Improved PT efficiency addressing specific needs and situations such as expected an unexpected events”	FACTUAL
T4.4 “Improved information and added-value services enhancing multimodality”	CERTH
T4.5 “Improved comfort, convenience, safety and attractiveness of transit services”	UITP
T5.2 “Incentivize PT offer and active modes in the living labs”	FACTUAL
T5.3 “Innovative strategies and solutions to improve public perception of PT”	FIT
T5.4 “Behaviour-change oriented mechanisms to promote the use of PT”	IBV

The aim of the group may be summarized as follows:

- To meet the goals foreseen in the Grant Agreement, in relation to the aforementioned tasks.
- To provide meaningful support to the cities’ representatives during the development of their measures.
- To ensure that all task leaders provide the same level of support to the cities developing measures under their task.
- For the cities to acquire a clear understanding of the steps needed to develop their measures and the support they will receive from task leaders (and other horizontal partners involved in the task).
- To monitor the progress of the measures’ preparation process and timely identify any challenges/delays.

To achieve all these, a template entitled Monitoring Template was created and used in order to monitor the progress of all measures’ development. The first draft was created by the group’s leader but was then circulated among all members to review it. Once it was finalized, each member of the MSLG had to fill it in for all the measures under their Task. The aim of the template is to briefly present each measure and its expected outcomes (extensive measures’ descriptions are included in D2.2) and to identify all steps needed to develop the measures. For each step a responsible partner is assigned as well as specific deadline. In addition, each step should be accompanied by a monitoring indicator; this indicator is not related to the evaluation process but it refers to the main output of the step so that the step is considered completed. The fields to be defined for each step in the Monitoring template are shown in the figure below:

Table 2: Table of steps to be defined by Project partners in the Monitoring template.

Steps to ready-to-demo measure

Steps	Description	Involved partners/externals	City contact person	Category of action	Deadline	Monitoring indicator	Comments
1	Define the step e.g., Definition of the area and the use cases	Define the partners responsible for this step	Email of the responsible person (Partner's name)	Choose from Data/Infrastructure/Legal/Safety/Social/ Technical/Software	Define the data when the step should be completed	Define what the output of the step will be e.g., Description of area and use cases	Include any clarifications etc.
2							
3							
4							
5							
LAUNCH OF THE DEMO (please fill in the date)							

Once the task leaders had filled the templates in, the templates were sent to the corresponding cities to review and finalize them. One monitoring template was created per measure. These templates were then utilized by each task leader to track the progress of the defined steps for the measures under their task. This was done through the following procedure: prior to each monthly MSLG meeting, each task leader contacted the partners responsible for the measures' development to ask about the progress of each measure under their Task. A short but concrete presentation was then created and presented during the meeting in order to report the progress and any challenges or delays (if applicable).

The completed templates for the 8 measures prepared under Task 4.3 can be found in Annex 2.

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3. Supporting resources: Reference tools and guides

This chapter provides a comprehensive overview of key projects, best practices, and tools that can serve as valuable references for the measures developed under Task T4.3. These resources offer insights, guidance, and practical examples to support the implementation and optimization of public transport services. Given the heterogeneity of the measures included in this Task, not all resources are relevant for all measures.

3.1. Data-Driven Approaches: Data Collection and Management

nuMIDAS Project[1]

The nuMIDAS (New Mobility Data and Solutions Toolkit) project is a valuable resource for cities seeking to improve the efficiency and reliability of their public transport systems. Developed under the Horizon 2020 program, nuMIDAS provides a comprehensive toolkit designed to support the development and implementation of new mobility solutions.

The nuMIDAS toolkit focuses on data collection, management, and analysis. It includes a user-friendly dashboard that allows for visualizing and exploring data, making it a valuable resource for measures like IDF_06, MAN_03, and VAL_03, which heavily rely on data-driven approaches.

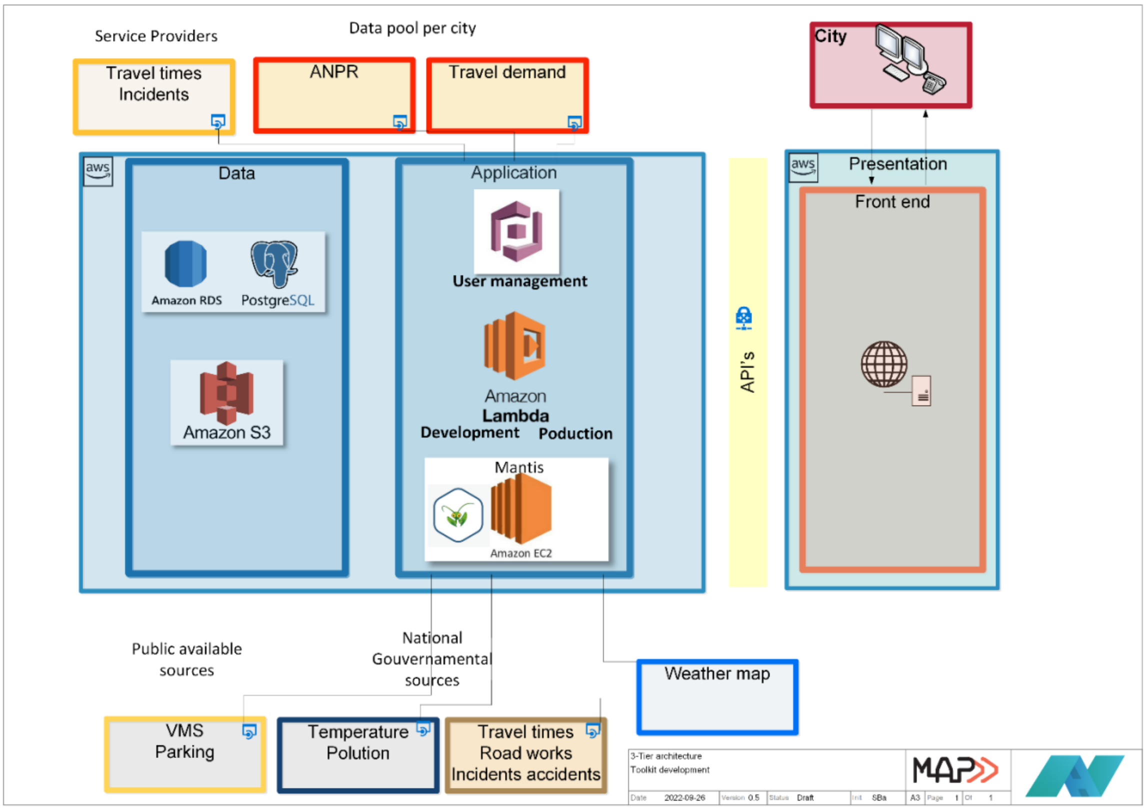


Figure 1: Technical architecture of the nuMIDAS toolkit

[1] (nuMIDAS, 2023)

The toolkit uses a three-tiered architecture (see Figure 1):

- Presentation tier: This tier acts as the user interface for the dashboard, providing a user-friendly way to interact with the data.
- Application tier: This tier handles the logic of the toolkit, including data processing, calculations, and execution of scenarios.
- Data tier: This tier stores and manages the collected data, using a combination of Amazon Web Services (AWS) resources like PostgreSQL and S3 storage for both geographical and relational data.

The nuMIDAS toolkit also incorporates various features to facilitate collaborative work among partners and cities. These include user management with different roles, flexible code for adaptability across different use cases, and a standardized JSON configuration for consistent and efficient data management.

European Mobility Data Spaces (EMDS), ITS Directive and National Access Points (NAPs)

The concept of Mobility Data Spaces (MDS) is gaining traction as a key enabler for more efficient and sustainable mobility systems. The report "Unlocking the Future of Mobility with European Data Spaces"[2], published by EIT Urban Mobility, Factual Consulting, and i2CAT Foundation, explores the potential of EMDS for unlocking the future of mobility. The report highlights the critical role of data in advancing sustainable and smart mobility, emphasizing the need for secure and trusted data sharing ecosystems. It also explores the key challenges and opportunities associated with EMDS and provides recommendations for cities, regions, and national and European actors in developing and implementing these data spaces.

Defining roles and responsibilities for data owners, providers, and users is paramount to ensure data privacy and security while guaranteeing data availability and accessibility. This necessitates establishing effective governance models that address these concerns. Seamless data integration and exchange across various stakeholders require the development of common standards and data models to ensure compatibility between different systems. To attract private sector participation, it's essential to create a clear value proposition and demonstrate a tangible return on investment for businesses, overcoming resistance to change and attracting investment in this new, data-driven mobility landscape.

Actively engaging cities and regions in developing and deploying EMDS is crucial, requiring them to understand the benefits of data spaces, define roles and responsibilities for public sector actors, and lead the development of governance frameworks. To accelerate the deployment of EMDS, the report recommends a phased approach, starting with small-scale pilot projects focusing on "Minimal Viable Data Spaces" (MVDS) which allow for rapid experimentation and iteration, addressing key challenges and refining the business case before scaling up.

Comprehensive and standardized metadata catalogues are essential. They act as a bridge between data owners and potential users, enabling them to understand the available data, identify potential use cases, and make informed investment decisions. The report cautions against re-centralizing data spaces into traditional data platforms, emphasizing the decentralized architecture of EMDS. This decentralized approach fosters data sovereignty, encourages innovation, and promotes competition within the ecosystem. A conceptual visualisation of an evolving data space for mobility is visible in Figure 2.

[2] (FACTUAL, i2cat, 2023)

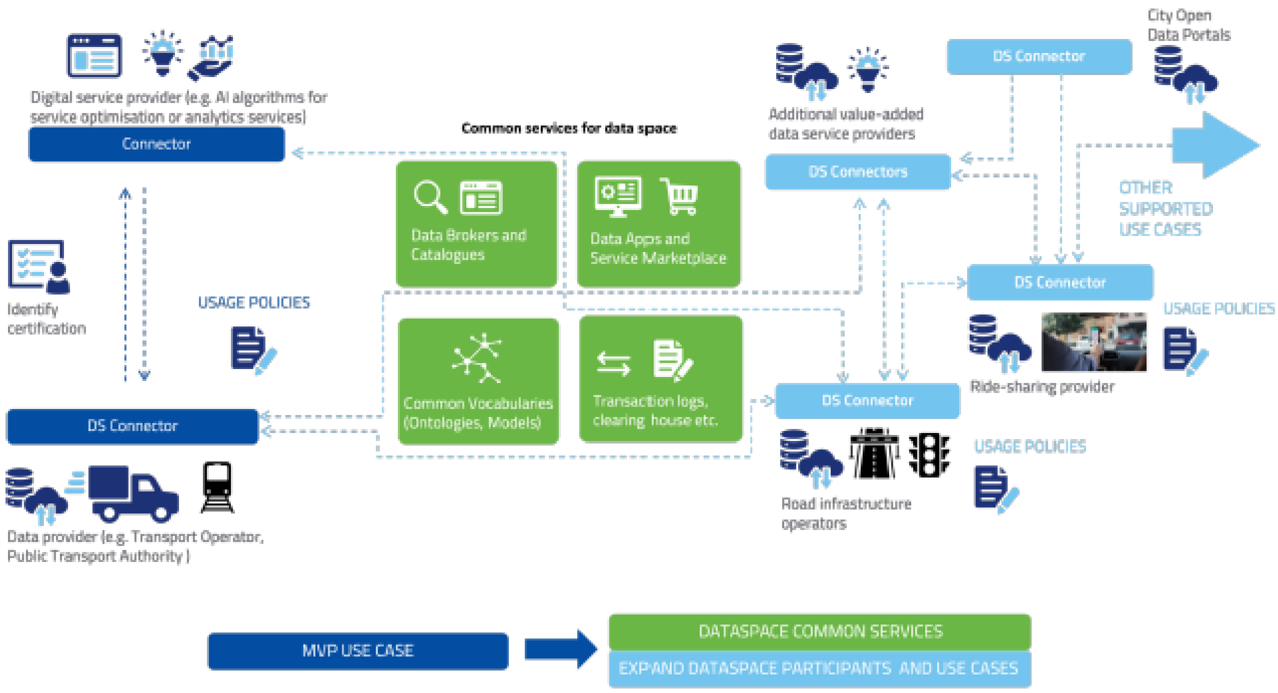


Figure 2: A conceptual visualisation of an evolving data space for mobility

ITS Directive[3]

The Intelligent Transport Systems (ITS) Directive is a European Union (EU) regulation that aims to promote the development and deployment of ITS technologies across member states. Its primary goal is to enhance road safety, reduce traffic congestion, and improve the efficiency of transportation systems. The directive sets out common frameworks and standards for ITS infrastructure, services, and applications.

NAPs: National Access Points[4]

National Access Points (NAPs) are designated entities within EU member states that serve as central points of contact for ITS-related information and services. They play a crucial role in facilitating cooperation between public and private stakeholders involved in ITS development and deployment. NAPs typically provide the following services:

- Information Dissemination: NAPs share information about ITS projects, initiatives, and best practices within their respective countries.
- Coordination: They coordinate activities related to ITS development and implementation, ensuring alignment with EU policies and standards.
- Technical Support: NAPs offer technical assistance and support to public and private organizations working on ITS projects.
- Networking: They foster collaboration and networking opportunities among ITS stakeholders.

[3] (European Commission, 2010)

[4] (European Commission, 2010)

In essence, NAPs serve as a bridge between the EU-level ITS Directive and the national implementation of ITS technologies within member states. They contribute to the harmonization of ITS policies and practices across Europe, promoting the efficient and effective deployment of ITS solutions.

Aligning EMDS with the ITS Directive and national NAPs (National Access Points) is crucial to facilitate data interoperability and efficient data sharing across the EU. This integration ensures data quality and reliability across national borders, making it easier for mobility service providers to access and use data from multiple sources. Demonstrating the economic and strategic benefits of EMDS for private sector stakeholders is key to attracting investment and participation. This involves creating compelling investment cases, highlighting the return on investment, and showcasing the potential for new business models and services.

3.2. Electrification of Bus Fleets

This subchapter references the valuable resource ¨Electrifying Transit: A Guidebook for Implementing Battery Electric Buses¨[5]. It provides a structure for implementing electric bus fleets, visible in a schematic way in Figure 3.

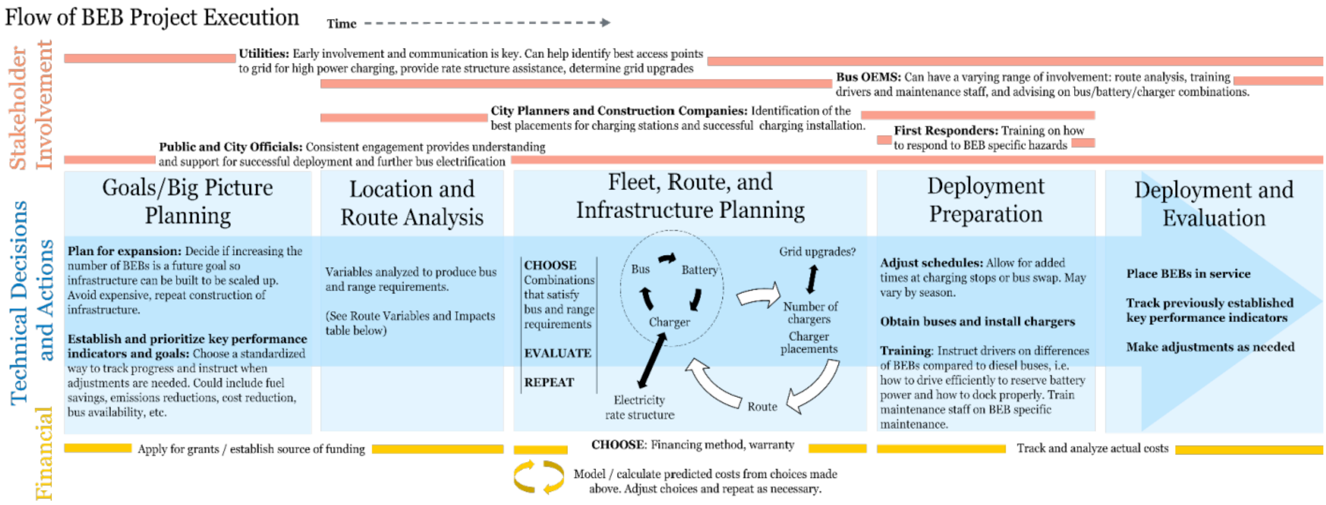


Figure 3: Flow of BEB project execution

Route Analysis

Thorough route analysis is essential to ensure BEBs achieve service comparable to diesel buses. This analysis informs battery range requirements and charging infrastructure needs.

The report recommends that transit agencies conduct a thorough route analysis to identify the most suitable routes for BEB deployment. This analysis should consider various factors, including:

- Physical Route Characteristics: The length, frequency of stops, and grade of the route can impact BEB range and charging requirements.
- Bus Operation and Route Variables: The size of the bus, bus speeds, passenger capacity, operational schedules, deadhead distance, and susceptibility to route interruptions can also influence BEB deployment decisions.

[5] (Aamodt, Cory, & Coney, 2021)

- Charging and Route Variables: The availability of layovers, traffic patterns, grid access, overlap with other routes, and land access are crucial factors to consider when planning charging infrastructure.
- Other Variables: External temperature differentials and weather conditions can affect BEB range and performance.

Fleet, Route, and Infrastructure Planning

After analyzing routes, it is important identify those that optimize BEB deployment. The report suggests that transit agencies consider the following (see Figure 4):

- Range Requirements: Determine the most suitable charging method(s), bus size, battery configuration, and desired state of charge (SOC) range.
- Electricity Rate Structure: Choose the charging method most compatible with existing electricity rates.
- Charging Installations: Determine the number, location, and capacity of charging stations based on range requirements, grid access, grid upgrades, land ownership, and future expansion plans.

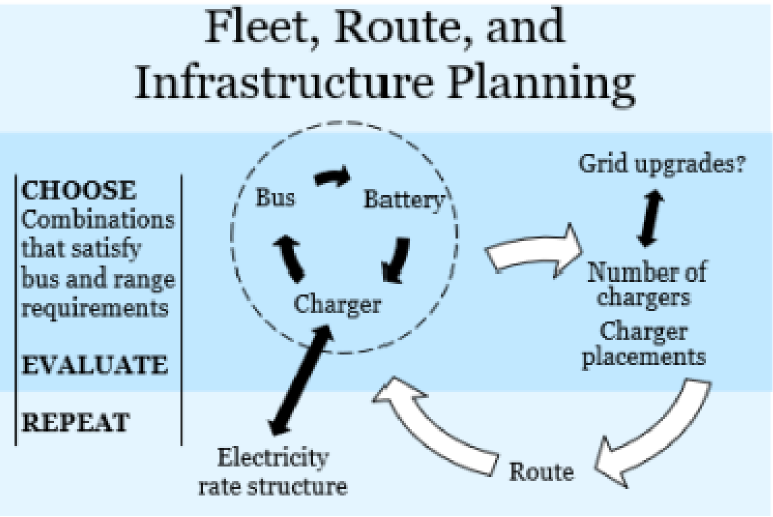


Figure 4: Fleet, route, and infrastructure planning

Deployment Preparation

The authors recommend that transit agencies begin preparing for physical deployment by budgeting for bus procurement and EVSE installation. They suggest that bus procurement timelines can vary depending on the degree of BEB OEM back orders, and that charging infrastructure installation can take months or even years if large grid upgrades are required.

In addition, the report suggests that transit agencies introduce electric charging, especially for on-route charging, by making necessary adjustments to bus scheduling, such as increased dwell time or changes in layover times. Seasonal adjustments may also be necessary to accommodate HVAC use and the corresponding range reduction.

3.3. User-Specific Solutions

Children's safe routes to school

This article, "Children's safe routes to school: Real and perceived risks, and evidence of an incapacity-incapability space"[6] offers valuable insights for developing safer and more inclusive school travel options for children. It highlights the complexities of understanding and addressing traffic risks for children, particularly focusing on how these risks evolve with age and are influenced by different factors. The evolution of risk exposure and the incapability-incapacity space is visible in Figure 5.

The study reveals that children's perceptions of traffic risks often differ significantly from the "objective" view based on injury data. Children may perceive situations as more dangerous, even if statistics don't reflect that. Moreover, children's ability to perceive and react to traffic dangers, understand rules, and make independent decisions in traffic develops over time, with different stages of risk exposure and risk-taking behavior. Parents, peers, and the built environment all play a significant role in shaping children's perceptions of safety and their choices related to active travel.

Moreover, the UPPER deliverable D2.1 defined the needs and expectations of children in public transport and was used as a reference.

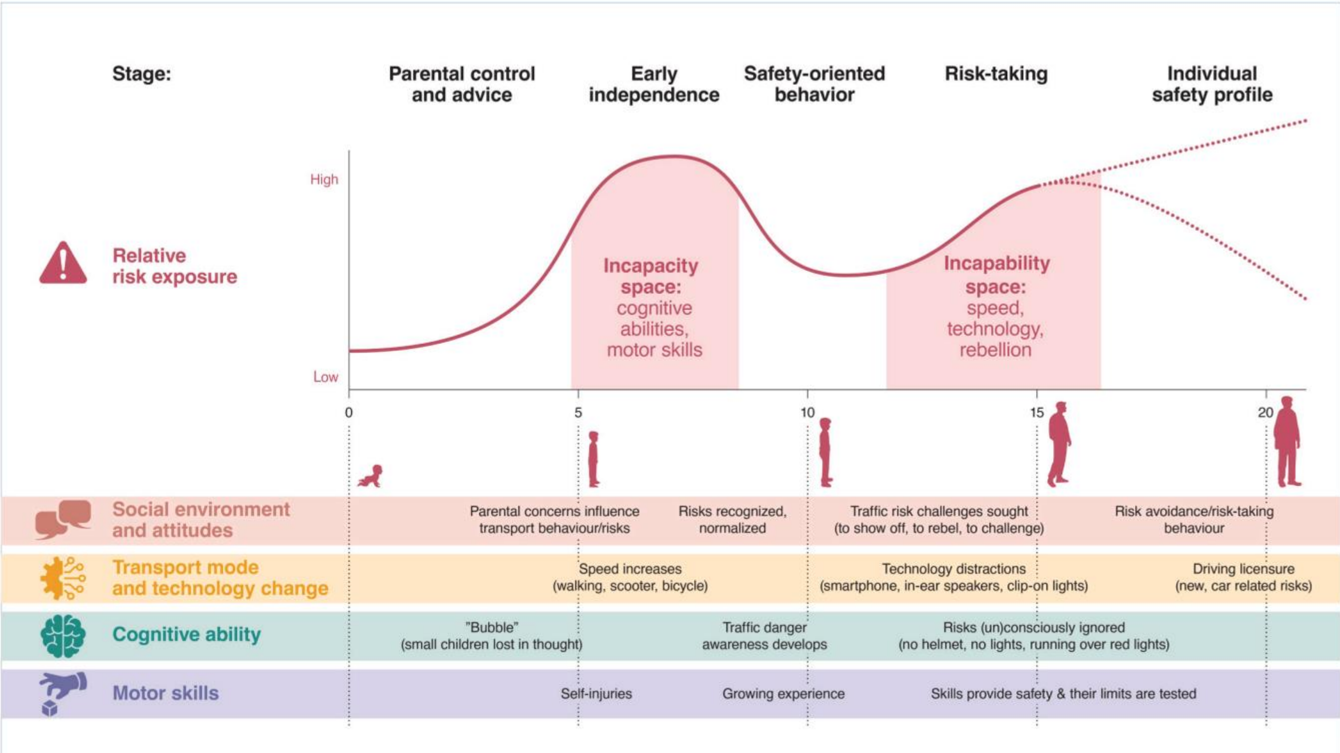


Figure 5: Risk exposure and the incapability-incapacity space

Function distribution method

Within the development of measure OSL_03, the principles of the Function Distributio Method are applied in a specific area of the city of Oslo. The Function Distribution Method is a planning tool designed to optimise the use of urban space

[6] (Gossling, Kees, Hologa, Riach, & von Stülpnagel, 2024)

by limiting the number of functions within a single street. The goal is to improve the coexistence of various transportation modes and urban activities, enhancing the overall quality of urban life. It operates through three planning levels:

- Strategic Level: This level focuses on city-wide mobility goals and prioritizes projects that align with broader transport policies.
- System Level: This level involves dividing urban areas into smaller zones and allocating specific functions to each zone. The method aims to limit the number of functions in each street to a maximum of three.
- Street Level: This level involves the detailed design of individual streets, ensuring they accommodate the functions assigned at the system level.

And three function definitions and categorisations:

- Primary Functions: These are the main activities that occur within a street and have the potential to conflict with other activities. Examples include walking, cycling, public transport, and vehicular traffic.
- Secondary Functions: These are activities that are generally compatible with other functions and do not significantly impact the overall functioning of the street. Examples include local cycling and parking.
- Static Elements: These are elements of the urban environment that do not actively interact with other elements, such as trees or parked cars.

The key principles of this method are the following:

- Maximum of Three Functions: To ensure smooth traffic flow and a pleasant urban environment, streets should ideally have no more than three primary functions.
- Hierarchical Classification: Transportation modes are classified into hierarchies based on their speed and purpose (e.g., through traffic, local traffic).
- Threshold Values: Quantitative thresholds are used to determine whether a specific function should be considered a primary or secondary function.
- Compatibility: Functions should be compatible with each other to avoid conflicts. For example, high-speed traffic and pedestrian areas are generally incompatible.

The methodology is planned to be included in the next edition of the of the street manual for Oslo. Nonetheless, it is currently still a draft (which was kindly shared by the Oslo City Council to include in this document) and it is not yet publicly available.

4.Organization of workshops

4.1. Workshop 1: PT service: Exploiting data for better planning and operation in Rome

The workshop was held on January 31, 2024. The list of cities and measures relating to this workshop are presented in the screenshot below (Figure 6).

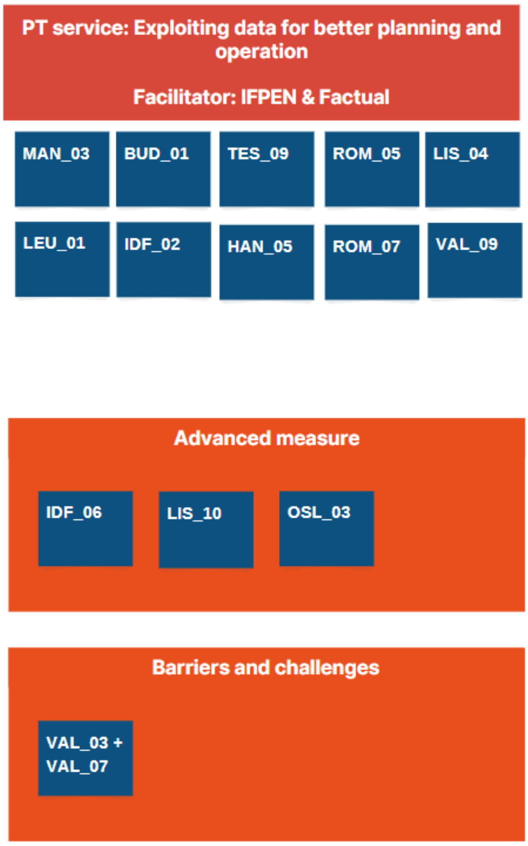


Figure 6 List of cities and measures relating to the workshop

It brought together representatives from 10 cities that have implemented mobility measures related to WP4 and, more precisely to the tasks T4.2 New services for users and PT operators based on the existing mobility data collection and sharing ((lead by IFPEN) and T4.3 Improved PT efficiency addressing the needs of targeted groups of users or situations (lead by FACTUAL). The objective of this workshop was to discuss, on the one hand, the usefulness and importance of data in mobility planning. On the other hand, it dealt with improving PT services to meet the needs of specific groups or situations. For each sub-theme, cities and their partners presented well-matured and advanced measures and those encountering challenges and barriers.

