

D1.5 MetaDesigned transferable ZESM use cases for the follower LLs

WP1

Date of document

27/02/2026 (M26)

Deliverable Version:

D1.5, V2.2

Dissemination Level:

Public

Deliverable Lead:

European Road Transport Telematics Implementation
Coordination Organisation-Intelligent Transport Systems &
Services Europe



Deliverable administrative information

Overview	
Project Acronym	metaCCAZE
Project Title	Flexibly adapted MetaInnovations, use cases, collaborative business and governance models to accelerate deployment of smart and shared Zero Emission mobility for passengers and freight
Project Coordinator	ERTICO – ITS Europe
Project Duration	48 months
Deliverable Title	MetaDesigned transferable ZESM use cases for the follower LLs
Deliverable No.	D1.5
Dissemination Level	Public
Work Package	WP1: Set the ground & Fertilise: Empathise, Specify, Engage, Transfer
Deliverable Lead	European Road Transport Telematics Implementation Coordination Organisation-Intelligent Transport Systems & Services Europe
Lead Authors	José Rodríguez; George Christou; John Paddington; Martina Ferrara Snider (ERTICO)
Main Contributor Authors	Melike Nur Ülsever; Breogan Sanchez (BABLE);
Other Contributors	Miłosz Kędracki, Jędynak Małgorzata (Krakow); Gkiotsalitis Konstant (NTUA); Pauline Forest-Colombel (Yvelines); Alessandro Giovannini (Amat-mi); Domokos Esztergár-Kiss (KJK); Karyn Scerri (UM)
Due date	27/02/2026
Submission date	27/02/2026
Reviewers	Vincenzo Punzo, Andrea Papola (UNINA), Hassan Mahdavi (VEDECOM)
Quality Assurance Reviewer	Loha Hashimy (FACTUAL), Philipp Havemann (FACTUAL)

©2024-2027 metaCCAZE Consortium Partners. All rights reserved.

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Climate, Infrastructure and Environment Executive Agency (CINEA). Neither the European Union nor the granting authority can be held responsible for them.

metaCCAZE is a Horizon Europe project supported by the European Commission under grant agreement No 101139678. metaCCAZE is a project under the CIVITAS Initiative, an EU-funded programme working to make sustainable and smart mobility a reality for all, and contributes to the goals of the EU Mission Climate-Neutral and Smart Cities. All information in this deliverable may not be copied or duplicated in whole or part by any means without express prior agreement in writing by the metaCCAZE partners. All contents are reserved by default and may not be disclosed to third parties without the written consent of the metaCCAZE partners, except as mandated by the Grant Agreement with the European Commission, for reviewing and dissemination purposes. All trademarks and other rights on third party products mentioned in this document are acknowledged and owned by the respective holders. The metaCCAZE consortium does not guarantee that any information contained herein is error-free, or up-to-date, nor makes warranties, express, implied, or statutory, by publishing this document. For more information on the project, its partners and contributors, please see the metaCCAZE website (www.metaccaze-project.eu).

Version History

Date	Version	Author	Comment
05/08/2026	0.1a	José Rodríguez (ERTICO)	Creation of the Table of Contents (ToC) and first draft of the deliverable.
15/01/2026	0.1	José Rodríguez (ERTICO)	Development of the draft deliverable, including contributions to Chapter 2.
23/01/2026	0.2	José Rodríguez; George Christou; Martina Ferrara (ERTICO)	Completion of Chapters 3 to 6 and alignment of their content with each of the follower LLs.
05/02/2026	1.0	José Rodríguez; George Christou; Martina Ferrara (ERTICO)	Version for review
12/02/2026	1.1	Hassan Mahdavi (VEDECOM)	First review
13/02/2026	1.2	Andrea Papola (UNINA)	Second review
17/02/2026	2.0	Loha Hashimy (FACTUAL)	Quality Check
27/02/2026	2.1	Martina Ferrara Snider (ERTICO)	Final check and submission
05/08/2026	2.2	Martina Ferrara Snider (ERTICO)	Revision based on CINEA's comments

Table of Contents

Abbreviations and Acronyms	VI
Background: About the metaCCAZE project	VII
Executive Summary	VIII
1. Introduction	1
1.1. Objectives of the Deliverable	1
1.2. Structure of the Document.....	2
1.3. Relation to Project Documents	2
1.4. Overall Approach	2
2. Comprehensive Guide - Reference to the D1.4	3
3. Outcomes – The 10 Metadesigned Use Cases and BIGMs of Follower Living Labs (LLs)	5
3.1. Optimized Scheduling and Route Planning for Electric Bus Integration in Athens (AT-UC01)	6
3.2. Optimal Planning of Locations of E-Charging Infrastructure for the Athens Electric Bus network (AT-UC02).....	19
3.3. Multimodal logistics and passenger hub in Krakow (KR-UC01 - A)	31
3.4. E-cargo bikes & e-bikes demand and monitoring in Krakow (KR-UC01 - B).....	63
3.5. On-demand automated mini-bus services in Gozo (GM-UC01)	82
3.6. Development of on-demand e-Pod service in Milan (MI-UC01)	99
3.7. Multimodal Passenger hub in Miskolc (MK-UC01).....	118
3.8. Multimodal journey planner in Miskolc (MK-UC02)	133
3.9. Intelligent road and smart traffic management in Poissy, Yvelines (Paris Region) (PO-UC01)	147
3.10. Shared vehicle services for enhanced mobility in Poissy, Yvelines (Paris Region) (PO-UC02)	168
4. Conclusions and next steps	183
5. Literature /References	184
Annex I - SIEF KPIs final table for T-LLs and F-LLs	1
Annex II – KPIs details for the Followers and LL5 workshop details	9

List of Tables

Table 1. MetaCCAZE - Deliberable 1.4 Reference guide for Consultation	3
Table 2. Overview of metaCCAZE Use Cases by follower City.....	5
Table 3: AT-UC01 Summary of BIGM	15
Table 4: AT-UC01- List of stakeholders and roles	16
Table 5: AT-UC01 - Business Model.....	18
Table 6: AT-UC02 Summary of BIGM	28
Table 7: AT-UC02- List of stakeholders and roles	29
Table 8: AT-UC02 Business Model	30
Table 9: KR-UC01 - A Summary of BIGM	55
Table 10: KR-UC01 - A- List of stakeholders and roles	56
Table 11: KR-UC01 - A - Business Model.....	59
Table 12: KR-UC01 - B Summary of BIGM	79
Table 13: KR-UC01 - B- List of stakeholders and roles	80
Table 14: KR-UC01 - B - Business Model.....	81
Table 15: GM-UC01 Summary of BIGM	96
Table 16: GM-UC01- List of stakeholders and roles	97
Table 17: GM-UC01 Business Model	98
Table 18: MI-UC01 Summary of BIGM.....	112
Table 19: MI-UC01- List of stakeholders and roles.....	113
Table 20: MI-UC01 - Business Model	115
Table 21: MK-UC01 Summary of BIGM.....	128
Table 22: MK-UC01- List of stakeholders and roles.....	129
Table 23: MK-UC01 - Business Model	131
Table 24: MK-UC02 Summary of BIGM.....	144
Table 25: MK-UC02- List of stakeholders and roles.....	145
Table 26: MK-UC02 - Business Model	146
Table 27: PO-UC01 Summary of BIGM	165
Table 28: PO-UC01- List of stakeholders and roles	166
Table 29: PO-UC01 - Business Model.....	167
Table 30: PO- UC02 Summary of BIGM.....	181
Table 31: PO-UC02- List of stakeholders and roles	181
Table 32: PO-UC02 - Business Model.....	182

List of Figures

Figure 1: AT-UC01- Governance Model.....	17
--	----

Figure 2: AT-UC02- Governance Model.....	30
Figure 3: KR-UC01 - A- Governance Model.....	59
Figure 4: KR-UC01 - B Governance Model.....	81
Figure 5: GM-UC01- Governance Model.....	98
Figure 6: MI-UC01- Governance Model.....	115
Figure 7: MK-UC01 Governance Model.....	130
Figure 8: MK-UC02- Governance Model.....	146
Figure 9: PO-UC01- Governance Model.....	167
Figure 10: PO-UC02 Governance Model.....	182

Abbreviations and Acronyms

ACRONYM	Description
API	Application Programming Interface
AV	Automated Vehicle
BAU	Business-as-Usual
BIGM	Business Innovation & Governance Model
CBA	Cost Benefit Analysis
CCAM	Connected, Cooperative and Automated Mobility
CEA	Cost Effectiveness Analysis
CINEA	European Climate, Infrastructure and Environment Executive Agency
CIVITAS	City-Vitality-sustainability
DCM	Dynamic Curbside Management
F-LL	Follower Living Lab
GHG	Greenhouse Gas
ITS	Intelligent Transport Systems
IoT	Internet of Things
KPI	Key Performance Indicator
LCA	Life Cycle Assessment
LL	Living Lab
OBU	Onboard Unit
SIEF	Standardized Impact Evaluation Framework
SUMP	Sustainable Urban Mobility Plan
T-LL	Trailblazer Living Lab
TMC	Tradable Mobility Credits
TUMS	Total Urban Mobility System
UC	Use Case
UKB	Urban Knowledge Base
VoT	Value of Time
WP	Work Package
ZESM	Zero Emission Shared Mobility

Background: About the metaCCAZE project

Transport is the second largest source of greenhouse gas emissions (GHG) and accounts for more than 30% of the total energy consumption. A series of global crises highlight the need for a significant shift from conventional vehicles to well-integrated, energy efficient, connected and automated passenger and freight services that meet the ambitious EU goals. To do so, a paradigm shift is required in the operations of electric vehicles that tackles their inherent vulnerabilities, including: the electric fleet-grid supply mismatch, the slow charging times, and the vehicle delays at charging stations. This requires automated charging processes, intelligent scheduling operations and matching to the grid, interconnectivity and automation of transport operations, and a shift from private cars to shared modes.

metaCCAZE is a Horizon Europe MISSION project co-funded by the 2Zero, CCAM-and Cities' Mission partnerships. It participates in the CIVITAS Initiative, an EU-funded programme working to make sustainable and smart mobility a reality for all and contributes to the goals of the EU Mission Climate-Neutral and Smart Cities.

The metaCCAZE project aims to revolutionise mobility in European cities, serving both passengers and freight, with innovative electric, automated, and connected solutions designed to make transportation smarter, net zero, and more efficient for all. It builds on the expertise of 44 partners from 12 different European countries and contributes to the green metamobility era that the Green Deal, 2ZERO, CCAM, Cities Mission, CIVITAS and other EU initiatives aim to reach by 2030. In the vibrant streets of four trailblazer cities – Amsterdam, Munich, Limassol, and Tampere – metaCCAZE implements, tests and demonstrates cutting-edge technologies and services that support shared zero emission mobility solutions for people and goods, contributing to climate neutrality. Successful technologies and activities are transferred and implemented to six Follower Cities – Athens, Krakow, Gozo, Milan, Miskolc, and Poissy, Yvelines (Paris Region), Yvelines (Paris Region).

metaCCAZE organises a series of metaDesign activities and develops a toolkit called metaInnovations. This toolkit is pioneered in passenger and freight services (public transport, on-demand minibuses, bike and scooter sharing, deliveries) and related infrastructure (mobility and logistics hubs, traffic management centres, charging infrastructure, transport and energy integration) and widely demonstrated in our four trailblazer cities for a whole year. Successful metaInnovations and metaServices are transferred, implemented and demonstrated in the 6 follower cities for up to 8 months, to ensure their transferability and resilience potentials.

Executive Summary

Cities often lack the technical expertise, structured methodologies and/or resources needed to address local needs while contributing to global priorities. Either emissions reduction or incidents require adaptable technologies and innovations that evolve with the urban complexities. Aspects addressed in metaCCAZE project through methodologies and frameworks that ensure transferability and replicability across project Living Labs (LLs) and European cities.

For reference, it is worth mentioning that the applied methodologies in the present report are described in detail in Deliverable D1.4 MetaDesigned Zero Emission Sustainable Mobility (ZESM) use cases for the Trailblazer Living Labs (T-LLs). D1.4 focuses on the use cases deployed in Amsterdam, Munich, Limassol, and Tampere. Through D1.4 methodologies, cities can proactively identify and mitigate potential barriers before implementation, define key stakeholders, infrastructure requirements, operational workflows, and risks – ensuring that mobility innovations are both locally relevant and implementation ready.

Aiming for the same successful results, D1.5 focuses on the MetaDesigned transferable ZESM use cases for the follower Living Labs (F-LLs). Leading to complement the work realised in the T-LLs by applying the same methodologies in different contexts. Extending the experiences to six additional cities (Athens, Krakow, Gozo, Milan, Miskolc, and Poissy, Yvelines (Paris Region)). Results expected to be replicated by observer, European and global cities.

Both, D1.4 and D1.5 lay on a co-design approach, engaging city officials, mobility stakeholders, and citizens in a multi-phase process. By the nature and logic of the tasks within Work Package 1 (WP1), they have been categorised into two complementary groups: tasks carried out for analysis and tasks carried out for monitoring and evaluation. The approach combines a multi-perspective alignment based on these task groupings:

Analysis of the Use Cases:

- Foundation analysis (Status Quo Mapping includes sub-tasks Capacity and Empathy Maps and Data Maps in T1.1)
- Fine-tuning the proposed solutions to systematically identify challenges, objectives, key stakeholders, infrastructure needs, operational processes, risks (Use Case definition in T1.2)
- Defining the roles and responsibilities of different stakeholders, ensuring structured collaboration between various stakeholders to barriers and features in business and governance (Business Innovation and Governance Models (BIGMs) in T1.3)

Monitoring and Evaluation of the Use Cases:

- Development of Key Performance Indicators (KPIs) and a well-structured evaluation methodology to assess the impact and effectiveness of the implemented Use Cases — both before and after deployment—thereby supporting future evaluations of what worked, what didn't, and why (Standardised Impact Evaluation Framework (SIEF) in T1.4).
- Evaluating user readiness, behavioural incentives, and social acceptance of new solutions and services to drive long-term adoption (Social Embrace in T1.5)
- Contributing to cross-fertilisation and transferability knowledge-sharing activities with other cities to refine their approach and prototype Use Cases (in T1.6).

The co-design approach was also embedded within the analysis phase through the metadesign activities (referred to as LL activities and detailed in the interaction with city actors). Specifically, LL2 and LL3 metadesign phases, held between July and September 2024, ensured that the Use Cases and BIGMs were grounded in the actual needs of each city. These phases also aimed to

maximise solution uptake by incorporating user feedback and addressing behavioural incentives to enhance adoption and long-term viability. These activities laid the foundation for the Use Case prototyping and BIGMs—later validated in LL4—which are presented in this deliverable, along with the outputs of LL5 and forthcoming Social Embracement Surveys (referred to as SS activities and detailed in 10.1.3. The interaction with city actors), focusing on KPI definition and travel behaviour.

1. Introduction

Robust pre-deployment planning is a critical prerequisite for the successful implementation of zero-emission shared mobility (ZESM) use cases. Cities frequently encounter difficulties in translating innovative mobility concepts into operational solutions, often due to fragmented planning approaches, insufficient structuring of use cases, and the absence of shared methodologies. Without a solid pre-deployment framework, mobility initiatives risk misalignment between technical design, governance arrangements, stakeholder engagement, and real-world operational and business constraints.

D1.5 – *MetaDesigned transferable ZESM use cases for the F-LLs* specifically addresses these challenges by focusing on the six Follower Cities: Athens, Gozo, Krakow, Milan, Miskolc, and Poissy, Yvelines (Paris Region). Building on the experience and lessons learned from the Trailblazer cities, this deliverable supports the transfer and contextual adaptation of selected use cases to diverse local environments. Its primary objective is to guide follower cities in structuring, tailoring, and refining their ZESM use cases prior to deployment, ensuring they are both locally relevant and methodologically consistent with validated project approaches.

Drawing directly on insights from the six F-LLs, D1.5 consolidates practical methodologies and structured guidance covering key pre-deployment components, including use case development, BIGMs, and implementation assumptions. This structured approach underlines the importance of a solid planning before deployment, to ensure technical feasibility, organisational readiness, economic viability, and stakeholder alignment from the outset.

As an annex to the deliverable, a consolidated set of KPIs for the F-LLs is included, providing a more comprehensive basis for monitoring, comparison, and future evaluation of the planned use cases.

This work builds directly on the metadesigned activities and initial BIGMs developed during Year 1 for the T-LLs (Amsterdam, Limassol, Munich, and Tampere). As the Trailblazer use cases matured, their associated business, innovation, and governance models were reviewed, refined, and validated to ensure coherence across technical, organisational, regulatory, and economic dimensions.

The same methodological framework is now being applied to the development of the first iteration of the BIGMs for the six F-LLs. This ensures continuity and comparability across the project while allowing sufficient flexibility for local adaptation to specific urban contexts.

1.1. Objectives of the Deliverable

The broader objective of the present report is to facilitate the creation of additional use cases and extend support to new cities beyond the metaCCAZE framework, enabling a catalogue of scalable, deployment-ready mobility solutions. This is achieved through an integrated methodology, initially applied to the Trailblazer Use Cases and combined with consortium's collective technical, regulatory, social, and economic expertise.

D1.5 follows the comprehensive frameworks described in D1.4 for pre-deployment and planning to guide Follower cities in developing structured use cases that respond to local mobility needs, regulatory requirements, governance frameworks, and user expectations. By focusing on early-stage preparation, D1.5 helps minimize implementation risks and supports informed decision-making reducing the waste of resources.

By building on proven methodologies established in D1.4, D1.5 provides a practical guideline for initiating the transfer of use cases into the specific contexts of the F-LLs. It supports cities and

stakeholders in adapting, structuring, and refining mobility solutions to local conditions, regulatory frameworks, and user needs. Effectively extending the work previously carried out for the Trailblazer cities, it lays the groundwork for deployment-ready solutions across diverse urban environments.

1.2. Structure of the Document

This deliverable provides both the latest co-designed ZESM Use Cases developed during metaCCAZE project and a practical set of guidelines to support the identification and implementation of similar solutions beyond the project. Focusing on the six F-LLs, the document includes the following sections:

- An **introduction** outlining the objectives, situating the work in the context of the six F-LLs, and describing the overall methodological approach.
- A **comprehensive guide** referencing the D1.4 where the methodologies have been described in detail.
- **Ten fully documented Use Cases**, showcasing a range of urban mobility challenges and priorities addressed across the six F-LLs. Each case details the challenges and objectives, concept location and infrastructure, operational aspects, costs and investments, and associated risks with mitigation strategies.
- **Conclusions and Next steps** summarizing the actions required to ensure successful deployment and adaptation of these solutions to other urban contexts.
- **Annexes** presenting the set of KPIs developed within the SIEF for the F-LLs.

1.3. Relation to Project Documents

D1.5 builds on the methodologies and outcomes of previous metaCCAZE deliverables, particularly those produced within Work Package 1 (WP1), including **D1.4 – MetaDesigned ZESM Use Cases for the T-LLs and the SIEF**. These foundations, further detailed in the Comprehensive Guide (Section 2), provide the basis for translating lessons learned from the Trailblazer activities into replication and adaptation work for the six F-LLs.

This deliverable also builds on the work of **D1.3 – Follower Cities: Status Quo Map and Prototype ZESM Use Cases**, which provided a detailed overview of the current mobility systems and preliminary use cases in the Follower Living Labs, forming the baseline for replication, adaptation, and co-creation activities in the replication of the use cases.

Overall, D1.4 serves as a central reference, as D1.5 adopts a similar structure to ensure consistency and continuity. D1.4 itself drew on **D1.1, which offered a detailed assessment of use cases across the four T-LLs** (Munich, Amsterdam, Limassol, and Tampere). This foundational work included not only the identification of existing barriers, services and resources, but also the capturing of stakeholder perspectives and local ecosystem challenges (via Metadesigned activities like capability maps, empathy maps, and mini dialogues).

1.4. Overall Approach

This deliverable presents a comprehensive framework for preparing and transferring ZESM use cases, ensuring they are scalable, adaptable, and ready for deployment. It draws on the foundations established in Work Package 1 (WP1), which defines and structures urban mobility solutions, and connects closely with the other work packages:

- **WP2**, which develops the metaInnovation and focuses on their technological development and adaptation to diverse local contexts.

- **WP3**, overseeing deployment and implementation in the Trailblazer Cities, providing validation and lessons learned.
- **WP4**, driving deployment and stakeholder engagement in the F-LLs.

By linking these efforts, the framework provides cities with a clear, stepwise pathway from identifying mobility challenges to implementing solutions that are technically robust, economically viable, socially inclusive, and transferable across urban contexts.

2. Comprehensive Guide - Reference to the D1.4

The metadesign process applied in metaCCAZE followed an iterative, stakeholder-driven approach structured around the WHY-WHAT-HOW framework. Through a combination of structured workshops, bilateral meetings, and continuous feedback loops with the Living Labs and their local ecosystems, the BIGMs were shaped to accurately reflect real local conditions.

Key stakeholders including city administrations, public transport authorities, mobility and logistics service providers, infrastructure and technology operators, and other relevant actors were actively engaged throughout the process. Their involvement ensured that the BIGMs remained aligned with policy objectives, regulatory frameworks, operational responsibilities, and end-user needs.

The resulting ten use cases and their corresponding BIGMs offer a consolidated view of collaborative governance arrangements, stakeholder roles, interaction mechanisms, and decision-making processes. At the same time, the business and innovation components (such as value propositions, cost structures, funding approaches, and revenue streams) provide the basis for operational feasibility, long-term financial sustainability, and the transferability of solutions beyond the duration of the project.

The metaCCAZE project has established a comprehensive, evidence-based methodology for defining use cases and developing BIGMs that translate zero emission mobility concepts into economic viable and sustainable implementations. This methodology described in detail in Deliverable D1.4 is referenced at the beginning of this report to support the reader whenever clarification is required on the processes that follow. It is presented in Chapter 2, structured into four subsections covering the holistic approach, the core WP1 tasks, and the metadesign activities. Table 1 provides a concise summary of the key elements of the methodology.

Table 1. MetaCCAZE - Deliverable 1.4 Reference guide for Consultation

SUBSECTION	CORE WP1 TASKS	SUMMARY OF CONTENT	LOCATION IN D1.4
2.1. Holistic Methodology	T1.1 (Status Quo), T1.6 (Fertilisation)	Maps the overall structured, multi-dimensional approach from initial Status Quo Analysis (T1.1) to a final Ready for Deployment (WP3) UC . Highlights the iterative engagement with stakeholders (Table 1).	Section 2.1
2.2. Analysis: Prototype UCs and BIGMs	T1.2 (UC Definition), T1.3 (BIGMs)	Details the structured definition of solutions using the WHY - WHAT - HOW logic , adhering to standards (CEN-CENELEC CWA 17381:2019). Explains Business Innovation	Section 2.2

SUBSECTION	CORE WP1 TASKS	SUMMARY OF CONTENT	LOCATION IN D1.4
		and Governance Models (BIGMs) (T1.3), which define roles, sustainability, and scalability. Refinement occurred through LL2/LL3, with formal validation in LL4 .	
2.3. Analysis: Social Embrace	T1.5 (Social Embrace)	Focuses on user acceptance and behavioral change. Outlines the execution of two rounds of surveys (post-co-design/before implementation and during/after implementation) targeting citizens and stakeholders to refine services and measure long-term adoption.	Section 2.3
2.4. Impact monitoring and Evaluation: SIEF	T1.4 (SIEF)	Presents the Standardized Impact Evaluation Framework (SIEF) , the core measurement tool. The SIEF is consistent and transferable, aligning with CIVITAS, CCAM, and local SUMP/CCCs . It defines KPIs across three levels (Project-wide, Solution-wide, Context-specific). The framework was validated in LL5 (T1.6.1) and requires comparison against a Business-as-Usual (BAU) scenario .	Section 2.4

3. Outcomes – The 10 Metadesigned Use Cases and BIGMs of Follower Living Labs (LLs)

Chapter 3 describes the metadesigned use cases of the follower cities, and the corresponding BIGMs utilizing the proven methodologies and experiences obtained from the T-LLs. Table 2 provides an overview of the six follower cities: Athens, Krakow, Gozo, Milan, Miskolc, and Poissy, Yvelines (Paris Region) where the use cases have been organized by country and city to facilitate easy identification. Self-explanatory naming conventions have been applied to each use case to enable stakeholders, practitioners, and interested parties to quickly locate and access relevant documentation for their specific contexts.

Table 2. Overview of metaCCAZE Use Cases by follower City

COUNTRY	CITY	USE CASES
Greece	Athens	3.1 Optimized Scheduling and Route Planning for Electric Bus Integration in Athens (AT-UC01)
		3.2 Optimal Planning of Locations of E-Charging Infrastructure for the Athens Electric Bus network (AT-UC02)
Poland	Kraków	3.3 Multimodal logistics and passenger hub in Krakow (KR-UC01 - A)
		3.4 E-cargo bikes & e-bikes demand and monitoring in Krakow (KR-UC01 - B)
Malta	Gozo	3.5 On-demand automated mini-bus services in Gozo (GM-UC01)
Italy	Milan	3.6 Development of on-demand e-Pod service in Milan (MI-UC01)
Hungary	Miskolc	3.7 Multimodal Passenger hub in Miskolc (MK-UC01)
		3.8 Multimodal journey planner in Miskolc (MK-UC02)
France	Poissy, Yvelines (Paris Region)	3.9 Intelligent road and smart traffic management in Poissy, Yvelines (Paris Region) (PO-UC01)
		3.10 Shared vehicle services for enhanced mobility in Poissy, Yvelines (Paris Region) (PO- UC02)

Following the same approach as D1.4, a **traffic light system might be used to classify some of the information in terms of accuracy:**

- : Confirmed—what you know for sure.
- : Needs verification—what you think you know.
- : Future-focused—what you don't know (yet)
- : Exploratory—what you aim to discover in the Use Case

3.1. Optimized Scheduling and Route Planning for Electric Bus Integration in Athens (AT-UC01)

3.1.1. Metadesigned Use Case

First Stage of Why – What – How Framework

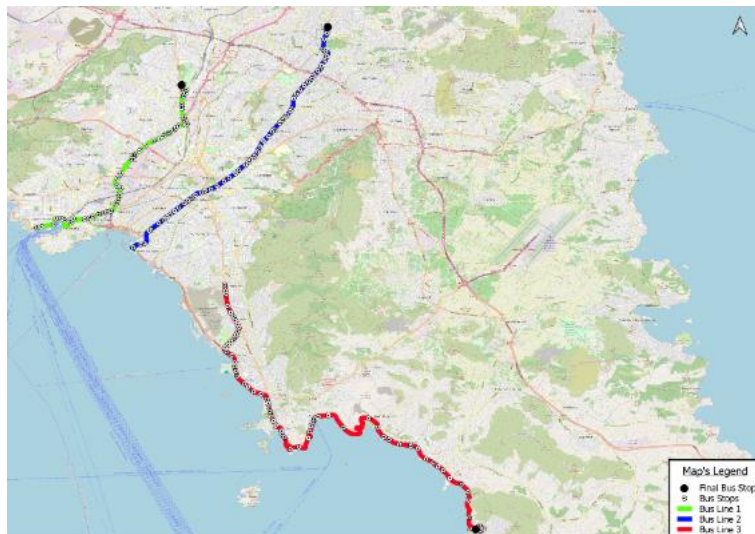
Why: Challenges and Objectives

Questions	Considerations
What specific challenges faced by the city will this Use Case address?	For Use Case 1, Optimized scheduling and route planning for Electric bus integration in Athens, the primary challenge lies in the operational integration of the 240 newly acquired electric buses into the existing transport system (Phase 1 of e-bus deployment). Although these vehicles have been delivered and are slowly being integrated into daily operations, their efficient scheduling and alignment with service needs remain incomplete, leading to risks of underutilisation of the bus system, as compared to the optimal practises. In addition to Phase 1 deployment, a Phase 2 is taking place where an additional 125 electric buses are being brought into operation in Athens. This two-stage deployment approach further complicates efficient operation of the fleet and necessitates decision support tools. Decision support tools can help with several challenges of OASA (Public Transport Operator). For example, the buses' deadheading trips, where buses travel empty to and from depots for charging, create inefficiencies, add unnecessary congestion, and increase operational costs. At the same time, without advanced optimisation tools, driver rostering and vehicle scheduling remain costly and less effective, considering the extra deadheading times and the downtimes required for charging. All these challenges will be supported by the decision support tools developed in this use case. Finally, connected to this use case, the transport authority in Athens must ensure service reliability, maintaining at least 1,100 buses in circulation daily (conventional buses & electric), while phasing out older Euro 2 and Euro 5 vehicles and balancing resources across a rapidly modernising fleet. This fleet size does not only serve the Municipality of Athens (which is the focus of the use case, but it concerns the wider Athens metropolitan area).
Which (at least 5) objectives does the city aim to achieve through this Use Case?	Through the metaCCAZE Use Cases, the Athens LL aims to achieve several objectives that respond to its sustainability and mobility challenges. Here is a list of the objectives for Use Case 1: Optimize the integration of electric buses into daily operations: Building on the successful deployment of 240 electric buses already in service, the Living Lab will focus on the seamless integration and performance optimization of an additional 125 new electric buses by early 2026, with further units added through the end of the project. This includes monitoring charging infrastructure performance (currently 70 double chargers installed and 50 under installation) and assessing network readiness to ensure operational stability and scalability.