The workshop structure consisted of a short presentation of the measures (5- 10 min) followed by an open discussion participated by all the attendees (10- 15 min). The moderator introduced the speakers, stimulated discussion, motivated attendees, and managed their intervention during the discussion. IFPEN and FACTUAL were in charge of moderating the workshop.

4.1.1. Results

Six measures were presented during the workshop by the cities and their partners: OSL_03, ROM_05, LIS_10, IDF_06, and VAL_03 and 07. Measures OSLO_03, ROM_05, and LIS_10 were linked to the public transit services of task T4.3, while IDF_06, VAL_03 and VAL_07 focused to the use of the data in mobility planning (T4.2). This sub-section presents the results related to these measures.

- OSL_03 - Improved use and accessibility of public transport in conjunction with alternative mobility to reduce private car ownership

  This mobility measure was presented by the city of Oslo. The city of Oslo is a city with a generally high/decent public transportation utilization (30%). Through this measure, the city wants to increase the efficiency, reliability, and attractiveness of TC (buses). However, facing a dense and compact architecture, widening and building more bus lanes is very challenging. The city has, therefore, developed a new method based on the distribution function method with three hierarchical levels (city, area, and street).

  The main challenge is the closure of the central ring road, Ring Road 1, which could have unforeseen consequences on the bus lines that the city wants to improve. To address this, the city intends to focus on the effects and possible gains that this can have for the overall transport network. In addition, prioritization could generate friction between the different traffic groups. The function distribution method will show the potential to reduce friction between the other modes.

- ROM_05 - New LEV and ZEV bus fleet – network adaptation

  Rome faces high private car use (52%) with low frequency and quality of PT services. This measure aims to re-balance the modal share in favour of PT in Rome by taking the opportunity to procure Low-Emission Vehicle (LEV) and Zero-Emission Vehicle (ZEV) buses thanks to the RFF funds. The design and adaptation and integration of the new buses in the PT network will be an important part of this measure. Around 200 electric vehicles with suitable stations are expected.

- LIS_10 - PT service, data for better planning and operation

  This mobility measure was presented by Transportes Metropolitanos de Lisbona (TML). This measure is one of the most advanced and mature measures. The presentation focused on new ticketing products for large-scale events such as the World Youth Day (WYD). For this event, specific tickets were produced considering a certain period of days, WYD volunteers, and intramodality with other TP services.

  The main challenges encountered were managing the very high number of participants (around 1 million) and the high risk. The solutions and actions taken focused on ticketing design, including simulations to define different types of days and pricing. In addition, each operator was responsible for adapting its Ticketing systems. Finally, a revenue distribution mechanism was set up for all operators.

- IDF_06 - Advanced technology to optimize the PT offer in line with users' needs

  This mobility measure aims of setting a **Mobility Observatory** by developing a dashboard to inform and provide support for cities in the knowledge and identification of possible actions to take on city planning and mobility for Versailles Grand Parc (VGP). RedLab presented the development progress of this measure. This is also a most advanced measure. This observatory includes mobility, air quality, and traffic conditions and three levels of observation: real time, playback, long term analysis.

  The main challenges encountered during the development of the measure concerned the building of a **robust and replicable solution and access and collect relevant data for decision-making.** To deal with the first challenge, the developers adapted generic data models. They undertook the development of the open-source platform. For data collection, a collaboration with all partners and stakeholders is needed to ensure a large panel of data and the use of generated (dummies) data while waiting for the actual data. Moreover, during the discussion phase, it was suggested that the backup of the data collected from the different providers must be considered–

- VAL_03 – To optimise PT offer based on advanced technology //– VAL_07 - To provide the citizens with clear and accessible information before and during the trip

These mobility measures were presented by EMT. These measures face many barriers and challenges. Barriers can be summarized as follows:

1. Privatization of a public good and "data",
2. Lack of governance of the data,
3. Lack of transparency and vision from the administrations.

Challenges concerned the need for more refinement, many errors in the collected data, and the need for entities to cooperate to improve data governance.
This presentation generated many comments during the discussion phase. Indeed, many cities mentioned the difficulty of sharing data in public administration. It is essential to work on data standardization by integrating all mobility stakeholders, the Original Equipment Manufacturers (OEM), operators, etc. We need to create internal development and collaboration initiatives to integrate public data. Actions to raise awareness of the opening and governance of public data have been carried out for politicians by colleagues from the Polytechnic School of Valencia who work with the municipality. The European Union and some NGOs, such as Green City are, also pushing for all climate and environmental data to be put on the portal and for every company and anyone who wants to access it to be able to download it.

4.1.2. Conclusions

The workshop highlighted six mobility measures across various cities, focusing on enhancing public transport (PT) services and optimizing data usage in mobility planning. The measures from Oslo (OSL_03), Rome (ROM_05), and Lisbon (LIS_10) centred on improving public transit efficiency, reliability, and accessibility. Oslo faced challenges related to urban density and road closures, while Rome aimed to shift the modal share towards PT by integrating Low-Emission and Zero-Emission Vehicles into its bus fleet. Lisbon's approach revolved around advanced ticketing solutions for large-scale events, managing high participant volumes through innovative pricing and distribution mechanisms.

On the other hand, measures from Versailles Grand Parc (IDF_06) and Valencia (VAL_03/07) focused on leveraging advanced technologies for better PT planning and providing accessible information to citizens. IDF_06 emphasized the creation of a Mobility Observatory, integrating real-time and long-term data analysis to support decision-making Valencia's measures faced significant barriers, such as data governance issues and the need for enhanced collaboration among stakeholders.

The discussions underscored the importance of data standardization and governance in public administration, with a strong push from various entities, including the European Union, for open and transparent data sharing.

4.2. Workshop 2: WP4 Workshop Data-driven mobility planning

EMTA led the organisation of the workshop to help cities refine their UPPER measures and improve their UPPER plans. The objectives of the workshop are to address the specific needs and questions of cities and regions that are implementing UPPER measures in the area of data-driven mobility planning. The workshop follows a consistent structure, similar to other workshops in WP3 and WP5. This consistency helps participants feel comfortable and familiar with the process. By challenging and enhancing their initial concepts and by providing extra support for the difficult parts of their measures. The process for this workshop was structured around several steps that were common across all the UPPER work packages and tasks where measures have been developed:

- Horizontal partners were asked to critically review the measures proposed by the cities. Not all the partners reviewed all the measures, and the reviewers were decided according to their expertise, or previous work.
- In their critical review of the measures, horizontal partners had to take into account the various documents already produced in UPPER, including but not limited to the user personas and experience notebooks of D2.1, the SWOT analysis included in D2.2, or the supporting policy frameworks and policy requirements in D2.4.
- Based on the critical review of the measures to be developed within each Work Package, the horizontal partners had to commonly agree on a limited number of *Points of attention*, areas they consider the cities and measures should be focusing more on, and should be addressed moving into the implementation phase.
- The goal of these *Points of attention* was to extract common challenges that are shared in the design/development of several measures within the same work package, rather than a checklist per measure.
- An online workshop (proposed duration 2h) was organized per WP – so 3 in total – where the horizontal partners presented the *Points of attention* they had identified, together with potential recommendations or examples of how these could be addressed. Representatives from the UPPER partners responsible for the development and subsequent implementation of the measures actively participated in the workshop.
- The workshop of WP4 was organized by EMTA, with the direct support of the WP4 task leaders.
- Cities had the opportunity to see in advance the points of attention referring to the measures they were developing and to respond to and actively engage with the horizontal partners. Following a plenary introduction of the points of attention, two breakout sessions were organised in parallel for WP4, thus fostering engagement and a lively exchange between the participants.
- The online workshops were recorded.

4.2.1. Categories for the measure appraisal

The *Points of attention* are defined as topics related to measure development that cities are not taking into consideration or that are not properly addressed (according to horizontal partners' criteria). With the aim of defining a common approach for measures appraisal, a set of categories has been defined, which are:

1. Mobility as a Right: Universal accessibility leaving no one behind, overcoming any type of barriers (economic, physical, cultural, technological, geographical, or related to the process, among others).
2. Seamless multimodality/inter-modality: soft transitions, physical space, ticketing, and information.
3. Tailored communication for increased acceptance and buy-in: Communication adapted to different target groups.
4. Active stakeholder engagement during measure development: to define clearly how the stakeholders contribute to the measure implementation.
5. Data management and privacy: GDPR compliance.
6. Environmental impacts: CO_2 emissions, Energy use, and Air quality.
7. Social impacts: public and user health and wellbeing, coexistence-living peacefully, security/safety (with special attention to women and elderly people).
8. Target groups mainly impacted: to identify the target group/s that are mainly impacted by the measure.

9. Other.

4.2.2. Template for appraisal

A template to appraise the measures was defined. The template consisted of a table in *Excel* format, with the following fields:

- *Measure ID*: The list of measures linked to WP4 could be selected from an unfold menu.
- *Appraised by*: The list of horizontal partners involved in the measures' appraisal (UITP, FAC, EMTA, RC, ICLEI, EITUM, IBV, EPF, ECF, IFP, FIT), could be selected from dropdown list.
- *Point of attention category*: The list of categories defined for the appraisal could be selected from a dropdown list.
- *Evaluation result*: In this column the entity performing the evaluation had to explain the issues or the aspects (point of attention) to be considered when developing the mobility measure.
- *Solution you can present/further reading or documents presenting this*: This column was included in order to the evaluator could provide references or implemented solutions related to the appraisal.

4.2.3. Recommendations per measures

This section presents specific points of attention raised during the appraisal exercise and the workshop process for each measure in T4.3.

OSL_03:

The appraisal exercise found that OSL_03 could be improved by ensuring that data collection is inclusive and represents all population segments. Additionally, it is recommended that privacy and data protection be prioritized throughout the data collection, storage, and analysis processes.

TES_09:

The workshop recommended exploring options for using public transport data to inform and support communication efforts aimed at raising environmental awareness. It was also suggested that the city consider the use of gamification or other engaging strategies to encourage behavioural change towards PT.

LIS_04:

The workshop suggested that the city evaluate the effectiveness of the "Amarelo Pilot Project" in terms of student satisfaction, parent engagement, and overall impact on PT usage. The appraisal process recommended considering expanding the "Navegante Escola PT ticket card" to other age groups or demographic groups with similar needs.

IDF_06:

It is recommended that the city ensure that the Mobility Observatory is accessible and user-friendly for both elected officials and transport stakeholders. The appraisal exercise found that a clear strategy for data collection, aggregation, and dissemination is necessary to ensure data quality and relevance for decision-making. The workshop recommended integrating the Mobility Observatory with existing urban planning and mobility management tools.

BUD_01:

The workshop recommended that the city utilize the data collected from the household survey to effectively update the Unified Transport Model and inform public transport planning decisions. It is recommended that the model considers evolving travel patterns and incorporates real-time data to improve accuracy and relevance. It is also recommended that the model be integrated with other data sources to enhance its predictive capabilities.

MAN_03:

It is recommended that the platform incorporate data from different sources, ensuring that the data is frequently accessible and available. The workshop recommended fostering community engagement and collaboration by involving stakeholders in the design, development, and ongoing improvement of the platform. The appraisal exercise highlighted the need to organize a survey on the use of PT for women and other minority groups to improve the quality of data collection and consider gender perspectives. The workshop recommended reviewing the methodology of the Mobility Gender Divide tool from the TRIPS project: https://trips-project.eu/deliverables/#MDI to ensure the platform includes gender-specific data and addresses gender disparities. It was also recommended that the platform integrates with city or other operator data, including data on traffic counting points from the city, or also DB Regio for various combined trips with regional or S-bahn style services. The workshop suggested that the city identify 1-2 features of this dashboard that a customer of rnv could use to increase support within the company. The Vervoerregio is participating in the SMALL project which is part of the Interreg program. They are working on a pilot to incorporate functionalities in an existing app. These functionalities should make it possible to show if certain assets in the station are available, like lifts or escalators.

VAL_03:

It is recommended that the city provide access to the U-NEED tool to transport operators and authorities. It is also recommended that the city provide training on the use of the tool to relevant personnel. Finally, the city should implement the corrective strategies outlined in the roadmap.

4.2.4. High-level recommendations

The workshop highlighted several key points of attention in common for all the cities involved in T4.2 and T4.3.

Cities recognized the importance of making public transport accessible to everyone, regardless of their financial situation or technological access. To address this, cities must ensure that the cost of transportation, the need for digital tools, credit cards, or smartphones, do not become barriers for individuals. They will explore alternative payment methods and non-digital options to make transportation more inclusive.

Additionally, cities must apply a gender lens to the data collected, ensuring that the needs and experiences of all genders are considered to enhance public transportation services. There will be a stronger focus on understanding users' needs and mobility behaviours, which will guide the planning of more user-friendly transportation services.

When replanning routes, cities must actively involve pedestrians, cyclists, and local organizations representing walkers and persons with disabilities. Their input will be essential in creating a transportation network that meets the needs of all users. Citizen engagement will also be extended to those who are not digital users, ensuring their voices are heard in the planning process.

Cities acknowledged the challenges of ensuring that data collected through surveys, questionnaires, and focus groups is representative and of high quality. To address this, Cities will develop methods to enhance the representativeness of data, ensuring it reflects the diverse population. User engagement and feedback will be central to this process, with special attention given to understanding user characteristics during data collection.

The integration of this data into public transportation tools will be prioritized to improve service planning and delivery. Moreover, the city will implement strict measures to protect data privacy, ensuring that all collected data is securely stored and used responsibly.

Cities must implement discount periods and rewards as incentives to encourage more people to use public transportation. Understanding the target audiences will be crucial in tailoring communication strategies to effectively promote these incentives. A mechanism will be established to analyse how users respond to these rewards, allowing for continuous improvement.

Engaging new users, particularly those not already commuting sustainably, will be a key focus. Cities must create outreach programs to attract these users, ensuring that the messaging resonates with their needs and encourages a shift towards public transportation.

For cities like Valencia, Thessaloniki, Oslo, and Mannheim, where Demand Responsive Transport (DRT) services are planned, accessibility will be a priority. Recognizing that automation can exclude vulnerable users who may not have smartphones or credit cards, the city will ensure that both digital and traditional reservation systems coexist. This dual approach will make DRT services accessible to a broader range of users29ravelled modelling routes and on-demand transport services, cities will analyse users' characteristics, needs, mobility behaviours, and perceptions of public transportation. This analysis will help in designing services that are truly responsive to the needs of the community. A coherent communication plan will be developed to reach the intended target audiences effectively.

Cities must further develop strategies to address environmental impacts, focusing on reducing CO2 emissions, energy use, and improving air quality. Additionally, more thought will be given to rewarding sustainable commuters, encouraging more people to choose eco-friendly transportation options. Further input will be sought to design public transportation systems that align with environmental goals, ensuring that the city's transportation network contributes positively to the environment.

By addressing these points of attention, the city aims to create a more inclusive, responsive, and sustainable public transportation system that meets the needs of all its residents.

UPPER

5. Measures preparation process

5.1. Valencia

5.1.1. Measure VAL_03

5.1.1.1. Description of the measure and main outcomes expected

This measure aims to carry out a geospatial analysis of passenger and traveler flows to determine the optimal transport offer for specific city situations. With support from U-NEED, public transport passenger flows and underlying trends in mobility will be evaluated. Inefficiencies in the current transport offer will be identified, and U-SIM.plan will be used to simulate potential corrective actions.

This measure will deliver:

- Modelling of citizens'; mobility patterns in Valencia, including the representation of PT OD matrices.
- Report on the main inefficiencies of the PT offer
- Simulation of some corrective actions and a roadmap on the PT adaptations (including infrastructure and service) to be implemented in the city. The implementation of some corrective strategies within the scope of the project will be assessed.

5.1.1.2. Preparation of the measure

Agreement with transport operators and authorities for data provision. The final objective of this measure is to help public transport operators and authorities to improve public transport infrastructure and supply (capacity, timetables, frequency, routes...) based on a detailed analysis of the demand and mobility patterns of the inhabitants and visitors of Valencia.

This measure benefits from the use of one of the tool developed in the framework of the project, U-NEED.

Since the measure aims at improving public transport, the first step was to contact the multiple stakeholders involved in public transport. This included:

- EMT, as bus operator
- ATMV, as public transport authority
- FGV, as metro and tram operator
- Renfe, as the train operator

Bilateral meetings were held with each of these entities to explain the scope of the measure, the potential benefits of using the U-NEED tool, as well as to specify the data needs in order to be able to proceed with the analysis of multimodal mobility.

Finally, data provision agreements were reached with EMT (data on urban buses) and ATMV (data on interurban buses). On a later stage, and after signing an NDA, data from FGV (metro/tram) could be potentially integrated.

UPPER

Data collection of different transport modes

To deploy the tool in Valencia, ETRA requires ATMV and EMT to provide access to origin-destination (OD) matrices. However, neither entity has complete OD matrices for the bus system because passengers only use their tickets when boarding the bus, not when disembarking. As a result, it was decided to use the drop-off stop inference algorithm to calculate these OD matrices.

To implement the drop-off stop inference algorithm, both entities need to supply ticketing data. **Bus ticketing data (urban and interurban) was requested, specifically:**

- Access to historical ticketing data for at least one representative month.
- Data should be provided in a single file per day, maintaining the minimal data structure (see Figure 7) (additional information may be included if deemed relevant).

Transport pass ID	Validation day	Boarding		Disembarking		Line or route	Transfer
		Validation time	Bus stop	Validation time	Bus stop		
xxxxxx	YYYY-MM-DD	HH:mm:ss	GTFS stop_id	HH:mm:ss	GTFS stop_id	GTFS route_id or short_name	Yes/No

Figure 7 - Ticketing data requested

The anonymisation of users' transport pass IDs must be done in such a way that all validations made with the same pass on the same day can be traced. It is crucial that the anonymisation does not break traceability within the same day.

Note that the algorithm developed by ETRA does not store any transport pass ID in memory; it simply calculates the inference of drop-off stops using complete data from a single day (full ticketing file). Finally, it stores the count of users traveling between stops for each hour of the day, as shown in the following example (Figure 8):

Day	Time	Number of users	Origin stop	Destiny stop
17/04/2024	8-9	5	0178	2114
17/04/2024	9-10	12	0178	2114
17/04/2024	10-11	1	0178	2114
17/04/2024	11-12	8	0178	2114

Figure 8 - O/D data requested

As shown, it is not necessary to identify the individual, but obtaining a reference value on the transport pass is necessary to calculate the flow of users between stops on the same day.

- For greater accuracy, the operator or authority may include conditions for a validation to be considered a transfer (e.g., time elapsed since the first validation, change of transport type, etc.).

The data provided by the participating entities includes:

- **EMT:** Ticketing data of 2024 (until July 2024). The provided information includes the following fields: “Día”, “Cód. Externo Línea”, “Hora:Minuto”, “Viajeros”, “Cód. Parada”, “Cód. Tarjeta”. Additionally, EMT provided the results of a recent survey-based study for estimating origin-destination matrices of Valencia citizens.
- **ATMV:** Ticketing data for a complete month (April 2024). The provided information includes the following fields: “FECHAHORA”, “LINEA”, “PARADA_ORIGEN”.

Data integration:

The ticketing data has been used to calculate urban and interurban bus OD matrices. After calculation, the information is being integrated into the U-NEED tool. The results from the survey-based study conducted by EMT will be also integrated.

5.1.1.3. Challenges & Mitigations

During the preparation of the measure, the primary challenges included the absence of origin-destination matrices from both the bus operator (EMT) and the transport authority (ATMV- providing data for interurban buses). This issue is a common challenge among many bus operators, where validation typically occurs only upon boarding, not upon disembarking. To address this, we utilized the drop-off stop inference algorithm. However, a limitation of this algorithm is its restriction to round trips, resulting in some trip-specific information being lost.

5.1.1.4. Next steps towards implementation

The next steps include giving access to the different transport operators and authorities to the tool, so they can carry out the required analysis, upon their particular interests, to identify inefficiencies or areas of actuation. Specific training will be provided by ETRA to the entities using the tool (EMT, ATMV, FGV…).

5.2. Budapest

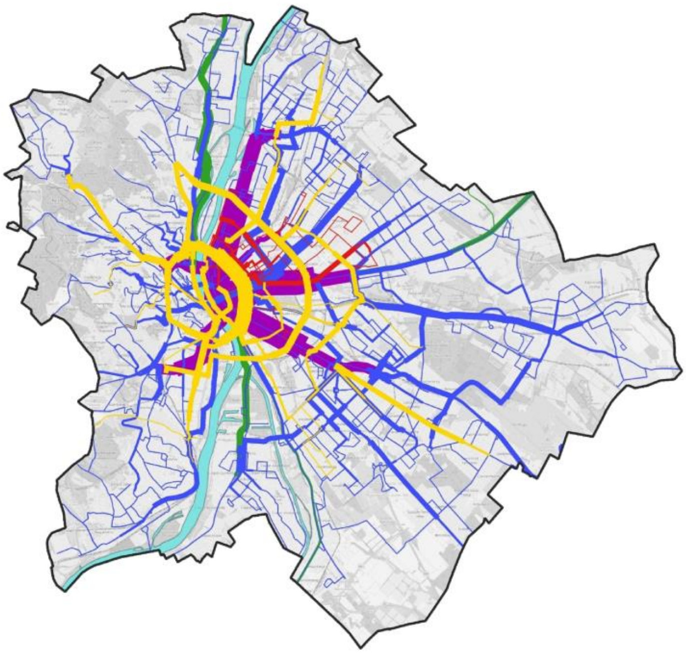
5.2.1 BUD_01: To improve the efficiency and convenience of PT service

5.2.1.1. Description of the measure and main outcomes expected

In general, a data-based decision-making process based on measured passenger numbers is not a requirement of the process for public transport service planning on a regular basis. BKK already has a macroscopic strategic transport model, but it is not (or just partly) capable of supporting the operation validation/optimization of public transport services. The Model is based on a complex system of different data sources, including traffic counting data, spatial data, infrastructure data, traffic behavior data and other data from external sources. This data should be updated regularly to ensure reliable transport planning. In this measure, the BKK will investigate the possible development solution of the model, which can strengthen the reliability of the model in the aspect of operational public transport planning.

Measure outputs:

- Data collection for the update the Unified Transport Model (e.g. household survey)
- Macroscopic model updated and validated based on the results of the data collection



9. Figure: Result of public transport assignment in EFM

5.2.1.1. Preparation of the measure

BKK is working on the Public Transport Network Strategy for Budapest, which is a sub-strategy of the city's SUMP. This UPPER measure supports the goals of this sub-strategy, as the operational modeling of public transport modifications is its backbone and must be reliable. To make the public transport layer of the model more reliable for operational modifications, a comprehensive update is necessary.

One of the most important parts of this update is collecting reliable data from citizens – specifically, when, how much, and how they are traveling. Travel habits have changed during the COVID pandemic, as evidenced by the difference in passenger numbers compared to pre-COVID levels. We know that this is partly due to the increase in remote work, but we lack detailed data on this. To better understand the changed travel habits, a large-scale household survey must be conducted in Budapest and its surrounding areas. This household survey must be representative in terms of area, household size, and age.

Based on BKK's experiences from previous household surveys and discussions with experts, it was decided that a sample of 12,000 households would be sufficient. A technical description has been prepared, and through an open tender, BKK has selected a company to implement the household survey, following the predefined criteria, between May and July 2024. The survey has started with larger households, where school-aged children are most likely to be living.

5.2.1.2. Challenges & Mitigations

From a technical point of view, it was clear what kind of data should be collected, but implementing a large-scale household survey like this is also challenging. We usually prefer to use data from late Spring or early Autumn, as this represents “average working day data.” Due to the municipal elections in Hungary in early June 2024, public opinion research companies were busy, and such companies are needed for this household survey. Finally, the tender was successful, and data collection started in late May, beginning with households with school-aged children to avoid surveying them during the summer break period.

5.2.1.3. Next steps towards implementation

The complex model update will be finished in late 2024. Until then, data will be collected from several other sources, including the results of the Hungarian census (2022), which provide data about the number of inhabitants in different zones, cross-section traffic data from loop detectors and cameras, public transport boarding numbers, a company database that provides data about workplaces in different zones, and other minor data sources.

Once the model update is ready, the modeling results applied in the Public Transport Network Strategy will be reviewed and, where necessary, updated based on the results of the updated model. Furthermore, individual network modifications will also be investigated by the new model, and decisions about implementation will be made based on the model's results. This will lead to more reliable and data-driven decisions than previously.

5.3. Thessaloniki

5.3.1. TES_09: To raise environmental awareness and trigger behavioural change towards PT

5.3.1.1. Description of the measure and main outcomes expected

The scope of TES_09 is to provide a robustness analysis, regarding the operation of the Yutong E-12 battery electric bus in the public transport system of Thessaloniki. For this purpose, the energy consumption and the autonomy of the studied vehicle was thoroughly analyzed under a broad range of operating conditions, employing mathematical modeling and simulation. The simulation results were then used to assess the feasibility of circulating the bus in Thessaloniki's bus lines, which are planned to be electrified and eventually suggest measures to mitigate potential vehicle's downtime. Additionally, an analysis is being performed for estimating the CO_2 savings due to the electrification of the studied bus lines, in order to define, at a later stage, mechanisms for communicating effectively this new (electrified) era for city's PT and raising awareness of sustainable transport options in favour of public buses.

5.3.1.2. Preparation of the measure

<u>Case study</u>

After many years without renewing Thessaloniki's public bus fleet, Thessaloniki is ready for entering a new era, with the incorporation of fully electric buses in the existing fleet. After a long procurement process, in May of 2024 130 electric buses arrived in the city and they gradually started operating. Moreover, it is anticipated that an additional procurement will be carried out within the following years for incorporating additional electric buses in the fleet. Despite that, this new era seems very promising, there is a challenge related to the vehicle's autonomy and charging, which needs to be addressed. In the framework of this measure, a thorough analysis is being implemented, and communicated to the local stakeholders, for ensuring the successful operation of the recently arrived e-buses.

UPPER

Data collection

The scope of Step 1 is to collect the necessary data in order to conduct the aforementioned model-based analysis. For this purpose, the following data sets were required:

- the technical specifications of the Yutong E-12 battery electric bus, with an aim to develop a mathematical model of the vehicle and
- a broad range of driving conditions (i.e. speed profiles and road slopes), to be used in order to assess the energy consumption and the autonomy of the studied battery electric bus.

The vehicle technical specifications are compiled in Table 3.

Table 3. Technical specifications of the Yutong E-12 battery electric bus.

Vehicle dimensions and mass		Comments
Vehicle Length [m]	12.17	Provided by the manufacturer
Vehicle Frontal Area [m2]	8.415	Based on the vehicle's width and height – provided by the manufacturer
Vehicle mass [kg]	13300	Kerb weight provided by the manufacturer (Yutong, 2024)
Passengers mass (70 kg/pass) [kg]	5200	Calculated based on the GVW (18.5t) and the vehicle's kerb weight
Drag force coefficient [-]	0.6	Mohamed et al., 2015
Wheels and Differential		
Wheel rolling radius [m]	0.499	Calculated based on the tires characteristics: 305/70 R22.5 (Yutong, 2024)
Coefficient of Rolling Resistance [kg/kg]	0.0075	Provided by the manufacturer (Yutong, 2024)
Velocity Dependent Resistance [s/m]	0.68·10-4	Skarlis et al., 2018
Gear Ratio [-]	5.73	Based on the ZF AV-132 rear axle – provided by the manufacturer (Yutong, 2024)
Electric Machine Characteristics		
Max. Motor Power Output [kW]	350	Provided by the manufacturer (Yutong, 2024)
Max. Motor Torque Output [Nm]	2400	Provided by the manufacturer (Yutong, 2024)
Max. Motor Revolution Speed [rpm]	3500	Skarlis et al., 2018 (Skarlis, y otros, 2018)
Nominal Operation Voltage [V]	600	Skarlis et al., 2018 (Skarlis, y otros, 2018)
Battery Pack Characteristics		
Max. Open Circuit Voltage [V]	601.6	Skarlis et al., 2018 (Skarlis, y otros, 2018)
Charging Power [kW]	60-150-300	Provided by the manufacturer (Yutong, 2024)
Nominal Battery Pack Capacity [Ah]	583	Calculated based on the battery's nominal voltage and energy content (350 kWh)
Auxiliary Units Input Power [kW]	5	(Skarlis, y otros, 2018)
Heating/Cooling power [kW]	37	Provided by the manufacturer (Yutong, 2024)

As far as the driving conditions are concerned, two data sets were collected. Speed profiles, which are published in the literature[7] were compiled first, in particular: the "Braunschweig" (10.9 km), the "NY" (1 km), the "Manhattan" (3.3 km) and the "UK bus" (12.1 km) cycles. These driving cycles are characterized by different minimum/maximum/average vehicle

[7] (DieselNet, 2024)

speeds and accelerations and hence can allow for evaluating the energy consumption of the studied e-bus under a broad range of driving conditions. Additionally, real driving data was collected. Given that there are currently no electric buses in Greece, speed profiles from Diesel buses were collected. A total of 4 bus lines from the city of Thessaloniki were studied, in order to depict bus speed profiles, which correspond to low-speed driving (e.g. driving in the city center), low/mid-speed driving and mid/high-speed driving (e.g. driving between the city center and the suburbs). Moreover, 1 trolley bus line from the city of Athens was evaluated, with an aim to collect driving data from a vehicle, which is equipped with an electric motor and hence may share similar acceleration behavior with a battery electric bus. The respective driving data was harvested by means of GPS software. Using GPS data, speed and elevation profiles were generated and used as input for simulating the studied e-bus's energy consumption and autonomy. Information related to the ensemble of the collected driving data are summarized in Table 4.

Table 4. Compilation of the collected driving data.

Driving cycle	Source	Mileage [km]	Average speed [km/h]	Average road slope [°]
Braunschweig	(DieselNet, 2024)	10.9	22.5	0
NY city cycle	(DieselNet, 2024)	1	5.94	0
Manhattan cycle	(DieselNet, 2024)	3.3	10.98	0
UK Bus cycle	(DieselNet, 2024)	12.1	13.27	0
Thessaloniki: L58 Pylaia-Center	GPS measurement	6.2	16.8	-0.0124859
Thessaloniki: L15 City Center	GPS measurement	2.23	14.32	0.00651563
Thessaloniki: L37 Center-Toumba	GPS measurement	3.18	19.14	0.01802411
Thessaloniki: L37 Toumba - Center	GPS measurement	4.18	13.43	-0.0091856
Thessaloniki: L17 City Center	GPS measurement	1.52	11.16	0.0079862
Athens: L11 trolley bus Pangrati	GPS measurement	1.8	13.35	-0.0168362

Definition of the simulation scenarios

In order to assess the studied e-bus' energy consumption and hence calculate its respective autonomy, a broad range of vehicle operating conditions were analyzed. According to studies published in the literature[8], an electric vehicle' energy consumption might be heavily affected by the vehicle's speed (and acceleration) profile, the carrying load, the driver's behavior, as well as the use of the cabin's air conditioning system. Therefore, in the frame of the present work, a thorough analysis of the effect of the aforementioned parameters on the Yutong E-12 electric bus energy consumption was conducted. Taking into consideration the technical specifications of the studied e-bus, the following sensitivities were simulated:

- Vehicle weight: The total vehicle weight was varied between 13300kg and 18500kg, assuming a passenger's capacity range of 0-80 (each passenger's average mass was considered equal to 65kg)
- HVAC system operation: The operation of the Heating Ventilation and Air Conditioning (HVAC) system operation was varied in the range of 0-100%
- Driver behavior: The driver behavior was also studied, assuming three driving modes; i) "neutral driving" style, according to which the driver follows the speed profile of each of the studied driving cycles, without any deviation, ii) "eco-driving", which includes e-bus driving at lower acceleration rates, than those prescribed in each driving cycle and iii) "aggressive-driving", which includes e-bus driving at higher acceleration rates, than those prescribed in each driving cycle

[8] (Skarlis, y otros, 2018), (Skarlis, Molos, Ayfantopoulou, Nikiforiadis, & Bakouros, 2023)

UPPER

The aforementioned sensitivities were studied under the speed profiles, presented in Table 4. The energy consumption and autonomy of the Yutong E-12 battery electric bus were simulated in 2 phases. First, each of the aforementioned sensitivities was individually simulated for each speed profile (both the literature based and the real driving speed profiles). This exercise allowed for identifying and also quantifying, which of the three sensitivities may be the most crucial for the studied e-bus traveling range. Then, the three sensitivities were simultaneously simulated for each of the aforementioned speed profiles. For this purpose, Monte Carlo simulation was employed, and the outcome was a probabilistic assessment of the battery electric bus energy consumption and autonomy under stochastic operating conditions. The probabilistic analysis of the e-bus energy consumption was then used to assess the feasibility of circulating the studied e-bus model in the bus lines of Thessaloniki, which are planned to be electrified. For this task, the statistical “Design Of Experiments” (DOE) approach was employed. According to this methodology, the autonomy and battery recharging frequency of the electric bus were assessed under various operating conditions, for the selected bus lines. The ultimate outcome of this work was to identify the most critical bus lines, where the likelihood of the electric bus downtime might be high, due to limited battery’s state of charge. Moreover, recommendations regarding the mitigation of the aforementioned risks were provided, including the suggestion of “opportunity charging” sessions, use of mobile battery charging sources etc.

<u>e-bus operation simulation</u>

This step includes a thorough simulation analysis of the Yutong E-12 electric bus’s energy consumption and autonomy, under a broad range of operating conditions. For this purpose, cost-effective mathematical modeling and simulation was used, employing the state-of-the-art electric vehicle simulator ARCHIMEDES™, engineered by e-Kinesis[9]. The governing equations of the e-Kinesis ARCHIMEDES™ have been presented in the reference[10]. The ARCHIMEDES™ mathematical model of the Yutong E-12 battery electric bus consists of several model-components, namely: a) vehicle, b) electric motor/generator, c) motor control unit (MCU), d) battery pack, e) battery pack management system (BMS) and f) vehicle control unit (VCU). The model-components performance is simulated based on a combined “forward/backward” approach[11]. Each model-component was parametrized employing the parameters shown in Table 4.

First, the Yutong E-12 mathematical model was validated against experimental data provided by the manufacturer. To do so, the vehicle’s energy consumption was simulated during the SORT2 driving cycle. The respective speed profile is shown in Figure 10. The autonomy calculated by the ARCHIMEDES™ mathematical model was 0.668 kWh/km, which is in reasonable agreement with the average energy consumption 0.693 kWh/km reported by the manufacturer during the same driving cycle[12].

[9] (ARCHIMEDESTM, 2024)

[10] (Skarlis, Molos, Ayfantopoulou, Nikiforiadis, & Bakouros, 2023)

[11] (Wipke, Cuddy, & Burch, 1994)

[12] (Yutong, 2024)

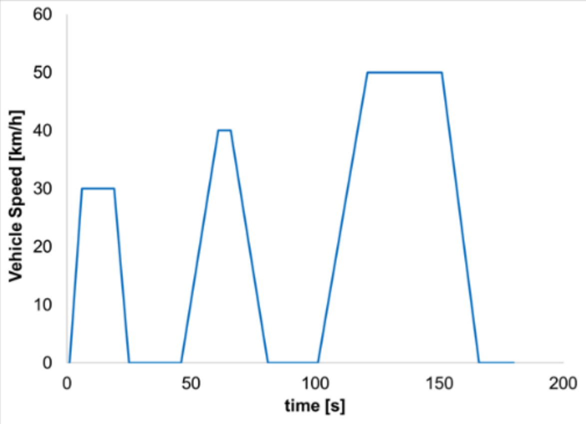


Figure 10. Speed profile of the SORT2 driving cycle[13].

Using the validated battery electric bus's mathematical model, the effect of the speed profile on the vehicle's energy consumption and autonomy were assessed. For this purpose, the driving data shown in Table 4 were used, whereas no passengers and zero power consumption by the HVAC unit were considered. The simulated energy consumption for each driving cycle is illustrated in Figure 11. In the same graph the average speed of each speed profile is also shown. The studied speed profiles resulted in an average energy consumption in the range of 0.8 – 0.9 kWh/km. This observation considers both the driving cycles reported in the literature and the speed profiles recorded through GPS measurements. When the electric bus was operated under the "NY Cycle" driving conditions, the vehicle's average energy consumption was maximized and reached around 1.19 kWh/km. On the other hand, the "Braunschweig" speed profile resulted in an average energy consumption as low as 0.7 kWh/km.

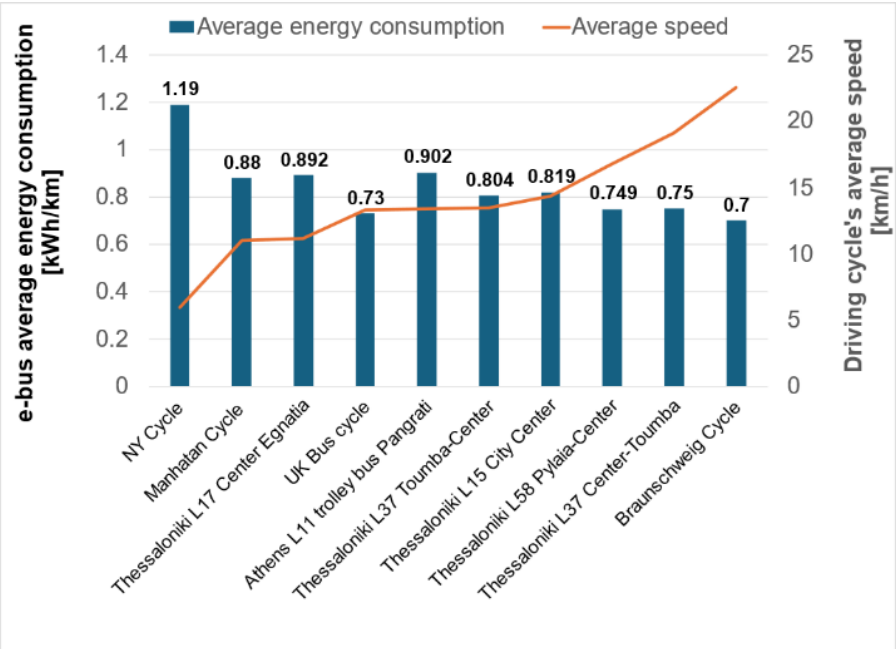


Figure 11. Simulated energy consumption for the driving cycles, studied in this work.

[13] (UITP, 2021)

At this stage, it should be noted that the studied electric bus energy consumption seems to follow an increasing pattern, when the average driving speed decreases. To test this assumption, linear regression analysis was conducted with respect to the aforementioned parameters and the respective results are shown in Figure 12. The linear regression between the average energy consumption (E in kWh/km) and the bus's mean speed (v in km/h) is formulated as: $E = 1.208 - 0.026 \cdot v + e$ (where e stands for the error between the regression model and the simulated energy consumption) and can explain the 67.8% of the variability of the simulated bus's energy consumption.

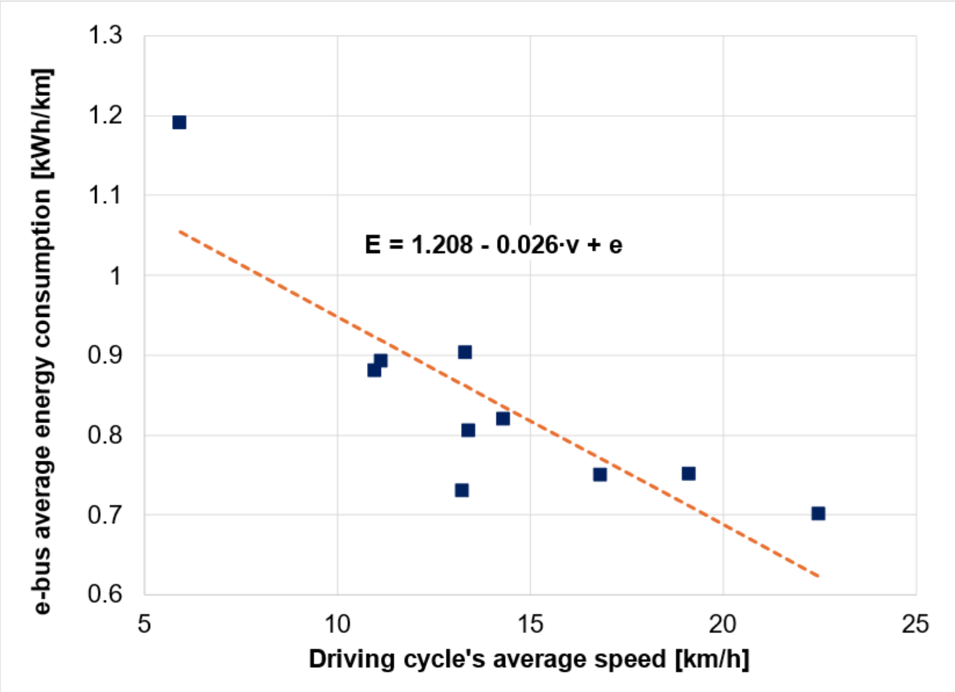
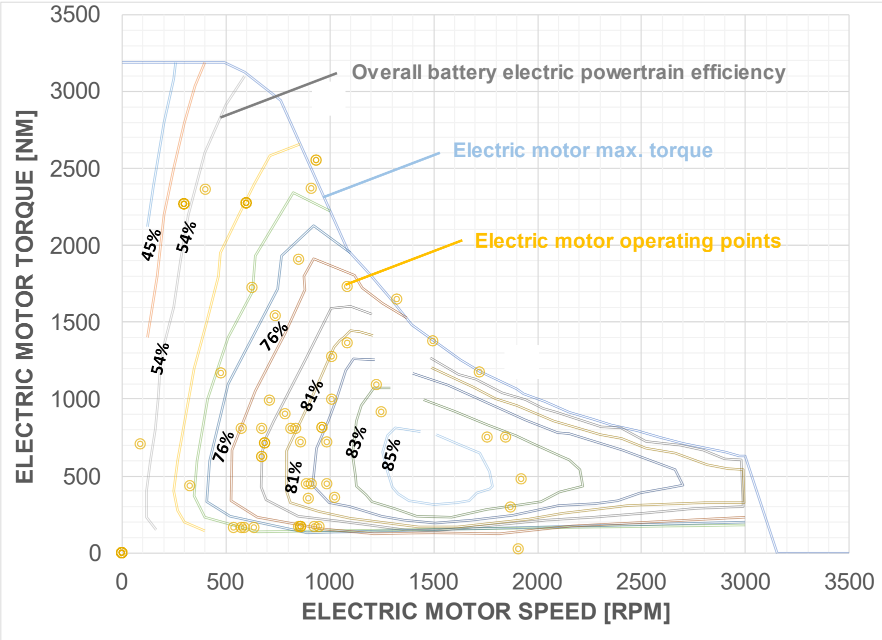


Figure 12. Regression analysis between the studied vehicle's average energy consumption and the mean driving speed.

In order to get deeper insight into the effect of the speed profile on the vehicle's energy consumption, the simulated electric motor operating points are shown in Figure 13. In the same graph, the overall efficiency of the battery electric powertrain is also added, comprising of the losses of the electric motor/generator, the battery pack, the controllers and the differential. In the case of the "NY cycle" (Figure 13, A), the electric motor operating points are spread over a speed range of 0 – 2000 rpm and a torque span of 0 – 2500 Nm, whereas the majority of the simulated operating points is populated within a 76%-81% powertrain efficiency range. When the vehicle is operated under the "Braunschweig" speed profile (Figure 13, B) the majority of the simulated operating points of the electric motor tend to shift towards higher motor speeds (1000 – 2000 rpm), where the overall powertrain efficiency is higher than 81%. As a matter of fact, the revolution speed of the electric motor is proportional to the vehicle's linear speed. In this respect, the lower average speed of 5.94 km/h observed in the "NY cycle" results in the electric motor frequent operation at speeds between 500 – 1000 rpm, where the powertrain efficiency is limited up to around 81%. On the other hand, in the case of the "Braunschweig" driving cycle, the average vehicle speed is as high as 22.5 km/h, which leads to the more frequent operation of the electric machine within the 1000 – 2000 rpm spectrum, where the powertrain energy efficiency is optimized. Focusing on the simulation results, when employing real driving data, recorded through GPS, it appears that the average bus's speeds may vary between 11 – 19 km/h, which results in energy consumption in the order of 0.75 kWh/km – 0.89 kWh/h.

Regarding the effect of the road slope on the studied electric bus energy consumption the real driving scenarios were studied only. For this purpose, the energy consumption was simulated with the originally recorded road elevation, as well as with zero slope. The respective results are shown in Figure 14. At this stage it should be commented that the recorded average road slope is rather low and lies in the order of -0.017° to 0.018°. As such, the simulated energy consumption appears to be relatively insensitive to changes in the studied elevation range. This is further confirmed by the results generated with a zero slope consideration, which deviate from those obtained using the originally recorded elevation by up to 1.5%.

A)



B)

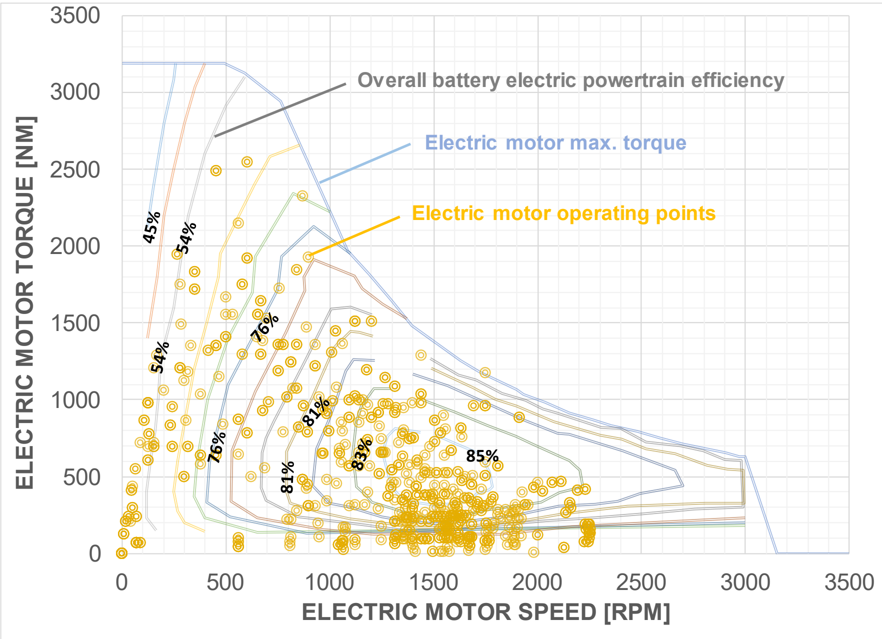


Figure 13. Electric motor operating points during the simulation of the Yutong E-12 bus operation under the A) "NY cycle" and the B) "Braunschweig" driving cycle conditions.

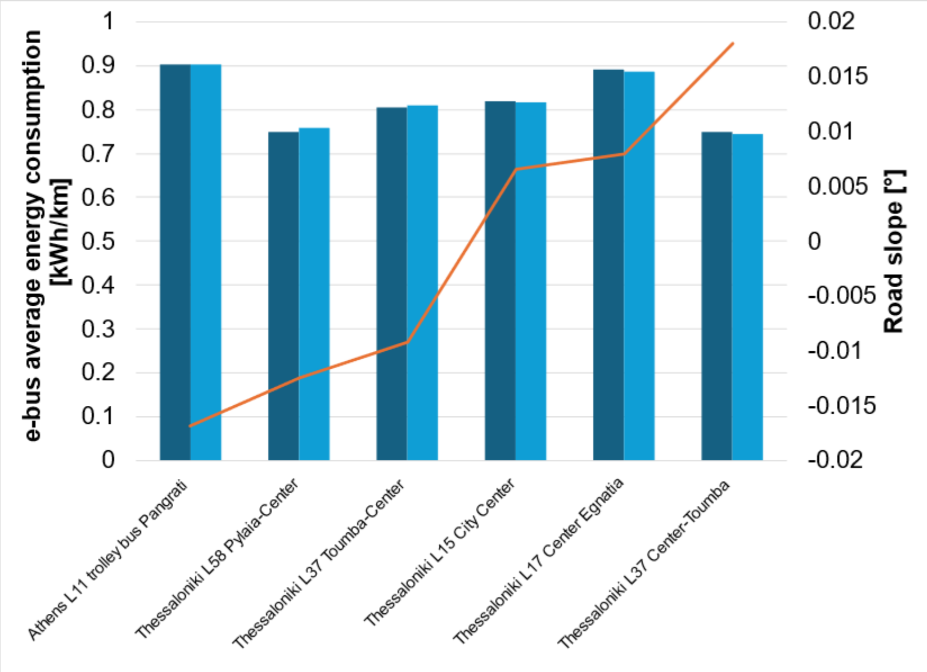


Figure 14. Effect of the road slope on the studied electric bus energy consumption.

Also, the simulated energy consumption and autonomy of the studied vehicle is examined, as a function of the sensitivities discussed in Table 3; i.e. the passengers' mass, use of the HVAC unit and the driver's behavior. These sensitivities were studied under the ensemble of the driving conditions, shown in Table 4.

First, the effect of the passengers' capacity on the studied electric bus energy consumption and autonomy, was analyzed for each driving cycle. The respective simulated bus's autonomy is presented through Figure 15. As expected, increasing the number of passengers and hence the overall vehicle's mass, the autonomy of the vehicle decreases. Increasing the number of passengers, the vehicle's energy consumption also increases. As discussed in an earlier publication of Skarlis et al.[14], when increasing the number of passengers and hence the overall vehicle's mass, both the electric bus's rolling resistance and inertial forces acting on the vehicle increase, which results in a higher energy consumption. In the same publication, it was also demonstrated that inertial forces have greater contribution to the energy consumption compared to the rolling resistance by approximately three times. Interestingly, the results of this work indicate that the speed profile should be also analyzed in conjunction with the vehicle's mass, in order to properly assess the latter effect on the vehicle energy consumption and autonomy. Focusing on the driving reported in the literature, it appears that the vehicle's autonomy may drop up to a maximum between 11% (NY cycle) and 24% (Braunschweig cycle), when the vehicle is fully loaded with passengers, depending on the speed profile. The average speed of the NY cycle is 5.94 km/h, which is almost four times lower compared to the average speed recorded in the Braunschweig driving cycle (22.5 km/h). This observation tends to further confirm the importance of inertial forces on energy consumption, as discussed above. As far as the real driving data are concerned, the passengers' mass can result in up to 19% decrease in the vehicle's autonomy (Thessaloniki L37 Center – Toumba, when the bus is fully loaded). As commented above, the speed profile is also a determinant of the decrease in the vehicle's range. In the case of real driving cycles, the average speeds vary between 13.4 – 19 km/h, which limits the variation of the maximum drop in the vehicle autonomy in the range of around 16%, when the vehicle is fully loaded with passengers.

[14] (Skarlis, y otros, 2018)

Passengers mass [kg]	Braunschweig cycle	NY Cycle	Manhatan cycle	UK bus cycle	Thessaloniki: L58 Pylaia-Center	Thessaloniki: L15 City Center	Thessaloniki: L37 Center-Toumba	Thessaloniki: L37 Toumba - Center	Thessaloniki: L17 City Center	Athens: L11 trolley bus Pangrati
0	0	0	0	0	0	0	0	0	0	0
520	-3%	-2%	-3%	-3%	-2%	-1%	-2%	-2%	-3%	-2%
1040	-6%	-4%	-5%	-5%	-4%	-3%	-5%	-3%	-5%	-4%
1560	-9%	-5%	-7%	-8%	-6%	-5%	-7%	-5%	-7%	-6%
2080	-11%	-6%	-10%	-10%	-7%	-7%	-9%	-6%	-8%	-8%
2600	-14%	-7%	-12%	-12%	-9%	-7%	-11%	-8%	-10%	-10%
3120	-16%	-8%	-14%	-14%	-10%	-9%	-13%	-9%	-11%	-12%
3640	-18%	-9%	-16%	-16%	-11%	-10%	-15%	-10%	-12%	-13%
4160	-20%	-10%	-17%	-18%	-13%	-12%	-17%	-11%	-13%	-15%
4680	-22%	-10%	-19%	-20%	-14%	-13%	-18%	-12%	-15%	-16%
5200	-24%	-11%	-20%	-22%	-15%	-15%	-19%	-13%	-16%	-18%

Figure 15. Decrease in the studied vehicle autonomy, as a function of the passengers' mass. The case of the empty bus is used as a reference (i.e. passengers' mass equal to 0 kg).

The effect of the Heating, Ventilation, and Air Conditioning (HVAC) system on the vehicle's energy consumption and autonomy was studied next. Power consumption due to the cabin HVAC unit was considered as an input of the ARCHIMEDES™ mathematical model. To quantify the impact of the HVAC energy consumption on the studied electric bus travelling range, the operating power of the HVAC unit was varied from 0% to 100% of its nominal power. Respective results are compiled in Figure 16. Reasonably, increasing the operating power of the air-conditioner, higher amounts of energy are removed from the battery pack resulting in a faster battery pack discharging and hence a shorter travelling range. From a quantitative point of view, this work demonstrates that cabin HVAC operation may decrease the studied electric bus range up to 36-56% (depending on the speed profile), which is somehow in line with previously reported studies, focusing on "A/C range anxiety"[15].

HVAC operation [%]	Braunschweig cycle	NY Cycle	Manhatan cycle	UK bus cycle	Thessaloniki: L58 Pylaia-Center	Thessaloniki: L15 City Center	Thessaloniki: L37 Center-Toumba	Thessaloniki: L37 Toumba - Center	Thessaloniki: L17 City Center	Athens: L11 trolley bus Pangrati
0	0	0	0	0	0	0	0	0	0	0
10	-12%	-10%	-7%	-8%	-20%	-19%	-18%	-19%	-22%	-9%
20	-22%	-18%	-13%	-14%	-33%	-32%	-30%	-32%	-36%	-18%
30	-30%	-25%	-19%	-20%	-42%	-42%	-39%	-41%	-45%	-24%
40	-36%	-31%	-24%	-25%	-49%	-49%	-46%	-49%	-52%	-30%
50	-42%	-35%	-28%	-29%	-55%	-54%	-52%	-54%	-58%	-35%
60	-46%	-40%	-32%	-34%	-59%	-59%	-56%	-59%	-62%	-40%
70	-50%	-44%	-35%	-37%	-63%	-62%	-60%	-62%	-66%	-44%
80	-53%	-47%	-38%	-40%	-66%	-66%	-63%	-65%	-69%	-47%
90	-56%	-50%	-41%	-43%	-69%	-68%	-66%	-68%	-71%	-50%
100	-59%	-53%	-44%	-46%	-71%	-70%	-68%	-70%	-73%	-53%

Figure 16. Decrease in the studied vehicle autonomy, as a function of the HVAC operation. The case of the HVAC being switch off is used as a reference (i.e. HVAC operation equal to 0%).

Finally, the effect of the driver's behavior on the vehicle's autonomy was analyzed. The respective simulation results (Figure 17) show that for all the studied speed profiles the potential extension/loss of the travelling range may be only marginally affected by the driving style of the bus driver. The upside in terms of vehicle autonomy, corresponding to a more "eco-driving" behavior lies in the order of 1%-2%, while a more aggressive driving behavior could limit the e-bus range by up to 4%-5%. In a recent publication of Varga et al.[16], it was reported that a light-duty electric vehicle's range may be affected up to 10% by the driver's style. The discrepancy between the latter figure and the simulation results presented in this study is attributed to the fact that the city buses speed and acceleration profiles are much smoother than those observed in the case of a passenger electric vehicle.