	Reduce block completion failures and energy inefficiencies under varying weather conditions: By applying AI-based scheduling and energy management tools, the Living Lab aims to decrease the current 3% rate of incomplete bus blocks, which often increases during extreme heat or cold due to additional energy consumption from heating, ventilation, and air conditioning (HVAC) and battery thermal management systems. Predictive charging and dynamic scheduling will be used to mitigate performance losses during harsh weather. ● Quantify CO₂ emission reductions using real operational data: Using OSY's (bus operator subsidiary) available energy consumption data from the 240 electric buses, the project will calculate and compare energy use and CO₂ emissions against conventional diesel buses, providing evidence-based metrics to guide fleet-wide decarbonization planning. ● Reduce deadheading times and optimize fleet utilization by 2027: Implement AI-driven scheduling and charging coordination models to minimize non-revenue trips (deadheading) and ensure efficient use of the electric fleet, reducing both operational costs and energy waste. ● Reduce rostering and scheduling costs through data-driven optimization by 2027: Deploy and validate advanced planning tools (Multi Depot Vehicle Scheduling, Electric Bus Line Modification, and Electric Bus Crew Scheduling models) to lower operational costs and improve workforce allocation across depots and routes.
--	---

What: The Concept, Location, and Infrastructure

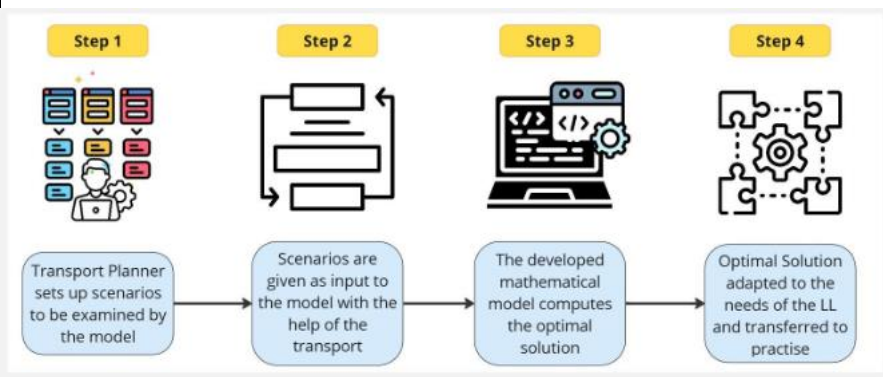
Use Case Code	● AT-UC01
Use Case Title	● Optimized Scheduling and Route Planning for Electric Bus Integration in Athens
Use Case Concept Definition	● Since the beginning of 2025, OASA, the public transport authority of Athens, together with its bus operations subsidiary OSY, has successfully integrated 240 electric buses into regular service. To support their operation, 70 double 180 kW chargers have been installed, with an additional 50 units currently under installation. While these deployments mark significant progress in the city's fleet electrification efforts, the full integration of the next 125 newly procured electric buses, and any additional units to follow, remains a key operational challenge. Ensuring efficient charging coordination, route adaptation, and reliability under varying weather conditions will be crucial to achieving full-scale integration within the existing public transport network. OASA (PT operator) will expand its existing tactical planning procedures and respective scheduling software, enabling integrated vehicle and crew scheduling optimized by the AI models developed by NTUA. To assist OASA and Anaplassis (Managing and Coordinating Authority for Urban Regeneration Interventions) in navigating this transition to electric mobility, ATH-UC01 will apply advanced Operations Research and algorithms to design optimal vehicle schedules (blocks) and driver assignments (duties) for the

	new e-bus fleet. These models will account for current slow-charging infrastructure and anticipate future fast-charging capabilities. The National Technical University of Athens (NTUA) will lead the development of a Multi Depot Electric Vehicle Scheduling Problem (MD-E-VSP) model to support decision-making for stakeholders in the Athens Living Lab. Additionally, a strategic challenge for OASA and Anaplassis is the creation of a Line Planning Model for electric buses (EV-LPP), addressing constraints related to vehicle autonomy. The Use Case will also examine the development and utilization of Electric Bus Crew Scheduling Problem (EB-CSP) model that will provide decision support regarding the optimal derivations of drivers' schedules (duties) considering the range and energy autonomy of the new electric buses. ATH-UC01 stands out due to its multifaceted approach to electrifying public transport in Athens. Unlike conventional fleet upgrades, it combines both operational and tactical planning through advanced modelling techniques. At the operational level, it introduces algorithms to optimize vehicle and driver schedules, ensuring that electric buses are deployed efficiently despite limitations in charging infrastructure. Strategically, it addresses the challenge of designing and modifying existing bus lines that account for vehicle autonomy and energy constraints, a problem few cities have tackled with such precision. What further distinguishes this initiative is its application within the dense and complex urban core of Athens, a historic, high-demand area with over 640,000 residents and multiple transport hubs. The models developed are not static; they are designed to be robust and be able to simulate "What-if" scenarios, allowing stakeholders to test future conditions such as expanded charging networks or changes in bus technology. This level of foresight makes the Use Case not only adaptive but also scalable to other cities.
Location (and its influence area)	● This Use Case is applied to the area of Municipality of Athens. Some public transport services are also examined that expand to the Athens Metropolitan area and the wider Attica Region. The study area for Use case 1 is the same as Use Case 2. 

	In the figure above, the Athens Metropolitan area including Bus lines 420, 122 and 550 that will be studied by the Electric Bus Line Planning and Modification models.
Which (physical and digital) infrastructure is needed?	● Use Case 1 mainly focuses on analysing and improving public transport services as well as operational aspects of integrating electric buses, mainly focusing on how to use existing electric buses and personnel in a more efficient way. This means that the requirements on physical infrastructure can be considered minimal. The first requirement is the electric buses themselves which need to be included in the analysis according to their technical specification. Also, another aspect of physical infrastructure connected to this use case are the stops of the bus network that may be affected from the EB-LPP model which may reorganize stops or stops sequences. On the digital infrastructure side, the requirements are the same as in Use Case 2. A central role is played by the OASA Telematics system, since the static and dynamic data collected by the system are very important input for the models developed by NTUA. Also, a very important role is played by Electric Bus Monitoring System/Platform which can provide data for the operation of the electric buses (energy consumption, battery levels, etc.). OASA has already provided timetables data and telematics data to the NTUA team. Ticketing data and OD survey data can be provided by OASA if necessary.
Who will be responsible for developing and managing this new infrastructure?	● NTUA is responsible for the development of the scheduling and line planning algorithms. The public transport authority of Athens, OASA, has acquired the necessary funding for the physical infrastructure (chargers etc.). OASA and Anaplassis are responsible for providing data and field-knowledge to NTUA.
What (physical & digital) infrastructure needs to be modified?	● In Use Case 1, the necessary infrastructure modifications concern the bus stops that may need to adapt according to the decision support derived from the EB-LPP model. It is possible through that no new stops may need to be added or stops being removed. It is possible that a new stop sequence is derived for some of the bus lines. There is no need for modifying any existing digital infrastructure.
Who will be responsible for these infrastructure modifications?	● For all the infrastructure modifications, the stakeholder responsible is OASA in cooperation with OSY (bus operations subsidiary OSY).
Which metalInnovation technology (WP2) is being tested linked to this UC?	● The metalInnovation technology being tested in this Use Case, under Work Package 2 (WP2) of the metaCCAZE project, is a smart, decision-support tool developed by the National Technical University of Athens (NTUA), the “Line Planning Modification & Vehicle Scheduling Problem for a Fleet of Electric Buses” Also, the Multi Depot Electric Vehicle Scheduling Problem (MD-E-VSP) tool is developed under this use case which is responsible for the bus scheduling process (buses assignment to trip schedules).

	These models are built to handle real-world data and will account for variable travel times and energy consumption, and are tested using actual operational data from OASA's telematics and fleet management systems.
--	---

How: Operation, Management and Stakeholder Interaction

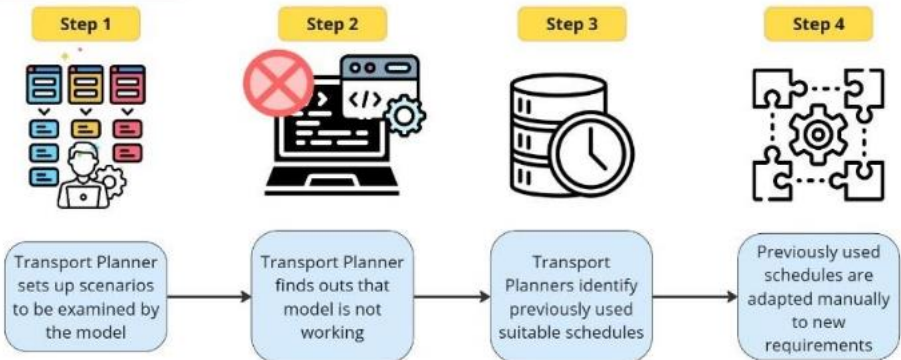
! How the Service will function (under normal conditions - operation on a daily basis)	● In Use Case 1, the developed tools are digital transport models built on scientific methods. These are mathematical models translated into software, capable of determining optimal scheduling scenarios and bus routes for the lines under study. The transport planning models under this case are mainly solving vehicle and crew scheduling problems for electric buses and are utilized in the tactical planning phase of the planning operations. ● Once the digital model is developed by the NTUA team, then it will be regularly used by the OASA team in order to produce optimal schedules for vehicles and crews in order to support the daily operation of electric buses. A flow chart of how this process looks is included below:  <pre> graph LR S1[Step 1: Transport Planner sets up scenarios to be examined by the model] --> S2[Step 2: Scenarios are given as input to the model with the help of the transport] S2 --> S3[Step 3: The developed mathematical model computes the optimal solution] S3 --> S4[Step 4: Optimal Solution adapted to the needs of the LL and transferred to practise] </pre> Four steps are included in the flow chart which begins with the conceptualization of scheduling scenarios to be examined by OASA. Then as a second step, the transport planner and transport modeller (NTUA) work together to give these scenarios as parameters to the model. Then in the third step the model processes the data and derives the mathematically optimal solution. In the forth step the transport planners (OASA) adapt the solution to the real-world schedules as required.
! How the User will interact (under normal conditions - operation on a daily basis)	● The users/transport planners will run the planning models in the form of a software program which will process the input data and return the results in a format that can either be directly read by the user or can be used as input to another software that will visualise the data.

! List of stakeholders and their roles	● The list of stakeholders is similar to Use Case 2. It includes the metaCCAZE Athens LL partners as well as: Municipality of Athens: The local authority responsible for implementing sustainable mobility policies and aligning the project with the city's Climate City Contract. OSY S.A.: the main bus operating company, directly responsible for fleet management of electric buses, driver supervision, and the reliable daily deployment of vehicles. DEI (Public Power Corporation): the energy provider responsible for electricity projects up to 10 MW that supply depot charging stations. DEDDIE (Hellenic Electricity Distribution Network Operator): the grid operator responsible for larger-scale upgrades above 10 MW needed for depot electrification. Attica Region Transport Consortium: The consortium was established through a public tender by OASA (Athens Urban Transport Organization) and has taken over the operation of 63 urban bus lines since 2024. Potential future collaboration and acquisition of new electric buses. National Technical University of Athens (NTUA): The Technical University of Athens is the main developer of the mathematical models and digital tools to be utilized in this use case.
---	---

Second Stage of Why – What – How Framework

What: Foreseen Internal Risks and Mitigation Actions

Internal Risk (Technical issues, operability, service reliability):			
Risk	Severity	Likelihood	Mitigation action
Higher energy demand from buses during extremely high or low temperatures (due to air-conditioning use), or traffic congestion.	Medium	Medium	Expand charging capacity during the summer / winter months by installing additional slots, accelerate the deployment of fast-charging units, and collaborate closely with grid operators to ensure sufficient energy supply.
Delays in grid upgrades at depots (DEI/DEDDIE responsibilities)	High	Low	Early coordination with DEI/DEDDIE; phased installation; backup diesel/CNG buses in service.
Charger malfunction or breakdown	Medium	Low	Implement a routine preventive maintenance schedule, establish service agreements with charger manufacturers to ensure timely support, and design the charging network with built-in

			redundancy by positioning backup chargers in close proximity to primary units.
Insufficient charging capacity during peak demand	Medium	Low	Install mix of slow and fast chargers; stagger charging schedules.
Driver/technician lack of training for new systems	Medium	Low	Robust training programs will be implemented to ensure personnel are fully equipped to operate and maintain electric bus systems. These will include formal certification processes to validate technical competencies, along with ongoing refresher courses to keep staff (OSY's drivers) updated on evolving technologies, safety protocols, and operational best practices.
How the Service will function (under the anomalous scenario)	The metaInnovation developed for Use Case 1 is intended for decision-makers (transport planners) responsible for designing and optimizing scheduling scenarios and bus routes. In the OASA environment, this is a transport planning team of approx. 5 or 6 members with extensive senior experience on planning such operations for the city of Athens. In that regard, the team already includes manual methods and other digital tools (e.g. Hastus) which support them in the daily operation. With the use of the new tool by NTUA they will be able to actually have mathematically optimal solutions to their planning operations. They will lead to benefits such as reduced rostering costs and less vehicle utilization. However, in the case that the NTUA models don't work, the transport planning team will still have the capability to carry out operations as they are currently, without enjoying the benefits offered by NTUA models. Here's a flow chart of the anomalous scenarios: Anomalous scenario  <pre> graph LR S1[Step 1: Transport Planner sets up scenarios to be examined by the model] --> S2[Step 2: Transport Planner finds out that model is not working] S2 --> S3[Step 3: Transport Planners identify previously used suitable schedules] S3 --> S4[Step 4: Previously used schedules are adapted manually to new requirements] </pre>		

How the User will interact (under the anomalous scenario)	Anomalous scenario does not affect the usage of the tool developed in Use Case 1.
---	---

What: Foreseen External and Other Risks and Mitigation Actions

External Risk (user acceptance: complex interface, trust,):			
Risk	Severity	Likelihood	Mitigation action
Complexity of digital tools, optimisation software may be difficult to handle by technical staff	Low	Low	Organize hands-on training workshops to equip users with the necessary skills to operate the system effectively, while also developing intuitive user dashboards and straightforward instructional materials to ensure ease of use and accessibility.
Difficulties in operation of the newly acquired electric buses, by the drivers	Medium	Low	Training programs for drivers to get used to the electric bus systems
Difficulties in acceptance for new charging routines by drivers/technicians	Medium	Low	Engage drivers actively in the co-design process and dedicated training sessions to ensure their insights shape the system's development. Charging schedules should be continuously refined based on operational feedback gathered from their daily experiences, fostering a more responsive and efficient deployment.
Difficulties in acceptance for the modified routes, that may arise due to the implementation of the tool of UC1, by citizens or drivers.	Medium	Medium	Launch a public information campaign using social media, local news outlets, and community boards to clearly communicate the benefits of the new routes, such as reduced travel times, environmental gains; Implement alternative solutions; Involve drivers early in the planning process to ensure operational feasibility and build ownership of the new routes. Implement the modified routes as pilot programs in selected areas, allowing for real-world testing and adjustments based on feedback;

			Ensure that modified routes are supported by adequate frequency, reliable schedules, and last-mile connectivity (e.g., micromobility options or feeder buses).
Other External Risks			
Risk	Severity	Likelihood	Mitigation action
Delays in supply and installation of chargers due to procurement or supply chain issues	High	Low	Establish relationships with multiple suppliers to diversify sourcing, implement a phased procurement strategy to manage timelines effectively, and incorporate buffer periods into project planning to accommodate potential delays or unforeseen challenges.
Grid upgrade delays caused by dependency on DEI/DEDDIE	Medium	Low	Initiate early collaboration with grid operators to align infrastructure needs, prioritize deployment at depots with existing electrical capacity, and maintain temporary backup using diesel/ gas vehicles to ensure uninterrupted service during the transition phase.

How: Investment, Costs, and Pricing

What kind of initial investment might be anticipated?	This information was marked as confidential by the partners.
What is included in this budget? (technology-based, consider running the service)	This information was marked as confidential by the partners.
How was the project funded? Under which funding schemas and co-financing?	● All the activities relevant to this use case are funded by the metaCCAZE project.

What is the cost per unit?	● This use case does not focus on a single, clearly defined unit. Instead, each individual planning tool can be considered a unit of analysis. The tools in question are open-source solutions developed by the university and made available to OASA. As a result, there are no direct acquisition or licensing costs associated with their use. The primary cost drivers are personnel-related, specifically the resources required to operate, adapt, maintain, and further develop these tools. Accordingly, the relevant cost per unit can be expressed in terms of the annual salaries of the transport planners and/or software engineers needed to support ongoing use and future development of the tools.
Do you need any human resources? If yes, what type of human resources are needed?	Yes, human resources are required. The effective use, maintenance, and further development of the planning tools depend on specialized personnel. In particular, transport planners are needed to apply the tools in planning and decision-making processes, while software engineers are required for technical maintenance, customization, and further development of the tools.
Please specify any additional costs not outlined above	● Currently the university uses several professional grade laptops and a cloud server to run these models.
Was the pricing of the proposed service defined? If yes, what is the pricing of the proposed service (for the user)	● No pricing applies to the tools, as they are developed through open and reproducible research and are made available without licensing fees.
Are there any incentives planned? If yes, would they motivate users to prefer this mobility solution more frequently? Why?	● Currently there are not incentives planned.

3.1.2. Metadesigned BIGM

Table 3: AT-UC01 Summary of BIGM

SECTION	DESCRIPTION
Summary of the BIGM	The BIGM for ATH-UC01 centres on OASA leading value co-creation via NTUA-developed models for tactical e-bus scheduling.

Core partners (OSY, Anaplassis, NTUA) provide data/ops expertise; enriching partners (Municipality) align policies; others (DEI, DEDDIE) support energy. Revenue from OPEX savings.

Governance Model	OASA coordinates the planning process and defines planning scenarios to be examined, which are then give as input to NTUA optimization models. Then as a third stage, OASA adapts for real-world operations. OSY (OASA subsidiary) validates field data and grid partners (DEI/DEDDIE) ensure energy resilience. Decisions via transport planner workshops; risks mitigated through training, pilots, and phased grid upgrades; aligns with Athens CCC/SUMP for 2030 neutrality. (Figure 1).
Business Model	Innovation This UC is framed around open, research-based decision-support tools (MD-E-VSP, EV-LPP, EB-CSP) that integrate into OASA/OSY planning processes and are funded as project/metalInnovation assets, which matches the Radar logic rather than a stand-alone Classic service with direct pricing to end users.
Co-Created Value in Use	Optimized electric bus operations through collaborative AI-driven scheduling, delivering reduced deadheading (non-revenue km), lower rostering costs, fewer incomplete blocks, better fleet utilization, and CO2 savings via data-shared models.

Table 4: AT-UC01- List of stakeholders and roles

	STAKEHOLDER TYPE	IDENTIFIED STAKEHOLDER	ROLE	STATUS
Focal	Public Transport Operator	OASA	Leads AI-optimized scheduling & planning for e-bus fleet	 Confirmed
Core	Bus Fleet Provider	OSY S.A.	Manages e-bus fleet & daily operations	 Confirmed
	Managing and Coordinating Authority for Urban Regeneration Interventions	Anaplassis S.A.	Supports depot/stop modifications & data	 Confirmed
	Technology Provider	NTUA (National Technical University of Athens)	Responsible for digital infrastructure, development of the mathematical models and digital tools	 Confirmed

	STAKEHOLDER TYPE	IDENTIFIED STAKEHOLDER	ROLE	STATUS
	Ministry of Transportation and Infrastructure	Ministry of Transportation and Infrastructure	Aligns with SUMP/CCC policies	✓ Confirmed
	Energy Provider	DEI (Public Power Corporation)	Supplies electricity depot	✓ Confirmed
	Grid Operator	DEDDIE (Hellenic Electricity Distribution Network Operator)	Grid upgrades to support depots	✓ Confirmed
Enriching	Service provider (Additional PT Operator)	Attica Region Transport Consortium	Operates PT, future e-bus	✓ Confirmed
Other	Regional Authority	Region of Attica	Oversees regional mobility	✓ Confirmed
Customer	Users	Users (commuters, tourists)	End beneficiaries & feedback providers	⌚ Future Engagement

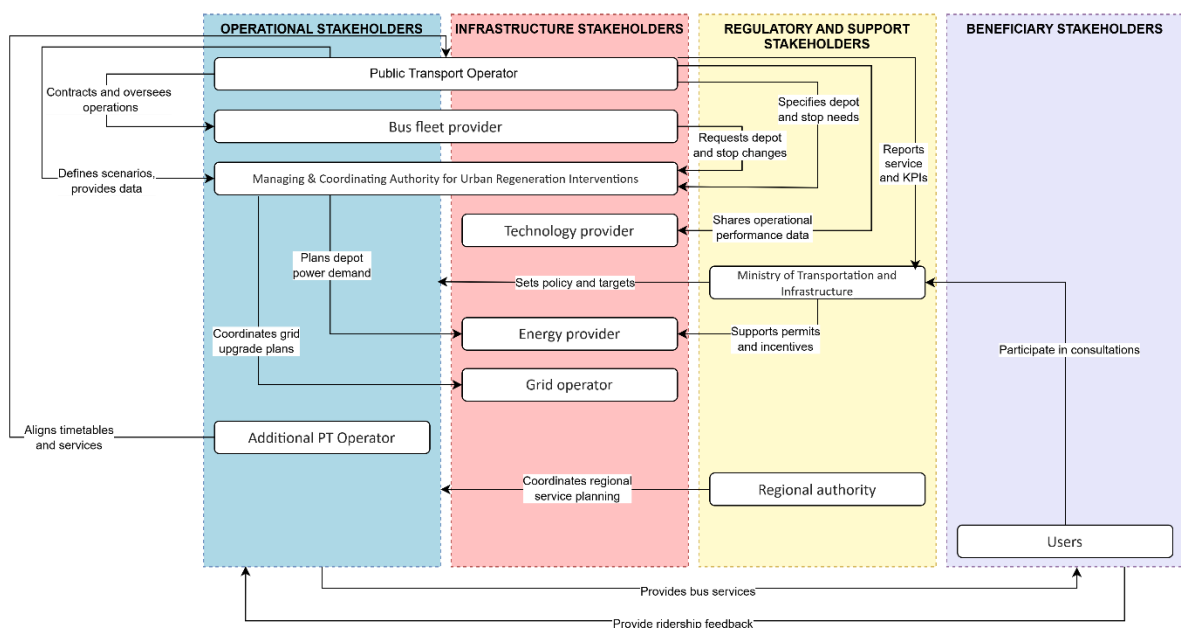


Figure 1: AT-UC01- Governance Model

Table 5: AT-UC01 - Business Model

STAKEHOLDER TYPE	COST (–) / BENEFIT (+)	CO-PRODUCTION ACTIVITY	VALUE PROPOSITION
Public Transport Operator	– Scheduling software expansion + Reduced deadheading/rostering costs	Provide telematics data, validate models	Efficient 240+ e-bus integration
Bus Fleet Provider	– Driver training, charging operations + Optimized utilization, reduction of block failures	Ops feedback, route testing	Reliable daily service, emissions cuts
Managing and Coordinating Authority for Urban Regeneration Interventions	– Infrastructure collaboration time, participatory and statutory planning + Charger/depot readiness	Depot data sharing, participatory and statutory planning, take part on decision-making for operations and planning.	Scalable e-bus infrastructure alignment
Technology Provider	– Model development resources + Research integration	Simulations with real data	Open-source optimization tools
Ministry of Transportation and Infrastructure	– Policy coordination + Urban mobility gains	Route approvals	Climate-neutral PT support
Energy Provider	– Grid supply + Power stability	Demand planning	E-bus charging reliability
Grid Operator	– Upgrade costs + No outages	Capacity coord	Fleet electrification enablement
Service Provider (Additional PT-Operator)	– Fleet transition + Network expansion	Model adoption	Regional ops scalability

STAKEHOLDER TYPE	COST (–) / BENEFIT (+)	CO-PRODUCTION ACTIVITY	VALUE PROPOSITION
Regional Authority	– Oversight + Broader alignment	Strategic input	Attica-wide sustainability
Users	– None + Better service	Usage feedback	Reliable, green PT access

3.2. Optimal Planning of Locations of E-Charging Infrastructure for the Athens Electric Bus network (AT-UC02)

3.2.1. Metadesigned Use Case

First Stage of Why – What – How Framework

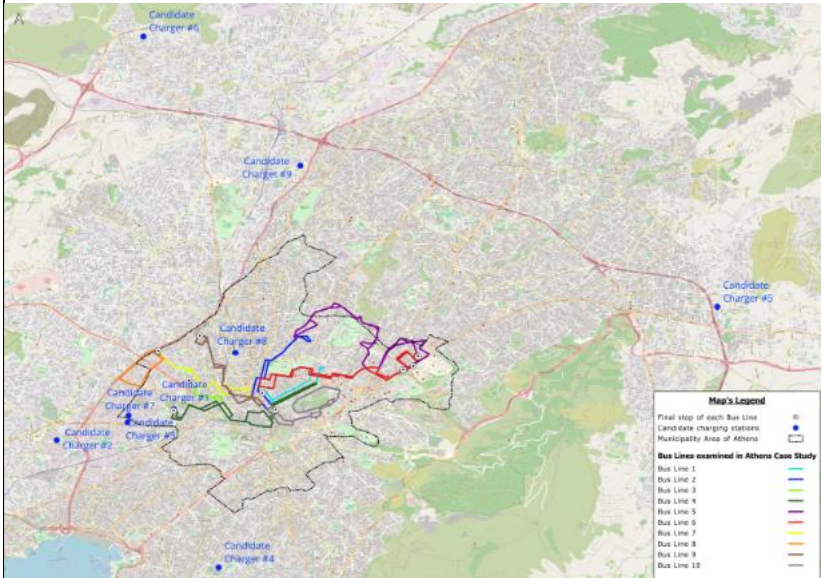
Why: Challenges and Objectives

Questions	Considerations
What specific challenges faced by the city will this Use Case address?	Regarding Use Case 2, the efficient setup of e-charging infrastructure, the main challenge is ensuring adequate capacity to support the growing fleet. Currently, 70 double 180 kW chargers are operational across Athen's depots, with an additional 50 units under installation, bringing the total network to 120 double chargers by early 2026. While this infrastructure will cover the needs of the 240 electric buses already in operation, further optimization and planning are required to support the upcoming 125 new e-buses and future fleet expansions. The charging system must adapt to diverse operational conditions, including the optimal mix of slow and fast chargers and their efficient placement within limited depot space provided by OASA. Significant grid upgrades, managed jointly by DEI and DEDDIE, continue to introduce complexity and occasional delays. Moreover, installation and maintenance costs remain high, underscoring the need for optimization to maintain financial sustainability. Finally, spatial constraints in several depots demand careful reorganization and smart layout planning to ensure safety, accessibility, and efficient energy distribution within each site.