[15] (Gehm, 2014)

[16] (Varga, Sagoian , & Mariasu, 2019)

HVAC operation [%]	Braunschweig cycle	NY Cycle	Manhatan cycle	UK bus cycle	Thessaloniki: L58 Pylaia-Center	Thessaloniki: L15 City Center	Thessaloniki: L37 Center-Toumba	Thessaloniki: L37 Toumba - Center	Thessaloniki: L17 City Center	Athens: L11 trolley bus Pangrati
Eco-driving	1.2%	2.5%	0.7%	0.0%	2.0%	0.6%	0.7%	1.2%	0.7%	0.2%
Neutral driving	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Aggressive driving	-3.3%	-4.1%	-5.1%	-3.6%	-3.6%	-3.8%	-2.6%	-4.5%	-3.7%	-4.4%

Figure 17. Decrease in the studied vehicle autonomy, as a function of the driver's profile. The case of neutral driving is used as a reference.

Combining the operational factors discussed above (passengers' mass, HVAC unit operation and driving style) a probabilistic analysis of the studied electric bus energy consumption and autonomy was conducted. For this purpose, the ARCHIMEDES™ vehicle model was coupled with Monte Carlo simulation. In more detail, the ARCHIMEDES™ model version is deployed in Microsoft Excel®. This way, a seamless coupling between ARCHIMEDES™ and the "XLRisk" add-in could be enabled. This coupling includes i) the definition of user specified input parameters of ARCHIMEDES™ as input parameters for the Microsoft Excel® "XLRisk" add-in, ii) the automatic variation of these parameters through the latter statistical tools and iii) the respective execution of the vehicle simulator for every set of generated input parameters.

The respective results of the Monte Carlo simulation ae presented in Figure 18 and Figure 19. When simultaneously varying the total passengers' mass, the power output of the cabin HVAC and the driver style, the most probable vehicle's energy consumption can range between 1.38 kWh/km ("Braunschweig" cycle) - 2.4 kWh/km ("NY cycle"). Interestingly, the simulation results show that under random operating conditions, the correlation between the average vehicle's speed and the most energy consumption is somehow distorted by the impact of the operational factors, and mainly that of the HVAC system operation, which as explained in section 4.2.2 constitutes the most important determinant of the vehicle's energy consumption and autonomy. Regarding the real driving scenarios recorded via GPS in the city of Thessaloniki, the most probable energy consumption lies in the order of 1.7 kWh/km – 2.1 kWh/km, depending on the driving conditions. As far as the vehicle's traveling range is concerned (Figure 10), the most probable autonomy may vary between 150 km ("NY cycle) – 250 km ("Braunschweig" cycle). Focusing on the real driving cycles, the most probable traveling range might lie in the order of 165 km – 200 km, depending on the driving conditions.

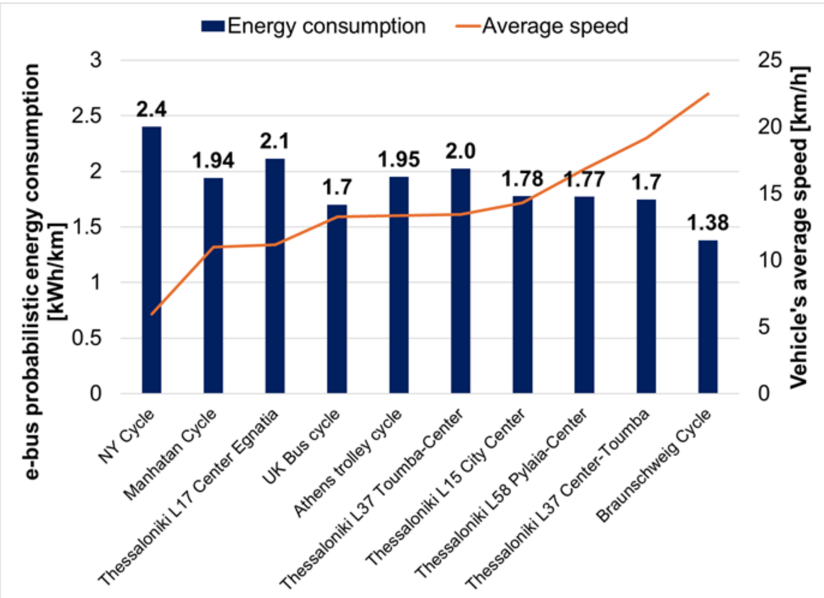


Figure 18. Probabilistic analysis of the Yutong E-12 battery electric bus energy consumption, based on Monte Carlo – ARCHIMEDESTM co-simulation. Results correspond to the most probable energy consumption level, simulated for each driving cycle.

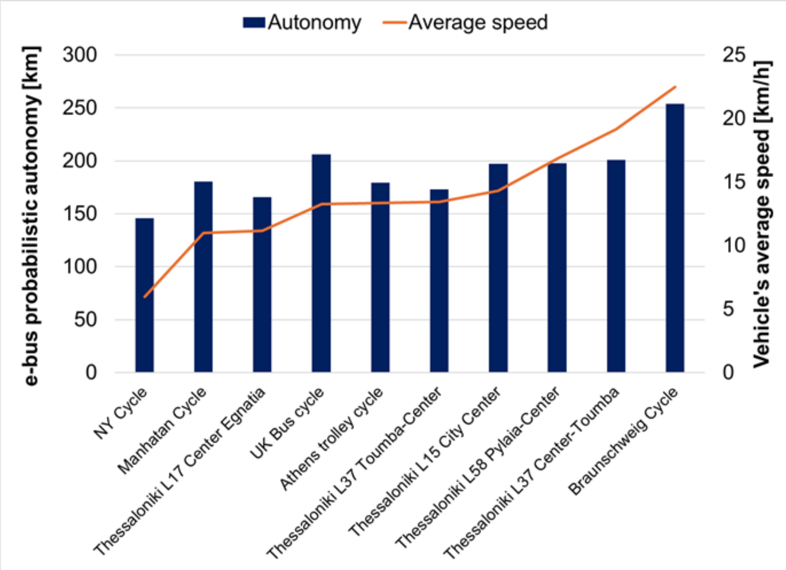


Figure 19. Probabilistic analysis of the Yutong E12 battery electric bus autonomy, based on Monte Carlo – ARCHIMEDESTM co-simulation. Results correspond to the most probable traveling range, simulated for each driving cycle.

Selection of lines for electrification and optimal charging options

The scope of this section is to provide a quantitative assessment of various charging strategies in order to maximize the studied electric bus's autonomy, when circulated in the bus lines shown above. For this purpose, Design of Experiments (DOE) statistical analysis was conducted, using the ARCHIMEDES™ vehicle simulator. In this case, the software was used to generate simulated data related to the energy consumption of the studied battery electric bus, which could then be fed to a DOE analysis, performed in Microsoft Excel®. In the present work, a total of 114 scenarios were formed and analyzed. The different scenarios include variations regarding:

- Passengers mass (250, 2600 and 5200 kg)
- HVAC power consumption levels (0%, 30% and 70% of units nominal power)
- driving styles ("neutral" and "aggressive)
- speed profiles (as presented in Table 3) and
- battery's state of health levels (fresh and aged battery)

The aforementioned scenarios were evaluated for 12 bus lines, which use the depot of Stavroupoli. A key metric used to assess the robustness of each electrified bus line is the "feasibility rate", which was defined as the percentage of the scenarios, where the vehicle's remaining battery pack energy content at the end of the route is at least 5% of the battery's energy content, when the battery is fully charged (i.e. 17.5 kWh). First, the feasibility rate was calculated, considering that for all bus lines an overnight charging session at the Stavroupoli depot is applied. The respective results are shown in Figure 20. In case the ensemble of the 114 scenarios discussed in the previous was taken into consideration, the simulated feasibility rate hovered below 60% for all the studied bus lines (blue bars). Such low feasibility rates tend to indicate that the single daily charge at the depot may not be adequate, resulting in potential frequent buses' downtime. To get deeper insight into the results, the feasibility rate was recalculated, by removing the scenarios corresponding to speed profiles lower than 11 km/h (orange bars). In this case, the feasibility rate is increased and reached up to 65% – 70%. As discussed above, the average bus speeds recorded in the city of Thessaloniki are in the order of 15 km/h and hence scenarios, where the bus mean velocity is lower than 11 km/h may be less relevant (even though they cannot be completely excluded). As such the 65%-70% feasibility rate may be more representative for the electrified bus lines in the city of Thessaloniki. Last but not least, the scenarios where the HVAC system power consumption was non-zero were removed (green bars). In this case, the feasibility was maximized and for most of the bus lines exceeded the threshold of 90%, indicating minor risks of buses' downtime.

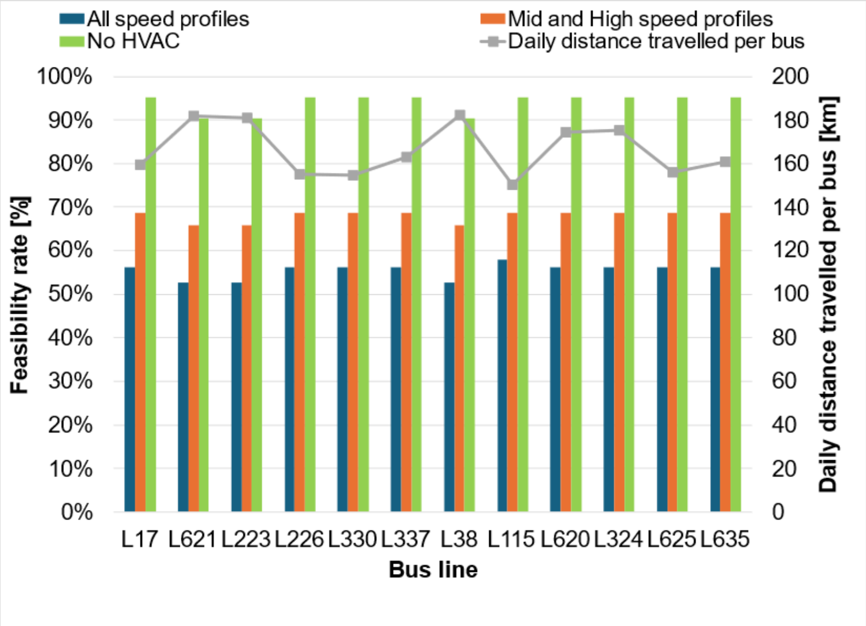


Figure 20. Summary of the design of experiments analysis results, corresponding to the bus lines, where overnight depot charging is planned.

The aforementioned analysis tends to indicate that for the buses charged only through overnight depot charging, a) the low speed driving under heavy traffic conditions and b) the intensive use of the cabin's HVAC system might be the most crucial factors that can materially limit their autonomy and eventually lead to unlike events of downtime. A scheduled opportunity charging could be a measure to mitigate the aforementioned risks. Alternatively, an emergency mobile charging unit could be used in order to prevent vehicles stall amid their service, due to low battery state of charge. To minimize the probability of buses downtime, a single opportunity charging might be suggested on a daily basis, on top of the overnight depot charging, discussed above. In Figure 21, feasibility rates are demonstrated, corresponding to cases where depot charging is combined with a daily 30, 45 and 60 min opportunity charging event. The feasibility rates were calculated for the ensemble of the 114 scenarios. Indeed, a 30 min opportunity charging allowed for increasing the feasibility rates up to 80% for almost all the studied bus lines. Increasing the opportunity charging duration up to 45 min, the feasibility rates further increase and can eventually reach up to almost 90% for the majority of the bus lines. Interestingly, by further prolonging the opportunity charging duration to 60 min (green bars) only minor increases in the simulated feasibility rates are observed.

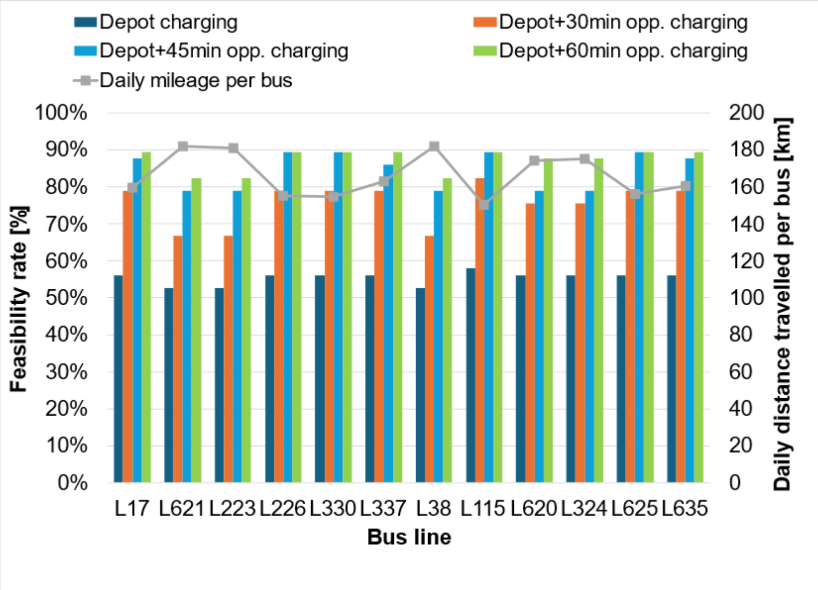


Figure 21. Summary of the design of experiments analysis results, corresponding to the bus lines, where overnight depot charging is combined with opportunity charging events.

Overall, a total of 83.220 simulations were launched, resulting in virtually testing the studied electric bus under approximately 391.400 km. Interestingly, the ensemble of the simulations was completed in less than 4-days week time, which underlines the interest of the followed approach. The main conclusions and recommendations of this study are summarized below:

1. The electric bus speed is among the most crucial determinants, which affect the vehicle's traveling range. The lower the speed profile, the lower the efficiency the electric motor is operated, which results in increased energy consumption and eventually limited autonomy. For the case of the city of Thessaloniki and based on the recorded driving cycles, it appears that the average speed profiles of currently in-service Diesel buses range between 13.3 – 19 km/h, which results in an energy consumption of the studied battery electric bus in the order of 0.75 – 0.9 kWh/km.
2. Moreover, based on the recorded driving cycles, in the city of Thessaloniki, the average road slope may be less than 1%, which results in this parameter having an almost negligible effect on the vehicle's autonomy.
3. Increasing the vehicle's mass tends to increase the inertial forces applied on the vehicle. Simulation results obtained using real driving data from in-service Diesel buses in the city of Thessaloniki showed that the autonomy of the Yutong E-12 battery electric bus may decrease up to a maximum of 13%-19%, when the bus is fully loaded with passengers (depending on the speed profile)
4. The HVAC operation appears to be the most critical factor that could potentially lead to the studied bus downtime, since it was simulated to decrease the bus's traveling range up to around 70%, when the cabin air conditioning system is operated at its nominal power output.
5. Finally, the driver's behavior seemed to have only a minor effect on the studied bus autonomy. "Eco-driving" may increase the vehicle's autonomy up to 2.5%, whereas a more aggressive driving behavior might decrease the bus's traveling range by up to 5%.
6. Randomly varying the operational characteristics of the studied battery electric bus, it appears that the most probable vehicle autonomy under the driving conditions recorded in the city of Thessaloniki may range between 165 – 200 km, at a single charge. The likelihood of a vehicle's traveling range beyond 200 km lies in the order of 21 – 57%, depending on the driving conditions.

UPPER

7. Buses charged only through overnight depot charging should be carefully monitored when they are systematically operated under low speed conditions (e.g. heavy traffic, where speeds may be inferior to 10 km/h) and high ambient temperatures, where the HVAC unit is activated. Both parameters constitute major risks for limiting the studied bus autonomy and could eventually lead to frequent vehicles' downtime, due to battery's insufficient state of charge
8. Combining overnight depot charging with a scheduled opportunity charging of up to 45 min, could mitigate the range anxiety and increase the likelihood of smooth buses circulation under random operating conditions. At the same time, the use of an emergency mobile charging system could constitute a measure to prevent vehicles stall on the street, under conditions where the level of the battery's state of charge is low.

Estimation of CO_2 savings

The scope of this step is to provide an analysis of the CO_2 emissions, related to the circulation of the Yutong E-12 battery electric bus in the city of Thessaloniki. These results are also compared against the respective emissions of a 12 m Diesel bus with an ultimate target to provide an estimation of the CO_2 savings, that can be created through the substitution of the Diesel buses, currently in service in Thessaloniki, with state-of-the-art battery electric buses. At this stage it should be noted that a thorough analysis of the CO_2 emissions of each bus's technology, throughout the lifecycle of each vehicle, is out of the scope of the present study. To calculate the CO_2 emissions generated during the circulation of each of the studied bus's technology, the total annual distance travelled by the bus fleet, the energy consumption of the bus and the CO_2 intensity of the energy source used to power the vehicle (i.e. electricity and the Diesel fuel) are required. Eventually, the CO_2 emissions can be calculated through the following formula:

$$m_{CO2}\left[\frac{g\ CO_2e}{year}\right] = \Delta x_{daily}\left[\frac{km}{day}\right]\cdot 365\,\frac{days}{year}\cdot E_{bus}\left[\frac{kWh}{km}\right]\cdot I_{CO2}\left[\frac{g\ CO_2}{kWh}\right] \quad (1)$$

Where: mCO_2 is the annual CO_2 emissions of the bus fleet [g CO_2e/year], Δxdaily is the total daily traveling distance of the bus fleet [km/day], Ebus is the average energy consumed by the bus fleet [kWh/km], ICO_2 is the CO_2 intensity of the source of energy, used to power the vehicle [g CO_2/kWh].

Regarding the battery electric vehicle, the energy consumption results, derived from the Monte Carlo simulations (Figure 9) were used. In more detail, an energy consumption of 1.88 kWh/km was considered, which corresponds to the average value of the most probable energy consumption levels, that were calculated for the driving cycles, where the average speed profile was between 13-16 km/h. Regarding the CO_2 emissions, related to power generation, public data from the European Environment Agency (EEA) were used[17]. Particularly for the case of the Greek capacity mix, the respective level of CO2 emissions averaged 416 g CO2e/kWh of produced electricity in 2022.

Combining the aforementioned values, the CO_2 emissions, for the Yutong E-12 battery electric bus were calculated for each bus line and the respective results are shown in Figure 22 (blue bars). As far as the CO_2 emissions, generated by a conventional Diesel bus are concerned, a CO_2 intensity of 2.69 g CO2e / l Diesel was considered, according to data provided by the U.S. Energy Information Administration[18]. Provided the Diesel fuel average energy content is in the order of 45.5 MJ/l fuel[19], the average CO2 intensity of the fuel can be calculated equal to around 213 gCO_2/ kWh Diesel (that is: 45.5 [MJ/l] · 1000 [kJ/MJ] / 3600 [s] · / 2.69 [g CO_2e /l]). Concerning the average fuel energy consumption, Volvo Buses have published that the average energy consumption of a battery electric bus can be up to 80% lower compared to that of a Diesel one[20]. Daimler Buses have earlier published a more detailed breakdown of the energy consumption

[17] (European Environmental Agency (EEA), 2023)

[18] (U.S. Energy Information Administration, 2023)

[19] (European Automobile Manufacturers' Association, 2024)

[20] (Volvo Buses, 2017)

of a battery electric and a Diesel bus, based on a SORT2 driving cycle[21]. In this benchmarking, the manufacturer has estimated that the average energy consumption of the company's latest Diesel bus model (EURO VI technology) was almost 2.3 times higher compared to that of the Daimler's battery electric bus eCitaro. Even though, the existing Diesel buses in service, in the city of Thessaloniki may not be EURO VI compliant, the aforementioned value was considered as a relatively reasonable assumption, for the purposes of this study. Therefore, the average energy consumption of a conventional Diesel bus was calculated equal to around 4.3 kWh/km (that is 1.88 kWh/km assumed for the electric bus, multiplied by 2.3). Injecting the aforementioned figures in equation 1, the annual CO_2 emissions generated by a conventional Diesel bus for each bus line were calculated and the respective results are shown in Figure 22 (orange bars). As it was expected, the CO_2 emissions generated by the battery electric buses fleet is lower than those of the Diesel buses, which results in CO_2 savings, shown with green bars in Figure 22. By aggregating the CO_2 saved from all the bus lines to be electrified it was calculated that up to 824 t CO_2 can be saved per annum.

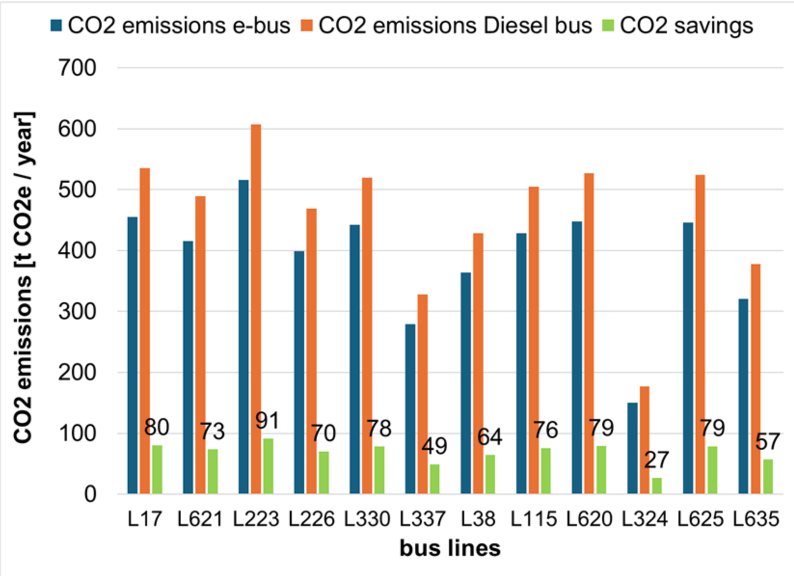


Figure 22: CO2 emissions generated through the circulation of the Yutong E12 battery electric bus and a typical conventional Diesel bus. CO2 savings are derived as the absolute difference between the CO2 emissions of the aforementioned bus technologies.

At this stage, it needs to be noted that the increasing penetration of renewables in Greece, as already prescribed in the National Energy and Climate Plan (NECP)[22], has the potential to further increase the demonstrated CO_2 savings. At the same time though, it should be acknowledged that a direct link between renewable energy generation and the CO_2 emissions reduction from the battery electric buses may be misleading. As a matter of fact, renewables and particularly photovoltaics tend to generate energy during specific time windows of the day. Moreover, both wind and solar power plants' generation is highly dependent on the weather conditions. That said and given that the battery electric buses may mainly charge overnight at the depot, it is highly probable that they would physically absorb electricity mainly produced via thermal assets, such as gas turbines and/or lignite plants, which can generate power, during the night hours, where renewables generation may be limited or even zero. In such a case, the electricity consumed by the electric buses, used in Thessaloniki may be related to CO_2 emissions, which exceed the level of 416 g CO_2e/kWh assumed above.

An effective way for increasing CO_2 savings, when deploying battery electric buses, in Greece, where renewables penetration is growing, would be to directly purchase "green" electricity from renewable energy generators, through a

[21] (Daimler Buses, 2024)

[22] (European Commission, 2023)

Power Purchasing Agreement (PPA). PPAs are typically signed between a renewable energy generator and a consumer of electricity, with an aim to provide a certain volume of “CO_2 free” electricity to the latter, for a certain period of time, at a fixed price. Currently, a typical tenor of a PPA in Greece may vary from 2-10 years, whereas the respective price of the contract is part of a negotiation between the generator and the offtaker. PPAs are typically accompanied by guarantees of origin (GoO), which can be further traded as commodities. The delivery of the energy may be physical (in case of proximity between the generator and the offtaker – less typical case) and/or virtual (which is the most typical case and a utility acts as the responsible party for delivering the energy). To demonstrate the effect of a PPA on the potential CO_2 savings that could be achieved by introducing battery electric buses in the city of Thessaloniki, it was assumed that 20%, 30% and 50% of the energy volume required for charging the fleet of the battery electric buses, could be secured via a power purchasing agreement. In such a case, the PPA volumes would be CO_2 free and hence could further increase the CO_2 savings discussed above. The respective results are shown in Figure 23. Indeed, the introduction of a PPA can significantly enhance the CO_2 savings, in all the studied bus lines. Overall, our analysis showed that:

- Without a PPA the total annual CO_2 savings may be up to 824 t CO2e
- By purchasing 20% of the total required energy for charging the electric buses’ fleet via a PPA, the total annual CO_2 savings may be doubled and reach 1756 t CO2e
- If the PPA volume increases to 35% the annual CO2 savings may be as high as 2456 t CO2e,
- whereas for purchasing 50% of the required electricity volume, the annual CO_2 savings could be maximized and eventually total 3155 t CO2e

The conclusion of this exercise may be obvious and clearly shows that a PPA between the association of public transport of Thessaloniki and a renewable energy generator would be beneficial for increasing the CO_2 savings, related to the deployment of the fleet of the Yutong E12 battery electric buses. At the same time though, it should be noted that the exact volume of electricity to be procured and the price of the purchase are topics for negotiation between the generator and the consumer, which is beyond the scope of the present study.

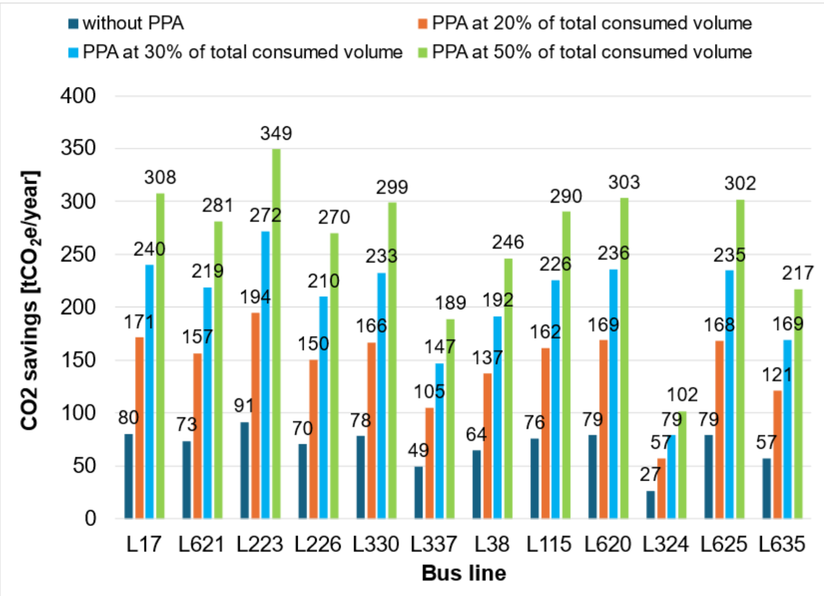


Figure 23: CO2 savings by purchasing 20%, 35% and 50% of the total electricity volume, required to charge the battery electric buses of the city of Thessaloniki, through a power purchasing agreement (PPA).

5.3.1.3. Challenges & Mitigations

No challenges were identified during the development of TES_09.

5.3.1.4. Next steps towards implementation

Having estimated the CO_2 savings from the electrification of the public bus fleet and considering that electric buses have already started operating in the city, as a next step, appropriate mechanisms for communicating this new “electrified era” to the citizens of Thessaloniki will be defined. These mechanisms could include direct messages for the public transport users, that could be transmitted through variable message signs (VMS) within buses or/and bus stations.

5.4. Île-de-France (Versailles Grand Parc)

5.4.1. IDF_06 : Observatory of mobility for Versailles agglomeration

5.4.1.1. Description of the measure and main outcomes expected

Measure IDF_06 aims to create a mobility observatory for elected officials and transport stakeholders for Versailles and the 18 municipalities of its conurbation. This involves creating a platform that collects, aggregates and returns all information relating and inherent to mobility to users of the platform.

The objective is to provide elected officials with clear information on the uses of mobility in the urban area in order to make decisions and put in place appropriate infrastructure and enable decision-making based on facts rather than opinions.