	The ultimate goal of the use case is to identify the setup of chargers that minimizes both upfront installation costs but also operational costs of the chargers that emerge from the day-to-day charging and scheduling.
Which (at least 5) objectives does the city aim to achieve through this Use Case?	● Achieve full operational readiness of a citywide charging network by early 2027: Support OASA and OSY in completing the deployment and optimization of 120 double 180 kW chargers across all major depots (Renti, Attiki, Petrou Ralli, Agios Dimitrios, and Votanikos). With 70 double chargers already installed and 50 under installation, the Living Lab will validate network efficiency and performance under real operating conditions. ● Ensure scalability for future electric bus integration: Design and test a charging network capable of supporting not only the existing 240 electric buses but also the additional 125 incoming electric buses by early 2026 and subsequent fleet expansions through the end of the project. Infrastructure planning will prioritize modularity, grid management coordination, and depot-level energy optimization. ● Eliminate operational interruptions caused by charging or energy deficits: By summer 2026 and onwards, achieve zero power-out incidents, even during extreme weather conditions that increase energy demand from HVAC and battery cooling/heating systems. This will involve predictive energy management and intelligent load balancing across depots. ● Reduce incomplete operational blocks through improved charging reliability: The project aims to reduce the current 3% rate of incomplete bus blocks (which rises during adverse weather) by improving energy availability and charging scheduling. This contributes directly to service continuity and operational resilience. ● Lower operational energy costs by at least 30% compared to diesel buses by 2026: Building on current measurements showing electric buses consume roughly one-third of the energy cost of diesel vehicles, optimize depot charging strategies to maximize off-peak electricity use and minimize total energy expenditure.

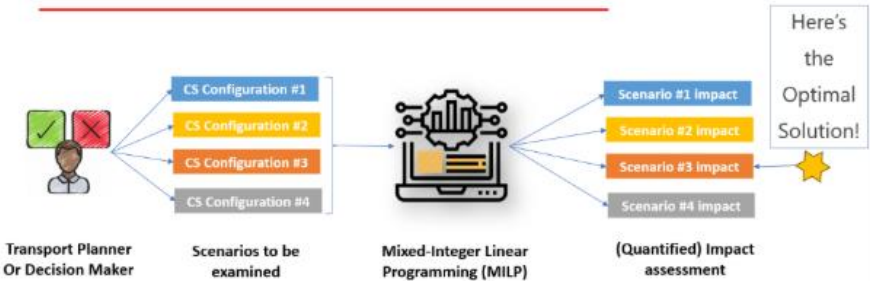
What: The Concept, Location, and Infrastructure

Use Case Code	● AT-UC02
Use Case Title	● Optimal Planning of Locations of E-Charging Infrastructure for the Athens Electric Bus Network
Use Case Concept Definition	● Use Case 2 is unique because it goes beyond simply installing charging stations and instead applies an optimisation framework to strategically design the entire charging network for Athens' electric bus fleet. While many cities focus on expanding infrastructure by adding chargers as demand grows, Athens is developing a data-driven, system-level approach that anticipates both current and evolving needs.

	The uniqueness lies first in the use of the Charging Station Location Problem (CSLP) model, developed by NTUA, which identifies the optimal number, type (slow or fast), and locations of chargers across multiple depots and bus routes. This model is specifically tailored to Athens' operational realities, such as spatial constraints at depots, the need to maintain 1,100 buses in circulation daily, and the simultaneous retirement of polluting Euro 2 and Euro 5 vehicles. Second, the approach integrates energy supply considerations, recognising that responsibilities are split between DEI (up to 10 MW) and DEDDIE (above 10 MW). Few solutions elsewhere account for such detailed alignment between transport operations and grid capacity. Finally, this Use Case ensures cost-efficiency and adaptability. By optimising placements, Athens expects to reduce installation and maintenance costs by at least 15 percent and minimise the number of chargers required, while still ensuring reliable service for 240 electric buses. This makes it a forward-looking solution that can evolve alongside the city's growing fleet and climate neutrality commitments.
! Location (and its influence area)	● The focus in the Athens Municipality area of control, while some bus line and respective services may expand in the wider Athens Metropolitan area. Bus depots that are also central in this Use Case and they expand in the wider Athens Metropolitan area (despite the fact that the actual electric buses may only serve the Athens Municipality area). 
! Which (physical and digital) infrastructure is needed?	● <u>Physical infrastructure</u> On the physical side, the main need is the deployment of charging infrastructure within key depots. At present, 70 double chargers are operational, with 50 more under installation, bringing the total to at least 120 double charging units by early 2026.

	These are distributed across Renti, Attiki, Petrou Ralli, Agios Dimitrios, and Votanikos depots, strategically supporting the 240 electric buses that will form part of the daily fleet. Additional infrastructure improvements are required in the electrical grid, as installations above 10 MW necessitate reinforcement by DEDDIE. While no new roads, bike lanes, or pedestrian pathways are directly required for this Use Case, depot reorganisations may be necessary to accommodate the chargers within limited space. The funding for the physical infrastructure within this use case is sourced from other funding tools (not metaCCAZE). The digital infrastructure will support the deployment of physical infrastructure through decision support. <u>Digital infrastructure</u> On the digital side, Use Case 2 of the Athens LL will rely on the Charging Station Location Problem (CSLP) optimisation tool developed by NTUA. This platform will determine the optimal number, type, and placement of chargers. Integration with existing OASA telematics and mobile apps is not required for this use case, but the data that we use come from these tools of OASA. OASA also has supporting digital services which include public transport management systems (covering at least 1,100 buses in daily circulation). Data from these systems will be used as well.
Who will be responsible for developing and managing this new infrastructure?	NTUA is responsible for the development of the planning models (digital infrastructure). OASA, and its subsidiary OSY, already have funding for physical infrastructure. OASA and Anaplassis are responsible for providing data and field-knowledge to NTUA. OASA, OSY and Anaplassis will be responsible for any modifications required at the depots.
What (physical & digital) infrastructure needs to be modified?	For Use Case 2, the main infrastructure modifications are focused on the bus depots where charging systems are being installed. On the digital side, there is no need for modifying any existing digital infrastructure. But it will be used in order to source the data.
Who will be responsible for these infrastructure modifications?	For the physical infrastructure, OASA and Anaplassis are responsible. For the digital infrastructure, NTUA is responsible.
Which metalInnovation technology (WP2) is being tested linked to this UC?	This use case is supported by the metalInnovation with title: "Charging Station Location Selection considering Charging Scheduling, Energy Pricing, and Travel Time and Energy Consumption Uncertainties"

How: Operation, Management and Stakeholder Interaction

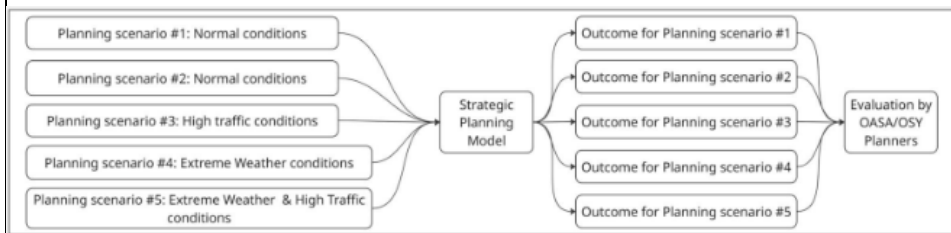
How the Service will function (under normal conditions operation on a daily basis)	● The metaInnovation (i.e. mathematical transport planning models) that will be used to support this use case are strategic planning transport models. This mean that they are mathematical models, implemented into software, that are run once, in an ex-ante assessment phase (prior to actual implementation of the use case), in order to derive decision support for Use Case and Living Lab stakeholders. With that being said, the metaInnovation within this use case has several software implementations and is progressively being developed according to the needs of the Living Lab. For each of these different implementations, the Living Lab can have different types of results based on what are the decision support requirements. Here is a flow chart of how this process works: Decision support with MILP for Charging Station Planning  <pre> graph LR A[Transport Planner Or Decision Maker] --> B[CS Configuration #1 CS Configuration #2 CS Configuration #3 CS Configuration #4] B --> C[Mixed-Integer Linear Programming (MILP)] C --> D[Scenario #1 Impact Scenario #2 Impact Scenario #3 Impact Scenario #4 Impact] D --> E[Here's the Optimal Solution!] </pre>
How the User will interact (under normal conditions operation on a daily basis)	● The user of this metaInnovation developed for Use Case 2 is a decision maker in the process of planning charging station networks. Namely, a transport planner, that needs to evaluate their options regarding planning a network for the transition to electric bus fleets. The transport planner or decision maker would need to have a basic technical background to use the tools developed in this Use Case.

! List of stakeholders and their roles	● The list of stakeholders is the same as in Use Case 1. It includes the metaCCAZE Athens LL partners as well as: Municipality of Athens: The local authority responsible for implementing sustainable mobility policies and aligning the project with the city's Climate City Contract. Region of Attica: The regional government coordinating broader mobility and infrastructure strategies across the metropolitan area. OSY S.A.: the main bus operating company, directly responsible for fleet management of electric buses, driver supervision, and the reliable daily deployment of vehicles. DEI (Public Power Corporation): the energy provider responsible for electricity projects up to 10 MW that supply depot charging stations. DEDDIE (Hellenic Electricity Distribution Network Operator): the grid operator responsible for larger-scale upgrades above 10 MW needed for depot electrification. Attica Region Transport Consortium: In the future, in collaboration with the primary bus operator (OSY S.A.), efforts can be made in fleet management and the operation of electric bus services. National Technical University of Athens (NTUA): The Technical University of Athens will be responsible for the development of the technical assets for this use case.
---	---

Second Stage of Why – What – How Framework

What: Foreseen Internal Risks and Mitigation Actions

Internal Risk (Technical issues, operability, service reliability):			
Scenario	Severity	Likelihood	Mitigation action
Higher energy demand from buses during high-temperature months (due to air-conditioning use)	Medium	Medium	Plan additional charging slots in summer; increase number of fast chargers; coordinate with grid operators to secure higher capacity during peak months.
Delays in grid upgrades at depots (DEI/DEDDIE responsibilities)	High	Low	Early coordination with DEI/DEDDIE; phased installation; backup diesel/CNG buses in service.
Charger malfunction or breakdown	Medium	Low	Regular preventive maintenance; service contracts with charger suppliers; redundancy with nearby chargers.

Insufficient charging capacity during peak demand	Medium	Low	Use CSLP optimisation tool to plan capacity; install mix of slow and fast chargers; stagger charging schedules
Driver/technician lack of training for new systems	Medium	Low	Comprehensive training programmes; certification requirements; continuous refresher courses
❗ How the Service will function (under the anomalous scenario) ● The service is based on planning models, which are mathematical and strategic tools designed to support decision-making. These models are not directly affected during anomalous scenarios because they are used in an ex-ante assessment phase. However, they can account for potential disruptions by incorporating uncertainties into their calculations. For example, if there are travel time uncertainties between chargers and bus stops due to congestion or unexpected delays, the models can integrate these variations as input parameters. This allows the optimisation process to produce robust charging and scheduling plans that remain reliable even under non-ideal conditions. In this way, the service does not fail under anomalies but rather adapts its recommendations, helping stakeholders plan with resilience to operational disruptions. Here's an example of the developed tools accounting for travel time uncertainties (as published in international peer-reviewed journals): https://www.sciencedirect.com/science/article/pii/S0968090X2500186X Here's a depiction of how that looks:  <pre> graph LR subgraph Scenarios S1[Planning scenario #1: Normal conditions] S2[Planning scenario #2: Normal conditions] S3[Planning scenario #3: High traffic conditions] S4[Planning scenario #4: Extreme Weather conditions] S5[Planning scenario #5: Extreme Weather & High Traffic conditions] end S1 --> SPM[Strategic Planning Model] S2 --> SPM S3 --> SPM S4 --> SPM S5 --> SPM SPM --> O1[Outcome for Planning scenario #1] SPM --> O2[Outcome for Planning scenario #2] SPM --> O3[Outcome for Planning scenario #3] SPM --> O4[Outcome for Planning scenario #4] SPM --> O5[Outcome for Planning scenario #5] O1 --> Eval[Evaluation by OASA/OSY Planners] O2 --> Eval O3 --> Eval O4 --> Eval O5 --> Eval </pre>			
❗ How the User will interact (under the anomalous scenario)	● Anomalous scenario does not affect the usage of the metaInnovation developed.		

What: Foreseen External and Other Risks and Mitigation Actions

External Risk (user acceptance: complex interface, trust,):

Risk	Severity	Likelihood	Mitigation action
Complexity of digital tools for planning (CSLP optimisation software may be difficult for non-technical staff)	Low	Low	Provide training workshops for users; create simplified user dashboards and clear guidelines.
Lack of trust in optimisation results among operators and decision-makers	Medium	Medium	Ensure transparency by explaining model assumptions; participation planning; run pilot tests and share results to build confidence.
Low acceptance by drivers/technicians for new charging routines	Medium	Low	Involve drivers in co-design and training sessions; adapt charging schedules with feedback from daily operations.
Other External Risks			
Risk	Severity	Likelihood	Mitigation action
Delays in supply and installation of chargers due to procurement or supply chain issues	High	Low	Secure multiple suppliers; phased procurement; include buffer time in project planning.
Grid upgrade delays caused by dependency on DEI/DEDDIE	Medium	Low	Early coordination with grid operators; prioritize depots with available capacity; temporary backup with CNG/diesel fleet.
Economic or policy changes slowing investment in e-bus infrastructure	Low	Low	Engage policymakers early, link project to EU climate neutrality commitments for stability of support.

How: Investment, Costs, and Pricing

What kind of initial investment might be anticipated?	● This question is not directly applicable to the current use case, as the primary objective is to support OASA in addressing an immediate challenge related to the initial planning of the charging station network. Given the nature of this challenge, it constitutes a strategic planning exercise that is typically undertaken once, with the resulting infrastructure expected to remain in place for many years, potentially decades. Future extensions of the charging station network would constitute a separate planning exercise, likely undertaken under significantly different conditions. As such, the
---	---

	specific challenges and solutions associated with those future expansions cannot be reliably anticipated at this stage.
What is included in this budget? (technology-based, consider running the service)	(see answer above)
How was the project funded? Under which funding schemas and co-financing?	● All activities related to this use case are fully funded within the scope of the MetaCCAZE project.
What is the cost per unit?	● This use case does not revolve around a single, clearly defined unit. Rather, the strategic planning tool may be treated as a unit of analysis. The tools are open-source solutions developed by the university and made available to OASA. Consequently, their use does not entail any acquisition or licensing costs. Taking the unit-cost consideration one step further, operating these open-source modelling tools entails several key infrastructure-related costs. First, sufficient space is required for charging-station installation, along with the charging units themselves. Electricity costs must also be considered to supply the charging installations, based on the charging-demand outputs produced by the modelling frameworks. In addition, human resources are needed, including skilled personnel and engineers on site to maintain the charging stations and supervise charging operations, as well as staff to operate, adapt, maintain, and further develop the open-source tools. Finally, to ensure smooth infrastructure operation, a dedicated maintenance budget should be included to proactively address issues and prevent charging-related malfunctions or irreversible equipment damage. Accordingly, the relevant unit cost can be reflected in the annual personnel costs of transport planners and/or software engineers needed to ensure continued use and further development, together with the charging-related infrastructure required to implement the charging modelling tools.
Do you need any human resources? If yes, what type of human resources are needed?	Yes, human resources are required. The effective application, maintenance, and further development of the strategic planning tools rely on the availability of appropriately skilled personnel. Similar to Use Case 1, two types of professionals can be expected to be required for the further re-use and extension of the tools. On the one hand, transport planners may be needed to be hired, on the other hand, software engineers may be required.

Please specify any additional costs outlined above	● The university currently utilizes several professional-grade laptops and a cloud-based server infrastructure to run the models.
Was the pricing of the proposed service defined? If yes, what is the pricing of the proposed service (for the user)	● No pricing is associated with the tools, as they are developed through open and reproducible research and are provided without licensing fees.
Are there any incentives planned? If yes, would they motivate users to prefer this mobility solution more frequently? Why?	● There are no incentives currently planned. The strategic tools are open and include detailed documentation. You may check one of our online open GitHub repositories: https://github.com/dimrizo/CSLP-Gurobi

3.2.2. Metadesigned BIGM

Table 6: AT-UC02 Summary of BIGM

SECTION	DESCRIPTION
Summary of the BIGM	The Radar (Service-Dominant Business Model Radar, SDBMR) fits best as it emphasizes multi-stakeholder co-creation, value exchange, and roles in urban mobility ecosystems. This UC involves NTUA's optimization tools enabling OASA/OSY infrastructure decisions with energy/grid partners.
Governance Model	OASA coordinates as focal entity, with NTUA providing decision-support models, Anaplassis in consulting role and OSY handling operations/infrastructure. Risks like grid delays mitigated via early DEI/DEDDIE collaboration and backups (diesel/CNG), ensuring resilience under metaCCAZE oversight. (Figure 1).
Business Innovation Model	This BIGM centers NTUA's CSLP metaInnovation for charger optimization, funded via metaCCAZE, with OASA/OSY leading depot implementation and DEI/DEDDIE ensuring energy supply. Open-source tools enable long-term replication, minimizing recurrent costs while supporting fleet growth.
Co-Created Value in Use	Optimized e-charging locations minimize installation/operational costs while ensuring reliable support for Athens' growing electric bus fleet (240 current +125 incoming), reducing energy inefficiencies and grid strain through NTUA's CSLP model. Stakeholders co-produce via data sharing (OASA telematics) and planning, yielding scalable decarbonization aligned with SUMP/CCC goals. Benefits include 30% lower energy costs vs. diesel and zero power-out incidents by 2026.

Table 7: AT-UC02- List of stakeholders and roles

	STAKEHOLDER TYPE	IDENTIFIED STAKEHOLDER	ROLE	STATUS
Focal	Public Transport Operator	OASA	Responsible for any manufacturing requirements along with providing data and field knowledge	Confirmed 
	Bus fleet provider	OSY S.A.	Manages electric bus fleet, drivers, daily deployment	Confirmed 
	Infrastructure manager	Anaplassis S.A.	Manages bus depots, charger installations	Confirmed 
	Technology provider	National Technical University of Athens (NTUA)	Develops optimization models for charger locations	Confirmed 
Core	Energy provider	DEI (Public Power Corporation)	Supplies electricity for depots	Confirmed 
	Grid operator	DEDDIE (Hellenic Electricity Distribution Network Operator)	Handles grid upgrades	Confirmed 
	Regional authority	Region of Attica	Coordinates broader mobility/infrastructure strategies	Confirmed 
	Municipality	Municipality of Athens	Implements sustainable policies, CCC alignment	Confirmed 
Enriching	Service provider (Additional PT Operator)	Attica Region Transport Consortium	Future engagement with additional bus lines	Confirmed 
Customer	Users	Bus users	Use electric bus services	 Future Engagement

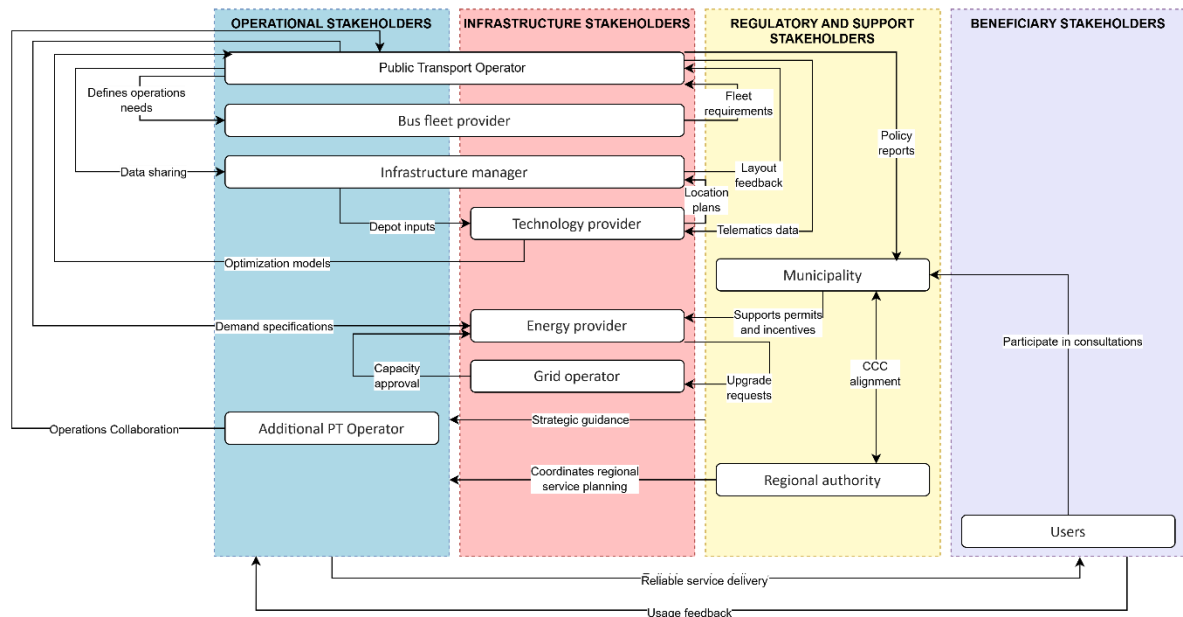


Figure 2: AT-UC02- Governance Model

Table 8: AT-UC02 Business Model

STAKEHOLDER TYPE	COST (–) / BENEFIT (+)	CO-PRODUCTION ACTIVITY	VALUE PROPOSITION
Public Transport Operator	– Scheduling software expansion + Reduced deadheading/rostering costs	Share telematics/OD data for models	Efficient 240+ e-bus integration
Bus fleet provider	– Driver training, charging operations + Optimized utilization, reduction of block failures	Fleet data input, depot reorganization	Reliable daily service, emissions cuts
Infrastructure manager	– Infrastructure collaboration time + Charger/depot readiness	Provide depot layouts/data to NTUA	Scalable e-bus infrastructure alignment
Technology provider	– Model development resources + Research integration	Build/test algorithms with OASA data	Open-source optimization tools
Energy provider	– Policy coordination + Urban mobility gains	Coordinate on energy needs	Climate-neutral PT support
Grid operator	– Grid supply + Power stability	Early planning with OASA	E-bus charging reliability

STAKEHOLDER TYPE	COST (–) / BENEFIT (+)	CO-PRODUCTION ACTIVITY	VALUE PROPOSITION
Regional authority	– Upgrade costs + No outages	Policy coordination for expansions	Fleet electrification enablement
Municipality	– Fleet transition + Network expansion	Approve alignments with SUMP/CCC	Regional ops scalability
Service provider (Optional Additional PT Operator)	– Oversight + Broader alignment	Collaborate online operations possible collaboration with PT operator	Attica-wide sustainability
Users	– None + Better service	Feedback on ops	Reliable, green PT access

3.3. Multimodal logistics and passenger hub in Krakow (KR-UC01 - A)

3.3.1. Metadesigned Use Case

First Stage of Why – What – How Framework

Why: Challenges and Objectives

Questions	Considerations
What specific challenges faced by the city will this Use Case address?	Environmental Concerns & Climate Goals 1. Reduction of CO₂ emissions and air pollution by replacing delivery vans with zero-emission cargo bikes. 2. Lower noise levels and improved air quality, especially in the dense and tourist-heavy medieval urban fabric of the Old Town. 3. Support for the city's climate neutrality goals, aligned with EU policies on sustainable urban development. Logistics & Urban Freight 1. Improved efficiency of last-mile deliveries in the SOR (<i>Strefa Ograniczonego Ruchu</i>, namely the Restricted Traffic Zone), where access for combustion vehicles is limited or prohibited. 2. Facilitated deliveries for local B2B businesses, such as restaurants, hotels, and shops operating in the Old Town, where traditional delivery vehicles face mobility constraints due to narrow streets and pedestrian zones. 3. Reduced street congestion and delivery-related disruption, especially during peak tourist hours.

	Traffic & Mobility Issues 1. Alleviation of traffic congestion through modal shift from vans to cargo bikes, particularly in areas where vehicle access is restricted. 2. Improved traffic flow and public space management in the historic center, enhancing the experience for both residents and visitors. Safety Concerns 1. Enhanced road safety in pedestrian-heavy zones by reducing the presence of large delivery vehicles. 2. Increased visibility and safety for cyclists, supported by the development of infrastructure adapted to cargo bikes and the unique spatial conditions of the Old Town. Urban Quality of Life 1. Preservation of the historic character of the city center, by minimizing motorized traffic and promoting sustainable delivery methods. 2. Support for local entrepreneurship, especially small and medium-sized businesses that rely on frequent deliveries but operate in areas with limited vehicle access. 3. Improved tourist experience, thanks to quieter, cleaner, and safer streets.
! Which (at least 5) objectives does the city aim to achieve through this Use Case?	1. 🟢 Cargo Bike B2B Deliveries – Kraków SOR & II Ring Road Increase the number of parcels using cargo bikes for B2B deliveries within SOR and the II Ring Road area of Kraków. Specific: Increase the number of businesses using cargo bikes Measurable: Achieve a 50% increase in the number of cargo bike deliveries and participating businesses by March-April 2027, compared to baseline data from 2025. Achievable: This growth will be supported through: • Legal incentives for businesses • Improved cycling infrastructure gain by creating the microhub • Awareness campaigns targeting local entrepreneurs Relevant: The initiative contributes to reducing urban congestion, lowering CO₂ emissions, and improving air quality in the historic city center. Time-bound: Target to be reached by March-April 2027. 2. Cargo Bike Adoption by Local Stakeholders Specific: Increase the number of cargo bikes actively used by local stakeholders (e.g., businesses, institutions, and service providers) for transport and deliveries within Kraków. Measurable: Achieve a 50% increase in the number of cargo bikes in operational use among participating stakeholders by March-April 2027, compared to baseline data collected in 2025. Achievable: This growth will be supported through:

	• Stakeholder engagement and co-design workshops to identify needs and barriers. • Incentives for data sharing and participation (e.g., visibility in city reports, access to pilot programs). • Infrastructure improvements, such as dedicated cargo bike parking and microhubs. • Awareness campaigns targeting local entrepreneurs and institutions. Relevant: The initiative supports Kraków's goals for sustainable urban logistics, reduced emissions, and improved air quality. It also fosters collaboration between the city and local actors in shaping future mobility solutions. Time-bound: Target to be reached by March-April 2027. 3. Cargo Bike B2B Deliveries – Kraków SOR & II Ring Road Increase the number of businesses using cargo bikes for B2B deliveries within SOR and the II Ring Road area of Kraków. Specific: Increase the number of businesses using cargo bikes Measurable: Achieve a 50% increase in the number of cargo bike deliveries and participating businesses by March-April 2027 compared to baseline data from 2025. Achievable: This growth will be supported through: • Legal incentives for businesses • Improved cycling infrastructure gain by creating the microhub • Awareness campaigns targeting local entrepreneurs Relevant: The initiative contributes to reducing urban congestion, lowering CO₂ emissions, and improving air quality in the historic city center. Time-bound: Target to be reached by March-April 2027. 4. Improve delivery time within the II Ring Road by 20% by March-April 2027, measured by average delivery time and route efficiency. Specific: Enhance logistics performance Measurable: +20% delivery fluidity Achievable: Via optimized routing and modal shift Relevant: Supports business operations and traffic flow Time-bound: By June 2027 5. Increase public and stakeholder acceptance of cargo bike deliveries by 50% by March-April 2027, based on survey data from residents, businesses, and tourists. Specific: Raise acceptance levels Measurable: +50% in positive perception Achievable: Through communication campaigns and pilot programs Relevant: Ensures long-term viability Time-bound: By March-April 2027 6. Achieve a 30% reduction in the number of fossil-fuel delivery fleet of stakeholders used in pilot area by March-April 2027, compared to baseline data from 2024, replacing them with zero-emission alternatives such as cargo bikes.
--	---

	Specific: Remove polluting vehicles Measurable: 30% replacement Achievable: Through regulation and support for alternatives Relevant: Aligns with climate goals and historic preservation Time-bound: By March-April 2027. 7. Improve the image of delivery operators and ZTP 50% by 2027, based on public perception surveys and stakeholder feedback. Specific: Enhance reputation Measurable: +50% improvement Achievable: Through visible improvements and engagement Relevant: Builds trust and cooperation Time-bound: By March-April 2027. 8. Long-Term Cargo Bike Rentals – Integration in Kraków Specific: Increase the number of long-term cargo bike rentals through the LajkBike system by integrating it into the city’s sustainable logistics strategy and promoting its use among local businesses and residents. Measurable: Achieve a 100% increase in the number of cargo bike rentals via LajkBike by March-April 2027, compared to baseline data from 2024. Achievable: This growth will be supported through: • Integration of LajkBike into city logistics programs and pilot zones. • Targeted outreach to local entrepreneurs, families, and institutions. • Incentives for long-term rental (e.g., subsidies, promotional campaigns). • Improved visibility and accessibility of cargo bikes in key urban areas. Relevant: The initiative supports Kraków’s goals for low-emission transport, promotes modal shift from vans to bikes, and strengthens the role of shared mobility in urban logistics. Time-bound: Target to be reached by March-April 2027. Supporting Evidence: Initial usage data from LajkBike and stakeholder feedback indicate growing interest in cargo bikes for both business and personal use. Further data collection and monitoring will help track progress and adjust strategies.
--	---