5.4.1.2. Preparation of the measure

<u>Identification of data sources and user experience</u>

A first phase allowed us to identify the main aspects of the technical and functional architecture of the observatory platform. Through several work sessions common between VGP and Redlab, we were able to highlight and identify the data as well as the philosophy of the observatory :

- The tool must make it possible to collect information from numerous data sources in real time.
- Each data source must highlight different indicators relevant to elected officials.
- The indicators may be of different nature (graph, cartography, charts, etc.)
- Different tabs will allow information to be grouped by category (Traffic, Air quality, etc.)
- The frequency of updating and availability of data are key factor success for the success of the observatory.
- The tool must allow consultation of data in real time as well as in the medium-long term to analyse trends and developments.
- VGP must have the possibility to customize the restitution of data to identify correlations between data sources.
- The observatory must offer a catalog of widgets allowing data to be rendered in different forms.

- The tool must be agnostic of VGP and its environment to allow deployment in other pilot cities of the UPPER project.

A court/moyen terme	A moyen/long terme
Données dynamiques à intégrer	**Données dynamiques à intégrer**
1. Qualité de l'air 2. Capteurs Agglo : remontée toutes les 15min sur les 15 stations de mesure de l'Agglo 3. Données AirParif sur la qualité du fond de l'air 4. Données météo (ensoleillement, vitesse du vent, ...) 5. Circulation 6. Comptages par caméras : remontée en quasi-temps réel sur une centaine de caméras orientées circulation. Selon les caméras, comptage VL, PL, VUL, motos, vélos, piétons 7. Données de circulation vélos via Geovélo (solution en cours d'acquisition par l'Agglo) qui remonte les trajets effectués via l'appli de bout en bout 8. Données Waze circulation globale	Transports en commun ▪ Données de validation des billettique bus via Ile de France Mobilité
Données statiques à intégrer	**Données statiques à intégrer**
1. Pistes cyclables 2. Lignes de Transports en Commun 3. Points durs identifiés par les chauffeurs de bus	▪ Places de livraison
Développements	**Développements**
1. Affichage simultané des données citées sur les points disponibles immédiatement (présence de caméra) 2. « combler les trous » entre les points de comptage (via comptages caméra + données Waze + Algorithme) 3. Faire apparaître de manière ergonomique la coexistence des conditions de circulation motorisée et cycliste	▪ Prédictif (conditions de circulation par mode, qualité de l'air) ▪ Affichage des parts modales (via estimation fine de la charge des bus grâce aux données billettiques)

Figure 24 : Identification and prioritization of data sources and needs for Versailles

5.4.1.3. Technical specifications and architecture

The solution is based on Docker and is composed of different development modules.

Centralized database : It stores all the information extracted from external data sources. The database contains all the reference information (municipalities, counting points, etc.) as well as the data relating to the indicators.

ETL (Python) : They are responsible for extracting, transforming and loading data from external sources (Waze, VGP Data lake, External Partners) to the central database

Backend (Java): This is the engine for calculating and processing information

Frontend (React): It allows the display of information and user interactions.

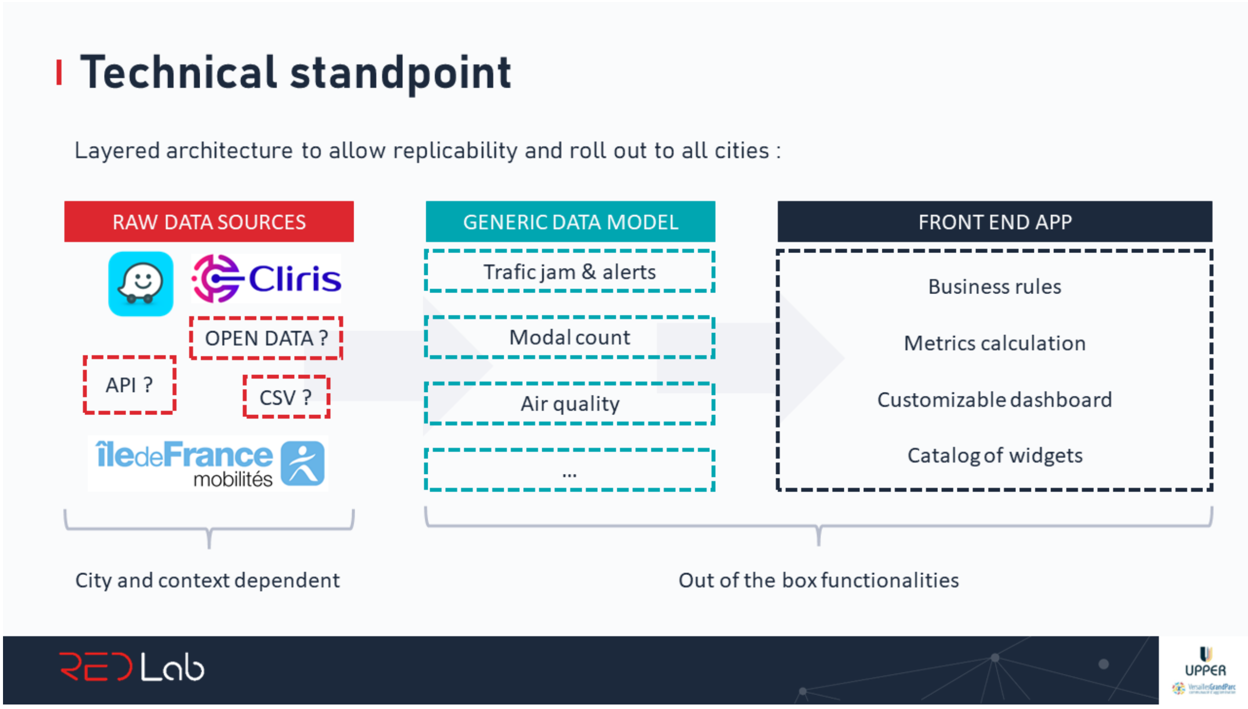


Figure 25: Technical architecture (Macro)

5.4.1.4. Functionnal specifications and printscreens

Figures 26, 27, 28, 29 and 30 below, illustrate the first developments carried out and the provision of data sources (Waze, Air quality analysis station, Cycle paths, Identification of counting flows by AI-boosted camera, Weather report and ETL scheduling).

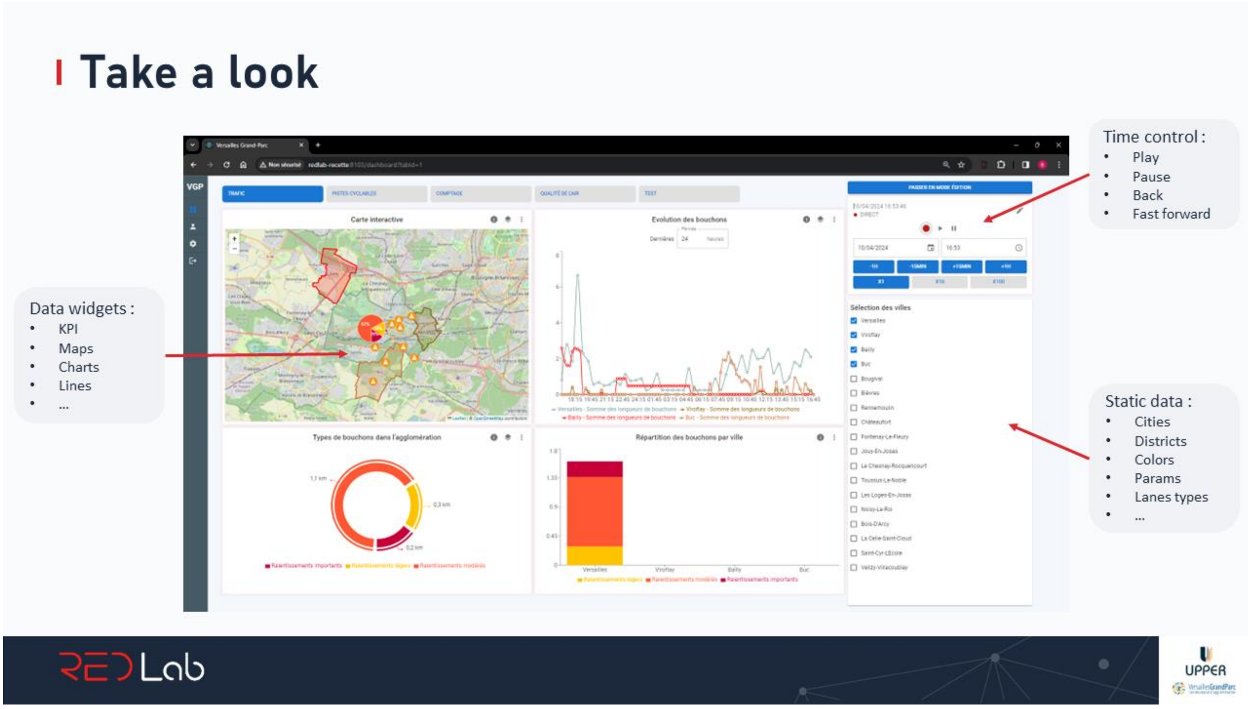


Figure 26 : Trafic jam and alerts in real time

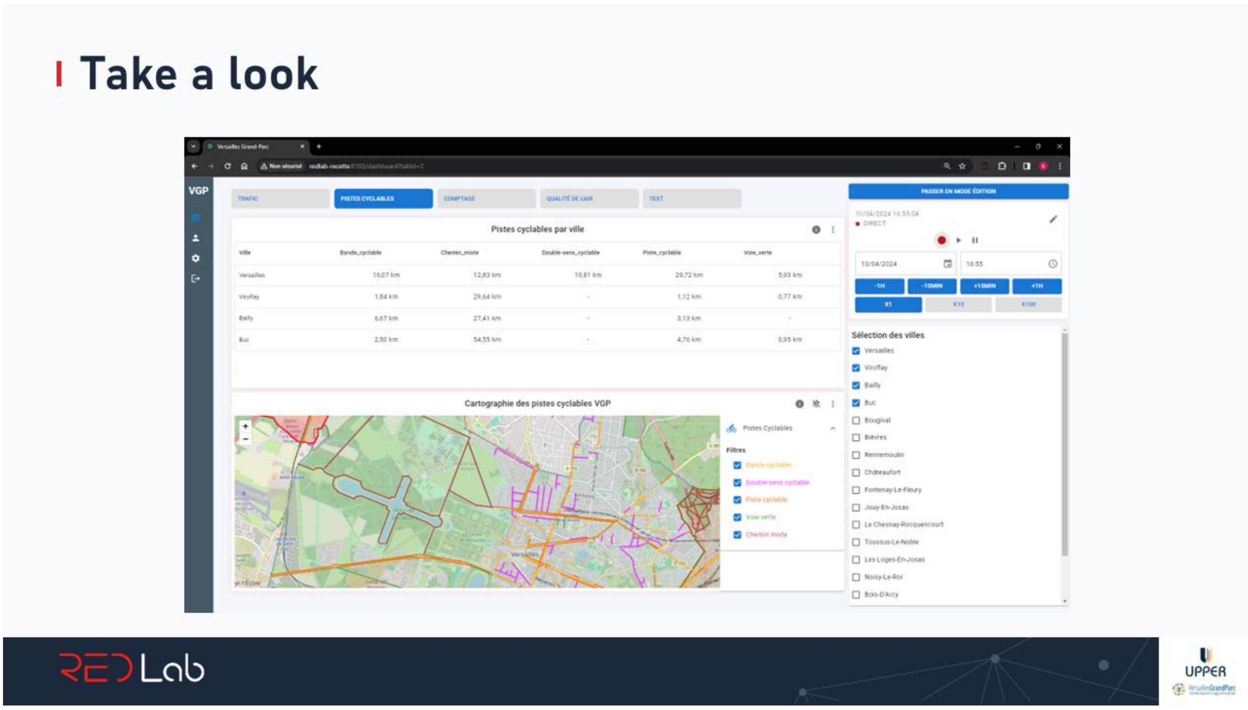


Figure 27 : Bycicle path

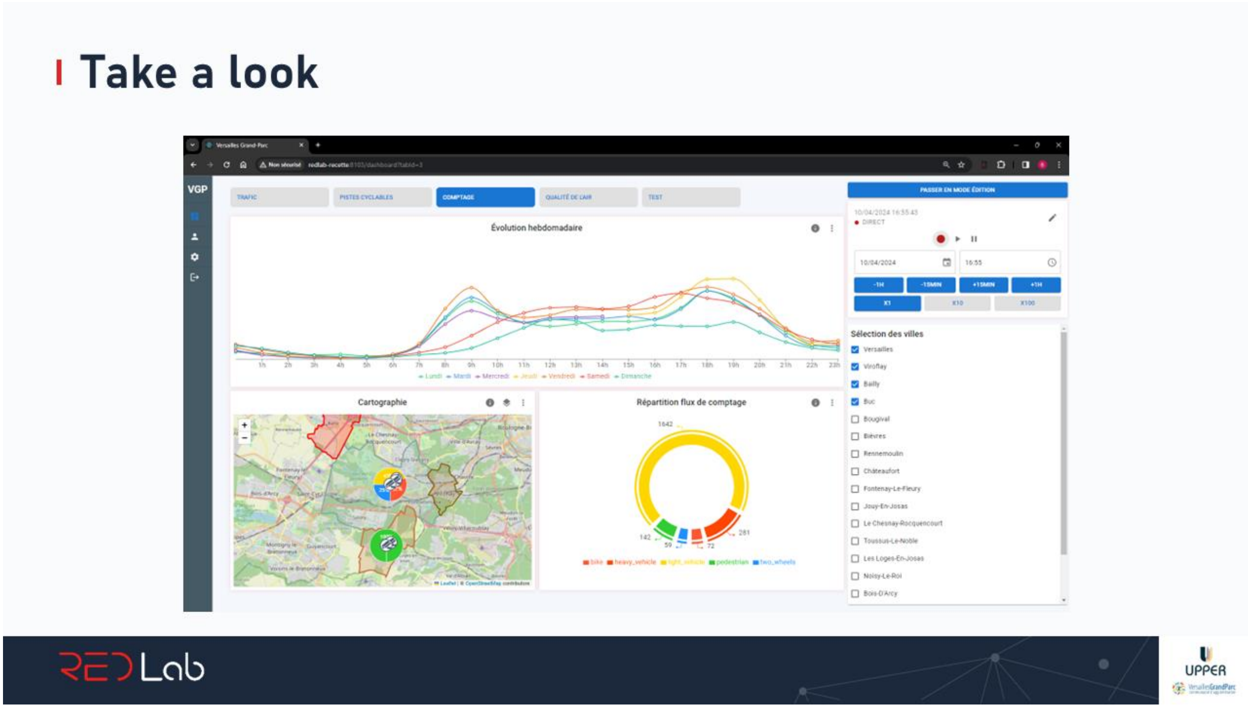


Figure 28 : Cameras and AI accounting for mobility types

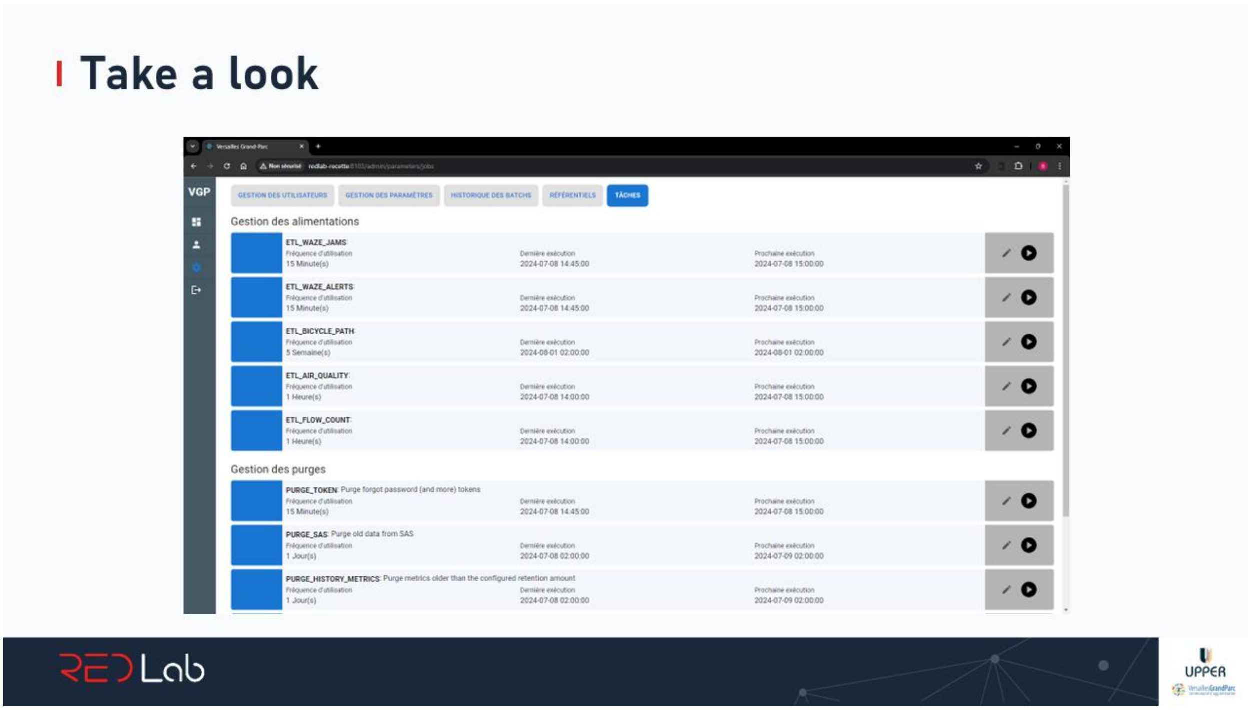


Figure 29 : ETL Scheduling and settings

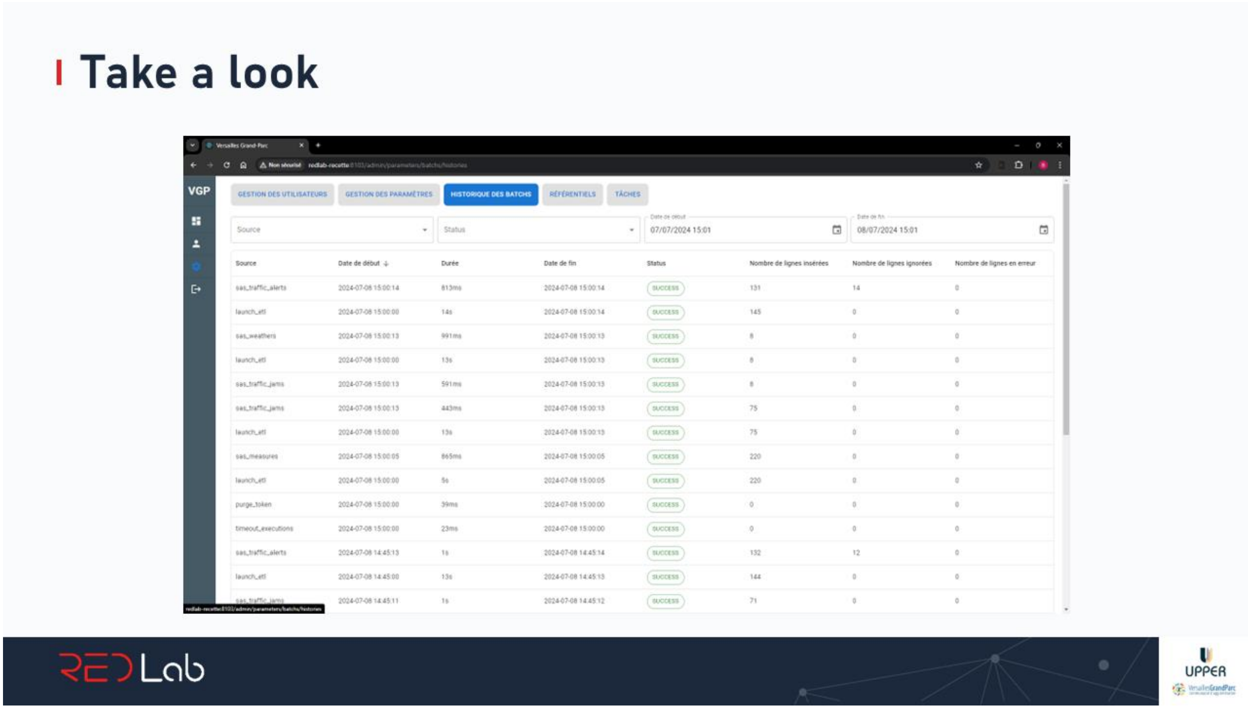


Figure 30 : Global view of workers activities

5.4.1.5. Challenges & Mitigations

The main technical difficulties are that the data sources are heterogeneous, refreshed at different frequencies and in various formats. We must keep in mind the idea of building an agnostic model of Versailles to create a real platform reusable in other contexts for UPPER. That implies the construction of an open data model which required several redesigns before being fully operational.

Beyond the technical difficulty, the availability of raw data remains the main challenge of the project. The design and ideation phase is relatively simple but it relies on the fact that the data will be available. The major difficulty we encounter here is being able to access data sometimes held by private organizations and who do not wish to make it available to Versailles.

5.4.1.6. Next steps towards implementation

The observatory's roadmap contains various major subjects such as the ability to aggregate information to study long-term trends. Initially we had envisaged the observatory as a platform which consolidates data over 3 to 4 weeks. This challenge having been accomplished, we have opened up the use to retention and a broader vision of the data.

The tool must provide an answer to this question “What was the impact of implementing this measure?” This information can only be assessed in the long term and we wish to offer the possibility to aggregate data over periods of time (days, weeks, months, years, etc.) to observe developments and trends.

In the meantime, we continue to feed the observatory with new data sources and test the limits of this agnostic model.

5.5. Rome

5.5.1. Measure ROM_05 “New LEV and ZEV bus fleet – network adaptation”

5.5.1.1. Description of the measure and main outcomes expected

The objectives of this measure are in line with the provisions of the SUMP that indicates, among the others, the need to re-balance the modal share in favour of PT in Rome. In addition, the pandemic emergency has contributed to move more people away from collective transport modes. The Rome bus fleet has an average age of 9 years, with most of the buses procured in 2002-2003. The local administration and ATAC have plans to lower the average age of the entire bus fleet to 5 years. Taking the opportunity to procure LEV and ZEV buses thanks to the RFF funds.

In compliance with the SUMP's goals supporting the need for investment in renewing the PT surface fleet with LEV and ZEV buses by 2030, ATAC, the main PT operator, has defined its need for new buses between 2023 and 2026: 1057. Rome has therefore implemented a major strategy to integrate LEV and ZEV buses into the PT surface fleet, while at the same time providing for a redesign of the PT's low-emission routes.

Indeed, the complex project of integrating ZEV vehicles within the current fleet requires careful route planning to enable the efficient operation of wide-area service. Also of paramount importance is the rescheduling of existing routes and depots, as well as the integration of new ones where necessary.

Targets of the measure are:

- Designing and Adapting the PT network to fit the needs of the new and sustainable bus fleet
- Reducing emissions of the PT fleet
- Increasing the Customer satisfaction on the PT service
- Ensure smooth operation of bus fleet during fleet renewal
- Reducing emissions due to PT
- Increasing the quality of the PT supply and of the customers’ satisfaction

Following the introduction of 411 electric buses, 269 hybrid buses, 344 methane buses, 33 EURO 6 buses and the implementation of a new depot, this measure will deliver:

- Identification of the need for the buses fleet renewal
- Introducing ZEV and LEV buses (procurement procedures)
- Design and adaptation and integration of the new buses (including LEV and ZEZ) in the PT network
- Participation process with the territorial representations for the design of the lines
- Evaluation of the Customers’ satisfaction, raising awareness on environmental issues
- Report on the assessment of the new services.

5.5.1.2. Preparation of the measure

This measure is strongly connected to measures ROM_01, ROM_02 and ROM_09 since the disincentive to use private transport is only possible through an improvement of the public transport service, road transport and rapid mass transport (ROM_04).

Preparation for the measure requires first a new strategy for depots and routes.

In fact, the new electric buses have a different mileage range from the traditional ones in use today, and the routes will have to be adapted to their new technology, requiring compatibility between battery consumption time and location of depots in the city.

This requires:

- electrification of existing depots
- design of new routes.

Concerning the first point, Rome is currently implementing the realisation of electrification of the five depots to be used for the parking of the new electric buses, of which four implemented by ATAC S.p.A. (Portonaccio - area called "bis" - Tor Sapienza, Grottarossa, Trastevere) and one by Roma Capitale (Piazza Ragusa depot, 'Tuscolana').

Specifically, the Ragusa depot, will be electrified through a complex public-private partnership procedure, which brings together an architectural project of total restoration and electrification of a listed building in the center of the city and a project financing that provides for a fifteen-year fee with which the administration will manage the building and the energy supply.

A study of the new routes is currently underway.

5.5.1.3. Challenges & Mitigations

Part of the measure usfruits from NRRP funds in the amount of 208,500,000.00 euros for the purchase of electric buses and 84,071,037.00 euros for the construction of charging infrastructure.

This requires meeting the milestones dictated by the type of funding, which have been met in full, with a time target of June 2026. Therefore, buses will be purchased and registered by December 2025, while depots will be finished by the summer of the following year.

To meet the targets, it has been necessary to choose different partners to manage the tenders, thus being able to start several procedures at the same time and increasing the staff dedicated to the activities.

5.5.1.4. Next steps towards implementation

The next step calls for the need to find:

- appropriate support and training of specialized personnel to manage the new charging systems installed in depots;
- adequate support for the maintenance of the new vehicles;
- identification of partners for electricity supply and contract management;
- recirculation of the necessary funds for the procurement of the new energy source.

5.6. Mannheim

5.6.1. Measure MAN_03: Data-driven platform for supporting PT planning and operations based on the concept of Mobility-as-a-Right

5.6.1.1. Description of the measure and main outcomes expected

The Rhein-Neckar-Verkehr (rnv) is still facing challenges with exponentially growing data volumes that are underutilized, amongst others with regards to wholistic and inclusive transportation planning as well as tailored user information.

To address these issues, rnv aims to leverage its data resources more effectively. This involves enhancing data quality, processing capabilities, and infrastructure. By establishing a robust data governance, including metadata management and cloud integration of key data sources, rnv seeks to develop tailored solutions for various use cases while ensuring data integrity.

Initial steps include deploying basic statistical models for use-cases like the monitoring of railroad crossing closures. Subsequently, rnv plans to explore advanced Machine-Learning techniques for applications such as demand forecasting and predictive maintenance. The initiative also emphasizes identifying and addressing gender-specific gaps in data collection to mitigate the Gender Mobility Data Gap.

The outcomes include integrating two data sources into rnv's cloud environment, implementing three basic statistical use cases, and installing one complex machine-learning use case. These efforts aim to optimize data utilization, enhance decision-making processes, and promote fair mobility solutions.

5.6.1.2. Preparation of the measure

The Rhein-Neckar-Verkehr (rnv) has undertaken significant steps to enhance its data governance and integration processes, setting a solid foundation for future initiatives.

Firstly, rnv has defined and finalized principles for data governance. These principles serve as clear guidelines, outlining responsibilities and ensuring consistency in data management practices across the organization. By establishing these principles, rnv aims to foster transparency, accountability, and data integrity throughout its operations.

Secondly, rnv has begun integrating data sources into its cloud environment in alignment with the newly defined data governance principles. The initial data source integration adheres closely to established protocols, ensuring that data is extracted, transformed, and loaded with accuracy and adherence to privacy and security standards. Despite encountering delays related to shortages in available resources, rnv remains committed to completing the integration of data sources by December 2024.

Overall, these steps reflect rnv’s initiative-taking approach to harnessing data as a strategic asset. By enhancing data governance, integrating critical data sources, and advancing analytical capabilities, rnv is poised to unlock significant opportunities for operational efficiency, customer service enhancement, and innovation in public transportation services.