What: The Concept, Location, and Infrastructure

Use Case Code	● KR-UC01 - A
Use Case Title	● Multimodal logistics and passenger hub
Use Case Concept Definition	● This use case is not just a logistics pilot — it’s a flagship demonstration of how infrastructure, identity and innovation can converge to create a new urban paradigm. This use case stands out due to its strategic integration of urban regeneration, multimodal logistics, and cultural revitalization within

	a historically and infrastructurally complex area. Unlike typical urban logistics solutions that focus solely on efficiency or sustainability, this concept is deeply embedded in the socio-spatial transformation of Kraków's Grzegórzki district. What makes it unique? Transformation of Underutilized Space The project leverages the newly created space around an elevated railway viaduct — a rare opportunity in dense urban environments. This linear park is not just a green corridor, but a multifunctional public realm that blends logistics infrastructure with social and ecological functions. Symbolic and Cultural Relevance The site is adjacent to Kraków's historic center, a UNESCO World Heritage Site, and directly interfaces with a revitalized market square. This adds symbolic weight to the project: it's not just about moving goods, but about redefining urban identity through inclusive, green innovation. Multimodal Accessibility The concept is a dual-function Hub at the Kraków Grzegórzki inner city railway station. Residents and micro-entrepreneurs will participate in the first branch of the initiative, benefiting from a dedicated free of charge cargo bike rental service, while urban logistics operators will be served in the second branch, providing free access to super short-term micro-warehouses and secure overnight storage for their cargo bikes. The proximity of the railway station and the integration of the Hub with the municipal bike-sharing system LajkBike, combined with nearby public transport stops, significantly increase the multimodality of this system. This strategic location not only improves passenger connectivity but also expands access to sustainable delivery solutions within the restricted traffic zone (SOR) for business. Additionally, the project includes a significant expansion of parking options for residents and rail travelers' private bicycles, with planned bike racks located directly also under the bridge spans. Scalable Urban Renewal Model By embedding logistics into a broader urban renewal strategy, the project becomes a template for sustainable transformation in other districts. It's not a standalone technical fix, but a holistic urban intervention. Inclusive Urbanism The concept promotes social inclusion by transforming neglected spaces into vibrant zones aligned with community needs. The mobility hub bridges cargo bike infrastructure with the adjacent railway yard and linear park, improving intermodal access. It also connects to the culturally significant Hala Targowa.
--	---

! Location (and its influence area)	The proposed solution is located in the immediate vicinity of Kraków Grzegórzki railway station, a site undergoing dynamic transformation. Until recently, the railway line ran atop an embankment, but following reconstruction, it now travels along an elevated viaduct. This change has opened up new spatial opportunities beneath the tracks, where a unique linear park is planned — a multifunctional public space that will integrate greenery, mobility infrastructure, and social functions. Directly across from the station lies a market square, a vibrant, semi-commercial and semi-cultural space that attracts both locals and visitors. Historically, this area was socially neglected and perceived as unsafe, but recent revitalization efforts have begun to shift its character toward a more inclusive and active urban zone. The location offers several strategic advantages: Proximity to key urban zones: 1. Only 100 meters from the II Ring Road, enabling efficient access for delivery vans and integration with regional road networks 2. 800 meters from the I Ring Road, border of SOR (Restricted Traffic Zone). 3. 1,000 meters from the Main Market Square, the heart of Kraków's historic center. 4. ~2,5 kilometres to the farthest point of the SOR (Restricted Traffic Zone), such as Kleparski Market. Excellent connectivity: 1. Direct access to tram, bus and rail infrastructure, enabling multimodal logistics. 2. Close to public transport nodes, including tram and bus lines. Economic and cultural relevance: The area serves both commercial functions (local businesses, gastronomy, retail) and cultural roles (public events, informal gatherings), making it ideal for piloting innovative urban logistics solutions. The influence area of the project includes: 1. The entire SOR zone, where traditional delivery vehicles face access restrictions. 2. The Historic Centre of Kraków was inscribed on the UNESCO World Heritage List and together with surrounding districts, characterized by high pedestrian traffic, tourism, and dense urban fabric. 3. The Grzegórzki district, which is undergoing urban renewal and offers potential for scalable, sustainable logistics models. This location was selected not only for its logistical potential but also for its symbolic value — transforming a previously neglected area into a flagship zone for green urban innovation.
---	--

! Which (physical and digital) infrastructure is needed?	Physical Infrastructure: In the initial phase, the Hub will be located beneath the railway viaduct to ensure accessibility and practicality, with a long-term plan to transition into a municipal building on Wrzesińska Street for a more permanent and secure setup. 1. Automated Rental Container A separate container equipped with automated systems for renting cargo bikes to micro-entrepreneurs, enabling flexible access to delivery tools. 2. Park-e-Bike rental station A public bike parking and rental station (Park-e-Bike) to support micromobility for residents, visitors, and small business operators. This station will complement the cargo bike hub by offering short-term and long-term bike rentals, encouraging modal shift and reducing car dependency. 3. Weather-Protected Loading Area A roof structure covering the transshipment zone to protect goods and workers from adverse weather. 4. ● Sanitary and Social Facilities A sanitary node including toilets and a staff room for delivery personnel and hub operators. 5. Bike Access Road A dedicated bike lane or access path connecting the hub to surrounding districts and the SOR zone, ensuring safe and efficient movement of cargo bikes. 6. The Maneuvering Yard – Connecting Communities and Cargo A dedicated area to safely maneuver and unload goods. 7. ● Cold Storage Trailer Spot A designated space for placing a refrigerated trailer owned by one of the stakeholders, ensuring temperature-controlled storage for perishable goods. 8. ● Transshipment Containers (for ~3 bikes) for designated stakeholders. Three modular containers serving as micro transshipment warehouses and nighttime parking stations for cargo Each container will support a fleet of up to 4 cargo bikes. Equipped with power connections for charging e-cargo bikes and basic lighting. Technical integration includes AI-based video monitoring and IT support from the municipality's internal team. ● Digital Infrastructure: 1. Establishing a reliable internet connection is essential for enabling digital infrastructure, including public Wi-Fi, CCTV monitoring, and intelligent transportation systems (ITS). This will facilitate improved urban mobility, safety, and access to digital services for staff and employees of stakeholders. 2. Video surveillance (CCTV) for safety and operational monitoring. ● Micromobility Services:
---	--

	• Park-e-Bike and LajkBIke station offering public bike rentals and parking. • Integration with public transport and e-scooter networks in the surrounding area.
! Who will be responsible for developing and managing this new infrastructure?	● The development and management of the new infrastructure will be overseen by the Public Transport Authority in Kraków (ZTP). ZTP will be responsible for planning and implementing key elements such as public transport infrastructure, bike-sharing stations (Park a Bike), and an automated cargo bike rental system dedicated to micro-enterprises. Other infrastructure components leased by ZTP will be managed and operated by designated stakeholders e.g. ● Macro, GLS, InPost, VeloHub, who will be accountable for their respective areas. This governance model may evolve in the future to include a dedicated operator responsible for managing the cargo bike system and related infrastructure. Such an operator could be selected through a public tender or partnership process, ensuring professional service delivery, system optimization, and long-term sustainability.
! What (physical & digital) infrastructure needs to be modified	● While the passenger mobility hub is already operational and integrates multiple transport modes, further improvements are necessary to support the new logistics functions. Specifically: • The entrance and exit to the Hub require reconstruction to improve traffic flow and accessibility. • Bicycle infrastructure across ul. Dietla (the designated street) needs to be upgraded to ensure safety and facilitate easier maneuvering of cargo bikes.
! Who will be responsible for these infrastructure modifications?	● Municipal departments – e.g., the City Roads Authority, the Infrastructure Department. Public Transport Authority – integration with public transportation systems and planning.
! Which metaInnovation technology (WP2) is being tested linked to this UC?	● Drone-Based Aerial Observations Mobilysis is leading this effort, focusing on drone-based data collection to fill gaps in existing sensing networks and enhance urban mobility analysis. Key developments include adapting the StrongSORT algorithm for aerial traffic scenes, introducing rule-based enhancements, clustering trajectories into standard paths, and identifying failure-prone zones to improve tracking robustness.

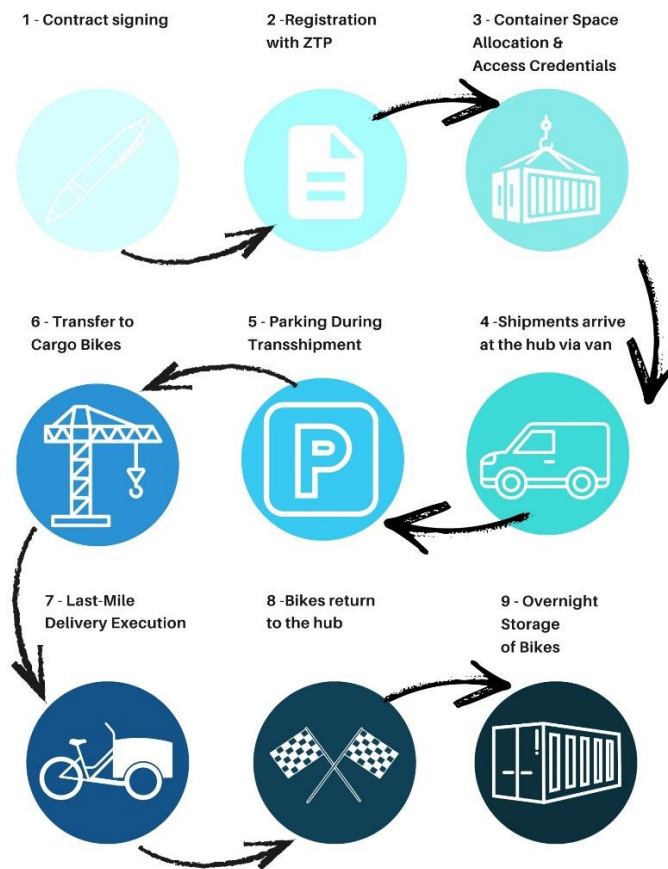
How: Operation, Management and Stakeholder Interaction

! How the Service will function (under normal conditions -	● Service Overview The ZTP Hub in Kraków will operate under a dual-function model, serving both:
---	---

operation on a daily basis)	Urban Logistics Operators The city provides free access to modular containers that serve as: - Super short-term micro-warehouses for last-mile deliveries, - Secure overnight storage for cargo bikes, - Access to utilities (electricity, water), - A shared social container for staff use. Micro-Entrepreneurs and Private Initiatives - The Hub also functions as a short-term cargo bike rental station and municipal eBike rental LajkBike, operated by trained ZTP staff. - Rentals are free of charge, - Intended for deliveries within Kraków's Second Ring Road, - Integrated with public transport (tram/bus stops), Kraków Grzegórzki railway station, and the LajkBike rental system. Cargo Bike Hub Workflow
-----------------------------	---

CARGO BIKE HUB WORKFLOW

Urban Logistics Use Case



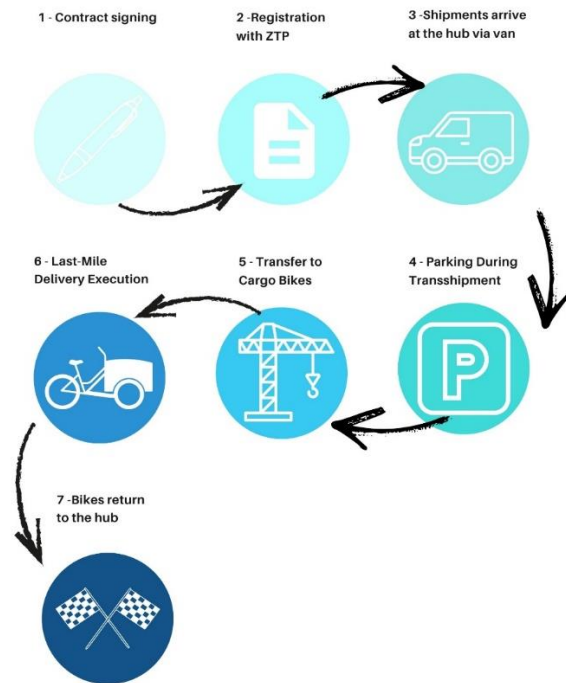
Urban Logistics Use Case

- Contract Signing
Formal agreement between the logistics company and ZTP.
- Registration with ZTP
Company account creation and assignment of credentials.
- Container Space Allocation & Access Credentials
Dedicated container space and secure access provided.
- Shipments arrive at the hub via van
- Parking During Transshipment
Van uses designated short-term parking zone for unloading.
- Transfer to Cargo Bikes
- Last-Mile Delivery Execution
Couriers deliver goods using cargo bikes within the city.
- After deliveries, bikes return to the hub
Charging is the responsibility of the logistics company.
- Overnight Storage of Bikes in the designated hub area for overnight storage.

Micro-Entrepreneur and Residents Use Case

CARGO BIKE HUB WORKFLOW

Micro-Entrepreneur and Residents Use Case



- Contract Signing
Formal agreement between the company and ZTP.
- Registration with ZTP and deposit payment.
Company account creation and assignment of credentials.
- ZTP staff verifies availability
- Cargo bike issued free of charge
- User completes delivery
- Parking During Transshipment
Van uses designated short-term parking zone for unloading.
- Transfer to Cargo Bikes
- Last-Mile Delivery Execution
- Bike returned to hub
- System analyzes rental (time, distance, condition)
- Points awarded, usage logged, maintenance scheduled if needed

Operational Considerations:

Peak vs Off-Peak:

- Peak: mornings and early afternoons (delivery hours)
- Off-peak: evenings and weekends (reduced staff, limited access)

Technical Restrictions:

- Operating hours: 6:00–22:00
- Geographic boundary: Kraków's Second Ring Road

	- Internet connectivity required for system access and tracking Dependencies: - Integration with public transport and LikeBike system Maintenance & Updates: - Regular bike inspections for Micro-Entrepreneur Use Case by ZTP staff - Notifications via email, or on-site signage - System updates managed centrally by ZTP IT team
How the User will interact (under normal conditions - operation on a daily basis)	User Journey Overview The ZTP Hub enables micro-entrepreneurs and private individuals to interact with the system: • After deposit payment can rent cargo bikes free of charge Mon-Fri between 6:00 and 22:00. • They can enter the Hub area for loading and unloading own car after making a prior reservation of a cargo bike. • Deliveries are allowed without restrictions within Kraków's Second Ring Road. • The hub is located just minutes from the Main Square, and is connected to: - Public transport stops, - Kraków Grzegórzki railway station, - The LajkBIke rental system, - Public bicycle parking. User Experience Considerations Usefulness in Daily Life: • Enables fast, eco-friendly deliveries without traffic or parking issues. • Saves costs for small businesses and individuals. Appealing Benefits: • Free access to cargo bikes and infrastructure. • Strategic location near city center and transport nodes. Potential Difficulties: • Limited operating hours Mon – Fri (6:00–22:00). • Requires basic digital literacy (app use, registration). Adoption Support: • Staff assistance on-site. • Simple interface and clear instructions. • No financial barrier to entry. Accessibility Features: • Staff support for elderly and disabled users. • Physical accessibility of hub and bikes.

	Interface Elements for Positive Impact: • Intuitive app design. • Real-time availability. Notifications for maintenance, updates, and rewards. Logistics companies (stakeholders) • Have free access to transshipment containers for short-term storage and overnight bike parking and battery charging. • Also provided with utilities and a social container for staff.
⚠ Please review the Prototype stakeholder map and make changes	• ● The Public Transport Authority in Krakow (ZTP) is an organisational unit of the Krakow Municipality responsible for: planning, implementing and supervising the organisation of public transport; managing and maintaining passenger service infrastructure; implementing municipal policies in the field of bicycle and pedestrian traffic, as well as personal transport devices (e.g. scooters); developing paid parking zones; coordinating the construction of the Municipal Information System; operating Park & Ride car parks; and implementing the Clean Transport Zone in Krakow. • The Department of Municipal Services and Infrastructure is a department of the Krakow City Council responsible for shaping city policy and creating and monitoring the implementation of long-term plans and programmes in the areas of municipal services, municipal waste and liquid waste management, maintaining cleanliness and order, transportation and traffic management. • The Department of Entrepreneurship and Innovation is a department of the Krakow City Council responsible for matters related to revitalisation, investor services, and business services and support. It acts as the operator of the Social and Economic Innovation Cluster and is responsible for science-related matters. • The City Architect's Office is a department of Krakow City Hall responsible for issuing opinions on projects aimed at ensuring the comprehensive and harmonious development of urban space. These projects are implemented by the Municipality of Krakow, represented by the relevant organisational units of Krakow City Hall and municipal organisational units. The unit is responsible for the land development concept under the SKA Grzegórzki railway flyovers. • MobilLysis is an EPFL spin-off that provides all-in-one mobility solutions using drone-based data collection and advanced computer vision analytics to monitor and optimize urban traffic. Their approach delivers high-quality, privacy-friendly insights to identify congestion sources and support sustainable mobility strategies

	● VELOHUB Private company that provides hub transshipment solutions and last-mile transport services using cargo bikes. ● InPost is an e-commerce logistics company known for its network of 24/7 self-service parcel lockers. ● Allegro is an e-commerce platform founded and operating in Poland and Europe. ● Max Pro is a manufacturer of cargo bikes. ● P.H.U. UNITARG is the lessee and operator of the 'Hala Targowa' market hall. ● GLS Poland is the Polish branch of the logistics company GLS. It offers domestic and international courier services, including parcel delivery for individuals and businesses. ● Makro Cash and Carry Polska S.A. is a leading Polish wholesale chain owned by the German METRO AG group. It specialises in serving the HoReCa sector, traditional trade, and companies and offices. ● DPD Polska is part of GeoPost, the second-largest international courier network, which delivers parcels worldwide every day in accordance with sustainable development principles. ● Local entrepreneurs ● Residents
--	--

Second Stage of Why – What – How Framework

What: Foreseen Internal Risks and Mitigation Actions

Internal Risk (Technical issues, operability, service reliability):			
Scenario	Severity	Likelihood	Mitigation action
Internet connectivity may be disrupted	Medium	High	Enable offline mode for basic operations; install local Wi-Fi hotspots at the hub
Number of available cargo bikes may be insufficient	High	Medium	Monitor usage trends; introduce reservation limits; expand fleet gradually
Users may return bikes late	Medium	Medium	Introduce reminder notifications; allow buffer time between bookings
Users may not return bikes	High	Low	Implement user identity verification prior to rental, equip each bike with GPS tracking for real-time monitoring, shorten rental durations

			to encourage timely returns, and send automated alerts both to users as reminders and to operators when a bike is overdue or deviates from its expected route.
Staff may not prepare bikes in time for next rental	Medium	Medium	Implement automated alerts for staff; optimize scheduling; add buffer time
Next user may become impatient due to delays	Low	Medium	Provide real-time status updates in app; offer waiting area and estimated wait times
Bike malfunction during rental	High	Medium	Provide emergency contact in app; enable quick swap at hub; regular maintenance checks
Risks related to the demolition of existing buildings and the formal procedures associated with transforming the surrounding urban fabric.	High	High	Early engagement with municipal departments, legal review, phased planning.
Premature battery depletion	High	Medium	Monitor battery levels in real-time; notify users; install charging stations at hub
How the Service will function (under the anomalous scenario)	Types of Likely Anomalies Technical: • Application failure (e.g., inability to make a reservation) • Connectivity loss (e.g., no internet at the station) • Hardware failure (e.g., bike not working) Operational: • No bikes available • Delayed return or no return • Staff did not prepare the bike on time External: • Power outage • Extreme weather conditions • Construction/demolition in the area (restricted access) How the system and staff respond Automatic alerts: The system detects missing bikes or failures and sends a notification to staff.		

Fallback for the user:

- In-app message: "We apologize for the delay; we suggest an alternative municipal cargo bike solution."

Escalation:

- If the issue is not resolved within X minutes → contact support via chat or phone.

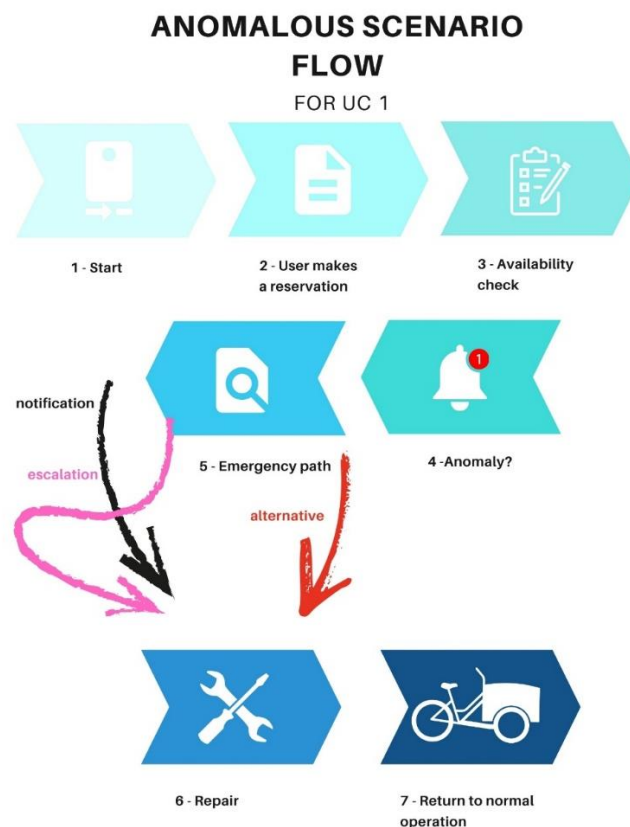
Recovery:

- In case of hardware failure → mobile service or redirect to another station.
- In case of system failure → offline mode (e.g., SMS code to unlock the bike).

Impact on user experience

- Minimizing frustration: clear messages, estimated wait time, compensation (e.g., discount for city activities).
- Transparency: repair status visible in the app.
- Alternatives: indication of the nearest available station.

Return to normal operation



	Start → User makes a reservation → Availability check → Anomaly? → Yes → Emergency path (notification + alternative + escalation) → Repair → Return to normal operation. Mitigation & Recovery Measures • Fallback manual procedures (paper logs, staff override) • Real-time alerts for staff to respond quickly • Redundant systems for battery monitoring and bike availability • Clear user communication via app and on-site signage • Compensation mechanisms (e.g., reward points, priority access) • Scheduled maintenance windows with prior notifications
! How the User will interact (under the anomalous scenario)	Overview of User Interaction During System Anomalies In the event of technical or operational anomalies, the user experience is adapted to ensure continuity, transparency, and support. The system is designed to respond to common disruptions such as: Technical: • Application failure (e.g., inability to make a reservation) • Connectivity loss (e.g., no internet at the station) • Hardware failure (e.g., bike not working) Operational: • No bikes available • Delayed return or no return • Staff did not prepare the bike on time External: • Power outage • Extreme weather conditions • Construction/demolition in the area (restricted access) User Interaction Flow Chart ANOMALOUS SCENARIO FLOW FOR USER  <pre> graph LR 1[1 - Start] --> 2[2 - User makes a reservation] 2 --> 3[3 - Availability check] 3 --> 4[4 - Anomaly detected] 4 --> 5[5 - User receives notification] 5 --> 6[6 - Option to contact support] 5 --> 7[7 - Continue ride or cancel] </pre> The flow chart illustrates the user's path through an anomalous scenario. It begins with '1 - Start' (light blue arrow with a bike icon), followed by '2 - User makes a reservation' (light blue arrow with a document icon) and '3 - Availability check' (light blue arrow with a checklist icon). An arrow leads to '4 - Anomaly detected' (teal arrow with a bell icon and a red '1' notification badge). From here, the flow splits into two paths: '5 - User receives notification' (teal arrow with a magnifying glass icon) leading to '6 - Option to contact support' (dark blue arrow with a phone icon), and '5 - User receives notification' leading to '7 - Continue ride or cancel' (dark blue arrow with a bicycle icon).

	User Experience Considerations Response Time: • Immediate feedback via app or staff intervention • Real-time alerts and fallback procedures Best Way to Inform the System: • Call center support • On-site staff assistance Feedback Mechanism: • Post-rental feedback form • Optional rating of support experience • Anomaly data used to improve system behavior Interface Elements for Positive Impact: • Friendly error messages • Step-by-step guidance during anomalies • Transparent status updates and estimated resolution time
--	---

What: Foreseen External and Other Risks and Mitigation Actions

External Risk (user acceptance: complex interface, trust,):			
Scenario	Severity	Likelihood	Mitigation action
Lack of awareness of service benefits	High	High	Run local awareness campaigns; partner with community groups
Low trust in system efficiency	High	High	Ensure transparency; publish uptime stats; offer live support
Emergence of competing services with better tech	Medium	High	Focus on public value; emphasize free access and integration with city infrastructure
Harsh winter conditions reduce trust in cargo bike efficiency	High	High	Equip bikes with winter covers; provide weather alerts; offer heated containers
Rainy days discourage usage and reduce visibility	Medium	High	Provide rain shoe and pants covers; allow flexible rebooking; offer incentives for off-peak use
Sophisticated app development may exceed functional ROI	Medium	High	Conduct cost-benefit analysis; prioritize essential features; use scalable architecture
Other external risks (Legislation, competitors (others))			
Scenario	Severity	Likelihood	Mitigation action

Delay in obtaining all legal approvals and permits to launch the Hub at Wrzesińska location due to appeals from neighboring property owners.	High	High	Parallel to continuing the legal process, the appeal proceedings are being monitored, with the decision having been postponed until the end of July. Due to this delay, the demolition and preparation of the hub during the timeline of metaCCAIZE project at Wrzesińska Street is no longer feasible. Consequently, a contingency plan is being implemented, which includes: negotiations with the railway operator – to secure an alternative underpass/crossing beneath the railway infrastructure and securing a third location – identifying an alternative site in the immediate vicinity, consisting of vacant buildings with access to basic utilities. This choice is justified by the minimal scope of required adaptation works. Finalizing the arrangements and commencing operational activities at the third location is scheduled for September–October 2026.
--	------	------	---

How: Investment, Costs, and Pricing

What kind of initial investment might be anticipated?	1. Budget from the metaCCAIZE project and additional support The organizational phase of the project was primarily supported by the municipality, which allocated staff from ZTP and its internal resources to handle key tasks such as coordination, planning, and initiating the permitting process to repurpose a city-owned property originally designated for demolition. These efforts included preparing the site to serve as a logistics HUB, with plans for essential infrastructure such as utilities and high-performance internet. This represents a substantial in-kind contribution from the city. At the same time, a significant portion of the project team's work has been financed through the metaCCAIZE project, which covered personnel costs for core activities and provided external expertise for specialized tasks such as demolition planning and infrastructure design. This combination of municipal in-kind support and external financial backing
---	--

	ensured both administrative progress and technical readiness, creating a strong foundation for successful implementation. 3. Components requiring upfront investment Infrastructure: • The first step in creating a multimodal hub was the purchase of cargo bikes, which are intended to form a fleet available to residents and micro-entrepreneurs. • Preparation of the HUB site, utility connections (electricity, water, internet), and physical installations • Hardware: Transshipment Containers • Personnel Training: Onboarding of municipal staff and external collaborators 4. Stakeholders covering operational costs During the pilot phase, operational costs are expected to be covered jointly: • Municipality: Covers internal coordination, communication, site preparation, and local logistics • metaCCAZE project: Covers expert involvement, technical development, and evaluation. • Stakeholders: Contribute their own equipment, including cargo bikes and a refrigerated trailer, which will be used during the pilot operations.
What is included in this budget? (technology-based, consider running the service)	1. Specific Technologies Included • Purchase of 10 professional-grade electric cargo bikes for fleet operations. • MobilLysis data integration: For monitoring change of micromobility traffic, including cargo bikes and scooters, to support rental optimization and delivery route planning. • Metadesign activities to co-create solutions; hiring specialized companies to conduct social embracement and behavioral change surveys; and commissioning a company to develop a marketing campaign to promote demonstrated services, including audiovisual content for TV, radio, and social media. • Monitoring & Security Systems: Surveillance and flow management tools for the logistics HUB and maneuvering yard. • Connectivity Infrastructure: High-speed internet and networking equipment to ensure stable system operation. 2. Recurring Costs • Software maintenance and updates for the rental platform • Cloud hosting and data storage 3. Projected Operational Costs