5.6.1.3. Challenges & Mitigations

Due to a lack of expert staff to implement the necessary changes, the progress of this measure was slower than initially planned. Nonetheless, rnv remains committed to the scope of this measure. To achieve this, some steps were parallelized while milestones had to be pushed backwards such as the integration of the 2nd data source and the

Machine-learning use cases implemented. The staff situation also has significantly improved since early 2024 due to intensified recruiting efforts.

5.6.1.4. Next steps towards implementation

In the next steps, rnv is actively engaging selected stakeholders to define specific requirements for various use cases. This collaborative effort ensures that the identified use cases align closely with stakeholder needs and organizational objectives, thereby maximizing the value derived from the integrated data sources.

Moreover, rnv is progressing with the design and implementation of three basic statistics use-cases. These use-cases are designed to leverage the integrated data for detailed analysis and actionable insights, contributing to informed decision-making across operational areas.

5.7. Oslo

5.7.1. Measure OSL_03 “Improve use and accessibility of public transport in conjunction with alternative mobility to reduce private car ownership”

5.7.1.1. Description of the measure and main outcomes expected

This measure aims to increase the use, accessibility and attractiveness of public transportation co-existing and sharing space with other modes of transport. The goal is to pilot a new working method, the Function Distribution Method, on an existing bus route. The method works by highlighting a location struggling with high friction between different functions, and utilizing this working method to improve the situation at the location by reducing and alleviating the friction experienced between the different functions.

After many rounds of measure development the resulting implementation will be located at Tjuvholmen bus stop. The measure have developed from the prior though of improvements occurring along a bus route between separate bus stops, to now being focused on a start/end stop of a bus route. This is due to the importance of improvement at this location, as well as the suitability of the pilot considering the projects time and budgetary limitations.

The Function Distribution Method in short works by highlighting the different functions existing on a location. After highlighting the different functions it seeks out the functions causing friction. Further the methods goal is to distribute the different functions on the area in the aim to improve the situation and reduce the friction experienced for all functions. For the location of Tjuvholmen, this includes the functions Bus, Taxi and Goods delivery.

The choice of Tjuvholmen as the location is not only because its experienced issues, but also because of its importance as the connection point for mobility for the Tjuvholmen area, as well as the planned new neighborhood of Filipstad which is about to be developed. To ensure the utilization of public transportation and other sustainable modes of transport, as well as to emphasize the city’s goal of promoting walking, cycling and public transportation and reduce car traffic by 33% within 2030 compared to 2009, it is important to improve the locations functionality as a junction point.

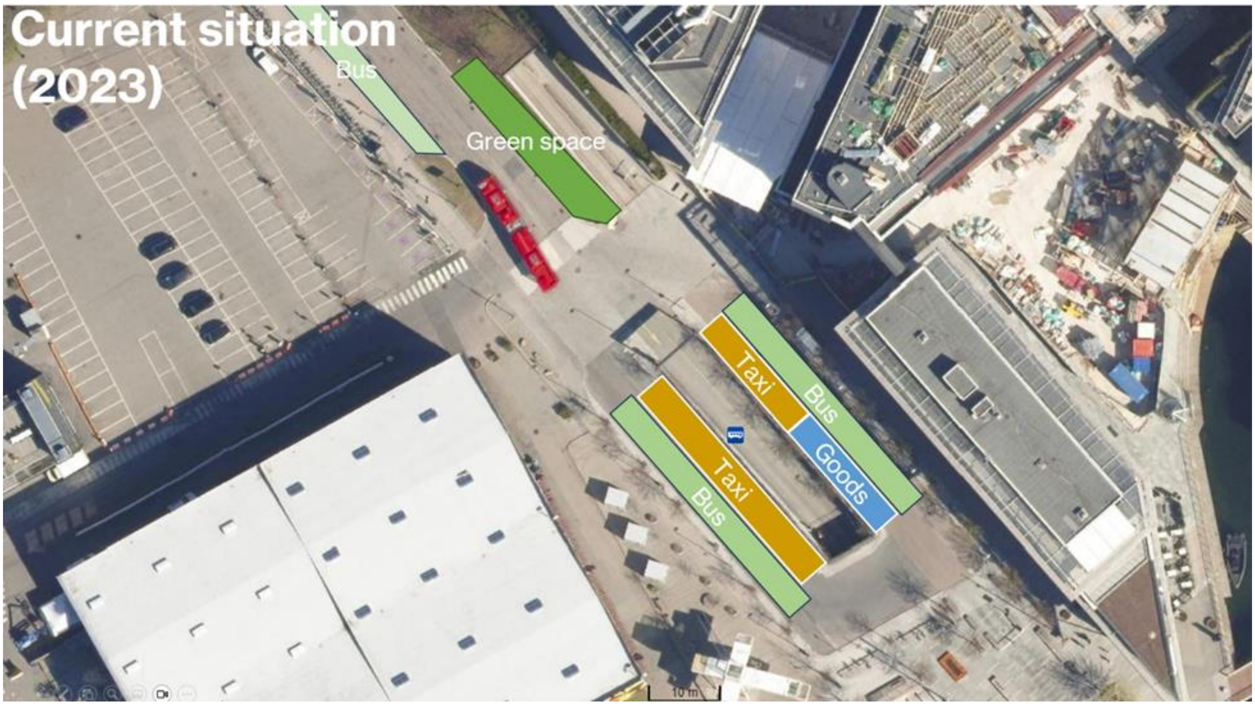


Figure 31: Current situation

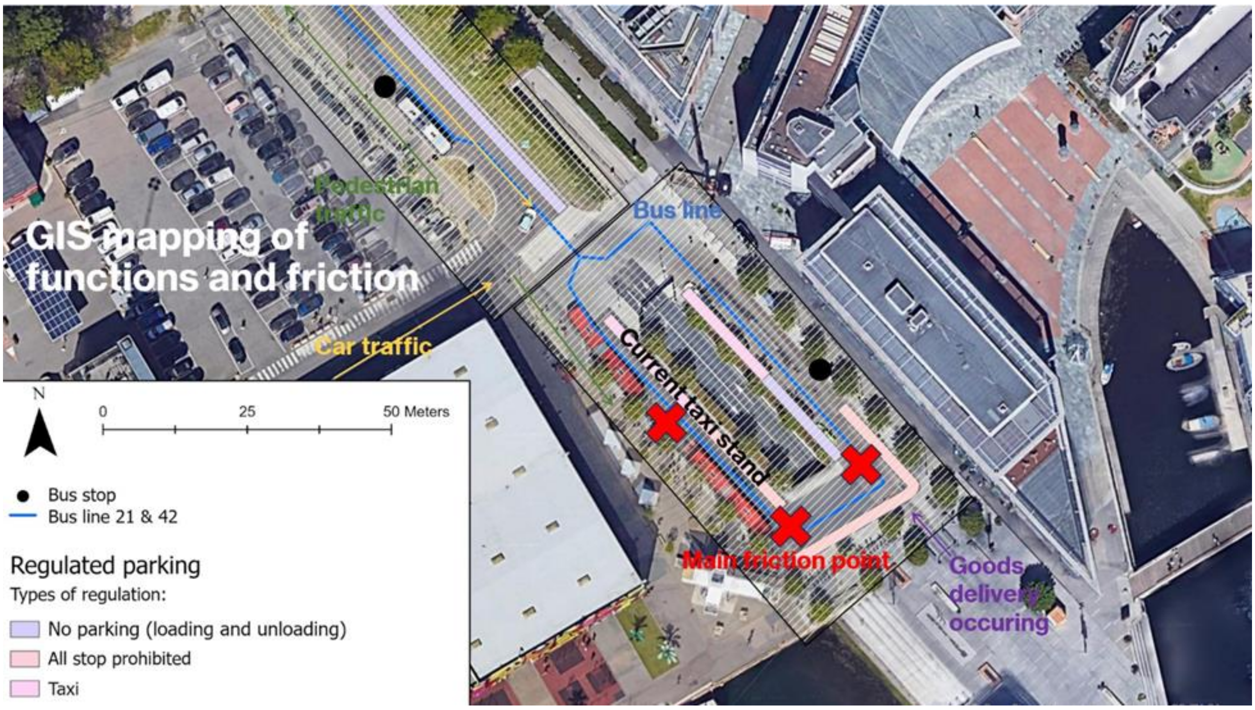


Figure 32: Mapping of functions and frictions

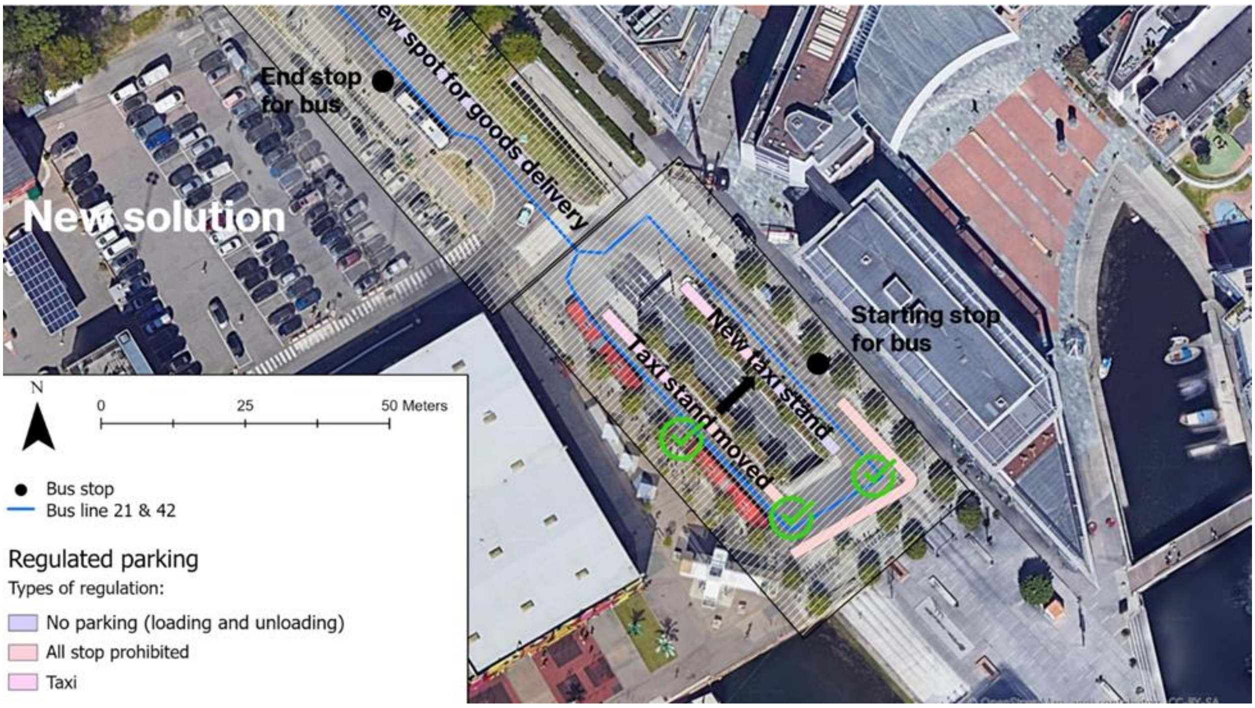


Figure 33: Planned solution

5.7.1.2. Preparation of the measure

During the course of this project, the measure OSL_03 have been through different development phases before its current shape and form. The measure originally started out as the creation of a SUMP, which Oslo currently does not have. However, it was early on clarified that this was a politically and time-consuming process. Thereby the measure was re-developed into the measure it is currently, the piloting of the Function Distribution Method (FFM).

In the process of preparing this measure it first began realizing what the pilot could include. This was done by arranging internal workshops and meetings for information gathering and cooperation. This involved the working method itself, as well as beginning the work of figuring out a suitable piloting location.

By the utilization and availability of accessibility data, as well as mapped locations experiencing problems in line with friction between functions, the search for a suitable piloting location was narrowed down.

The scope of the pilot was also something that also had to be established, and it was eventually realized what could be accomplished within the UPPER time and budgetary limitations. This influenced the selection of locations available for the pilot, as some would anticipate larger and more time-consuming work than the project is suitable for.

The eventual selection of a suitable location made it possible to begin applying the Function Distribution Method (FFM) to the given location. This involved mapping out the different functions present at the location, and further realizing which was causing frictions. Thereafter the process of alleviating friction by distribution of the functions began, and a plan was prepared.

After the plan for the location was concluded, the next process was to clarify the necessity of permits and regulations before implementation can begin. Among which was the element of a flowerbed/greenery which needed to be relocated before being allowed to start the work to improve the solution for goods delivery. This, as well as the availability of necessary entrepreneurial work, influences the starting time for the implementation. Starting point for implementation is estimated at the end of August / start of September.

5.7.1.3. Challenges & Mitigations

The key challenges experienced for measure OSL_03 was originally the unfeasibility of the planned SUMP evaluation due to time constraints as well as the large politically related work needed to be done. This caused the necessity to rethink the measure, basically starting from scratch.

Furthermore, the realization of time and budgetary limitations for the piloting of the Function Distribution Method, whereas some locations and plans were deemed not suitable for the project. Originally the method was supposed to be tested along a bus route in-between different stops. The realization of this was important so the measure could be further developed to fit within the project with the help of PTO Ruter and other internal colleagues.

As the original plan was not applicable, and the more suitable location ended up being at the start/end stop of a bus line, this has influenced the evaluation indicators previously selected for the measure. New indicators suitable for the current measure status will thereby have to be realized and applied.

An additional challenge is the closure of Ring Road 1 which have just occurred. This will last for 3 years and can have unforeseen effects on the measure and its results. This is something we will have to try to calculate the effects of, but at the same time something that can be challenging due to the recentness of the closure and its unknown effects on the traffic circulation throughout the whole city.

5.7.1.4. Next steps towards implementation

The next steps towards implementation will include awaiting further information regarding the entrepreneur's availability.

Before implementation can begin, the relocation of the greenery/flowerbed needs to be done. This is planned to occur during the end of August / beginning of September.

There is need to update and realize new evaluation indicators for the measure due to its development. The prior indicators of waiting time and average speed between bus stops is not applicable for the resulting location which is a start/end stop. We are working on new evaluation indicators.

5.8. Lisbon

5.8.1. Measure Lis_04: To improve PT offer, adapted to school students

5.8.1.1. Description of the measure and main outcomes expected

This measure has two sub-measures described below as task 1 and task 2.

- Sub-Task 1: *Amarelo* Pilot project – Using the regular bus service, we provide on-board monitors to assist school rides on selected routes.
- Sub-Task 2: *Navegante Escola* PT ticket card – expand *Navegante Escola* PT card to kindergartens and high school to promote PT use in the student community.

5.8.1.2. Preparation of the measure

Sub-Task 1: Amarelo Pilot project

This sub-measure comprises an annual demo of testing routes/buses careers and schools.

For 2023-2024 school year:

In August 2023 the public tender for the company that prospectively collects and analyses data was launched and finally adjudicated in October that year.

In the first school trimester (September to December'23) the engagement of stakeholders was conducted through bilateral meetings. With these stakeholders on board, it was possible to select 16 schools. These were the 5 parish and respective schools identified:

- Benfica – EB Jorge Barradas, EB Professor José Salvado Sampaio, EB Parque Silva Porto, EB Pedro Santarém, EB Quinta de Marrocos.
- Estrela – EB Fernanda Castro, EB nº 72.
- Olivais – EB Paulino Montez, EB Arco-Íris, EB Viscondessa Olivais, EB Adriano Correia de Oliveira, EB Alice Vieira.
- Santa Clara – EB Pintor Almada Negreiros, EB Eurico Gonçalves.
- Parque das Nações – EB Parque das Nações, EB Vasco da Gama.

In order to serve these schools 70B, 67B, 29B, 40B, 26B bus routes were identified, and for some of them its schedule was adjusted to the school entrance time.

Figure 34: Example of flyer distributed at school entrance to promote the project

This pilot project is promoted by the Municipality and CARRIS (municipal company). The parishes also play a very important role as the operational partner, in charge of the day-to-day management, for example, the contraction of the monitors, the follow-up to the daily service, etc.

For students to have access to this service, their parents/tutors must sign up online, in the respective school link at CML website https://www.lisboa.pt/temas/mobilidade/escolar/amarelo

The student data is collected, according to the General Data Protection Regulation legislation, and the parish coordinator of the AMARELO is responsable for all the interactions with parents/tutors CML conducts a daily monitorization of the project, collecting the data about the number of participants, number of seats available and the actual time of arrival to school. The monitor on the bus has the task to fill up, every day, a quick inquiry in an specific platform.

CML prepared all promotion and publicizing materials and campaigns giving full support to parishes and schools in this matter. Several promoting activities in each school were conducted, at least one per school, at morning entrance schedule that allowed the interaction with parents/tutors and several other school agents.

Benfica - carreira 70B

EB Jorge Barradas

O AMARELO destina-se apenas aos alunos do Jardim de Infância e 1º ciclo (1º, 2º, 3º e 4º anos de escolaridade).

A carreira de bairro 70B tem um serviço de monitores, com o apoio da Junta de Freguesia de Benfica, que vão acompanhar os alunos a bordo e os levam até às escolas.

Circulação 1: O monitor entra na paragem Estação de Benfica (2805) às 8h07 e segue até à paragem R. João Ortigão Ramos (13702) onde sai às 8h34
Circulação 2: O monitor entra na paragem Bairro Boavista (8802) às 8h29 e segue até à paragem R. João Ortigão Ramos (13701) onde sai às 8h45

Inscrição ↗

Figure 35: Example of online enrollment for school EB Jorge Barradas

Olivais - carreira 29B

EB1 Adriano Correia de Oliveira

Nesta escola o AMARELO destina-se apenas aos alunos do Jardim de Infância e 1º ciclo (1º, 2º, 3º e 4º anos de escolaridade).

A carreira de bairro 29B tem um serviço de monitores, com o apoio da Junta de Freguesia dos Olivais, que vão acompanhar os alunos a bordo e os levam até à escola.

O monitor entra na paragem C. Comercial Olivais (8421) às 8:10h e segue até à paragem R. Cidade da Beira (7518) às 8h39.

Inscrição ↗

Figure 36: Example of online enrollment for school EB1 Adriano Correia de Oliveira

For the second school trimester, a revision was necessary, based on data. One more parish was identified bringing the total number to 6 parishes. The number of schools remained the same (16), even though there were 4 school changes:

Benfica – EB Jorge Barradas, EB Professor José Salvado Sampaio, EB Parque Silva Porto, EB Pedro Santarém.

Estrela – EB Fernanda Castro, EB nº 72.

Olivais – EB Paulino Montez, EB Arco-Íris, EB Viscondessa Olivais, EB Adriano Correia de Oliveira, EB Alice Vieira.

Santa Clara – EB Alta de Lisboa, EB Eurico Gonçalves.

Parque das Nações – EB Parque das Nações.

Penha de França – EB Arquiteto Vítor Paulla, EB Professor Oliveira Marques.

In order to serve these schools one more bus route was added: 37B.

Figure 37: Another example of flyer distributed at school entrance to promote the project

In April 2024, the midterm report from the company led us to the decision of the following changes for the third trimester: the Santa Clara Parish and the respective school were withdrawn from the project, once there were no students using the service. As for the remaining schools/parishes they all continued in the project.

With the school year ending, bilateral meetings with parishes and schools were conducted in June 2024, providing a space for experience sharing and recommendations.

At this moment, we are preparing for the new school year (2024-2025) based on the final school-yearly report from the company.

Sub-Task 2: Navegante Escola PT ticket card

In the beginning of the school year 2023 there was the executive decision to expand the Navegante card to a broader student community, namely from kindergartens to high school pupils. Subsequently, changes to the Navegante Escola card Platform were conducted, being operational by October 2023. Minor changes had to be made meanwhile and the Platform was fully operational by January 2024.

After that, parents were able to request the card on the Platform at https://apps.cm-lisboa.pt/PACNE/HomePage.aspx?_ts=1720519478454 free of charge.

Figure 38: Image portraying the Platform for Navegante request

These PT cards are personalized, with the identification of the student. Cards are sent directly to the respective schools where parents can pick them up easily.

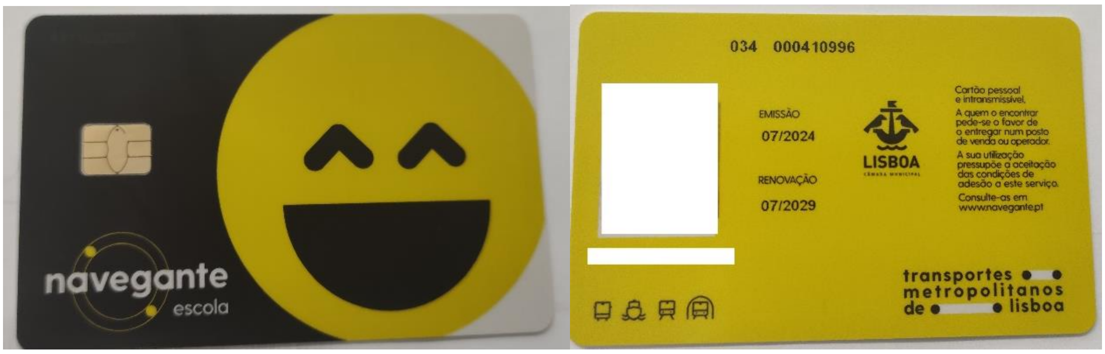


Figure 39: Example of a Navegante Card

Promotion of the *Navegante Escola* PT ticket card is an ongoing process, namely at Lisbon website https://www.lisboa.pt/temas/mobilidade/escolar/cartao-navegante-escola

5.8.1.3. Challenges & Mitigations

Sub-Task 1: Amarelo Pilot project

The biggest challenge was to involve Parishes and actively participate in the project and spread the word within the community. To overcome, CML lead by example, being present, promoting the project in the schools and establishing a trusting relationship with all the Parishes coordinators to incentivize and reinforce participation.

Sub-Task 2: Navegante Escola PT ticket card

The Platform changes and the Navegante Card issuing is done by TML is sometimes delayed. CML overcomes this challenge by urging by direct channels (one-to-one phone and e-mail contacts) with TML.

The online process of submission requires several documents that sometimes are incorrect or misplaced delaying the emission process. CML overcomes this challenge by contacting parents/tutors by email (this email is sent through the platform).

5.8.1.4. Next steps towards implementation

Sub-Task 1: Amarelo Pilot project

The next step is to prepare the school year 24/25 accordingly and take the project to the next level (from pilot to an established service), leading the Parishes to fully engage and take ownership in order to be completely responsible for the operational tasks.

Sub-Task 2: Navegante Escola PT ticket card

Keep up the production/issuing of the Navegante Escola card and its promotion.

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6.Conclusion

This report has highlighted the innovative approaches being developed within Task T4.3 of the UPPER project to enhance the efficiency and reliability of public transport (PT) systems. The task is focused on leveraging technology and data to improve PT offerings and reduce reliance on private vehicles.

The report has underscored the critical role of data-driven approaches in optimizing PT systems. This includes using data to identify and address inefficiencies, adapt operations dynamically, and create new services that cater to user needs. The report has examined the use of various tools and technologies, such as the nuMIDAS toolkit, mobility data spaces and the Function Distribution Method to unlock the potential of mobility data for public transport planning and operations.

The report has also explored the challenges and opportunities of fleet electrification, focusing on the deployment of battery electric buses (BEBs). It has detailed the benefits of BEBs, including lower emissions, reduced maintenance costs, and improved performance, while also highlighting the challenges of high upfront costs, the need for robust charging infrastructure, and the impact of BEBs on the electrical grid.

Moreover, the report has emphasized the importance of user-specific solutions, highlighting the need to tailor PT offerings to meet the diverse needs of different user groups. This includes addressing accessibility challenges, promoting inclusion, and engaging users in the development and implementation of new services.

The report has outlined a series of recommendations to support cities in successfully implementing innovative measures to enhance PT systems. Key recommendations include prioritising a phased approach to adopting data spaces, standardizing metadata catalogues, ensuring seamless integration with existing systems, and engaging stakeholders early in the planning process. The report underscores the importance of a holistic approach to BEB deployment, carefully considering the entire ecosystem, including the bus technology, charging infrastructure, route design, and the impact on the electrical grid. It also highlights the importance of user engagement, accessibility, and environmental sustainability in developing new PT solutions.

Key findings from the UPPER workshops on PT service improvement and data-driven mobility planning include:

- Prioritising accessibility: Public transport should be accessible to all, regardless of financial circumstances or technological access. Cities should explore alternative payment methods and non-digital options.
- Gender-responsive planning: Data collection and service design should incorporate a gender perspective to ensure the needs and experiences of all genders are considered.
- User-centric design: Engaging with users is crucial for understanding their needs and mobility behaviours. This includes involving pedestrians, cyclists, and disability advocates when replanning routes. Citizen engagement should extend to non-digital users.
- Data quality and representativeness: Cities need robust methods to ensure data collected through surveys and other means accurately reflects the diverse population.
- Data privacy: Strict measures are necessary to protect data privacy and ensure secure storage and responsible use of collected information.
- Travel behaviour analysis: Understanding user characteristics, needs, perceptions, and travel behaviour through route modelling and surveys is crucial for designing truly responsive public transport services.

Moreover the following recommendations for cities implementing data-driven mobility measures were collected:

- Standardise data: Focus on data standardization and governance to facilitate public administration data sharing.
- Collaborate with stakeholders: Promote collaboration among stakeholders, including Original Equipment Manufacturers (OEMs), operators, and public entities, to achieve data integration.
- Prioritise privacy: Ensure strict adherence to General Data Protection Regulation (GDPR) compliance throughout data collection, storage, and analysis.
- Integrate data with existing tools: Integrate data collected from public transport use with existing urban planning and mobility management tools for informed decision-making.

Overall, the report has demonstrated the significant potential for improving public transport systems through innovative data capture and sharing methods, fleet electrification, and user-centred design. By implementing the recommendations outlined in this report, cities can move towards more efficient, reliable, and sustainable transportation systems that meet the needs of all citizens.

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7.References

Aamodt, A., Cory, K., & Coney, K. (2021). *Electrifying Transit: A Guidebook for Implementing Battery Electric Buses.* National Renewable Energy Laboratory.

ARCHIMEDESTM. (2024). *e-Kinesis ARCHIMEDESTM*. Retrieved from http://e-kinesis.com/archimedes.html

Caprari, G., Castelli, G., Montuori, M., Camardelli, M., & Malvezzi, R. (2022). Digital Twin for Urban Planning in the Green Deal Era: A State of the Art and Future Perspectives. *Sustainability*.

CIVITAS. (2024, 08 19). *Home CIVITAS*. Retrieved from Civitas Web Site: 3.1.1.1. CIVITAS Initiative

CIVITAS, E. (2024, 08 19). *ECCENTRIC CIVITAS* . Retrieved from CIVITAS Web Site: https://civitas.eu/projects/eccentric

CIVITAS, P. (2024, 08 19). *PORTIS CIVITAS*. Retrieved from CIVITAS Web Site: https://civitas.eu/projects/portis

consortium, C. P. (2024, 08 19). *CIVITAS PORTIS transferability fact sheets - Smart Mobility.* Retrieved from CIVITAS Web site: https://civitas.eu/resources/civitas-portis-transferability-fact-sheets-smart-mobility

Daimler Buses. (2024). *eCitaro presentation*. Retrieved from https://www.mercedes-benz-bus.com/en_DE/models/ecitaro/efficiency.html

Data4PT. (2024, 08 19). *Home*. Retrieved from Data4PT Web site: https://data4pt-project.eu/

DieselNet. (2024). *Emission test cycles*. Retrieved from https://dieselnet.com/standards/cycles/index.php

Dominik Ziemke, I. K. (2019). The MATSim Open Berlin Scenario: A multimodal agent-based transport simulation scenario based on synthetic demand modeling and open data. *Procedia Computer Science*, 870-877.

European Automobile Manufacturers' Association. (2024). *Differences between diesel and petrol explained*. Retrieved from https://www.acea.auto/fact/differences-between-diesel-and-petrol/#:~:text=The%20calorific%20value%20of%20diesel,to%2033.7%20MJ%2Flitre

European Commission. (2010). *Directive 2010/40/EU of the European Parliament and of the Council of 7 July 2010 concerning the framework for the deployment of Intelligent Transport Systems (ITS) in the European Union.* Official Journal of the European Union, L 192, 1-23.

European Commission. (2010). *Implementing Regulation (EU) No 661/2010 of the European Parliament and of the Council of 13 July 2010 laying down detailed rules concerning the designation and operation of National Access Points.* Official Journal of the European Union, L 192, 24-31.

European Commission. (2023, December). *Commission Recommendation, Assessment (SWD) and Factsheet of the draft updated National Energy and Climate Plan of Greece*. Retrieved from https://commission.europa.eu/publications/commission-recommendation-assessment-swd-and-factshe

European Environmental Agency (EEA). (2023, October). *Greenhouse gas emission intensity of electricity generation in Europe*. Retrieved from https://www.eea.europa.eu/en/analysis/indicators/greenhouse-gas-emission-intensity-of-1

FACTUAL, i2cat. (2023). *Unlocking the Future of Mobility with European Data Spaces.* EIT Urban Mobility.

Gehm, R. (2014). *BYD Electric Bus Provides 30-h Service on Single Charge.*

Gossling, S., Kees, J., Hologa, R., Riach, N., & von Stülpnagel, R. (2024). Children's safe routes to school: Real and perceived risks, and evidence of an incapacity-incapability space. *Journal of Cycling and Micromobility Research 2 (2024) 100019*.

UPPER

GTFS. (2024, 08 19). *Resources*. Retrieved from GTFS Web site: https://gtfs.org/resources/

ibi-group. (2024, 08 20). *datatools-ui*. Retrieved from ibi-group: https://github.com/ibi-group/datatools-ui

ipeaGIT. (2024, 08 20). *ipeaGIT gtfstools*. Retrieved from ipeaGIT: https://github.com/ipeaGIT/gtfstools

MobilityData. (2024, 08 19). *Home*. Retrieved from GTFS Web site: https://gtfs.org/

MOVE21. (2024, 08 21). *Main Home - Move21*. Retrieved from Move21 Web site: https://move21.eu/

MOVE21-WP5-D5.2-Technological-Framework. (2024, 04 30). Retrieved from Move21 Web site: https://move21.eu/wp-content/uploads/2024/05/MOVE21-WP5-D5.2-Technological-Framework.pdf

NeTex. (2024, 08 19). *NeTEx _ Network Timetable Exchange*. Retrieved from NeTex Web site: https://netex-cen.eu/

nuMIDAS. (2023). *https://numidas.eu/*.

Sebastian Hörl, M. B. (2021). Synthetic population and travel demand for Paris and Île-de-France based on open and publicly available data,. *Transportation Research Part C: Emerging Technologies*, 107622.

SIRI. (2024, 08 19). *Home*. Retrieved from SIRI Web site: https://www.siri-cen.eu/home.aspx

Skarlis, S., Molos, T., Ayfantopoulou, G., Nikiforiadis, A., & Bakouros, L. (2023). Light commercial electric vehicles with hydrogen fuel-cell range extender: Refueling strategy evaluation. *Research in Transportation Business & Management, 50, 101040.*

Skarlis, S., Molos, T., Skarlis, M., Karvountzis-Kontakiotis, A., Bernatchez, O., & Pronovost, C. (2018). Towards Electrification of Urban Buses Using Model Based Analysis. *SAE Technical Paper No. 2018-01-0408. https://doi.org/10.4271/2018-01-0408.*

Transmodel. (2024, 08 19). *Transmodel – CEN Reference Data Model for Public Transport*. Retrieved from Transmodel Web site: https://www.transmodel-cen.eu/

U.S. Energy Information Administration. (2023, September). *Carbon Dioxide Emissions Coefficients*. Retrieved from https://www.eia.gov/environment/emissions/co2_vol_mass.php

UITP. (2021). *GRPE workshop on low- and zero-emissions heavy duty vehicles : Regulatory gaps and expected egislators' needs.*

Varga, B., Sagoian , A., & Mariasu, F. (2019). *Prediction of electric vehicle range: A comprehensive review of current issues and challenges.* Energies, 12(5), 946. https://doi.org/10.3390/en12050946.

Volvo Buses. (2017). *New Volvo 7900 Electric offers greater range and flexibility*. Retrieved from https://www.volvobuses.com/en/news/2017/oct/volvo-7900-electric-offers-greater-range-and-flexibility.html#:~:text=The%20new%20Volvo%207900%20Electric

Wipke, K., Cuddy, M., & Burch, S. (1994). ADVISOR 2.1: a user-friendly advanced powertrain simulation using a combined backward/forward approach. *IEEE Transactions on Vehicular Technology, vol. 48, no. 6, pp. 1751-1761, Nov. 1999, doi: 10.1109/25.8067*.

Yutong. (2024). *Yutong E-12 city bus*. Retrieved from https://en.yutong.com/products/xE12.shtml

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ANNEX 1: WORKSHOP 2 'POINT OF ATTENTION'

Measure ID	Appraised by	"Point of attention" category	Evaluation result: Point of attention/Comment	Solution you can present	Task
MAN_03		Active stakeholder engagement during measure development	Foster community engagement and collaboration by involving stakeholders in the design, development, and ongoing improvement of the platform.		T4.3
MAN_03	IFPEN	Active stakeholder engagement during measure development	No partners are involved or externally involved in the development of this measure. Does the IT department have all the skills required to perform all technical software development and data processing actions?		T4.3
MAN_06	ICLEI	Active stakeholder engagement during measure development	How did the survey of potential users go, and were there any lessons learnt from the process or gaps that still remain? How diverse/representative was the sample from the population that was obtained?		
MAN_03	EMTA	Data management and privacy	Make sure that data from different kind of sources can be incorporated in the platform. Data that you can rely on to be frequently accessible and available.		T4.3
MAN_06	ICLEI	Data management and privacy	is before and after data being collected across all modes (not just PT) in a given origin-destination? for example, this might help indicate demand or potentially how investment into other modes, e.g. active travel, could provide a cost effective alternative to PT for certain corridors		
MAN_06	IFP	Data management and privacy	Walkability of catchment area will be collected?	Have indicators of quality of access to PT hub	

Measure ID	Appraised by	"Point of attention" category	Evaluation result: Point of attention/Comment	Solution you can present	Task
MAN_05	EPF	Mobility as a right: Universal accessibility leaving no one behind.	It is important to consider people who have difficulties using digital services; e.g., people with a visual impairment. Additionally, there are other groups who might have difficulties in using digital apps, for instance, the elderly, and people who cannot afford the purchase of smart phones. These groups risk being left behind.	awareness raising and training for the handling of new technologies, including mobility technologies, should be reinforced (inclusion is important)	T4.4
MAN_06	ICLEI	Mobility as a right: Universal accessibility leaving no one behind.	Proposed indicators refer to distance to the distance between inhabitants and PT stops - has any further data been gathered to ascertain the quality of this experience (such as presence of footpaths, lighting, perceptions of safety, pollution etc.) that could affect people's own accessibility reality (albeit over a relatively short distance for some people).		
MAN_06	EPF	Mobility as a right: Universal accessibility leaving no one behind.	Do you intend to engage users and find out what they need? How do you intend to design the lines and the areas that they are going to serve?	important to always engage users and have them at the center when new mobility services are being designed or implemented.	
MAN_06	EPF	Mobility as a right: Universal accessibility leaving no one behind.	Important to communicate clearly about the service and make sure it is easy to use - can people e.g. also book it by telephone (using other than digital channels)? Around 20-30% of all passengers are lacking digital skills so alternatives should be offered not to exclude them.	Ensure non-digital communication channels for passengers lacking digital skills (up to 30%!).Solutions proposed by SHOW project to familiarise people with the new service (DRT and/or AV): tutorial at the stop and/or on board; travel coaches or buddies; stewards on board; training; open days; good signage.	
MAN_03	EMTA	Mobility as a right: Universal accessibility leaving no one behind.	Special features to make sure everyone can use public transportation, for instance: information on accessible routes or vehicles	The Vervoerregio is participating in the SMALL project which is part of the Interreg program. They are working on a pilot to incorporate functionalities in an existing app. These functionalities should make it possible to show if certain assets in the station are available, like starts or escalators	T4.3
MAN_03	IFPEN	Mobility as a right: Universal accessibility leaving no one behind.	There is no specification on improving the quality of the collected data to consider gender, particularly women and other minority groups.	Organize a survey on the use of PT for these populations.	T4.3
MAN_03	UITP	Mobility as a right: Universal accessibility leaving no one behind.	It is not clear whether the data sources you have within rnv actually account for gender data or not. If yes, it would actually be interesting to have a description of what data this is and methods of obtaining it.	have a look at the methodology of the Mobility Gender Divide tool from the TRIPS project: https://trips-project.eu/deliverables/#MDI	T4.3
MAN_03	UITP	Seamless multimodality/intermodality	I would argue (but for the moment it is unclear if this will be the case) that at least one of the use cases should be looking at the ticketing/validation data and understand how transfers from various lines/services vary at different times.		T4.3
MAN_03	UITP	Seamless multimodality/intermodality	While it's primarily rnv data that is identified as a source, is there no data from other sources that may be included and intgrated here, most probably data on traffic counting points from the city, or also DB Regio for various combined trips with regional or S-bahn style services	integrate with city or other operator data	T4.3
MAN_03	UITP	Tailored communication for increased acceptance and buy-in	Even internally, if there is some type of a public product that shows results from the dashboard integration, this could increase support within the company	identify 1-2 features of this dashboard that a customer of rnv could use	T4.3

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Measure ID	Appraised by	"Point of attention" category	Evaluation result: Point of attention/Comment	Solution you can present	Task
OSL_03	ECF	Active stakeholder engagement during measure development	Involve local cyclist/pedestrian organisations when replanning the route		T4.3
OSL_05	ICLEI	Active stakeholder engagement during measure development	How did the recent qualitative testing with users go? Were both existing (elderly) users and potential wider new users included? How was the recruitment of potential new users done to ensure inclusivity across potential target groups? Sharing information about the sessions would be useful		T4.5
OSL_05	ICLEI	Active stakeholder engagement during measure development	It seems necessary that potential users can see and feel the vehicles before taking a view - is a physical demonstration being planned in Olso?		T4.5
OSL_03	ICLEI	Mobility as a right: Universal accessibility leaving no one behind.	In planning the corridors, it would be helpful to gain data about the population characteristics surrounding the chosen bus route. This would help determine how "typical" it is, in the Oslo context, and suitable it is for being a test bed that can be replicated in a similar way across the city. This could include factors such as income, age, marital status etc. which can vary, and should be taken into account when planning for needs of consumers (rather than "one size fits all"). Data could come from other sources the local authority might hold, e.g. from census surveys.		T4.3
OSL_03	ECF	Mobility as a right: Universal accessibility leaving no one behind.	When making the assessment of the existing situation on the route, have a detailed look at the situation of cyclists and pedestrians as well - existing infrastructure, but also actual usage (e.g.: Maybe people cross the street not at official crossing points?) Then evaluate how existing issues for pedestrians and cyclists could potentially be improved at the same time as the bus route.		T4.3
OSL_05	ICLEI	Mobility as a right: Universal accessibility leaving no one behind.	Has there been a final decision as to whether phone booking will be permitted (following the serious game)? Would an automated phone booking system be an efficient way of doing this?		T4.5
OSL_05	IFPEN	Mobility as a right: Universal accessibility leaving no one behind.	Digitalizing the entire DRT service can cause difficulties (or even abandonment) for elderly people who are less familiar with new technologies.	Initially, the old reservation system (via telephone) should coexist with the new system, and elderly people should be raised to awareness and supported in the change process.	T4.5
OSL_05	EPF	Mobility as a right: Universal accessibility leaving no one behind.	Around 20-30% of all passengers are lacking digital skills so alternatives should be offered not to exclude them. In addition, in case of AVs, people may not feel safe using an AV if there is no one on board to ask for help if needed. Lack of assistance may deter especially elderly people or PRM from using AVs. Something might go wrong, for example: a blind person loses orientation because stops are not correctly announced; due to deviations (e.g. roadworks) the shuttle may stop at another point, ... In such cases, support is needed. Both for DRT and/or AV services, there's a need to familiarise people with the service and make them confident to use it.	Ensure non-digital communication channels for passengers lacking digital skills (up to 30%!). Solutions proposed by SHOW project to mitigate absence of human assistance on board of AVs: surveillance camerias monitoring problems; pre-ordering help in advance; possibility to call someone e.g. through a button. Solutions proposed by SHOW project to familiarise people with the new service (DRT and/or AV): tutorial at the stop and/or on board; travel coaches or buddies; stewards on board; training; open days; good signage.	T4.5

Measure ID	Appraised by	"Point of attention" category	Evaluation result: Point of attention/Comment	Solution you can present	Task
OSL_03	ICLEI	Other	p.s. I am not familiar with what FFM is - if this could be explained in the measure descriptions further, that would be helpful.		T4.3
OSL_03	EPF	Seamless multimodality/intermodality	Which other mobility services/stakeholders will be included in this measure? Will city planners also be involved, since this measure seeks to improve street design? not clear as to how the different modes will be integrated (there are a lot of hubs being developed with multi-modal options but there is no clear vision for the user as to how to integrate them and have a seamless experience. Additionally, users have difficulties with planning their journey's due to different apps.	a one-stop-shop would be beneficial (integrated application for instance, Floya app). It is also important to put the end users at the centre of these new developments because end-users give excellent input to validate and/or steer the results of new developments	T4.3
OSL_03	EPF	Seamless multimodality/intermodality	The scope of this measure is not entirely clear and neither are some concepts used; for example, what are KFT - 'powerful accessibility measures'? For the 'function distribution model', how would it work that 'all (modes??) are prioritized'? Overall, the aim seems to be to improve reliability (rather than 'accessibility') on a specific bus corridor - but on the other hand, it is said that a bus route 'where all possible physical improvement has been made' will be chosen so what exactly are the concrete objectives and proposed interventions?	Clarify the scope of the measure (overall framework vs making one bus route more efficient?), how the different elements (regulatory intervention, street design elements, ...) are related and interact.	T4.3
OSL_05	ICLEI	Seamless multimodality/intermodality	No infrastructure needs are identified, but would one or two common stops with facilities and information on-street help to build awareness and understanding of the autonomous service?		T4.5
OSL_05	ICLEI	Seamless multimodality/intermodality	Is there an opportunity to run a scheduled core service using the autonomous vehicles, supported by demand responsive services at non-peak times? Hearing more about the expected demand and how capacity can respond should the service gain popularity could also be helpful (given the very restricted capacity, particularly seated, of some autonomous shuttles)		T4.5
OSL_05	ICLEI	Tailored communication for increased acceptance and buy-in	How far has branding of the service yet been considered? Removing terms such as DRT, if they are used, might help the new service appeal to new users if it appears to be part of the mainstream transport offer.		T4.5

City	Measure ID	Appraised by	"Point of attention" category	Evaluation result: Point of attention/Comment	Solution you can present	Task
VAL	VAL_09	UITP	Active stakeholder engagement during measure development	Facial recognition has the potential to be a threat to users' privacy as it allows for the collection and analysis of personal data without consent.	Passengers must be informed on the measure, its purpose, and the implications on their privacy.	T4.2
VAL	VAL_07	EITUMF	Data management and privacy	Might be good to ensure accessibility and user-friendliness of the platforms and apps provided to disseminate this information. Are there plans for user testing and feedback integration to optimise the usability and effectiveness of these tools?		T4.2
VAL	VAL_07	EITUMF	Data management and privacy	It might be beneficial to explore how focus on real-time data for public transport integrates with broader urban planning strategies. For instance, how does it align with efforts to improve pedestrian infrastructure or promote cycling as alternative modes of transportation.		T4.2
VAL	VAL_09	UITP	Data management and privacy	Facial recognition has the potential to be a threat to users' privacy as it allows for the collection and analysis of personal data without consent. In addition, as the data will be channelled via cloud/internet, cybersecurity safety measures to prevent cybercrime are required; the transfer needs to be encrypted to ensure there is no data breaches, especially of individuals related data.	Ensuring compliance with regulations on legal and ethical aspects of the measure person-recognition, concretely regulations on data privacy.	T4.2
VAL	VAL_06	EPF	Mobility as a right: Universal accessibility leaving no one behind.	What do you mean when you say 'automatize the DRT service'? Using an app alone is not inclusive considering the fact that you are trying to target 'vulnerable' (groups vulnerable to exclusion) eg elderly and low income household groups. The DRT service alone doesn't promote inclusivity. There are a lot more factors to address e.g. financial barriers, gender etc.	other ways that can be implemented in addition to the DRT service and the way they book the services can be through phone calls, messages. The service should have a flexible timetable that goes beyond conventional timing.	T4.5
VAL	VAL_06	EPF	Mobility as a right: Universal accessibility leaving no one behind.	Around 20-30% of all passengers are lacking digital skills so alternatives should be offered not to exclude them. Both for DRT and/or AV services, there's a need to familiarise people with the service and make them confident to use it.	Ensure non-digital communication channels for passengers lacking digital skills (up to 30%!). Solutions proposed by SHOW project to familiarise people with the new service (DRT and/or AV): tutorial at the stop and/or on board; travel coaches or buddies; stewards on board; training; open days; good signage.	T4.5
VAL	VAL_07	EPF	Mobility as a right: Universal accessibility leaving no one behind.	It is important to consider people who have difficulties using digital services; e.g., people with a visual impairment. They also need access to real-time information. Additionally, there are other groups who might have difficulties in using digital apps, for instance, the elderly, and people who cannot afford the purchase of smart phones. These groups risk being left behind. Not all applications are available in every country. Language barriers in the PT announcement, messages.	awareness raising and training for the handling of new technologies, including mobility technologies, should be reinforced. Be aware of the country restrictions of the application. Ensure that language translations are enabled on the applications. All of the solutions proposed in the measure description should be available to the same time and everywhere.	T4.2
VAL	VAL_06	EITUMF	Tailored communication for increased acceptance and buy-in	How the communication campaign will reach out to vulnerable users which will be the main target users? How the uptake of the DRT tool will be encouraged and facilitated for the vulnerable users, for example the elderly?	One idea is to organise a series of sessions facilitated by the City Hall to communicate the introduction of the new DRT service to the elderly and families with low income. Public libraries or other public gathering spaces could serve as suitable venues for these sessions. To encourage the use of the new public transport service, the organiser may distribute sample tickets to be used on buses	T4.5
VAL	VAL_07	EPF	Tailored communication for increased acceptance and buy-in	Design the API to connect with the 'screens, apps (TBD) to be used by the PT users' - to decide indeed which communication channels are being used / will be used towards end-users (passengers). Make sure that the information provided to passengers is up-to-date, reliable and consistent across all channels (e.g., PTO app, website, Google maps if applicable, screens at bus stops, internal PTO monitoring).	Ensure consistency of information (real-time) across all channels to have a maximum positive impact	T4.2
VAL	VAL_09	EPF	Tailored communication for increased acceptance and buy-in	It might be a better approach to inform the public more generally about the efforts done to improve air quality on the bus, plus to inform drivers so they can take action if needed - rather than showing real-time data (on CO_2?) on board of the vehicles. On the one hand, since the peak of the pandemic is over, this is not a big concern anymore to most passengers; and on the other hand, showing increased values e.g. when buses are crowded might actually create more rather than less anxiety, and deter people from using public transport.	Consider how to communicate in a positive way to passengers without drawing attention to increased CO_2 measures on buses which might have an unwanted negative effect on perceived air quality	T4.2

Measure ID	Appraised by	"Point of attention" category	Evaluation result: Point of attention/Comment	Solution you can present	Task
BUD_01	EPF	Mobility as a right: Universal accessibility leaving no one behind.	little attention on users perceptions and needs. Data alone cannot provide detailed information about users needs and mobilty choices (important to consider different gender perspectives);	important to conduct qualititave research (interviews, focus groups etc) and also important to have diverse samples.	T4.3
BUD_01	EMTA	Active stakeholder engagement during measure development	Make public transportation services more accessible to people with disabilities and other user groups by ensuring the availability of accessible vehicles, stations, and information. Ask different kind of groups what their needs are or what holds them back from using PT.	EMTA could present the Amsterdam "volunteering transport". People offering rides and getting a subsidy to help. Surveys are made to reveal how isolated people would have been without the service.	T4.3
BUD_01	IFPEN	Data management and privacy	Is there a recent household travel survey of Budapest? In addition to the HTS, what other data sources have been identified? Dynamic data from (e.g., FCD and FMD) make it possible to have more up-to-date information about the population's mobility behavior. Is this measure related to U-Sim.plan?		T4.3
BUD_01	EMTA	Data management and privacy	Much car and PT traffic in Budapest comes from nearby towns. The model must capture travel behavior, population trends, network service levels, etc. outside of Budapest to perform accurate predictions inside Budapest. This requires data sharing agreements and protocols.	EMTA could share thoughts on lifting the barriers to data sharing, drawing from the European Mobility Data Spaces on the one hand, drawing from ITF reports authored by Alexandre Santacreu on the other hand: https://www.itf-oecd.org/sites/default/files/docs/big-	T4.3
BUD_01	EPF	Active stakeholder engagement during measure development	Theoretic modelling needs to be validated in practice. Ask people living in the new targeted catchment areas (suburbs) what they want/need and check if the solutions proposed suit their needs. Take into account other factors, e.g. the existence of multimodal interchanges to cover first-last mile, integrated tickets. Informing people about the new services and incentivising their use, e.g. by offering try-out	Consider outreach and communication activities with target groups throughout the development process. Offer incentives for using the new services, e.g. free tickets for trying them out.	T4.3

Measure ID	Appraised by	"Point of attention" category	Evaluation result: Point of attention/Comment	Solution you can present	Task
IDF_06	EMTA	Active stakeholder engagement during measure development	The uptake of the tool by municipalities is uncertain. It would be worth anticipating the use cases a little more. A use case directly related to PT (such as PT priority) would be important to develop as it could guide the elaboration of the dashboard! Are the promised workshops with the "smart city commission" taking place?	EMTA could seek a preentation from Oslo, Ruter being involved in many AI projects, building on various data inputs	T4.3
IDF_02	IFP	Data management and privacy	Digital twin includes catchment areas?	Include catchment areas	T4.2
IDF_06	IFPEN	Data management and privacy	Some points of attention on i) the quality and availability of the collected data, particularly those from sensors; ii) the perpetuation of collected data to have a history, particularly those coming from external partners	Check the collected data before sending it to the platform. Back up external collected data on VGP servers.	T4.3
IDF_02	EMTA	Environmental impacts on CO2 emissions, energy use, and air quality.	The modelling of CO2 and other emissions will be a key strength of the tool. Yet results could be grossly misleading if the wrong technical choices are made. The most basic models should not be used as they are misleading in urban traffic: they would associate a lower speed limit with higher emissions. Demonstrating that the tool is sensitive to such policy decisions, and reacts in the right manner, is essential to guarantee its adoption!		T4.2
IDF_02	EMTA	Other	A digital twin is costly to maintain. Surveys that capture the changing PT interactions with other mobility options are expensive. What can we do now to maximize the chances that the tool will be supported financially after launch?		T4.2
IDF_02	EMTA	Other	Restricting a model to subset of a wider urban area is a choice that raises many questions. When testing various scenarios, how will the model depict the real-world mechanisms that are best modelled at the scale of the region, for instance the redistribution of trip destination and the re-routing of through traffic? Failing to address these will result in a model that lacks elasticity: it will exaggerate road congestion caused by bus priority measures for instance. Such model behaviour would favour status quo by discouraging political leaders from investing in bus priority, low-traffic neighbourhoods, etc.	EMTA could seek help from TfL (Transport for London) whose modelling practices have historically involved sub-regional models + have been improved following recent low-traffic neighborhood scheme implementations and evaluations + have been used in the simulation of LEZ effects.	T4.2
IDF_06	IFP	Seamless multimodality/intermodality	The digital twins will include the catchment areas?	Produce digital twins of 300 meters from PT hubs	T4.3

Measure ID	Appraised by	"Point of attention" category	Evaluation result: Point of attention/Comment	Solution you can present	Task
ROM_05	EITUMF	Active stakeholder engagement during measure development	how will the measure address issues such as accessibility, frequency, and reliability of services to ensure a positive experience for PT users?		T4.3
ROM_05	UITP	Active stakeholder engagement during measure development	one of the measure outputs refers to evaluating customer satisfaction, but it is not further detailed in the documents		T4.3
ROM_05	UITP	Data management and privacy	The measure description does not take into account any needs to improve the data storage, management and use of either the operator of the city to understand operational parameters	further reading: https://cms.uitp.org/wp/wp-content/uploads/2023/	T4.3
ROM_05	UITP	Environmental impacts on CO2 emissions, energy use, and air quality.	It is quite important that the fully electric vehicles are used on lines with the highest levels of reliability and punctuality, so they can complete the number of runs.		T4.3
ROM_05	EITUMF	Mobility as a right: Universal accessibility leaving no one behind.	How will potential disruptions, such as charging infrastructure requirements or fleet maintenance procedures, be addressed to maintain service reliability during the transition period?		T4.3
ROM_05	UITP	Other	It is for the moment unclear what is the type of vehicle to prepare for: are the vehicles 12m buses, longer, shorter? This will impact the operational characteristics, as well as several of the other comments made here, the sooner the information is provided, the better.		T4.3
ROM_07	EMTA	Other	A real-time digital twin and forecasting engine is rarely what PT operators put high on their wish-list. Also the list of data inputs is impressive, and yet much work will be needed to turn data into information. It would be an opportunity to embrace the concept of European data spaces (distributed storage, data sovereignty and security, etc.) rather than create a data lake. What is lacking is a set of convincing examples of how the tools could help grow PT ridership and PT user satisfaction. Such use-cases are essential: they should serve as the foundation on which to develop smart city tools.	EMTA could make a presentation on data space principles. OECD smart city report can be critical of advanced tools that serve little purpose. Exposure to such critics in advance could help avoid common pitfalls. https://www.oecd.org/publications/how-can-smart-cities-boost-the-net-zero-transition-bc554887-en.htm	T4.2
ROM_05	UITP	Seamless multimodality/intermodality	one of the measure outputs mentions a participatoru process for the design of the lines, but is not taken further. I believe leaving it like that would be a lost opportunity, as indeed, the new vehicles may offer an opportunity for a rationalisation of the lines in operation.		T4.3
ROM_05	UITP	Tailored communication for increased acceptance and buy-in	Is there a plan to highlight the LEV/ZEV features of the buses. Is there any plan to inform the passengers and all other road users that the respective vehicles are low emission?		T4.3
ROM_07	FACTUAL	Tailored communication for increased acceptance and buy-in	How will the realtome informtation communicated to the end users?		T4.2