	• Electricity: For HUB operations, IoT devices, lighting, and security systems • Internet Services: Stable connectivity for real-time data transmission and system control • Technical Support: System monitoring, maintenance, and emergency response • Platform Operations: Server uptime, database management, and user authentication • Social Facilities Node A small on-site facility for staff and delivery personnel, including: ○ Sanitary facilities (toilets, washbasins) ○ Rest area with basic kitchen equipment (kettle, microwave, seating) ○ Lockers and charging stations for personal devices ○ Cleaning and maintenance services • Estimated monthly operational cost: PLN 650/m (utilities, cleaning, consumables, minor repairs) 4. Staffing, Training, and Support • Initial training for municipal staff and stakeholders • Ongoing user support and system administration • Operational oversight for HUB activity and incident response • IT support provided by the municipality's internal technical team, ensuring system stability, troubleshooting, and integration with city infrastructure 5. Marketing and Stakeholder Engagement • Awareness campaigns to promote the service • Stakeholder workshops and co-design sessions • Public communication tools (website, social media, printed materials) 6. Testing, Monitoring, and Evaluation • Pilot testing of the automated rental system and HUB operations • Performance monitoring through real-time dashboards • Impact evaluation including user feedback and operational analysis
How was the project funded? Under which funding schemas and co-financing?	1. metaCCAIZE Project Budget • A portion of the funding was provided through the metaCCAIZE initiative, which supported: ○ The involvement of an external expert integrated into the municipal team ○ Technical development and innovation components ○ Monitoring and evaluation activities This funding was provided as a grant,

	covering both financial and in-kind contributions. 2. Public-Private Partnership (PPP) - The project also operates under a two-year public-private partnership agreement between the City of Kraków and key stakeholders. This model includes: - Shared responsibilities for service delivery and infrastructure use - Stakeholders contributing equipment (e.g., cargo bikes, refrigerated trailers) - Joint operational planning and data sharing This arrangement ensures long-term engagement and co-ownership of the service. 3. City of Kraków Budget – Department of Municipal Economy (Wydział Gospodarki Komunalnej) The City of Kraków contributed through: - Allocation of municipal staff and internal resources - Preparation of city-owned property for HUB development - IT support and coordination These contributions were made in-kind, but represent a significant investment in terms of time, expertise, and infrastructure.
What is the cost per unit?	Initially, the project planned to acquire 10 cargo e bikes. However, after conducting market research, it was discovered that the actual unit cost of professional-grade cargo e bikes was significantly higher than preliminary estimates. Budgetary Details: - Planned unit cost (estimate): approx. €3,000 per bike - Actual unit cost (market price): approx. €5,000 per bike - Reason for higher cost: To ensure durability and compliance with professional delivery standards, we opted for robust models with advanced features (e.g., reinforced frames, high-capacity cargo boxes). - Parking for municipal bike-sharing system Park E Bike and private bicycles for HUB users. 20 sets of racks, each set includes 3 racks Cost per set: 1,348.08 PLN (approx. 320 €) Total Cost: 26,961.60 PLN (approx. 6.400 €) - Surface preparation (including base, paving, curbs, and labor):

	Total cost for approx. 15,000–18,000 PLN. (approx. 4.270 €) 3. Container Rental The project includes the deployment of four containers to support the automated cargo bike rental system and HUB operations: - Basic Containers (x3) - Purpose: Storage and shelter for cargo bikes, equipped only with lighting and electricity - Estimated monthly rental cost per unit: approx. 2,000–2,500 PLN (approx. 600€) - Installation and connection (one-time): approx. 10,000 PLN per unit (approx. 2.400 €) - Maintenance and utilities: approx. 300–400 PLN/month per unit (approx. 100€) 4. Social Facility Container Providing basic amenities for staff and delivery personnel, including: - Toilet and washbasin (connected to water and sewage) - Small kitchen area with refrigerator, microwave, and sink - Table and seating for meals - Electrical installation, lighting, and heating Estimated Costs: - Monthly rental cost: approx. 1,800–2,500 PLN net (approx. 600€) - One-time transport and installation: approx. 1,500–3,000 PLN net (approx. 650€) - Monthly operational costs (utilities, cleaning, hygiene supplies): approx. 400–600 PLN net (approx. 100€) 5. Site Preparation and Demolition Costs - The demolition of the existing building at Wrzesińska Street is estimated at PLN 711,749, based on the official cost assessment. (approx. 150€) - Following demolition, a provisional maneuvering and transshipment area will be established to support cargo bike operations and light delivery vehicles. - The estimated cost of preparing and hardening the 400 m² site (including ground leveling and surface stabilization) is approximately PLN 80,000. (approx. 20.000 €)
Do you need any human resources? If yes, what type of human resources are needed?	Yes, the project requires human resources at different stages, with evolving roles and responsibilities: 1. Initial Phase (Pilot Stage) Role: Dispatcher from the Public Transport Authority (ZTP)

	○ Responsibilities: Oversee system operations, respond to incidents, coordinate with stakeholders ○ Training: Specialised training provided to ensure familiarity with the integrated rental platform, IoT systems, and HUB operations ○ Cost Considerations: ○ Training materials and sessions: approx. 2,000–3,000 PLN (one-time) (approx. 600€) ○ Salary covered by the municipality as part of in-kind contribution In the initial phase, the infrastructure will be managed by the Maintenance Department of ZTP. In the subsequent phase, this role will be gradually transferred to the system operator. 2. Post-Pilot Phase • Role: Independent Operator (outsourced or hired) ○ Responsibilities: Day-to-day management of the system, user support, coordination with maintenance teams, data reporting ○ Cost Considerations: ○ Monthly salary or service contract: approx. 6,000–9,000 PLN, depending on scope and experience (approx. 2000). ○ Potential additional costs for recruitment, onboarding, and ongoing training
Please specify any additional costs not outlined above	-
Was the pricing of the proposed service defined? If yes, what is the pricing of the proposed service (for the user)	The pricing of the proposed service is structured within a public-private partnership (PPP) model. This allows for flexible pricing tiers tailored to different user groups: • Individuals may benefit from free access under specific conditions, such as trial periods or government subsidies aimed at promoting sustainable urban mobility. • Businesses and public institutions are offered subscription-based plans, with options for monthly or annual billing, depending on the scale of usage and integration needs. • The service may also include tiered pricing based on usage volume or additional features (e.g., analytics dashboards, API access). This PPP approach ensures affordability for end users while enabling long-term sustainability and innovation through private sector involvement.

Are there any incentives planned? If yes, would they motivate users to prefer this mobility solution more frequently? Why?	- Financial accessibility: Free trials remove cost barriers. - Environmental appeal: Users increasingly value sustainable options. - Operational efficiency: Businesses benefit from optimized logistics and reduced delivery costs.
--	--

3.3.2. Metadesigned BIGM

Table 9: KR-UC01 - A Summary of BIGM

SECTION	DESCRIPTION
Summary of the BIGM	This use case fits within a multi-stakeholder ecosystem with co-production roles, as the hubs emphasize public-private partnerships and value co-creation. Therefore, the Business Model Radar is the most suitable tool to describe the business model. The use case involves one core public authority and several private-sector support partners working together within a multi-stakeholder ecosystem. The core organization is a municipal transport authority responsible for planning, coordinating, and supervising the development of shared mobility and logistics infrastructure and operating bike-sharing and cargo-bike rental systems; and infrastructure or hub operators responsible for the daily functioning, maintenance, and service continuity of specific facilities. It is complemented by multiple support partners that collectively ensure the system's operation: logistics and delivery companies that manage last-mile services and freight infrastructure. Together, these organizations contribute complementary expertise, enabling co-production, value co-creation, and the long-term sustainability of the overall system.
Governance Model	The stakeholders involved in the use case include the Public Transport Authority in Kraków (ZTP), which will oversee the development and management of the new infrastructure public transport facilities, Park a Bike stations, and an automated cargo bike rental system for micro-enterprises. While ZTP will coordinate and lease the infrastructure, operational responsibilities for specific components will be delegated to partners such as Macro, GLS, InPost, and VeloHub. Over time, this governance model may evolve to include a dedicated operator selected through a tender or partnership responsible for managing the cargo bike system and ensuring professional service delivery and long-term sustainability. ZTP leads via PPP agreements, coordinating municipal departments for sites/permits and logistics firms for operations. Decision-making involves joint workshops for risks like approvals, with data-sharing protocols for monitoring. (Figure 1).

Business Model	Innovation	Because this UC depends on public orchestration led by ZTP and supported by key city departments alongside shared infrastructure and distributed operations carried out by multiple private partners (such as VELOHUB, InPost, GLS, DPD, Makro, and others), it aligns with the Business Model Radar logic of ecosystem co-creation and blended funding rather than functioning as a stand-alone “Classic” service with direct end-user pricing. Governance within this model is multi-layered: strategic governance is provided by municipal bodies (ZTP, the relevant city council departments, and the City Architect’s Office), ensuring policy alignment, spatial coherence, and the delivery of public value, while operational governance is distributed among partners responsible for their respective components through leases, SLAs (Service Level Agreements), concessions, or service contracts. Over time, this model may evolve toward appointing a dedicated system operator, selected via public tender or partnership, capable of managing the cargo bike system and related infrastructure end-to-end to improve professionalization, operational optimization, and long-term scalability.
Co-Created Value		The hub enables zero-emission last-mile deliveries via cargo bikes, reducing congestion and emissions in Kraków's SOR zone while integrating with rail and bike-sharing for multimodal access. Stakeholders co-produce efficiency through shared infrastructure and data, yielding cleaner streets and business savings.

Table 10: KR-UC01 - A- List of stakeholders and roles

STAKEHOLDER TYPE			IDENTIFIED STAKEHOLDER	ROLE	STATUS
Focal	Public authority	transport	Public Transport Authority in Krakow (ZTP)	Designs and manages the multimodal logistics and passenger hub, supervises PT, bike and pedestrian policies, Clean Transport Zone and integration of cargo bikes and shared bikes with rail/tram/bus. In this particular Use Cases oversees site preparation (demolition, paving, access). Connects entrepreneurs to the service and integrates it with innovation clusters.	✓ Confirmed
Core	Municipality department (Services and Infrastructure)		Department of Municipal Services and Infrastructure	Participates in meetings and activities concerning strategic planning for	✓ Confirmed

STAKEHOLDER TYPE	IDENTIFIED STAKEHOLDER	ROLE	STATUS
		transport, traffic management, municipal services, and connections to city networks.	
Municipality department (Entrepreneurship and Innovation)	Department of Entrepreneurship and Innovation	Primarily participates in coordination meetings and provides input within the scope of their broader responsibilities.	✅ Confirmed
Municipality department (Architecture and Urbanism)	City Architect's Office	Issues opinions on land development and hub integration with the linear park.	✅ Confirmed
Cargo bike system solutions provider	VELOHUB	Provider of a hub transshipment infrastructure and professional last-mile cargo bike operations, and contributes expertise gained from other cargo-bike transshipment projects and collaborations with logistics companies.	🕒 In Discussion
Logistic company	InPost	Integrates parcel flows with the hub, using cargo bikes and short-term storage to serve its 24/7 locker network and customers in and around the SOR zone.	🕒 In Discussion
Location operator	P.H.U. UNITARG	Manages the 'Hala Targowa' market hall adjacent to the hub, providing key trip generation and potential space coordination for logistics and passenger flows.	🕒 In Discussion

Enriching	STAKEHOLDER TYPE	IDENTIFIED STAKEHOLDER	ROLE	STATUS
	Logistic company	GLS Poland	Uses the hub as a micro-fulfilment point for domestic and international parcels, switching part of its fleet to cargo bikes for last mile.	🕒 In Discussion
	Logistic company	Makro Cash and Carry Polska S.A	Organises wholesale deliveries (especially HoReCa and business clients) using the hub as a transshipment point for smaller, bike-based trips into dense areas.	🕒 In Discussion
	Logistic company	DPD Polska	Integrates its parcel operations with the hub, using cargo bikes for last-mile deliveries in the pilot area.	🕒 In Discussion
	Drone Data Provider	Mobilysis	Supplies drone-based traffic data collection and computer vision analytics to monitor cargo bike flows, safety and performance around the hub and main corridors.	✅ Confirmed
	Business	Allegro	Generates e-commerce demand that can be fulfilled via hub-based cargo bike services, influencing volumes and service design.	🕒 In Discussion
	Local entrepreneurs	Local entrepreneurs	Small firms and self-employed users who rely on the hub and free cargo-bike rentals for deliveries and multimodal mobility.	✅ Confirmed
	Cargo bike manufacturer	Max Pro	Supplies suitable cargo bikes to operators and hub partners, ensuring vehicles match professional delivery needs.	🕒 Confirmed

STAKEHOLDER TYPE	IDENTIFIED STAKEHOLDER	ROLE	STATUS
Customer	Residents	Residents	End users of the passenger and micromobility elements of the hub, and beneficiaries of cleaner, safer streets.
			 Future Engagement

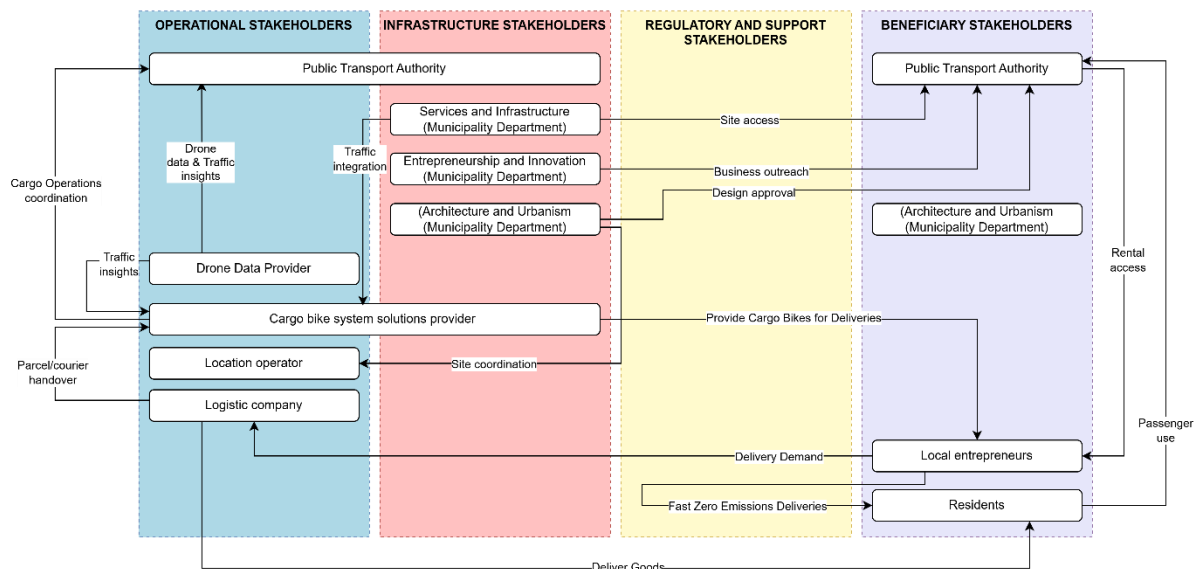


Figure 3: KR-UC01 - A- Governance Model

Table 11: KR-UC01 - A - Business Model

STAKEHOLDER TYPE	COST (–) / BENEFIT (+)	CO-PRODUCTION ACTIVITY	VALUE PROPOSITION
Public transport authority	– Staff time for planning, operations supervision and dispatching; maintenance of hub assets and IT; in-kind operational costs Capital/expenditure for demolition and construction plus internal staff resources for permitting and coordination. + Achieves climate and SUMP goals, improves PT image and service quality, and	Leads service design, contracts partners, defines operating rules, manages booking/monitoring systems and coordinates with all core partners. Delivers and maintains basic infrastructure, coordinates road/bike access improvements and traffic measures around the hub	Reliable, coordinated zero-emission logistics and passenger hub anchored in municipal mobility policy.

STAKEHOLDER TYPE		COST (–) / BENEFIT (+)	CO-PRODUCTION ACTIVITY	VALUE PROPOSITION
		gains operational data to scale cargo-bike logistics		
Municipality department (Services and Infrastructure)	and	– N/a + Urban renewal of underused space, better traffic flow and cleaner environment in Grzegórzki and SOR.	Supports the logistics hub	Ready-to-use, serviced hub location enabling low-emission logistics and improved public realm.
Municipality department (Entrepreneurship and Innovation)		– Staff time for outreach, programme design and supporting entrepreneurship schemes linked to cargo bikes. + Stronger local SME ecosystem, new green business models and innovation branding for Kraków.	Supports the logistics hub	Access to tailored support for SMEs adopting zero-emission logistics solutions.
Municipality department (Architecture and Urbanism)	and	– Expert time for urban design review and approvals. + High-quality, accepted urban design that reinforces the hub as a flagship regeneration project	Reviews proposals, sets design conditions and coordinates with other municipal units on layout and public-space design.	Well-integrated public space that combines logistics, mobility and community use
Drone Provider	Data	– Development and operation of drone and analytics systems, including hardware, software and staff expertise. + Validated technology references, rich datasets and potential for future commercial deployments	Plans and executes drone campaigns, processes data, and shares analytics that inform hub optimisation and route planning	High-resolution insights on demand, safety and efficiency to refine hub design and policy

STAKEHOLDER TYPE	COST (–) / BENEFIT (+)	CO-PRODUCTION ACTIVITY	VALUE PROPOSITION
Cargo bike system solutions provider	– Investment in cargo bikes, hub equipment and operational staff for last-mile services. + Priority access to centrally located micro-hub infrastructure and new customers in Kraków's dense inner city.	Co-designs operational concept with ZTP, runs cross-docking and delivery operations and shares performance data.	Professional, scalable cargo-bike logistics backbone that makes the hub commercially viable.
Logistic company	– Reallocation of fleet resources, provision of parcels and potentially cargo bikes/couriers; process adaptation and staff time. + Lower delivery times and costs in restricted areas, improved customer service and greener brand	Adapts operations to use the hub, coordinates schedules, and shares operational feedback and indicators	High-performing last-mile deliveries in difficult historic areas using shared infrastructure.
Business	– Limited direct financial cost; staff time to coordinate with logistics partners on hub-based delivery options. + More reliable, greener deliveries for platform sellers and buyers, supporting customer satisfaction.	Participates in discussions on service design and provides demand data/requirements through logistics partners.	Access to cleaner, more reliable last-mile options for e-commerce orders in central Kraków. Deliverable 1.3 - Follower cities status quo map and prototype ZESM use cases.pdf
Cargo bike manufacturer	– Production, customisation and potential pilot discounts or testing support. + Market visibility and product feedback to improve designs for urban logistics	Co-designs bike specs with operators, provides maintenance advice and supports pilots.	Robust, tailored cargo bikes that can handle intensive last-mile operations
Location operator	– Management time to coordinate operations, possible adjustments to market logistics and	Aligns market operations and loading activities with hub processes,	Better-organised, low-emission deliveries and

STAKEHOLDER TYPE	COST (–) / BENEFIT (+)	CO-PRODUCTION ACTIVITY	VALUE PROPOSITION
	access. + Improved access for suppliers and customers, enhanced attractiveness of the market area and reduced traffic conflicts.	facilitates communication with traders.	access for a major local attractor.
Logistic company	– Investment in bikes/couriers, process changes, and coordination with hub schedules. + Improved performance and compliance in the SOR and historic centre, plus image gains from zero-emission deliveries.	Plans and runs delivery rounds from the hub, tests new routing patterns and shares KPIs	Efficient, regulation-proof parcel deliveries in constrained inner-city areas.
Logistic company	– Reconfiguration of supply chain to add hub transshipment, potential use of cargo bikes or contracted services. + More reliable and flexible deliveries to urban customers and alignment with sustainability expectations.	Coordinates wholesale flows and schedules with hub operators and tests consolidated/pooled deliveries.	Flexible, greener supply for restaurants and businesses in the historic centre.
Logistic company	– Investment in vehicles/couriers and process adaptation to use the shared hub infrastructure. + Faster access to central delivery zones, reduced fuel and parking costs and improved corporate sustainability profile.	Uses the hub for staging, participates in service refinement and shares data on performance and customer feedback	Cost-effective, zero-emission parcel distribution leveraging shared facilities.

STAKEHOLDER TYPE	COST (–) / BENEFIT (+)	CO-PRODUCTION ACTIVITY	VALUE PROPOSITION
Local entrepreneurs	– Time spent learning/using the system, deposits, and adapting business practices to bikes. + Lower delivery costs, new service options and positive green image for customers.	Co-create service features through feedback, participate in pilots and demonstrate practical use cases	Affordable, accessible logistics tools enabling small players to compete in central areas.
Residents	– No direct financial cost; some time contributing feedback in surveys. + Better access to PT and bikes, quieter neighbourhoods and improved air quality.	Participate in surveys and consultations, use services and provide behavioural data.	More liveable inner-city environment with convenient sustainable mobility.

3.4. E-cargo bikes & e-bikes demand and monitoring in Krakow (KR-UC01 - B)

3.4.1. Metadesigned Use Case

First Stage of Why – What – How Framework

Why: Challenges and Objectives

Questions	Considerations
! What specific challenges faced by the city will this Use Case address?	● 1. Environmental concerns and climate goals Kraków aims to reduce greenhouse gas emissions and achieve climate neutrality. Promoting cycling and cargo bikes as low-emission transport options is a key part of this strategy. Measuring bicycle and cargo bike traffic helps the city: • monitor progress toward climate goals, • identify areas where sustainable transport is growing or needs support, • plan targeted interventions to reduce car dependency. 2. Logistics and infrastructure planning

	Accurate data on bicycle and cargo bike usage supports better urban planning by enabling: • optimal placement of bike lanes, parking infrastructure, city bike rentals and cargo bike hubs, • integration of cargo bikes into last-mile delivery systems, • more efficient use of public space in line with actual mobility patterns. 3. Traffic and congestion management Understanding where and when bicycles and cargo bikes are used allows the city to: • manage congestion by promoting cycling in high-traffic areas, • identify bottlenecks and improve traffic flow, • support modal shift from cars to bikes in strategic zones. 4. Safety concerns Traffic measurements help improve safety by: • identifying accident-prone areas for cyclists, • informing the design of safer intersections and bike paths, • supporting education and awareness campaigns for all road users. 5. Policymaking and evaluation Reliable data is essential for: • evaluating the effectiveness of mobility policies, • making evidence-based decisions, • justifying investments in cycling infrastructure to stakeholders and the public.
! Which (at least 5) objectives does the city aim to achieve through this Use Case?	1. Increase Bicycle Traffic in the Target Area • <i>Specific:</i> Promote the use of bicycles, particularly cargo bikes, for urban logistics and daily commuting in the Kazimierz–Grzegórzki - Old Town districts. • <i>Measurable:</i> Achieve a 15% increase in bicycle traffic (measured by counters) within 24 months of launching the intermodal hub. • <i>Achievable:</i> Based on existing infrastructure, planned improvements (e.g. Dietla, Wrzesińska, and Grzegórzecka, Blich crossings modernization), and stakeholder engagement, the goal is realistic and supported by local mobility trends. • <i>Relevant:</i> Aligns with Kraków's Sustainable Urban Mobility Plan (SUMP) and climate neutrality goals, addressing congestion and air quality challenges. • <i>Time-Bound:</i> Progress will be monitored, with the first assessment done before launching the Hub (Sep, 2025)

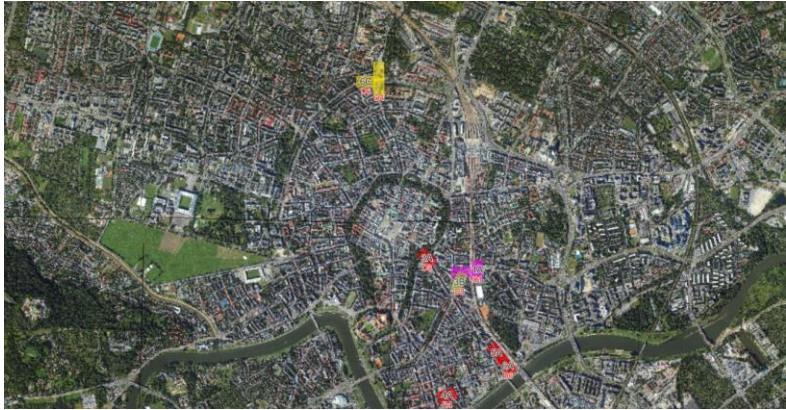
	and two more sessions planned for the full evaluation scheduled for Q4 2027 2. Develop an integrated measurement system for bike traffic by Q4 2027 • Specific: Conduct research using a swarm of drones developed by MobiLysis. After AI processing, the collected data will provide insights to optimize traffic flow, intermodal connections between regional rail and bike-based transport and enhance overall safety. • Measurable: Deliver actionable traffic flow and safety reports for at least 20% of monitored delivery corridors. • Achievable: Leverage MobiLysis drone technology and AI-driven analytics. • Relevant: Supports accurate assessment of last-mile logistics efficiency and risk points. • Time-Bound: System operational by Q4 2027. 3. Improve satisfaction among citizens using cargo bikes by 20% by 2027 • Specific: Enhance infrastructure, routing, and support services for all bike users including regular cyclists, cargo bike users, and those renting from Park e-Bike. • Measurable: Conduct further AI analysis of bike-based solutions and satisfaction surveys among residents and participating businesses. • Achievable: Address feedback through targeted improvements. • Relevant: Encourages wider adoption of sustainable delivery methods. • Time-Bound: First survey in Q2 2026, with 20% improvement by end of 2027. 4. Create a dynamic map of optimal cargobike transport flows along designated corridors based on delivery time windows • Specific: Use data collected through MobiLysis drone swarm research to develop an interactive map that visualizes traffic flow and identifies safety-critical points along designated corridors. • Measurable: Generate detailed flow and safety analysis for at least 80% of monitored cargo corridors, updated regularly based on drone observations. • Achievable: Apply AI-driven analytics to drone-collected data for dynamic visualization and risk assessment. • Relevant: Enhances understanding of cargobike movement efficiency and safety, supporting sustainable last-mile logistics. • Time-Bound: Map fully operational and accessible to stakeholders by Q4 2027.
--	--

	● 5. Supporting evidence and data sources: • Impact of infrastructure on hub performance: Analysis of how the physical layout, accessibility, and connectivity of the hub influence its usage rates and operational efficiency. This includes proximity to cycling routes, public transport nodes, and delivery zones. • Effect of traffic organization changes on bicycle usage: Monitoring how modifications in local traffic patterns (e.g. reduced car access, dedicated bike lanes, traffic calming measures) affect the volume and flow of cargo and personal bicycle traffic in the surrounding area. • Surveys among local businesses indicate growing interest in cargo bike logistics. • Pilot programs in other European cities show measurable benefits of cargo bike adoption.
--	--

What: The Concept, Location, and Infrastructure

Use Case Code	● KR-UC01 - B
Use Case Title	● E-cargo bikes & e-bikes demand and monitoring
Use Case Concept Definition	● This use case is not just a tech deployment — it's a smart, adaptive and climate-conscious urban logistics solution, tailored for cities balancing heritage preservation with modern mobility needs. This use case introduces a modular, automated urban mobility monitoring system of the next generation, developed by Mobilysis, which employs a swarm of drones to collect high-resolution traffic data during selected project phases. The solution significantly surpasses traditional approaches based on fixed sensors or manual counts, providing precise insights into cargo bike and conventional bicycle flows, as well as analysis of intermodal connections with regional rail transport. The uniqueness of this UC lies in combining innovative measurement with social research, which includes deploying a dedicated application to analyze transport behavior of volunteers selected for the study. These two rounds of research will deliver critical information on travel patterns and public acceptance of new mobility solutions, enabling data-driven and user-oriented design of transport services. This makes the solution scalable, replicable, and socially accepted, clearly distinguishing it from existing approaches. 1. Traffic Flow and Safety Optimization Through AI-driven processing, the system transforms raw data into actionable insights, enabling cities to optimize traffic flow, strengthen intermodal integration, and significantly enhance

	safety for last-mile logistics—setting a new benchmark for sustainable urban mobility management. 2. Climate and Efficiency Monitoring ta, it will be possible to assess the impact of changes in last-mile increase in bicycle usage frequency. These insights will support alignment with sustainability policies, adding a strategic to urban logistics that conventional solutions often lack.
Location (and its influence area)	Location  The solution is deployed in central Kraków, with a focus on the Grzegórzki district and its surroundings, including the UNESCO-listed Historic Centre and the SOR (Restricted Traffic Zone). The system is designed to be mobile and modular, enabling the placement of distributed monitoring points across key urban locations. Influence Area and Monitoring Network Monitoring points will be strategically placed in: - Delivery Hotspots near Marketplaces and the Hub area - o 1A D1 – Grzegórzecka & Blich crossing (Hala Targowa) - o 4C D4 – Długa & Słowackiego crossing - Cultural and Commercial Zones - o 2A D2 – Dietla & Wielopole crossing - o 3B D3 – Dietla & Wrzesińska crossing - o 3B D3 – Wielopole & Westerplatte crossing - o 4A D4 – Plac Wolnica & Bonifraterska & Bocheńska & Mostowa crossing - o 5A D5 – Rzeszowska & Halicka crossing - o 6A D5 – Halicka & Podgórska crossing - High Pedestrian and Cyclist Corridors - o 5C D5 – Prądnicka & Wrocławska crossing - o 6C D6 – Słowackiego & Śląska crossing

	 These locations allow for: - High-resolution traffic and delivery data collection - Assessment of cargo bike accessibility and usage - Support for future hub expansion planning Advantages of the Location • Multimodal transport integration: Close to tram, bus, and rail nodes. • Dense urban fabric: High demand for last-mile delivery and sustainable transport. • Heritage-sensitive zone: Requires low-impact, flexible infrastructure. • Economic and cultural activity: Ideal for testing logistics models in real-world conditions.
! Which (physical and digital) infrastructure is needed?	● Modular, automated urban mobility monitoring system by Mobilysis requiring no new physical infrastructure. Drone swarm with AI analytics delivers real-time insights on traffic, intermodal links, and safety. 1. Physical Infrastructure Not required 2. Digital Infrastructure Required (software only): ○ Drone Coordination Platform: mission planning, geofencing, dynamic coverage. ○ AI Analytics: user classification, speed/flow metrics, safety hotspots, automated reports. ○ Dashboards & APIs: secure data ingestion, visualization, export. ○ Deployment of a dedicated application for analyzing transport behavior of selected volunteers. The research will provide essential insights into mobility patterns and user acceptance, supporting data-driven service design. 3. IoT & Real-Time

	On-board drone sensors only; no roadside IoT. Continuous real-time data processing. 4. Services & Fleet No transport services. Drones and their operators hired locally.
! Who will be responsible for developing and managing this new infrastructure?	● MobiLysis will develop a system based on the analysis of data collected using drones. In addition, an application will be purchased to enable research on transport behaviors based on the location of participants/volunteers and surveys conducted among them.
! What (physical & digital) infrastructure needs to be modified	● None
! Who will be responsible for these infrastructure modifications?	● Nobody
! Which metaInnovation technology (WP2) is being tested linked to this UC?	● The metaInnovation (WP2) technology being tested in this use case is the "Predictive Traffic Management System by collecting and analysing traffic flow data from drones." Developed by MobiLysis under the metaCCAZE project, this solution is part of WP2's rollout of open, smart systems for zero-emission and shared mobility. It leverages drone-based aerial observations to enhance urban mobility analysis, adapting the StrongSORT algorithm for aerial traffic scenes, introducing rule-based enhancements, clustering trajectories into standard paths, and identifying failure-prone zones to improve tracking robustness.