Measure ID	Appraised by	"Point of attention" category	Evaluation result: Point of attention/Comment	Solution you can present	Task
HAN_05	EITUMF	Active stakeholder engagement during measure development	Is the administration of Hannover the primary target audience for this measure, or are citizens also intended to use this tool? If citizens are meant to use this tool, how do you ensure engagement with them? How will the administration of Hannover utilise this tool?		T4.2
HAN_05	EMTA	Data management and privacy	Requires seamless integration of data from different providers, raising the data sharing question. Incentives to make sure contributors to the tool always upload the data online on time.	EMTA could share the example of Amsterdam data on lift availability from various stakeholders is fed into an app for journey planning using wheelchair-accessible routes. How to secure the agreement of stakeholders for data sharing – and the maintenance of sensors? Is it	T4.2
HAN_05	EMTA	Data management and privacy	Integrating various data sources requires lots of IT development cost, whereas some standard building blocks may exist	EMTA could present the concept of mobility data space to facilitate the use of standard trust layers, privacy protection layers, contract templates, user authentification layer, etc.	T4.2
HAN_05	IFP	Data management and privacy	Is walking properly colected?	Include walking as trips and as stages of a trip	T4.2
HAN_02	ECF	Mobility as a right: Universal accessibility leaving no one behind.	When evaluating the Sprinti service, also make an evaluation in which cases (electric) cycling could be a more cost-efficient alternative - for which groups yes, for which groups not, what are the barriers (e.g. lack of safe, comfortable and direct cycling infrastructure in peri-urban/rural areas? construction of "cycle highways"?)		T4.5
HAN_02	EPF	Mobility as a right: Universal accessibility leaving no one behind.	Important to communicate clearly about Sprinti and make sure it is easy to use - can people e.g. also book it by telephone (using other than digital channels)? Around 20-30% of all passengers are lacking digital skills so alternatives should be offered not to exclude them. In the 'lessons learned' brochure, include user satisfaction & how the Sprinti actually contributed to tackling transport poverty issues	Ensure non-digital communication channels for passengers lacking digital skills (up to 30%!). Solutions proposed by SHOW project to mitigate absence of human assistance on board of AVs: surveillance camerias monitoring problems; pre-ordering help in advance;	T4.5
HAN_05	EMTA	Other	Take training into consideration for anyone using the tool. Make tutorials always available and accessible		T4.2
HAN_02	EPF	Tailored communication for increased acceptance and buy-in	Even though it is important to have feedback from the pilots, local contexts are still the important factor to be taken into account. How do you intend to get the feedback from the users?	important to engage different users in an inclusive manner so that all groups are represented.	T4.5

Measure ID	Appraised by	"Point of attention" category	Evaluation result: Point of attention/Comment	Solution you can present	Task
LIS_04	EPF	Environmental impacts on CO2 emissions, energy use, and air quality.	not clear how the students get to the PT stop where they would be picked up by the bus monitor (if the parents drop them by car then there will still be pollution). Why are the students not being dropped of directly at school (some parents might be uncomfortable with doing this because of safety&security reasons or fear of the children skipping class)	implement bus lines that pick up children from their homes and drop them off directly at school. these buses can be organised per neighbourhood.	T4.3
LIS_04	EITUMF	Other	What is the intended goal of the pilot programme "Amarelo"? Will bus rides become paid once the pilot ends, or will they continue to be free of charge? Is it cost-effective to maintain school bus rides? Have carpooling or other shared mobility options been considered as less costly alternatives?	Examples of creating sustainable mobility for school students commute: Cascais - https://marketplace.eiturbanmobility.eu/best-practices/cascais-improving-mobility-children?check_logged_in=1 Fyfield - https://marketplace.eiturbanmobility.eu/best-practices/fyfield-rural-school-big-mobility-needs	T4.3
LIS_04	IFP	Mobility as a right: Universal accessibility leaving no one behind.	Are the routes to school safe?	Implement 30 km/h zones and traffic calming in the routes from PT to School	T4.3
LIS_04	IFP	Active stakeholder engagement during measure development	Are you you considering to work with local NGOs that work with school mobility?	Engage with organisations that have been working with school mobility	T4.3
LIS_04	EPF	Active stakeholder engagement during measure development	Wondering if it is feasible to accompany a larger group of small children esp. during peak hours when the buses are crowded? Or are dedicated buses used only to transport the school children? Are small children supposed to bring their own PT card to use for paying - what if they forget or lose it? Also important to align schedules with school times (involve schools!) so that children arrive neither too early nor too late. Check if practical arrangements are feasible and acceptable esp. to parents of small children.	Present practical approach to parents and see if there are any barriers to take into account and possibly adapt the concept	T4.3

Measure ID	Appraised by	"Point of attention" category	Evaluation result: Point of attention/Comment	Solution you can present	Task
TES_07	EITUMF	Active stakeholder engagement during measure development	Will the DRT service be based on the results of the serious game and the survey? How the survey is engaging with all the buyer personas?		T4.5
TES_09	ICLEI	Environmental impacts on CO2 emissions, energy use, and air quality.	Also consider whether the energy sourcing policy (is it 100pc renewable) can back up any "zero" emissions claims that could be challenged/made controversial.		T4.3
TES_09	EPF	Environmental impacts on CO2 emissions, energy use, and air quality.	just putting e-buses in place is not enough to impact behavioural change or impact environmental awareness. important to consider the impact of charging stations and the impact they can have on the population.	integrate the e-buses to other sustainable mobility options for a seamless experince (e.g bikes, e-scooters...). important to promote these sustainable e-buses (campaigns, incentives...). it is also	T4.3
TES_07	EITUMF	Mobility as a right: Universal accessibility leaving no one behind.	How to ensure that the service is accessible to everyone and does not leave anyone behind due to price, difficulty of use, lack of awareness?		T4.5
TES_07	EPF	Mobility as a right: Universal accessibility leaving no one behind.	Around 20-30% of all passengers are lacking digital skills so alternatives should be offered not to exclude them. Both for DRT and/or AV services, there's a need to familiarise people with the service and make them confident to use it.	Ensure non-digital communication channels for passengers lacking digital skills (up to 30%!). Solutions proposed by SHOW project to familiarise people with the new service (DRT and/or AV): tutorial at the stop and/or on board; travel coaches or buddies; stewards on board; training; open days; good signage.	T4.5
TES_07	EITUMF	Other	How the frequency of the DRT services will be determined to ensure cost effectiveness and operability? Is the booking model the optimal in this case or would it be better to establish fixed timetables with fixed routes? If the objective is to connect the Panorama area to key locations and other public transportation nodes, it would be worthwhile to study the frequency of service usage, including peak and off-peak hours.		T4.5
TES_07	EITUMF	Tailored communication for increased acceptance and buy-in	How the introduction of the new DRT will be commnicated to the inhabitants of Panorama?		T4.5
TES_09	ICLEI	Tailored communication for increased acceptance and buy-in	Suggest a focus group is undertaken to understand target audience's potential receptiveness to different messaging. Would other comfort factors associated with e-buses (such as comfort from newness of vehicle) be more powerful a message than focussing marketing on the drive train itself? Do your consumers actually care how the vehicle is powered? Sometimes environmental messaging can not be persuasive (not negating its policy importance - better results may be obtained by focussing on other non-environmental primary messaging).		T4.3
TES_09	ECF	Tailored communication for increased acceptance and buy-in	When designing the communication campaign, also make citizens aware of sustainable multimodality options like cycling to reach the stations of the new electric buses for example.		T4.3

ANNEX 2: MONITORING TEMPLATES OF T4.3 MEASURES

Monitoring template for Measure VAL_03 “To optimise public transport offer based on advanced technology”

Objectives of the measure

At measure level:

- Improve geographic coverage of PT to reduce private car trips.
- Reduce travel times with PT.
- Boost night-time PT demand (mainly bus).
- Understand mobility patterns of private vehicles and adapt PT offer (schedules, routes, PT stops) accordingly.

At city level:

- Reduce trips made by private vehicles.

Description of the measure

Measure description

This measure will use the geospatial analysis of passenger flow to define the optimal transport offer according to specific city situations. This measure will develop an advanced data analytics and a big data visualization tool to evaluate public transport passengers’ flows, analyse potential underlying trends in mobility and transport modes, detect inefficiencies in the current offer and elaborate future recommendations (increase frequency of some bus lines, add/move new bus stops…). With the support of U-NEED, the OD matrix and mobility patterns of PT users and private vehicle users will be analysed and compared, with the final goal of detecting areas not well covered and identify the most relevant inefficiencies in the PT offer (in terms of travel times, multimodality, door-to-door mobility…). Moreover, with the support of U-SIM.plan, potential corrective actions will be simulated to support the decision-making process.

Measure outputs:

This measure will deliver:

- Modelling of citizens' mobility patterns in Valencia, including the representation of PT OD matrices.
- Report on the main inefficiencies of the PT offer and recommendations for adapting it to the real demand.
- Simulation of some corrective actions and a roadmap on the PT adaptations to be implemented in the city.

U-tools related:

- U-NEED
- U-SIM.plan

UPPER

Steps to ready-to-demo measure

Steps	Description	Involved partners/externals	City contact person	Category of action	Deadline	Monitoring indicator	Comments
1	Agreement with transport operators and authorities for data provision	ETRA, EMT, other transport operators and authorities	ETRA I+D	Data	M14	Agreements reached	
2	Data collection of different transport modes	EMT, VALENCIA, ETRA	ETRA I+D	Technical	M16	Database created	
3	Data integration. Tool ready for carrying out the geospatial analysis of passenger flows and identification of inefficiencies	EMT, VALENCIA, ETRA	ETRA I+D	Technical	M18	Data integrated	
4	Training to users of the tool	ETRA, EMT, other transport operators and authorities	ETRA I+D	Technical	M24	Trainings finalized	

LAUNCH OF THE DEMO (January 2024**)**	The implementation phase include: • Identification and simulation of corrective strategies and selection of the most suitable ones. • Development of roadmap on the PT adaptations to be implemented in the city

Monitoring template for Measure TES_09 “To raise environmental awareness and trigger behavioural change towards PT”

Objectives of the measure

- Secure the smooth operation of the e-buses fleet.
- Raise awareness of sustainable transport options.
- Increase PT modal share.
- Reduce pollutant emissions.
- Reduce noise levels, especially in the city centre.

Description of the measure

This measure aims to support the smooth operation of PT after the incorporation of e-buses. To achieve this, suggestions regarding bus lines electrification will be reported based on e-buses simulation results. Different scenarios of charging options will be examined. In addition, mechanisms for communicating effectively this new (electrified) era for city’s PT will be defined to raise awareness of sustainable transport options in favour of public buses.

Measure outputs:

This measure will deliver:

- A plan for the operation of e-buses based on the simulation’s results.
- A plan for utilizing the positive momentum of the fleet renewal and raise awareness of sustainable transport options.

Related UPPER tools:

U_SIM.plan: It can be used for validating analyses of CERTH regarding e-buses charging options.

U-SUMP: CERTH recently developed a platform regarding CO2 emissions for the Municipality of Thessaloniki, U-SUMP can support in the definition of additional KPIs and the calculation of CO2 savings for various possible interventions.

U-GOV: It can be used in the definition and implementation of appropriate mechanisms for raising environmental awareness.

UPPER

Steps to ready-to-demo measure

Steps	Description	Involved partners/ externals	City contact person	Category of action	Deadline	Monitoring indicator	Comments
1	Data collection	TheTA, CERTH	CERTH	Data	15/01/2024	Data ready to be used in the simulation process	Data regarding e-buses are needed as well as data on bus lines and vehicles currently operating. DONE
2	Definition of simulation scenarios	CERTH, TheTA	CERTH	Technical	15/02/2024	Description of the simulation scenarios	DONE
3	E-buses operation simulation	CERTH	CERTH	Technical	31/03/2024	Conclusions about lines that have potential for electrification and proper charging options	ONGOING
4	Selection of lines for electrification and optimal charging options	CERTH, TheTA	CERTH	Technical	30/04/2024	Final proposal for electrified lines and charging options	This step will include consultations that will use the simulation results as a basis.
5	Estimation of CO_2 savings	CERTH	CERTH	Technical	30/04/2024	Detailed impact on $C0_2$ emissions (before/after)	
6	Define behavioural change mechanisms	TheTA	CERTH	Social	31/07/2024	Description of the actions needed for promoting efficiently the new “electric” era of PT in the city.	U-GOV can be used for assisting in this process

Monitoring template for Measure ROM_05 “New LEV and ZEV bus fleet – network adaptation”

Objectives of the measure

At measure level:

- Designing and Adapting the PT network to fit the needs of the new and sustainable bus fleet
- Reducing emissions of the PT fleet
- Increasing the Customer satisfaction on the PT service
- Ensure smooth operation of bus fleet during fleet renewal

Contributing to city level objectives of:

- Reducing emissions due to PT
- Increasing the quality of the PT supply and of the customers’ satisfaction

Description of the measure

General description:

The SUMP claims the need for investment for the renewal of the PT surface fleet, with LEV and ZEV buses by 2030. ATAC, the main PT operator, has defined its needs for new buses between 2023 and 2026: 1057.

In the time frame of the project, Rome will integrate into the PT surface fleet LEV and ZEV buses. This activity expects a re-design of PT low-emission lines, due to the complexity of the integration of ZEV vehicles and careful planning of the routes to allow the efficient operation of the service over a large area, with a choice of the bus depots and of the lines.

Sub-measures description (if applicable)

ROM_05_01: introduce low emission and zero emissions vehicles into the PT fleet – procurement procedures identification of the optimal solutions.

ROM_05_02: design of new bus lines, according to the buses performances.

Measure outputs:

Following the introduction of 411 electric buses, 269 hybrid buses, 344 methane buses, 33 EURO 6 buses and the implementation of a new depot, this measure will deliver:

- Identification of the need for the buses fleet renewal
- Introducing ZEV and LEV buses (procurement procedures)
- Design and adaptation and integration of the new buses (including LEV and ZEZ) in the PT network,

- Participation process with the territorial representations for the design of the lines
- Evaluation of the Customers' satisfaction, raising awareness on environmental issues
- Report on the assessment of the new services.

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Steps to ready-to-demo measure

Steps	Description	Involved partners/externals	City contact person	Category of action	Deadline	Monitoring indicator	Comments
1	Identification of typology and number of new buses needed	ATAC		Technical	Done	List of buses needed	PT surface fleet's renewal plan 2023-2026: 1057 new buses (of which 411 full electric buses)
2	Definition of requirements and needs of new buses	Rome LA, ATAC		Technical	Done	Requirements and needs defined	
3.a	Execution of tendering procedures for 354 new buses	Giubileo Company		Legal	31.12.2024 (ongoing)	New fleet of buses procured	110 Hybrid buses 244 methane buses
3.b	Execution of tendering procedures for 411 electric buses procurement	ATAC		Legal	Done	New fleet of buses procured	Completion by 31.12.2023 (1st NRRP milestone)
	Electric buses delivery	Rome LA, ATAC,		Legal	1st step 31.12.2024 (ongoing)		31.12.2024 109 full electric buses purchase (2nd NRRP milestone)

					2nd step 30.06.2026 (ongoing)		30.06.2026 411 full electric buses available (3rd NRRP milestone)
4	Electrification of 5 buses depots	Rome LA, ATAC		Legal /Technical	1st step 31.12.2024 (ongoing)	Number of depots electrified	31.12.2024 (estimated) 2 depots electrified
					2nd step 30.06.2026 (ongoing)		30.06.2026 5 depots electrified
5	Design and adaptation of existing lines to the needs of the new buses (including LEV and ZEZ) and local administrations	RSM, Rome LA, ATAC		Technical/Social	Monitor in progress	Lines adapted	01.01.2025 ~ 30.06.2026 (estimated)
6	Planning of monitoring of the measure and dissemination	RSM, Rome LA		Social	Monitor in progress	Measure implementation monitoring planned and disseminated	
	LAUNCH OF THE DEMO (please fill in the date**)**						

Monitoring template for Measure OSL_03 “Improve use and accessibility of public transport in conjunction with alternative mobility to reduce private car ownership”

Objectives of the measure

At measure level:

- Increase the use, accessibility and attractiveness of public transport co-existing and sharing space with other modes of transport.
- Establish and test a new working method/strategy, which includes both bus and alternative mobility functions, to improve existing processes and understand how different strategies affects each other.

Contributing to city level objectives of:

- The city of Oslo is working on promoting walking, cycling and public transport in that priority as well as reduce the car traffic by 33% within 2030 compared to 2009. This measure will contribute to these goals.

Description of the measure

General description:

This measure will use a bus route that has been improved, where all possible physical improvement has been made or a new bus route which is under improvement to test how we can further improve the mobility offer beyond traditional activities. Part of this measure will be to test/implement the function distribution model in context with mobility services and function of the area. Through this approach we can both work at system and street level to understand actual impact of implemented measures or lack of them. The idea is to create a basis for a framework for further improvement of bus routes with connection to different mobility services. Through this work we want to shed light on how existing regulations and framework affects each other both creates challenges opportunities.

Measure outputs:

This measure will deliver:

- Improved design of selected bus route to increase accessibility
- Real test of new model FFM (prerequisite: no big changes in the infrastructure). Better collaboration between different agencies to secure horizontal streamline and simpler process for identification of new measures.
- Strategic approach towards alternative mobility. Understand dependencies between different processes.

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Steps to ready-to-demo measure

Steps	Description	Involved partners/externals	City contact person	Category of action	Deadline	Monitoring indicator	Comments
1	Anchoring and classification	Internal process		Technical	15.02.2024	3. Establish a work-team 4. Establishing a more defined timeframe including sub-tasks based on possibilities and limitations. 5. Concrete scope of the measure.	
2	Collect and analyze information	Internal process (maybe		Technical/legal/data	M20 - 01.08.2024 (D4.3).	*Report of past and current activities,*	

		necessary for external input)				*regulations and strategies in place.* 1. Collect knowledge from past and running activities. 2. Collect information regarding regulations & strategies that affect the measure. 3. Gather alternative geographic sections based on KFT (if applicable). 4. Understand (analyze) the relationship and impact potential of FFM on	

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						existing regulations. 5. Summarize gathered information to make a decision.	
3	FFM scenarios	Internal process (maybe necessary for external input)		Technical/social	M25 – 01.01.2025 (Milestone 7)	*Report on impact and connections between FFM and existing regulations and its role in the real implementation.* Design and development of the measure. Evaluate in a "safe environment" of possible scenarios to make a decision. (deadline 01.11.2024) Final preparation of implementation (deadline 01.01.2025)	

	LAUNCH OF THE DEMO (please fill in the date**)** **Est. 01.01.2025**	

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Monitoring template for Measure MAN_03 “Data-driven platform for supporting PT planning and operations based on the concept of Mobility-as-a-Right”

Objectives of the measure

At measure level:

- Improve data quality, data processing, and data storage
- Create added value use-cases from data science applications

Contributing to city level objectives of:

- Increasing efficiency of mobility planning and operation, reducing costs and gaining awareness for data-driven decision making.

Description of the measure

General description:

The rnv wants to make better use of the large amount of available data and gain important additional insights and results through pointed approaches. To implement the necessary approaches, rnv must first improve the general data quality, data processing, and data storage. Based on this, rnv will develop solutions for different use cases. In doing so, rnv stresses the importance that the data is not falsified, and that mobility is a basic right of all citizens.

First, rnv will improve data governance by extracting, creating and persisting available and relevant metadata from sources. Designating responsible and accountable Data Owners and providing an easy and handy access to this information will create a single source of truth. Second, relevant data sources will be permanently integrated to rnv’s cloud environment, ensuring a continuous and reliable data input as foundation for the data platform. Based on this, rnv will develop solutions for different use-cases and problems at hand.

A first step to improve data usage and to overcome certain barriers, is to use simple statistical models that provide dashboard results, such as monitoring the duration of barrier closures at railroad crossings. In a second step, more complex Machine-Learning approaches can be tested and used, e.g., for demand forecasting or predictive maintenance.

The Gender Mobility Data Gap will also be further highlighted in the data analysis and gender-specific gaps in data collection will be further recognized.

Measure outputs:

This measure will deliver:

- Integration of at least two data sources connected to rnv’s cloud environment
- Implementation of at least three basic statistics use-cases
- Implementation of at least one complex machine-learning use-case

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Steps to ready-to-demo measure

Steps	Description	Involved partners/ externals	City contact person	Category of action	Deadline	Monitoring indicator	Comments
1	Define principles for data governance	RNV	MAN, RNV	Legal	01/01/2024	Principles for data governance defined.	DONE
2	Integration of at least two data sources connected to rnv's cloud environment, extract and persist metadata	RNV	MAN, RNV	Data/ Software	01/08/2024	Data sources integrated following previously defined data governance principles.	2nd source to be integrated by December 2024
3	Definition of requirements for use cases with stakeholders	RNV	MAN, RNV	Social	01/11/2024	Requirements defined.	
4	Design and implementation of at least three basic statistics use-cases	RNV	MAN, RNV	Software	01/01/2025	Use cases designed and implemented.	
5	Design and implementation of at least one complex machine-learning use-case	RNV	MAN, RNV	Software	01/08/2025	Machine-learning use cases designed and implemented.	
	LAUNCH OF THE DEMO (please fill in the date)						

Monitoring template for Measure LIS_04 “To improve PT offer, adapted to school students”

Objectives of the measure

At measure level:

- Encourage the use of PT among students at all school levels;
- Influence student’s mindset towards sustainability modes and boost kid’s autonomy;
- Reduce congestion.

Contributing to city level objectives of:

- Increase PT usage;
- Reduce trips made by private vehicles.

Description of the measure

Situation before:

School mobility is one of the biggest triggers to car use. Parents prefer to use private car while taking kids to school and fail to understand that it contributes to congestion, poor safety, poor air quality and public space chaos around the schools. Consequently, children recognize no other forms of mobility since they are continuously carried around by car. The use of PT commuting to school is quite limited, thus it is necessary to increase and create a practice of using PT, from an early age.

General description:

Through the implementation and dynamization of the two sub-measures, this measure intends to increase the number of students who go to school by bus.

This measure is divided into two sub-measures:

- (LIS_04_01) The ‘*Amarelo’* pilot project proposes the creation of a free service of PT on-board monitors to assist school rides on selected routes in the existing general network. It allows parents to leave their children at the PT stop knowing that they arrive safely to school, as they are accompanied by monitors. Children are enrolled in the program by filling an online form, identify the school, the bus stop where they intend to enter the bus, and inform the time schedule that’s more convenient. The child is then instructed to be at a specific time and place accordingly. The monitor, who is informed that the child is going to get on the bus, registers his entry. The children use their PT card, and when they arrive at the school stop, they are walked there (according on age, after primary school this action is not carried out). This is a joint venture with CARRIS, the transport operator, and the parish councils (the monitors).
- (LIS_04_02) Expand ‘*Navegante Escola’* PT Ticket Card to kindergartens and high schools to promote PT use for a wider community of students in the city. Parents request the PT card on a platform, free of charge. This card is good

to charge tickets for all the metropolitan area PT, including the free monthly tickets that Lisbon city resident students are entitled to. The PT card is personalized with the identification of the school;

Measure outputs:

- This measure will deliver:
- Analysis and report of the collected data;
- Adjust PT services and align them with the community needs, namely by offering routes and timetables that are adequate to school requisites.

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Steps to ready-to-demo measure

Steps	Description	Involved partners/ externals	City contact person	Category of action	Deadline	Monitoring indicator	Comments
Sub-Task: "Amarelo" pilot project							
1	Identification & engagement of Parish Councils	Parish Councils	CML	Social/Data	Done	Parish councils selected	Partners and stakeholders identified
2	Selection of schools for the '*Amarelo'* pilot	Parish councils, CARRIS, Schools	CML	Technical/Social/Data	November 31st 2023 (for 2022/2023 school year)	Schools selected	For the second term they have expanded the number of bus routes/ schools. Now they have scaled-up two more parishes. At the moment they have 9 bus routes serving a total of 18 schools.
3	Public Tender: data collection and geospatial analysis	External (tbd)	CML	Technical/Data	June 30th 2024	Delivery of the annual analysis and prospective insights for the coming year	

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4	Information & engagement	Parish Councils, Schools, Students & Community	CML	Technical/Social	June 30th 2024 (for 2022/2023 school year)	Students' parent satisfaction Number of students registered (for 2022/2023 school year)	Communication and spread-the-word activities
	LAUNCH OF THE DEMO November 1st, 2023 (Annual DEMO per school year - Testing routes/buses careers						

Steps	Description	Involved partners/ externals	City contact person	Category of action	Deadline	Monitoring indicator	Comments
Sub-Task : Navegante Escola PT Card							
1	Expand the production of *'Navegante Escola'* card to kindergartens and high schools	CML	CML	political/ Technical	October 30st 2023	Platform adaptation for new requests	*'Navegante Escola'* card for 5 –18 years
3	Distribution and promotion of the ¨Navegante Escola¨	CML	CML	Social	Ongoing	Number of issue requests of ¨Navegante Escola¨ cards	The number of applications for the card has increased Ongoing well
	LAUNCH OF THE DEMO November 1st, 2023						

Monitoring template for Measure IDF_06 “Advanced technology to optimize the PT offer in line with users’ needs”

Objectives of the measure

At measure level:

- To improve data-collection efforts regarding PT
- To get more use out of existing mobility data
- To provide a strong data-driven foundation for public transport policy making

Contributing to city level objectives of:

- To contribute to the professionalization of data management.

Description of the measure

General description:

Development of a dashboard to inform and provide support for cities in the knowledge and identification of possible actions to take on city planning and mobility.

Planned themes are : Mobility, Air quality, Traffic conditions

The research of correlation between observations in order to draw a better portrait of a situation, a better understanding or a plan of action will be made by overlapping different sources of data.

Measure outputs:

Although we cannot anticipate the actions that will be taken by the cities following observations they will be allowed to make thanks to the Observatory, we expect outputs to concern mostly pacification and thinning of traffic, increase of cycling facilities, reduced delays of intervention on road damages, improvement of air quality.

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Steps to ready-to-demo measure

Steps	Description	Involved partners/externals	City contact person	Category of action	Deadline	Monitoring indicator	Comments
1	Definition of requirements with stakeholders through workshops and iterative work	REDLab	VGP	Technical	Q1 2023	Requirements defined	
2	Definition of the tabs, bricks and overall design, and the data usage serving these purposes	REDLab	VGP	Technical	Q2 2023	Specifications built	
3	Implementation of new data sources into the dashboard, data refinement data and analysis	REDLab	VGP	Software	Q1 2025	Data implemented and correlations identified	
4	Extraction, transformation and definition from raw data to useful widgets	REDLab	VGP	Software	Q1 2025	Final version of dashboard	
5	Workshop and training on how to use the dashboard	REDLab	VGP	Social	Q2 2025	Users trained	
	LAUNCH OF THE DEMO (Q1 2025						

Monitoring template for Measure BUD_01 “To improve the efficiency and convenience of PT service”

Objectives of the measure

At measure level

- The aim of this measure is to define the appropriate spatial and temporal optimum capacities and frequencies of public transport services by using modelling tools.

Contributing to city level objectives of:

- Develop the existing decision-making tools for strategic transport network planning of the Budapest
- Optimize capacity and maintenance cost of public transport services
- Improve the service level of the public transport in suburbs and newly built residential areas

Description of the measure

Situation before:

In general, data-based decision-making process based on measured passenger number is not a requirement of the process for public transport service planning on a regular basis. The BKK already has a macroscopic strategic transport model, but it is not capable of supporting the operation validation/optimalization of the public transport services.

General description:

The BKK operates the Unified Transport Model of Budapest, which is a macroscopic model for the city and its surroundings. The Model is based on a complex system of different data sources, including traffic counting data, spatial data, infrastructure data, traffic behaviour data and other data from external sources. This data should be updated regularly to ensure reliable transport planning. In this measure the BKK will investigate the possible development solution of the model, which can strengthen the reliability of the model in the aspect of operational public transport planning.

Measure outputs:

- Data collection for the update the Unified Transport Model (e.g. household survey)
- Macroscopic model updated and validated based on the results of the data collection

Use of U-tools:

U-SIM.plan

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Steps to ready-to-demo measure

Steps	Description	Involved partners/externals	City contact person	Category of action	Deadline	Monitoring indicator	Comments
1	Identify the method and type of data collection	Data collection and analysis department of BKK		Technical	Q1 2024	Identified data collection type and method	
2	Data collection and analysis	External contractor		Data	Q4 2024	Contract	
3	Update and validate the Unified Transport Model based on the results	Data collection and analysis department of BKK		Software	Q1 2025	Up to date Unified Transport Model	
	LAUNCH OF THE DEMO (please fill in the date**)**						

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Unleashing the Potential of
Public Transport in Europe

This project has received funding from the European Union’s Horizon Europe research and innovation programme under Grant Agreement No 101095904

UPPER contributes to achieving the aims of the CIVITAS Initiative and the goals of the EU Mission: Climate Neutral and Smart Cities