How: Operation, Management and Stakeholder Interaction

! How the Service will function (under normal conditions - operation on a daily basis)	● Daily Operational Flow
--	---------------------------------



	6. Safety Analysis - Emphasize safety of all traffic participants, with special attention to vulnerable users (pedestrians, cyclists, cargo bike riders). - Detect potential conflict points and risky interactions. 7. Behavioral Insights - Analyze multimodal behaviors: cargo bikes, Park-e-Bike rentals, private cyclists, rail commuters, and car users. - Identify patterns of interaction and modal shifts. 8. Data Processing & Analysis MobiLysis processes raw data into actionable insights. - Apply algorithms for safety assessment, behavioral trends, and infrastructure recommendations. 9. Report Generation - Prepare structured reports and dashboards. - Deliver results to Zarząd Transportu Publicznego (ZTP) Kraków for decision-making. 10. Three Research Sessions - Conduct data collection in three phases: before, during, and after the project to evaluate changes over time.
! How the User will interact (under normal conditions - operation on a daily basis)	● This system is designed for urban logistics professionals, city planners, and public transport authorities in Kraków. It enables strategic decision-making by providing real-time monitoring and behavioral analysis of traffic participants, with a strong focus on safety and multimodal mobility patterns. Users interact with the system through an intuitive dashboard that offers access to monitoring phases, data in sights, and downloadable reports. USER INTERACTION  1. Perception of Usefulness Users (e.g., ZTP officials, city planners) see the system as a tool for improving traffic safety and optimizing multimodal mobility.

	- Provides actionable insights for infrastructure planning and policymaking. 2. Specific Benefits - Access to clear dashboards and reports. - Identification of risk factors for vulnerable road users. - Support for strategic decisions based on real-world data. 3. Potential Difficulties - Complexity of interpreting large datasets. - Digital accessibility for elderly or disabled users. 4. Importance of Adoption - Transparent process and clear communication of benefits. - Demonstrates direct impact on safety and efficiency. 5. Interface Elements - Dashboard with interactive maps of monitoring points. - Filters for time periods (before/during/after project) and user types (cargo bikes, pedestrians, cyclists). - Notifications for new reports and maintenance updates. Considerations Usefulness in daily operations: Enables data-driven decisions for logistics optimization. Key benefits: Improved efficiency, reduced emissions, better infrastructure planning. Potential challenges: Requires digital literacy and reliable internet access. Adoption support: Intuitive interface, training modules, and integration with existing systems. Accessibility features: Configurable dashboards, visual aids, and simplified reporting tools. Positive interface elements: Clear navigation, real-time alerts, and exportable insights.
❗ Please review the Prototype stakeholder map and make changes	 The Public Transport Authority in Krakow (ZTP) is an organisational unit of the Krakow Municipality responsible for: planning, implementing and supervising the organisation of public transport; managing and maintaining passenger service infrastructure; implementing municipal policies in the field of bicycle and pedestrian traffic, as well as personal transport devices (e.g. scooters); developing paid parking zones; coordinating the construction of the Municipal Information System; operating Park & Ride car parks; and implementing the Clean Transport Zone in Krakow. The Department of Municipal Services and Infrastructure is a department of the Krakow City Council responsible for shaping city policy and creating and monitoring the implementation of long-term plans and programmes in the areas of municipal services, municipal waste and liquid waste management, maintaining cleanliness and order, transportation and traffic management.

	• The Department of Entrepreneurship and Innovation is a department of the Krakow City Council responsible for matters related to revitalisation, investor services, and business services and support. It acts as the operator of the Social and Economic Innovation Cluster and is responsible for science-related matters. • The City Architect's Office is a department of Krakow City Hall responsible for issuing opinions on projects aimed at ensuring the comprehensive and harmonious development of urban space. These projects are implemented by the Municipality of Krakow, represented by the relevant organisational units of Krakow City Hall and municipal organisational units. The unit is responsible for the land development concept under the SKA Grzegórzki railway flyovers. • Mobilysis is an EPFL spin-off that provides all-in-one mobility solutions using drone-based data collection and advanced computer vision analytics to monitor and optimize urban traffic. Their approach delivers high-quality, privacy-friendly insights to identify congestion sources and support sustainable mobility strategies.
--	---

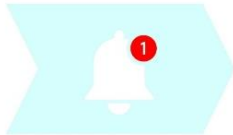
Second Stage of Why – What – How Framework

What: Foreseen Internal Risks and Mitigation Actions

Internal Risk (Technical issues, operability, service reliability):			
Scenarios	Severity	Likelihood	Mitigation action
Temporary no-fly constraints / aviation authorization delays	Medium	Medium	Pre-mission U-Space/PAŽP checks, buffer flight slots outside peak events
Data inconsistency or loss	High	High	Cloud backups, real-time synchronization, data validation routines
Adverse weather	High	Medium	Weather gating (wind/rain thresholds), on-site anemometer checks, dynamic rescheduling within the same peak window, all-weather airframes/props, protective enclosures for sensors
Internet connectivity issues	Medium	High	Offline data caching, fallback protocols, mobile network support

Camera/data quality degradation	Medium	Medium	Polarizing filters, HDR/auto-exposure profiles per site, higher shutter speeds, dusk/dawn exclusion, QA spot checks each sortie
!How the Service will function (under the anomalous scenario)	● This system is designed to remain operational and informative even during unexpected disruptions, ensuring that urban logistics professionals can continue to make informed decisions. Types of Anomalous Scenarios Considered Internal anomalies: • Sensor failure or hardware breakdown • Software glitches or update errors • Internet connectivity loss • Data corruption or inconsistency External anomalies: • Power outages • Extreme weather conditions • User misuse or unauthorized access Impact on User Experience • Temporary loss of real-time data • Reduced accuracy in traffic analysis • Limited access to dashboards or reports • Delayed decision-making for hub optimization		

	HOW THE SERVICE WILL FUNCTION UNDER THE ANOMALOUS SCENARIO FOR UC 2    1 - Normal Operation 2 - Anomaly Detection 3 - Cease the action    6 - System Restoration 5 - Technical Support Intervention 4 - Impact Assessment   7 - Post-Incident Logging 8 - Resume Normal Operation 1. Normal Operation System functions as expected. 2. Anomaly Detection Operators detect irregularities (e.g., sensor offline, data gaps). 3. Cease the action Immediate notification sent to technical team. 4. Impact Assessment Operators evaluates how the anomaly affects data quality and service reliability. 5. Technical Support Intervention Manual diagnostics, hardware replacement, or software patching. 6. System Restoration Full functionality is restored. 7. Post-Incident Logging Incident is documented for future analysis and prevention. 8. Resume Normal Operation System returns to standard performance.
 How the User will interact (under the	This flow describes how professional users interact with the urban logistics monitoring system when technical or external anomalies occur (e.g., sensor

anomalous scenario)	failure, software glitches, connectivity issues, power outages, or user HOW THE USER WILL INTERACT UNDER THE ANOMALOUS SCENARIO FOR UC 2   1 - Receive Notification of Delay or Change 2 - Reschedule Monitoring Session   4 - Continue Data Access and Reporting 3 - Confirm Updated Mission Parameters misuse). 1. Receive Notification of Delay or Change Users are informed via system alerts or email about postponed sessions due to adverse weather or operational constraints. 2. Reschedule Monitoring Session Access the dashboard to select a new time slot within the allowed window for the affected phase (before/during/after project). 3. Confirm Updated Mission Parameters Review revised flight plans and monitoring points; approve changes to ensure data comparability across sessions. 4. Continue Data Access and Reporting Once the rescheduled session is completed, users retrieve updated datasets and reports through the same interface.
---------------------	---

What: Foreseen External and Other Risks and Mitigation Actions

External Risk (user acceptance: complex interface, trust,):			
Risk	Severity	Likelihood	Mitigation action
Low user trust in data accuracy	Medium	Medium	Weather gating with clear thresholds; pre-approved alternate time windows within the same peak period; event/NOTAM checks and

			contingency site list for rapid re-planning.
Urban constraints and temporary disruptions (roadworks, police operations, crowd surges)	Medium	Medium	Weekly sweep of city works/event feeds; predefined backup waypoints per monitoring point; on-the-day readiness checklist and micro-replanning template.
Other External Risks			
Risk	Severity	Likelihood	Mitigation action
GNSS/C2 reliability issues during peak hours (positioning or mobile network congestion)	Medium	Medium	Multi-constellation GNSS with inertial fallback; dual-SIM multi-carrier setup; store-and-forward edge buffering; automated RTL failsafe.
Data comparability across the three sessions (before/during/after)	High	Low	Templated mission parameters (time window, altitude, camera profile); session-level QA gates and completeness checks; immutable logs and standardized reporting.

How: Investment, Costs, and Pricing

What kind of initial investment might be anticipated?	● 1. Funding Source: Entire investment is covered by the MetaCCAZE project, financing all technical and operational activities performed by MobiLysis. 2. Municipality Contribution: No direct financial input; ZTP provides in-kind support through staff participation in concept development and coordination, also funded under MetaCCAZE. 3. Upfront Components: • Hardware: drones, sensors, batteries, ground support kits. • Software: analytics platform, dashboards, cloud infrastructure. • Personnel training and operational costs during the pilot phase (handled by MobiLysis).
---	--

	4.Data Storage: All collected data will be securely stored in the Data Warehouse owned by ZTP, ensuring compliance and future accessibility.
What is included in this budget? (technology-based, consider running the service)	● The budget for this project covers a comprehensive set of technology-based components and operational costs necessary to deploy and run an innovative, AI-powered urban mobility monitoring system in Kraków. The key budget categories include: 1. Technology and Infrastructure software and licenses: ○ AI-based video analytics software (real-time classification of road users) ○ Software licenses for analytics, cloud storage, and data visualization tools 2. Operational and Recurring Costs Running the service: • Cloud hosting and data storage 3. Human Resources and Support • Staffing: ○ Technical team for deployment and system monitoring ○ Data analysts and AI specialists for model development and reporting ○ Project coordination and stakeholder engagement roles
How was the project funded? Under which funding schemas and co-financing?	● metaCCAZE Project Budget • The funding was provided through the metaCCAZE initiative, which supported: • The involvement of an external expert integrated into the municipal team • Technical development and innovation components • Monitoring and evaluation activities This funding was provided as a grant, covering both financial and in-kind contributions.
What is the cost per unit?	-N/A
Do you need any human resources? If yes, what type of human resources are needed?	• ● External Specialists: All operational and technical tasks, including drone deployment, data collection, and initial analysis, will be carried out by MobiLysis specialists, fully funded by the MetaCCAZE project. • Municipality Support: Limited involvement from ZTP Kraków experts in road infrastructure and traffic flow analysis to complement MobiLysis insights. These contributions are in-kind and covered under

	the MetaCCAZE project budget (no additional hiring costs). • Training and Upskilling: No additional training or upskilling required for ZTP staff beyond their existing expertise. MobiLysis handles all technical competencies internally. • Hiring Costs and Salaries: None anticipated outside the MetaCCAZE-funded scope. No new hires by the municipality.
Please specify any additional costs not outlined above	-N/A
Was the pricing of the proposed service defined? If yes, what is the pricing of the proposed service (for the user)	-N/A
Are there any incentives planned? If yes, would they motivate users to prefer this mobility solution more frequently? Why?	-N/A

3.4.2. Metadesigned BIGM

Table 12: KR-UC01 - B Summary of BIGM

SECTION	DESCRIPTION
Summary of the BIGM	This BIGM outlines drone-enabled demand monitoring for e-bikes/cargo bikes in Krakow's Grzegorzki-SOR zone, with flows from MobiLysis data provision to ZTP analytics.
Governance Model	ZTP Krakow leads as focal entity, coordinating MobiLysis for technology delivery and the consortium for funding, via PPP-like arrangements with phased drone missions and risk mitigations like weather gating. Decision-making involves joint workshops for report validation, ensuring data comparability and stakeholder buy-in per prototype guidance. (Figure 1).
Business Innovation Model	The Radar Business Innovation and Governance Model is suggested for KR-UC01 - B as it captures the multi-stakeholder ecosystem involving public authorities, technology providers, and end-users in co-creating data-driven insights for e-cargo bike monitoring, aligning with the Why-What-How framework. This model suits data services with drone tech and behavioural analysis,

enabling detailed mapping of roles, costs, benefits, and co-production.

Co-Created Value in Use

The co-created value lies in precise drone-based monitoring of e-cargo bike and e-bike demand in Krakow's central areas, delivering AI-processed insights on traffic flows, safety risks, and modal shifts to optimize infrastructure and support climate goals. Stakeholders jointly produce actionable reports through MobiLysis data collection and ZTP analysis, enhancing urban planning and last-mile logistics efficiency.

Table 13: KR-UC01 - B- List of stakeholders and roles

	STAKEHOLDER TYPE	IDENTIFIED STAKEHOLDER	ROLE	STATUS
Focal	Public authority	Public Transport Authority (ZTP Krakow)	Responsible for urban transport planning as well as bike and pedestrian traffic management, paid parking zones,	✓ Confirmed
	Municipality department (Services and Infrastructure)	Department of Municipal Services and Infrastructure	Responsible for city cleaning and monitoring implementation of long-term plans in liquid waste management, cleanliness, transportation and traffic management	✓ Confirmed
Core	Drone Data Provider	MobiLysis	EPFL spin-off providing all-in-one mobility solutions using drone-based data collection and advanced computer vision analytics to monitor/optimize urban traffic	✓ Confirmed
	Users	Citizens and local businesses	They participate in surveys and studies, and by using different modes of transport they demonstrate actual travel flows and routes.	✓ Confirmed
Customer				

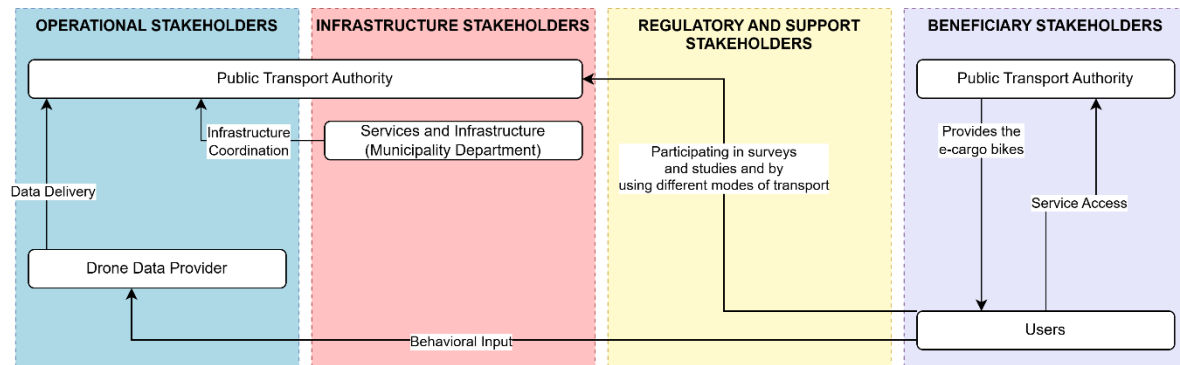


Figure 4: KR-UC01 - B Governance Model

Table 14: KR-UC01 - B - Business Model

STAKEHOLDER TYPE	COST (–) / BENEFIT (+)	CO-PRODUCTION ACTIVITY	VALUE PROPOSITION
Public Transport Authority	– Staff time, infrastructure coordination + Data for SUMP, safety enhancements, policy decisions	Data integration/analysis, report validation, behavioural surveys	Evidence-based mobility optimization
Municipality department (Services and Infrastructure)	– In-kind planning resources + Improved infra planning, reduced congestion	Site/infra provision, policy alignment	Efficient urban logistics support
Drone Data Provider	– Drone ops, AI processing + Tech validation, data insights	Drone monitoring, AI analytics/reports	Privacy-friendly traffic optimization
Customer	– Usage fees (assumed) + Efficient deliveries	Data sharing via app/surveys	Better last-mile logistics

3.5. On-demand automated mini-bus services in Gozo (GM-UC01)

3.5.1. Metadesigned Use Case

First Stage of Why – What – How Framework

Why: Challenges and Objectives

Questions	Considerations
! What specific challenges faced by the city will this Use Case address?	● Malta is an island state with a population of 516K (NSO, 2021), has two sister islands, Gozo and Comino. The project will be extended to the two main Maltese Islands, Gozo and Malta. According to 2022 Data, the public transport share of transportation stands at 9%. 1. Population density along with high car dependency results in traffic chaos. 2. More than 97% of the cars are petrol/diesel-powered and less than 3% uses alternative fuel. 3. Public transport is not an attractive option, with a modal split of less than 10% 4. Public transport routes are perceived as inefficient, as they serve many different areas along the same journey. Therefore, it is very challenging for Malta to reach its climate neutrality goals while it is also challenging to change a heavily car-oriented transport system to become greener and multimodal. The use case will demonstrate on-demand automated e-bus service across two routes to understand how this new service can be designed effectively and attract new users within the island context. The choice of e-buses directly addresses Malta's dependence on petrol and diesel vehicles, contributing to decarbonisation and reduced local emissions. Meanwhile, the on-demand system responds to the inefficiency and inflexibility of current fixed routes, offering a more responsive and user-oriented alternative. Essentially, it is aimed to understand the feasibility of deploying such new technology, assess aspects like accessibility, cost-effectiveness, safety, and equity.

! Which (at least 5) objectives does the city aim to achieve through this Use Case?	● 1. To pilot automated e-bus services on selected routes in Malta and Gozo 2. To evaluate public perceptions of safety associated with the automated bus 3. To measure public awareness and acceptance of automated public transport 4. To assess citizens' and stakeholders' perceptions of automated public transport services. 5. To evaluate the automated bus's technical and operational compatibility with local conditions and requirements
--	---

What: The Concept, Location, and Infrastructure

Use Case Code	● GM-UC01
Use Case Title	● On-Demand automated mini e-bus services
! Use Case Concept Definition	● The project will showcase an innovative automated e-bus service designed to provide zero-emission mobility for residents and tourists on the islands of Malta and Gozo. This on-demand service will adapt to passenger needs and pilot Malta's first automated public transport vehicle. Through co-creation activities (metaDesign) and stakeholder engagement, the project will address key challenges such as regulatory requirements, operational parameters, and the implementation of monitoring and booking technologies. During the 8-month demonstration, the service will gather feedback from residents and tourists via surveys, focusing on their expectations, experiences, satisfaction, accessibility, and suggestions for improvement. The insights from real-world operations will help evaluate the system's scalability, reliability, and integration with existing infrastructure. The project aims to refine the service to tackle specific mobility challenges while promoting sustainable, zero-emission transport solutions.
! Location (and its influence area)	● The solution will be implemented in Gozo and Malta. In Gozo it will focus on connecting Għarb (Ta' Dbiegi Crafts Village) to San Lawrenz Church, passing through the core of San Lawrenz village. This covers the village centre, which is narrow and difficult to serve with large buses, connects key community and tourist nodes (crafts village, church, nearby Dwejra area) and provides last-mile connectivity to residents, elderly citizens, and tourists visiting cultural and natural attractions. Advantages / Reasons for Selection:

- Accessibility: Small, narrow village streets make it unsuitable for standard buses, but ideal for smaller automated shuttles.
- Tourism & Culture: Links Ta' Dbiegi Crafts Village (an artisan/tourist hub) with San Lawrenz, a destination with cultural heritage and proximity to Dwejra Bay, a major tourist attraction.
- Community Value: Serves local residents with sustainable, accessible mobility, especially for elderly users or those without cars.

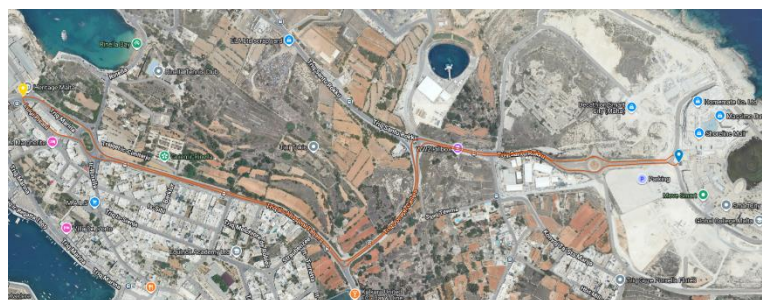
In Kalkara, a loop service will be provided around Smart City Malta (a technology and business hub) and the Esplora Interactive Science Centre. This connects business, education, and leisure facilities in the Grand Harbour area. and serves workers commuting to Smart City, families and tourists visiting Esplora and Shoreline shopping mall.

Advantages / Reasons for Selection:

- Economic Hub: Smart City is a growing technology and employment centre, attracting daily commuters, shopping mall visitors and tourists.
- Community Accessibility: Supports sustainable access to jobs, leisure, and education.
- Symbolic Value: Piloting cutting-edge mobility around Smart City reinforces Malta's positioning as a hub for innovation and digital transformation.

Map:

Esplora – Smart City (pending the review of the area traffic management)



San Lawrenz – Craft Villages

	
Which (physical and digital) infrastructure is needed?	One electric automated bus will be deployed. The vehicle comes pre-equipped with all necessary technology for the operation. The cellular network is key for the vehicle's operation as it is used to receive GNSS RTK correction and to communicate with the remote supervision centre. Good and stable 3G/4G/5G connectivity on the site is a requirement. The GNSS (GPS) localization requires GNSS corrections to work properly and get enough precision (< 4cm). It is confirmed that the coverage in Malta is enough and no additional equipment is required to enhance the connectivity. Road markings and signs should be in good estate and needs to be maintained along the duration of the pilot. Current already existing bus stops will be used during this phase – no additional bus stops are being considered as the current infrastructure should be enough. The existing Malta Public Transport Control Centre to monitor the operations and be ready to answer in case of any eventuality needs to be prepared. Vehicle will be safely parked during night, in an area with CCTV and away from passing traffic, ideally the bus depot where other vehicles are already parked. The EV model chosen does not require any adapter for charging, and any plug will work facilitating the charging process in almost any location chosen for the storage. On Demand booking system will take advantage of the already in-use system integrated in the existing PT app (Tallinja app).
Who will be responsible for developing and managing this new infrastructure?	MPT will assess the needs, with TM/MTIP assistance for deployment. MPT shall submit to TM any requests to deploy the automated vehicle on the road network. Permission and approval may be required to carry out any changes in infrastructure such as road markings, signs and traffic management.

	MPT will be responsible for the implementation of changes to the infrastructure and the deployment of the automated bus.
! What (physical & digital) infrastructure needs to be modified?	● Bus stop bays need to be clearly signalled and free of obstructions. No major infrastructure modification is expected, as the vehicle needs to operate in normal traffic conditions. Parking clearance might be required to provide a safe space for the EV to turn around/layover. Good enforcement of normal traffic rules is expected. The automated routes need to be imported on the On Demand software managed inside of Tallinja App, including times of operation, bus stops and vehicle seating specifications. MPT needs to work in close consultation with MTIP/TM during the pilot. Local Councils, public organisations and the business community along the routes that will be involved in the pilot to support the use case and to allow for any required parking space for the bus during the night.
! Who will be responsible for these infrastructure modifications?	● Clearance of bus stops by local enforcement (TM). Clearance of route by local enforcement (TM). Collaboration with TM and Local Councils to provide any parking/space clearance needed. MPT personnel will adapt the on-demand system and to add the automated routes, including the scheduled service, into the Tallinja App.
! Which metalInnovation technology (WP2) is being tested linked to this UC?	1. Automate: Remote operations framework for automated buses/shuttles; 2. Charge: Development charging system; 3. Manage & Operate: on-demand service; 4. Harmonize: AI-models based on city data.

How: Operation, Management and Stakeholder Interaction

! How the Service will function (under normal conditions - operation on a daily basis)

● MPT (PT operator) will manage the daily operation, assigning a trained operator daily to be on board of the vehicle during the service hours.

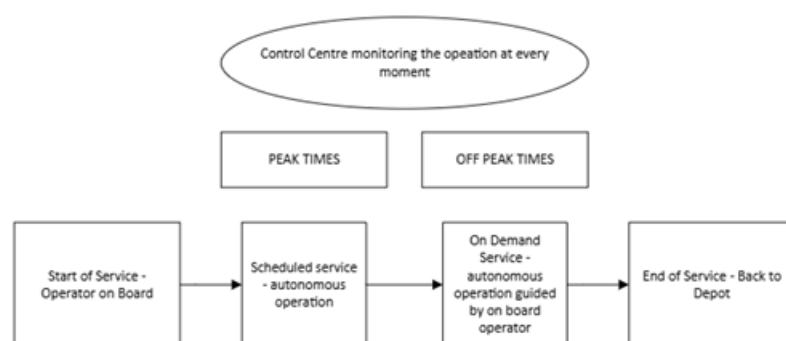
Safety operators will work in a roster based on the personnel available – these personnel should have received a training either from the provider of the vehicle itself, or by one of the authorized trainers that the provider will train out of MPT's chosen personnel. The training includes theoretical notions of the vehicle itself to be able to diagnose issues during the operation, and the manual driving of the vehicle for those instances where the automated driving is not available (when returning to depot, mostly). Additionally, they will be prepared to engage passengers and general public solving doubts and when required, surveying users on their views. The operator will also register any incidence that happen during the normal operation of the bus, including switching to manual mode during the automated driving route or other interruptions that may occur.

Safety operator will start its day by doing a safety check of the vehicle, ensuring everything is in order, taking note of any anomalies, and making sure the vehicle is fully charged for the day operation.

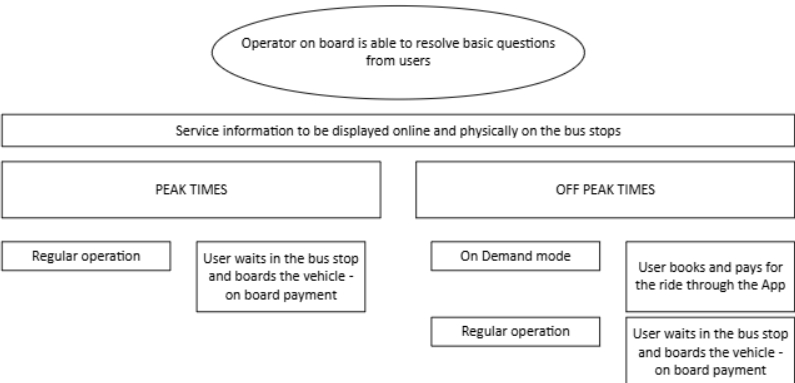
Control Centre personnel will receive a basic training on the automated bus operation to facilitate problem resolution of low-level problems.

The on-board operator will report to the Control Centre any issue that they may encounter. A basic troubleshooting will be performed, but if the issue persists the operator will contact the vehicle supplier through the appropriate channel.

The safety operator will keep track of the number of passengers on board the vehicle per trip and will take note of any incidence out of the ordinary (e.g.: switching to manual mode because the vehicle couldn't overtake a wrongly parked car). They will also engage with passengers or people approaching the vehicle while on layover, answering questions or doubts and promoting the service.



The service will be scheduled from 7am to 7pm but these operation times will be subject to change in case demand justifies so – either by shifting the operational hours, reducing them or extending them. Operational hours may be extended on particular days whenever there's a reason for it and will be agreed with stakeholders and announce to the passengers.

	At the end of the service, the safety operator will drive the bus to the designated charging and parking spot where the vehicle will be visually inspected, cleaned and charged to be ready for next day. The service will operate daily as long as the vehicle is available. Preventive maintenance will be programmed ahead of time in order to keep passengers informed. Any disruption to the normal planned operation of the service will be communicated through public channels. Automated bus (when not in a demo route) will appear in the Tallinja App (existing PT app), seamlessly integrated along the rest of the public transport routes, providing prediction to bus stop arrivals and the moving bus feature (passengers will be able to see the bus moving on the map). On Demand services will be integrated in the current On Demand platform within Tallinja app. A night service is not envisaged. The Bus will be charging during the night at a fixed charging point close to the pilot route.
How the User will interact (under normal conditions - operation on a daily basis)	 ● Service will be scheduled with a frequency enough to allow for the whole trip to operate including delays such as traffic. During peak hours, the bus will have a schedule. Therefore, any person willing to board the vehicle will be able to do so in any bus stops during the operation times as long as there is space. During off peak the service will be on demand basis through the operator's app. Information regarding the service will be available through the website, Tallinja app and through physical schedules on the bus stops used during the service. ● Passengers will be able to book their trips in the same manner they book the existing on demand service, just by choosing the area of operation of the automated vehicle, that will not overlap with another on demand service.

	When operating on “on-demand” mode, the vehicle will still pick up passengers waiting at the bus stops if there’s enough space for them, however they will be encouraged to book to avoid being left stranded. When the passenger boards in the bus, they will be requested to tap their public transport card, in case they have one. The service will be free of charge; the tapping will be used only for data gathering purposes (passenger number per trip, location of boarding, times, etc). Operator on board will resolve questions in case they arise during the trip. Passengers will be encouraged to ask doubts to get an informed opinion about the service. They may be asked to fill in a short survey to understand their perception of the service and vehicle while they are travelling on board, or immediately after the end of the trip. The vehicle will have accessibility features to ensure everyone can use it; operator on board will assist anyone that might require extra assistance.			
! List of stakeholders and their roles	Stakeholder type	Identified stakeholder	Role	Status
	Ministry	Ministry for Transport, Infrastructure and Public Works	Lead co-design initiatives and ensure strong citizen and stakeholder engagement and align pilot with community needs.	Confirmed
	Public entity	Transport Malta	Technical insight on automated bus deployment and legislation for pilot	Confirmed
	Local community representatives	Local and Regional Councils	Represents community needs and concerns during minialogues and workshops. Will assist in attracting users during pilot	Confirmed

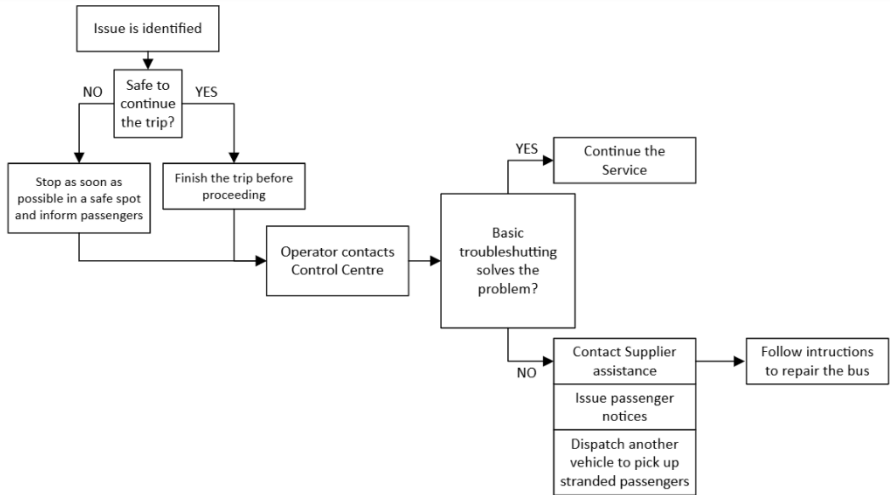
	<i>Academic</i>	<i>University of Malta</i>	<i>Data collection and analysis - demonstration</i>	<i>Confirmed</i>
	<i>Public entity</i>	<i>Infrastructure Malta</i>	<i>Assisting in identifying risks with routes and future infrastructural works which may affect the route</i>	<i>Confirmed</i>
	<i>Operator</i>	<i>Malta Public Transport</i>	<i>In charge of the operation, training, and implementation of the bus. Will also incorporate on-demand feature into existing app</i>	<i>Confirmed</i>
	<i>Businesses</i>	<i>Businesses (Esplora, Crafts Village, Smart City, shopping centre, etc.)</i>	<i>Will assist in reaching a wider audience by promoting the bus during events and activities</i>	<i>In discussion</i>
	<i>Organisations</i>	<i>Local Organisations (Band clubs, scouts, summer schools)</i>	<i>Will promote and share content about the pilot to attract users. Possibility of coordinating activities between the pilot and the organisation</i>	<i>to be contacted</i>

Second Stage of Why – What – How Framework

What: Foreseen Internal Risks and Mitigation Actions

Internal Risk (Technical issues, operability, service reliability):			
Scenario	Severity	Likelihood	Mitigation action
Longer testing/training phase than expected	Medium	Medium	Establish clear dates of implementation. Assign buffer times on the deployment dates Follow supplier guidelines and provide as much information on routing as possible to make some groundwork before the arrival of the vehicle.
Lack of availability of the vehicle due to maintenance/accidents/ technical issues	High	Medium	- Identify most common issue and have personnel ready to deploy to fix them ASAP - Have a spare bus ready to take over the operation to mitigate passenger inconvenience - Proper training for onboard operator to guarantee correct preventive maintenance
Vehicle unable to continue planned service due to low charge	High	Low	Provide proper training to the onboard operator Establish solid procedures to guarantee the correct charge of the vehicle and constant monitoring both by the on-board operator and remotely if available Accessibility to a charger along the route, to ensure there are chargers available as needed.
Lost connectivity or failure of the vehicle software	High	Low	Establish redundant communication systems and proper tested software.

			Operator on board to receive proper training to identify any issue and switch to manual mode if sensors fail
On demand System	Low	Low	System may not function properly and timely during the deployment – to ensure that if the system is not working, the service is provided based on a schedule.
! How the Service will function (under the anomalous scenario)	- Generally, the operator on-board identifies an anomaly and they will initially assess whether is safe to continue until the end of the trip. - o If it's safe, the trip will continue to minimize passenger inconvenience, and only then the vehicle will be safely parked in a designated area. - o If the anomaly requires stopping the trip, the operator will stop in the safest spot possible and inform the passengers of the issue. - They will contact the Control Centre who should be trained to provide a solution on a variety of situations. - Decision in taken according to the circumstances - o PT operator may dispatch an alternative vehicle to avoid leaving people stranded - o Technician may be dispatched on site to resolve certain technical issues - o For technical issues that can't be resolved on site, the vehicle will be taken to the operator's workshop - o If the anomaly extends in time, a notice might be posted in bus stops and website to alert users that the service won't be available during certain period. - Certain anomalies will be anticipated: - o An initial safety checked will be performed before the start of the service to guarantee the safety and good up-keep of the bus - o period maintenance will be scheduled according to the manufacturer recommendations - o Extreme weather, although unlikely for most of the year in Malta, is forecasted - o The supplier is providing with preventive maintenance plan and support. - Charging: in the unlikely event of lack of power supply, portable charges will be ready to install in an area where power supply is available		

	 <pre> graph TD A[Issue is identified] --> B{Safe to continue the trip?} B -- NO --> C[Stop as soon as possible in a safe spot and inform passengers] B -- YES --> D[Finish the trip before proceeding] C --> E[Operator contacts Control Centre] D --> E E --> F{Basic troubleshooting solves the problem?} F -- YES --> G[Continue the Service] F -- NO --> H[Contact Supplier assistance Issue passenger notices Dispatch another vehicle to pick up stranded passengers] H --> I[Follow instructions to repair the bus] </pre>
! How the User will interact (under the anomalous scenario)	- On board operator will inform passengers of the issue and the estimated time it will take to be solved in case the information is available. - Whenever possible, the trip will be finished to minimized inconveniences. Public announces will be made through App and other social media channels in order to inform passengers of a current service disruption. - If it's not possible to continue the trip, the PT operator will dispatch an alternative vehicle to pick up the passengers that were left stranded on the stops. Notices may be installed in the physical bus stops as well for those not checking online updates. - In case a trip operating on-demand can't be operated, the users who booked will receive a notification informing them of the cancellation of the trip.

What: Foreseen External and Other Risks and Mitigation Actions

External Risk (user acceptance: complex interface, trust):			
	Severity	Likelihood	Mitigation action
Residents complaints	Medium	Low	Work closely with Local Councils and other stakeholders if necessary to inform residents

			before the start of operation, PR campaign
Public rejection due to the inconvenience	Medium	Low	Operator on board to build trust, PR campaign before the start of operation
Vandalism of the vehicle/infrastructure	Medium/High	Low	Install CCTV systems within the facilities, prioritizing areas that are already under surveillance to strengthen existing coverage. Coordinate awareness and prevention campaigns in collaboration with the police. When the vehicle is not in service, it will be parked in a secure parking area, preferably one monitored by a security guard.
Other external risks (Legislation, competitors (others))			
	Severity	Likelihood	Mitigation action
Limited space for legal operation of automated features	Medium	High	Automated features will only operate in legal areas – legislation already on the works way ahead of deployment
Insurance availability	High	Low	Contact insurance companies beforehand to explain the project and get them onboard
Bus availability by providers	High	Medium	Tender issued and is on the market. Issued it well in advance to have time to manufacture and deliver the vehicle on time. Level 4 requested might be lowered if no other availability given the mandatory presence of the operator on board.
Lack of power supply	High	Low	Portable charger allows the bus to be moved to another location with supply availability

How: Investment, Costs, and Pricing

What kind of initial investment might be anticipated?	● - MetaCCAZE project funding will support most of the initial investment, including the leasing of the vehicle for the duration of the pilot ● - The on-demand software already in use by the PT operator needs to be adjusted to the particularity of the use case, therefore a small development may be required. - During the pilot, users will not pay for the service; both scheduled and on demand will be provided free of charge for any passenger. - the salaries of officer on board will be covered by PT operation (MPT) - Any enforcement required will be covered by TM - PR campaign will be covered by the project
What is included in this budget? (technology-based, consider running the service)	● Leasing of an automated vehicle Training and working hours of the staff ● Internet and connectivity – WIFI will be included in line with the current standard on scheduled public bus transport in Malta ● Marketing and public stakeholders' engagement include events within the community, demonstration activities and promotional material for users.
How was the project funded? Under which funding schemas and co-financing?	● - MetaCCAZE project funding - Operator will contribute with its own personnel and software (Tallinja app for the scheduled route information and the on-demand service).
What is the cost per unit?	This information was marked as confidential by the partners.
Do you need any human resources? If yes, what type of human resources are needed?	Remember: this is just an estimate and subject to change ● Yes, on-board safety operators and other staff members are needed for managing the operation. Operator and controllers need to be trained – personnel already working for the operator (MPT) can be used. Enforcement officers within TM need to be trained on the legislative framework and to understand how this new technology works to support on any traffic management related actions required during the pilot
Please specify any additional costs not outlined above	● Towing the bus in case it's not drivable in the relocation given the different places of operation. Cost of electricity to charge the vehicle.
Was the pricing of the proposed service defined? If	Remember: this is just an estimate and subject to change

yes, what is the pricing of the proposed service (for the user)	● The pilot will be free of cost for users – proposed price afterward is same cost as regular public transport - 2€/2.5€ cash/contactless and included on the FPT scheme. The price will be for non-personalized tallinja card holders.
Are there any incentives planned? If yes, would they motivate users to prefer this mobility solution more frequently? Why?	Remember: this is just an estimate and subject to change ● The incentive for the end user to use the service is that it is a convenient, innovative mode of transport compared to the existing services. Integrated in the current PT system – easy to use and familiar to the users. Added frequencies for Gozo San Lawrenz route adding convenience. For Malta, there is no service from Esplora to Smart City (there is the opposite way), the route will also connect residents of Kalkara to Smart City (a shopping and office centre).

3.5.2. Metadesigned BIGM

Table 15: GM-UC01 Summary of BIGM

SECTION	DESCRIPTION
Summary of the BIGM	This UC aligns with multi-stakeholder co-creation, value exchange, and roles, as detailed in the Why-What-How framework and stakeholder interactions. Radar captures the ecosystem dynamics, including co-production activities and mutual benefits.
Governance Model	Decision-making led by Public Transport Authority with ministry approvals, involving councils for community feedback, while the service is operated by the Public Transport Operator (Malta Public Transport). (Figure 1).
Business Innovation Model	The Radar BIGM centers the Public Transport Operator as Focal Organisation coordinating the relevant authorities (ministries/agencies) for operations and infrastructure developments, with enriching partners providing data. Costs for the service are projected to be covered from increased revenues from tickets.
Co-Created Value	The service delivers zero-emission, flexible on-demand e-bus mobility tailored to island challenges like high car dependency and inefficient routes, enhancing accessibility for residents, elderly, and tourists in narrow areas, fostering sustainable multimodal shifts.

Table 16: GM-UC01- List of stakeholders and roles

	STAKEHOLDER TYPE	IDENTIFIED STAKEHOLDER	ROLE	STATUS
Focal	Public transport operator	Malta Public Transport	Operation, training, on-demand app integration	 Confirmed
	Ministry of Transport	Ministry for Transport, Infrastructure and Public Works	Lead co-design and ensure citizen/stakeholder engagement; align pilot with needs	 Confirmed
Core	Public Transport Authority	Transport Malta	Technical insight on deployment/legislation	 Confirmed
	Public infrastructure authority	Infrastructure Malta	Identify route risks and perform infrastructure works	 Confirmed
	Academia	University of Malta	Data collection/analysis-demonstration	 Confirmed
	Ministry of Gozo	Ministry for Gozo and Planning	Support in co-design and stakeholder engagement	 Confirmed
Enriching	Local community representatives	Local and Regional Councils	Represent needs; attract users	 In Discussion
	Businesses	Businesses (Crafts Village, Smart City, Esplora, shopping centre, etc.)	Promote to wider audience/events	 In Discussion
	Local user organisations	Local Organisations (Band clubs, scouts, summer schools)	Use on-demand e-bus and provide feedback	 To Be Contacted
Customer	Users	Users (commuters, tourists, students)	Use the On-Demand automated e-bus services	 Confirmed

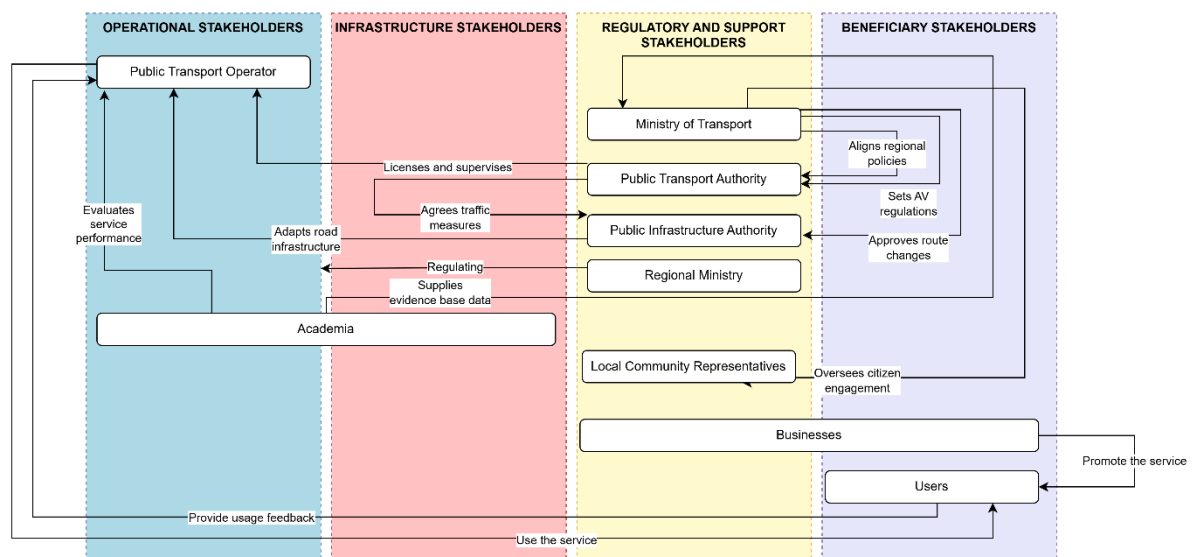


Figure 5: GM-UC01- Governance Model

Table 17: GM-UC01 Business Model

STAKEHOLDER TYPE	COST (–) / BENEFIT (+)	CO-PRODUCTION ACTIVITY	VALUE PROPOSITION
Public transport operator	– Operations/training costs + PT expansion	Daily operations, monitoring	Efficient, scalable service
Ministry of transport	– Policy coordination effort + Aligned climate-neutral goals; enhanced PT attractiveness	Workshops	Stronger multimodal policy framework
Public Transport Authority	– Regulatory approvals + Safer, legal AV operations	Infrastructure assessment	Expertise in AV integration
Public infrastructure authority	– Infrastructural support + Mitigated disruptions	Risk identification	Reliable operations
Academia	– Research resources + Data for scalability insights	Surveys, analysis	Evidence-based improvements
Regional Ministry	– Policy coordination effort + Aligned climate-neutral goals; enhanced PT attractiveness	Regulating	Alignment with regional policy

STAKEHOLDER TYPE	COST (–) / BENEFIT (+)	CO-PRODUCTION ACTIVITY	VALUE PROPOSITION
Local community representatives	– Promotion time + Community accessibility boost	User attraction during pilot	Responsive local mobility
Businesses	– Promo effort + Tourism/business access	Event coordination	Attracted visitors/customers
Local user organisations	– N/A + Convenient zero-emission travel	Feedback via consultation	Flexible, accessible mobility
Users	– Fare + Convenient zero-emission travel	Feedback via surveys/app	Flexible, accessible mobility

3.6. Development of on-demand e-Pod service in Milan (MI-UC01)

3.6.1. Metadesigned Use Case

First Stage of Why – What – How Framework

Why: Challenges and Objectives

Questions	Considerations
! What specific challenges faced by the city will this Use Case address?	● The Milan use case supports the city's decarbonisation objectives set out in its Climate City Contract (CCC) by piloting a zero-emission on-demand service with on-board interchange. A fleet of docking e-Pods (electric modular mini-vehicles) developed by NeXT can couple and uncouple along the route to improve DRT efficiency and user level of service. This technology enables passengers to transfer between vehicles seamlessly during a trip, while allowing the DRT service to serve more trip requests, improving public-transport accessibility and reducing car dependency.
! Which (at least 5) objectives does the city aim to achieve through this Use Case?	● - Decreasing perceived car dependency: 10% of a representative sample of service users reporting to be fully or highly dependent

	on car for their daily urban mobility before using the DRT service FRIMBO, - Increasing perceived accessibility to public transport: 30% of service users perceiving an increase in the accessibility to public transport, - Reducing pollution: reduction in pollutants emissions by users shifting to FRIMBO, corresponding to 20,000 km of auto saved and expressed in tonnes/year, for three pollutants: Particulate Matter (PM), Nitrogen Oxides (NOx), Volatile Organic Compounds (VOC). - Reducing transport energy demand: reduction in energy demand of users shifting to FRIMBO from personal car (10k Litres of Gasoline, 4k litres of Diesel, 40 kWh of Electricity), - Increasing perceived accessibility of vulnerable groups: 20% increase in perceived level of accessibility by users in vulnerable groups, - Economic viability of the system: 50% of stakeholders that considers the system will be / is economically viable
--	--

What: The Concept, Location, and Infrastructure

Use Case Code	● MI-UC01
Use Case Title	● Development of an on-demand e-Pod service leveraging enhanced autonomous e-Pod features.
! Use Case Concept Definition	● The main concept of the use case is to augment a classical Demand Responsive Transport (DRT) service with innovative modular vehicles, capable of coupling and uncoupling along the route, with passengers able to transfer between coupled vehicles through an internal connection, without alighting and boarding another vehicle. In other words, a user can start his/her journey in one vehicle and finish it in another, without having to get out from one vehicle and get into a new one. This option makes the service more comfortable for users and more effective in meeting the mobility requests with the same number of vehicles used from the company side. The service is managed using a technological platform that dynamically defines the optimal routes for vehicles based on users requests, planning where vehicles will meet and connect to allow one or more users to change vehicles when this improves the quality of the service.
! Location (and its influence area)	● We still need to confirm the area where the case study will be implemented, among a series of preliminary hypotheses presented during the LL2–LL3 event. The discussed possibilities are: ● Paderno Dugnano, Melzo–Gorgonzola, Cernusco sul Naviglio, San Donato Milanese, MIND–C.na Merlata, Trezzano sul Naviglio, Gudo Visconti–Vermezzo con Zelo. All of them are located within the metropolitan area of Milan and are sites characterized by a population between 7,000 and 47,000 inhabitants, a total surface area between 4 and 20 km², limited

	public transport service (a maximum of 7 lines), and the presence of a limited number of activity hubs. During LL4, discussions converged towards ● San Donato Milanese as the most promising candidate area, given its combination of metro accessibility (M3), employment hubs and current service gaps, while keeping the other options as backup scenarios. In this phase we are developing the service simulator to perform scenario-based simulations to support service planning in terms of service area and stop locations in relation to fleet size and operating conditions. It models demand, vehicle operations and network conditions to assess system performance under different planning and operational configurations. Once the simulation phase is concluded, further discussions will be held with local stakeholders to formally confirm the final implementation area.
! Which (physical and digital) infrastructure is needed?	● - IoT sensors and real-time monitoring systems will be used for managing the coupling and uncoupling phases between the modular PODs and parking operations. These sensors facilitate vehicle communication, particularly during docking, where precise alignment is crucial. Additionally, parking infrastructure like lots will signal occupancy or availability, allowing vehicles to autonomously select their parking spot. Several of these core technologies, including autonomous docking, summoning, and parking, are being developed within the scope of Work Package 2 (WP2). Next has already conducted successful testing of one of its modules in a private area. These tests focused on the module's autonomous navigation capabilities, specifically assessing its throttling, steering, and braking performance. The vehicle successfully navigated autonomously around a parking lot, demonstrating its ability to avoid obstacles and reach the destination effectively. - Four vehicles will be used to operate the DRT service, one of which will have a low-floor design to ensure accessibility for wheelchair users.
! Who will be responsible for developing and managing this new infrastructure?	● Agenzia TPL will be responsible for the service deployment, with the support of: AMAT that will work on service planning (also through simulations) and is responsible for promoting the service. NEXT that will provide the electric vehicles capable to autonomously dock/undock and park will be responsible for their extraordinary maintenance A Public Transport Operator (PTO) that will be selected to manage the service and provide a wheelchair accessible vehicle.

	Factual that will provide the platform to manage the DRT service UNINA will oversee the service monitoring and evaluation.
! What (physical & digital) infrastructure needs to be modified	● The existing app used to manage the DRT service will need to be enhanced with new functionalities to optimise the interchange points between the different modular vehicles. ● All modular vehicles produced by Next are currently type-approved as vehicles rather than buses. Therefore, an additional type-approval is required to authorise their operation while coupled. This is also necessary to ensure a unique vehicle identification, since coupled vehicles will display two different licence plates: one on the front of the first vehicle and one on the rear of the docked one. If this type-approval is not obtained within the project timeline, vehicle coupling will be carried out only while the leading vehicle is stationary. This will still achieve the main objective of coupling, namely enabling onboard passenger exchange between vehicles.
! Who will be responsible for these infrastructure modifications?	● Regarding the app, Factual will be responsible for its adaptation and the integration of new functionalities to support the modular vehicle system. Regarding type-approval, Next will provide three vehicles homologated as "M1." This M1 approval allows for the offering of a Demand-Responsive Transport (DRT) service with modular interchange at predetermined points where the head vehicle will be stationary. Furthermore, efforts will be made to obtain M2 approval, which is required to drive on the road the vehicles in a coupled configuration. As mentioned in previous paragraphs, not achieving this second goal will not impede the service core functionality. Note: M1 and M2 type approval vehicle categories classify passenger vehicles by seating and weight. M1 vehicles carry up to eight passengers plus the driver, while M2 vehicles carry more than eight passengers and weigh up to 5 tonnes.
! Which metaInnovation technology (WP2) is being tested linked to this UC?	● In WP2, Next and the University of Naples Federico II are jointly working on the algorithm that manages the coupling and uncoupling manoeuvres of the modular vehicles, ensuring that these operations are carried out in complete safety — both with respect to the movements of other vehicles and the potential crossing of pedestrians.

How: Operation, Management and Stakeholder Interaction

! How the Service will function (under normal conditions - operation on a daily basis)	● The service will be operated with the utilisation of a management platform that will enable the management of vehicles providing them journey details to satisfy user requests. The heart of the platform is an optimisation algorithm able to create vehicle routes that best serve users by minimising waiting and travel times while maximising resource efficiency, by exploiting the possibility of vehicles to couple, to allow users to change vehicles, when this improves service performance. Actors and responsibilities The service is operated by the selected PTO continuously within predefined time windows and service areas. At the start of operations, the PTO verifies vehicle readiness (battery, health, connectivity). Users submit trip requests via the app, specifying origin, destination, time preferences, and accessibility needs. The platform validates each request against operating hours, geographic boundaries, capacity, and service rules, and returns an acceptance or rejection. Accepted requests are forwarded to the optimizer, which evaluates feasible insertions based on current routes, time windows, and vehicle constraints, selecting the most suitable e-pod and confirming the booking and ETA. Before pickup, users receive notifications with pickup details and vehicle information. The e-pod arrives at the pickup point, boarding is logged, and the trip status is updated. During the trip, the optimizer may re-optimize routes to accommodate new requests or operational changes, updating vehicle instructions and user ETAs accordingly, under the Operations Control Center (OCC) supervision. At drop-off, the trip is completed, data are stored for monitoring and evaluation, and vehicles are reassigned to the next trip, a staging area, or charging, depending on operational needs. Drivers receive routing and timing instructions through the driver App, continuously updated by the optimizer. When the service requires an encounter and coordination between two vehicles, drivers are notified in advance with clear indications on the meeting location and timing. Any updates due to re-optimisation are propagated in real time, while the Operations Control Center (OCC) supervises these interactions and may intervene if needed. Peak and off-peak operations During peak hours, the service applies tighter waiting-time constraints, more frequent re-optimisation, and active vehicle staging near demand hotspots. During off-peak hours, routing is more flexible, fewer vehicles are active, and part of the fleet may remain in standby or charging to optimise efficiency. Technical restrictions and dependencies The service operates within defined hours, geofenced areas, and vehicle capacity limits. Reliable internet connectivity is required for user interactions, vehicle monitoring, and real-time dispatching. Accurate digital maps and network representations are essential to ensure feasible routing. Maintenance, updates, and notifications
---	---

	Vehicles and software are maintained through scheduled off-peak updates and corrective interventions when needed. Users are informed of service disruptions or planned maintenance primarily through in-app notifications, ensuring transparency and continuity of service.
! How the User will interact (under normal conditions - operation on a daily basis)	● The user submits its trip request through the app, specifying the origin stop, destination stop, desired departure time, number of passengers, and whether any of them are wheelchair users. The system responds in real time, indicating whether it can accommodate the request. If confirmed, it provides the estimated time window for pick-up at the origin stop and the maximum arrival time at the destination stop. The user can then choose to accept or decline the proposed service. While on board, users will be notified—via both the app and the vehicle/driver—if a vehicle change is required during the trip. One of the four vehicles used to operate the service is equipped with a low-floor design to ensure accessibility for wheelchair users <pre> [User] — submits trip request [User App] — sends request (origin, destination, time, passengers, accessibility) [Management Platform] checks service rules (operating hours, service area, capacity) +- NO → [Request Rejected] +- YES → optimises route [Optimisation Algorithm] vehicle assignment (direct trip or with vehicle interexchange) [Vehicle / Driver App] driver follows routing and timing instructions +- direct trip → [Drop-off] +- vehicle interexchange coordinated encounter between two vehicles passengers change vehicle v [Second Vehicle / Driver App] driver follows updated instructions v [Drop-off] </pre>

! List of stakeholders and their roles.	Stakeholder Type	Identified Stakeholder	Role	Status
	● Mobility Agency	AMAT (Mobility Agency of Milan)	Coordinates the Living Lab, support planning and integration with the public transport system, oversees local communication.	Project Partner
	● Public Authorities	Agenzia TPL (Public Transport Authority)	Contracts the public transport service, supervises local transport operations and tariff integration with the on-demand service	Project Partner
	● Public Authorities	Metropolitan City of Milan	Ensures integration with metropolitan strategies.	Confirmed
	● Public Authorities	Municipality where the service will be realized	Defines local transport policies, ensures service alignment with the SUMP and zero-emission strategies.	To Be Contacted
	● Public Authorities	Ministry of Infrastructure and Transport (MIT)	Authorizes docking in motion procedure and bus homologation for e-pod	In Discussion
	● Mobility & Infrastructure Operators	ATM (Azienda Trasporti Milanesi)	PT operator integrates the e-pod service with existing PT lines and digital infrastructure.	In Discussion
	● Mobility & Infrastructure Operators	Autoguidovie	PT operator integrates the e-pod service with existing PT lines and digital infrastructure.	In Discussion

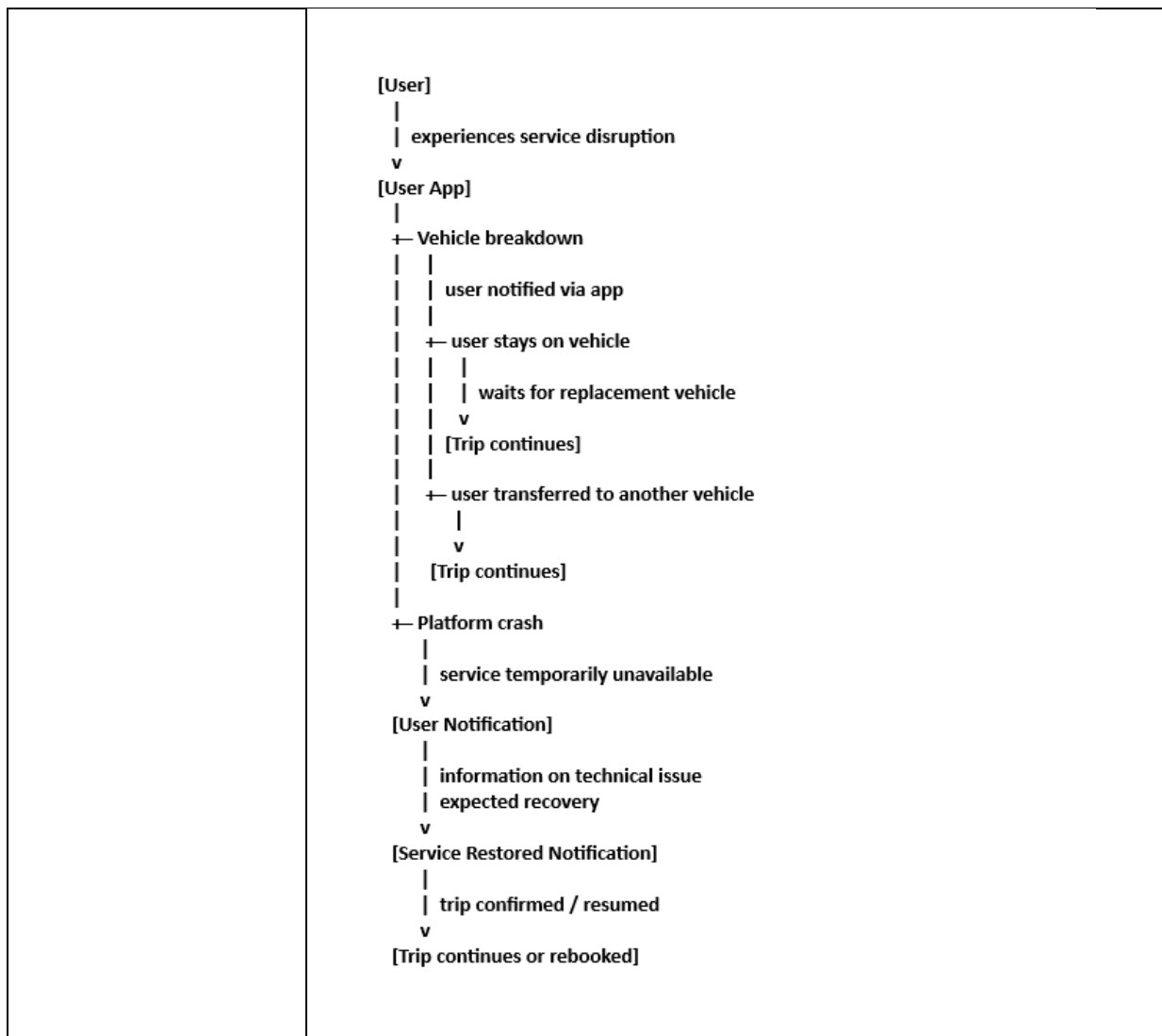
	Private Sector / Business	NExT	Supplies the e-pod vehicles for the on-demand service and leads the development of autonomous driving functionalities	Project Partner
	Technology Providers / Platforms	NEMI	Develops DRT algorithms and user interfaces; supports real-time service optimization.	Confirmed
	Research & Academia	Università Federico II di Napoli	Leads impact assessment on accessibility, emissions, and efficiency.	Project Partner
	Research & Academia	University of Milano-Bicocca	Studies user perception, social acceptance, and behavioral changes related to the pilot.	In Discussion
	Citizens & Associations	UTP – Public Transport Users Association	Represents users' needs and provides feedback on quality and accessibility.	Confirmed
	General Public & Media	Citizens and students	Participate in co-creation workshops, provide feedback, and test the vehicle.	Confirmed
	General Public & Media	Local media outlets	Disseminate project updates, raise awareness, and promote engagement.	To Be Contacted

Second Stage of Why – What – How Framework

What: Foreseen Internal Risks and Mitigation Actions

Internal Risk (Technical issues, operability, service reliability):			
Scenario	Severity	Likelihood	Mitigation action
Vehicle breakdown	medium	low	To reduce the severity: Always have a service management plan ready that can operate with a reduced number of vehicles. To reduce the likelihood: Preventive maintenance and specialized driver training.
Platform crash	high	low	To reduce the severity: Ability to restart the platform by recreating routes based on the service state at the time of the crash. To reduce the likelihood: Extensive testing, including edge cases, and system redundancy to recover from potential hardware crashes.
! How the Service will function (under the anomalous scenario)	Vehicle breakdown The vehicle driver reports the issue to the control centre. This event is managed by reassigning the users scheduled on that vehicle to the other vehicles in the fleet, updating the operational plan accordingly. Platform crash The platform is restarted, and an operational plan for each vehicle is recreated based on the state of vehicles and requests before the crash. This ensures service quality is optimized for users and minimizes discomfort.		

	<pre> [Anomalous Event Detected] +- Vehicle breakdown driver reports issue v [Operations Control Centre] assesses vehicle status updates operational plan v [Management Platform] reassigns users to other vehicles updates routes and timings v [Other Vehicles / Driver Apps] v [Service continues with reassigned vehicles] +- Platform crash platform unavailable v [System Restart] restore vehicle states restore active requests v [Management Platform] recreates operational plan optimises routes again v [Vehicles / Driver Apps] v [Service restored] </pre>
! How the User will interact (under the anomalous scenario)	Vehicle breakdown Users already on board can choose to remain in the out-of-service vehicle until another vehicle arrives to take them to their destination. Platform crash Users who have already made a reservation will be notified via the app about the temporary unavailability of the service due to technical issues, and subsequently informed once the service is restored.



What: Foreseen External and Other Risks and Mitigation Actions

External Risk (user acceptance: complex interface, trust,):			
	Severity	Likelihood	Mitigation action
Issue in User acceptance of the new service	low	medium	To reduce the severity: User interviews to understand the main reasons behind their low level of acceptance, followed by actions to solve the issues and targeted communications to bring users back to the service. To reduce the likelihood: Effective communication about the service and its operation to reassure users.

Other external risks (Legislation, competitors (others))			
	Severity	Likelihood	Mitigation action
Type approval of the docking system (in motion)	low	high	The docking will be operated with the vehicles stopped.

How: Investment, Costs, and Pricing

What kind of initial investment might be anticipated?	1. Service Planning and Demand-Supply Alignment Funding is needed to support the use of analytical models and simulation tools to align available resources with demand patterns. This phase involves collecting and processing mobility data (e.g., census data, mobility surveys, travel patterns), defining service parameters (service area, operating hours, fleet size), and identifying the most suitable deployment area. This step ensures the service meets real needs and avoids inefficient deployment. 2. Vehicle Leasing or Procurement Depending on the projected demand and duration of the pilot, vehicles such as electric modular pods need to be either leased (ideal for flexibility during pilots) or purchased (better for long-term operations). The investment covers not only the vehicles themselves but also their customization, equipment, insurance, and possibly installation of charging infrastructure. 3. Engagement of a Public Transport Operator A reliable public transport operator should be contracted to manage the day-to-day operations of the service. This includes staff recruitment, driver training (especially for handling modular or semi-autonomous vehicles), maintenance protocols, and compliance with safety standards. This ensures operational readiness and integration with existing mobility services. 4. Acquisition of an On-Demand Service Management Platform (as-a-service) A core component of the system is a digital platform that handles dynamic ride requests, real-time vehicle dispatching, and route optimization. The investment covers both the central management interface and mobile apps for drivers and users. This software is typically acquired through a licensing or subscription model, ensuring updates and technical support. 5. Fare System Integration To maximize user uptake and ensure interoperability with existing public transport services, the on-demand service should be integrated into the city's fare system. This includes coordination with local authorities and system providers to enable seamless ticketing and payment solutions (e.g., via smartcards, apps, QR codes), possibly requiring backend system upgrades. 6. Communication and Citizen Engagement Campaign An effective launch requires a targeted communication campaign to inform and engage citizens. Activities include
---	---

	designing and distributing informative materials, hosting public info sessions or demo days, leveraging social media, and working with local organizations. This helps raise awareness, clarify how the service works, and encourage early adoption. 7. Service Monitoring and Evaluation Continuous monitoring during the pilot phase is essential to assess service performance, identify user needs, and fine-tune operations. This involves data collection (e.g., ridership, waiting times, satisfaction), technical system monitoring, and coordination with stakeholders to review KPIs. It enables iterative improvements and supports long-term planning or scaling.												
What is included in this budget? (technology-based, consider running the service)	● The municipality of the area where the service will be realized will provide in-kind support in terms of staff involved in the communication, organization of events, bureaucratic accomplishments and other related activities. ● Costs for platform upgrade and development, simulation tool development, initial communication, driver and service operator training, stakeholder engagement and events organization, testing phases are also included in the initial investment.												
How was the project funded? Under which funding schemas and co-financing?	● Some private partners are cofounding the project within the HE co-funding scheme (NEXT, Factual, AMAT).												
What is the cost per unit?	● <table border="1"> <thead> <tr> <th>Cost item</th><th>Annual cost per vehicle (€)</th><th>Notes</th></tr> </thead> <tbody> <tr> <td>E-pod leasing (EV)</td><td>30.000</td><td>Leasing</td></tr> <tr> <td>Driver</td><td>50.000</td><td>Gross annual cost (salary + social contributions); 1 FTE per vehicle</td></tr> <tr> <td>On-demand platform (SaaS)</td><td>5.000</td><td>License fee per vehicle per year</td></tr> </tbody> </table>	Cost item	Annual cost per vehicle (€)	Notes	E-pod leasing (EV)	30.000	Leasing	Driver	50.000	Gross annual cost (salary + social contributions); 1 FTE per vehicle	On-demand platform (SaaS)	5.000	License fee per vehicle per year
Cost item	Annual cost per vehicle (€)	Notes											
E-pod leasing (EV)	30.000	Leasing											
Driver	50.000	Gross annual cost (salary + social contributions); 1 FTE per vehicle											
On-demand platform (SaaS)	5.000	License fee per vehicle per year											
Do you need any human resources? If yes, what type of human resources are needed?	Remember: this is just an estimate and subject to change ● <table border="1"> <thead> <tr> <th>Function</th><th>Key Roles</th><th>Typical Engagement</th></tr> </thead> <tbody> <tr> <td></td><td></td><td></td></tr> </tbody> </table>	Function	Key Roles	Typical Engagement									
Function	Key Roles	Typical Engagement											

	Planning & Analytics	Transport planner, data analyst	Setup + periodic
	Operations	Drivers, operations manager	Continuous
	Technology	Platform admin, IT support	Continuous / vendor-supported
	Customer & Outreach	Support agent, communication officer	Launch + continuous
	Monitoring & Evaluation	M&E specialist, project manager	Continuous
	Governance	Legal, safety officer	Part-time
Please specify any additional costs not outlined above	☒ No additional cost is foreseen		
Was the pricing of the proposed service defined? If yes, what is the pricing of the proposed service (for the user)	Remember: this is just an estimate and subject to change ☐ During the launch phase, the service will be offered free of charge in order to incentivise user adoption and to collect operational and behavioural data. In parallel, during the execution of the pilot, an additional activity will be carried out using the simulation framework, aimed at exploring future mobility scenarios in which e-pod fleets operate on a regular basis as a complement to public transport services. This activity will allow the assessment of different operational configurations and demand levels, and will support an initial evaluation of potential pricing schemes that could contribute to the long-term economic sustainability of the service, while maintaining accessibility and alignment with public mobility objectives.		
Are there any incentives planned? If yes, would they motivate users to prefer this mobility solution more frequently? Why?	Remember: this is just an estimate and subject to change ☐ As mentioned in the previous field the service will be free of charge during the pilot period.		

3.6.2. Metadesigned BIGM

Table 18: MI-UC01 Summary of BIGM

SECTION	DESCRIPTION
Summary of the BIGM	The BIGM for MI-UC01 organises a multi-actor partnership where AMAT and Agenzia TPL steer design and contracting, NeXT, Factual and NEMI provide vehicles and digital optimisation, PTOs operate the service, and UNINA plus user groups ensure impact monitoring and social embracement. Costs for vehicles, platform upgrades,

simulations, training, communication, and evaluation were identified, while future pricing scenarios are studied via simulations to prepare scalable, economically viable models after the pilot.

Governance Model	Governance combines regulatory oversight (MIT for type approval), strategic coordination (Metropolitan City, Municipality, AMAT, Agenzia TPL), and operational management (PTO, OCC and platform providers), ensuring alignment with CCC/SUMP and clear decision pathways for deployment, risk mitigation, and scaling. (Figure 1).
Business Innovation Model	Radar is recommended because the MI-UC01 e-Pod service is co-produced by multiple interdependent actors—Agenzia TPL for deployment, AMAT for planning and promotion, NeXT for modular vehicles and automation, Factual/NEMI for DRT platform and algorithms, PTOs for daily operations, UNINA for evaluation, and user groups for feedback—forming a service ecosystem rather than a single-provider value chain.
Co-created value in use	The on-demand e-Pod service creates value through flexible, low-emission DRT that improves accessibility to PT, especially in peripheral areas, by using modular vehicles and dynamic routing to increase DRT level of service and so contribute to reduce car dependency and energy use.

Table 19: MI-UC01- List of stakeholders and roles

STAKEHOLDER TYPE		IDENTIFIED STAKEHOLDER	ROLE	STATUS
Focal	Urban Mobility Agency	AMAT (Mobility Agency of Milan)	Coordinates Living Lab, supports planning and PT integration, oversees local communication .	Confirmed
	PT Contracting Authority	Agenzia TPL (Public Transport Authority)	Contracts the service, supervises operations and tariff integration .	Confirmed
Core	PT Operator	PT Operator	Potential PTO integrating e-Pod with existing PT lines and digital infrastructure	In Discussion
	e-Pod Manufacturer	NeXT	Supplies modular e-pod vehicles, develops automated driving and docking features; maintains vehicles .	Confirmed
	DRT Algorithm Developer	NEMI	Provides and adapts the DRT management platform and app .	Confirmed

	STAKEHOLDER TYPE	IDENTIFIED STAKEHOLDER	ROLE	STATUS
Enriching	Research & Academia (Technical)	Università Federico II di Napoli	Contribute to simulation with demand estimation, oversee the service monitoring and evaluation framework. .	 Confirmed
	Metropolitan Authority	Metropolitan City of Milan	Ensures integration with metropolitan strategies and SUMP	 Confirmed
	Local Authority	Municipality where the service will be realized	Sets local transport policies, aligns service with SUMP and zero-emission strategies .	 To Be Contacted
	Research & Academia (Social)	University of Milano-Bicocca	Leads impact assessment on accessibility, emissions, efficiency .	 In Discussion
	PT Users Association	UTP – Public Transport Users Association	Represents users' views on perception, social acceptance, behaviour change .	 Confirmed
Other	Ministry of Infrastructure and Transport	Ministry of Infrastructure and Transport (MIT)	Authorises docking-in-motion procedure and bus homologation for e-pods .	 To Be Contacted
	DRT Platform Provider	FACTUAL	Disseminate updates, raise awareness, promote engagement .	 Confirmed
	Local Media	Local media outlets	Participate in workshops, provide feedback, test vehicles .	 To Be Contacted
	Citizens	Citizens and students	Represents user needs; provides feedback on quality and accessibility .	 Confirmed
Customer	Users	Service users	Use the e-Pod DRT service via the app .	 Confirmed

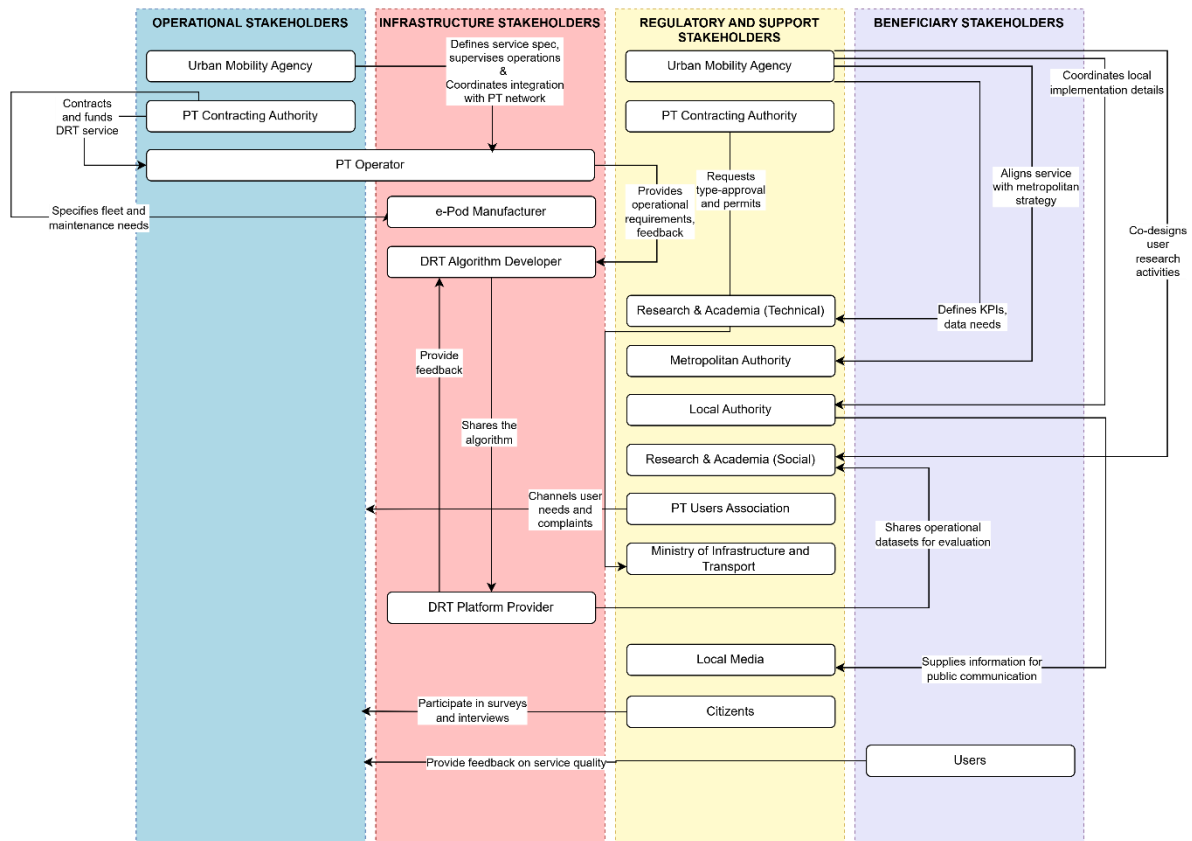


Figure 6: MI-UC01- Governance Model

Table 20: MI-UC01 - Business Model

STAKEHOLDER TYPE	COST (–) / BENEFIT (+)	CO-PRODUCTION ACTIVITY	VALUE PROPOSITION
Urban Mobility Agency	– Staff time for planning, simulations, communication . + Achieves CCC decarbonisation and accessibility goals; strengthens PT network	Leads service design, simulation-based planning, stakeholder coordination .	Strategically planned zero-emission feeder service improving access to main PT
PT Contracting Authority	– Contracting, supervision, integration workload . + More efficient, flexible PT offer and data for future contracting	Defines service contract, integrates e-Pod into PT/tariff framework .	Stable DRT service embedded in regional PT system .

STAKEHOLDER TYPE	COST (–) / BENEFIT (+)	CO-PRODUCTION ACTIVITY	VALUE PROPOSITION
Main PT Operator	– Operational costs, driver time, integration effort (if selected) . + New service product, higher ridership, data for optimisation	Operates vehicles, coordinates timetables and data with platform .	Reliable daily service connected to PT Operator network .
e-Pod Manufacturer	– Vehicle R&D, provision, maintenance costs . + Demonstration of technology, market validation and co-funding impact	Delivers vehicles, docking algorithms, safety functions .	Innovative modular vehicles enabling on-board interchange and efficient fleet use .
DRT Algorithm Developer	– Platform upgrade, integration, operation costs; co-funding. + Reference case for advanced modular DRT, business development .	Develops optimisation, booking, notification and monitoring features .	User-friendly app and control platform enabling responsive, accessible DRT .
Research & Academia (Technical)	– Cost for simulation and demand estimation . + Validation of algorithm performance in modular DRT context	Contribute to simulation with demand estimation, oversee the service monitoring and evaluation framework	Shorter waits and efficient routing through advanced optimisation .
Metropolitan Authority	– Policy work and coordination + Contribution to metropolitan climate-neutral mobility objectives	Aligns UC area and KPIs with SUMP/CCC	Consistent metropolitan-scale zero-emission mobility corridor
Local Authority	– In-kind staff support for communication, events, admin . + Better accessibility in underserved areas; political visibility	Local engagement, permits, support for stops and communication .	Local feeder service improving access to jobs, education, hubs

STAKEHOLDER TYPE	COST (–) / BENEFIT (+)	CO-PRODUCTION ACTIVITY	VALUE PROPOSITION
Research & Academia (Social)	– Research staff time, data analysis . + Evidence for policy, publications, improved design	Defines KPIs, analyses before–after data	Quantified environmental and accessibility benefits supporting scale-up
PT Users Association	– Survey and analysis effort . + Insights on acceptance and barriers for replication	Represents public transport users and participates in meetings and co-design sessions, sharing user views, concerns and suggestions on service quality, accessibility, social acceptance and behaviour change.	Improved user-centric design and communication strategies
Ministry of Infrastructure and Transport	– Regulatory process and oversight . + Enables innovative modular DRT under national rules .	Type-approval and legal framework for coupled vehicles .	Legal certainty for safe modular e-Pod operation .
DRT Platform Provider	– Coverage and production resources . + Content and visibility on innovative mobility	Campaigns and reporting on pilot and results .	Increased awareness and uptake of the service
Local Media	– Time spent testing and adapting behaviour . + Access to flexible zero-emission mobility and co-designed features	Pilot use, surveys, co-design sessions	Convenient, comfortable trips and reduced car reliance .
Citizens	– Voluntary time and engagement . + Service better aligned with user expectations	Participates in co-creation, validation, feedback loops	Trustworthy, user-endorsed service design
Users	– Time; later fares once pricing is introduced, though pilot is free . + Better accessibility,	Booking trips, sharing feedback, adapting travel choices .	On-demand, reliable, accessible journeys in underserved areas .

STAKEHOLDER TYPE	COST (–) / BENEFIT (+)	CO-PRODUCTION ACTIVITY	VALUE PROPOSITION
	comfort, reduced car costs		

3.7. Multimodal Passenger hub in Miskolc (MK-UC01)

3.7.1. Metadesigned Use Case

First Stage of Why – What – How Framework

Why: Challenges and Objectives

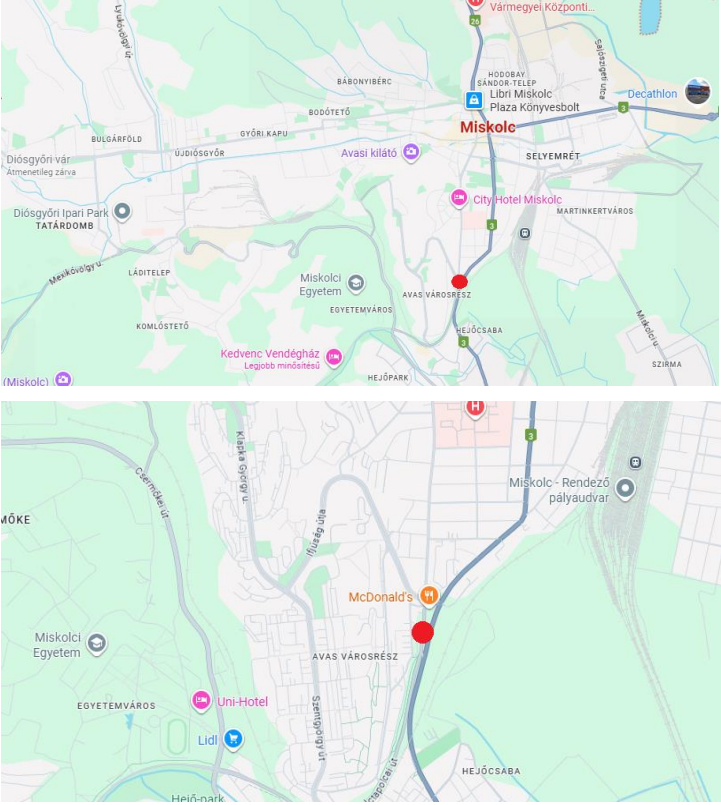
Questions	Considerations
❗ What specific challenges faced by the city will this Use Case address?	● One of the key challenges within Miskolc's public transport system lies in enhancing the interoperability among various transport modes (bus, tram, micromobility, and private car) and ensuring the spatial and temporal coordination of these services. The existing transport hubs (e.g. Tapolca junction, Bagolyvár area) currently does not provide sufficient integration between micromobility options (e.g. bike or scooter) and the public transport network.
❗ Which (at least 5) objectives does the city aim to achieve through this Use Case?	● • <u>Reducing the dependence on private car usage and supporting the achievement of climate neutrality goals:</u> This objective is highly relevant as it is fully aligned with CCC climate neutrality and SUMP objectives for sustainable mobility. The target percentage of reduction in car modal share (baseline: 45% car from SUMP 2016) has to be defined based on CCC/SUMP goals. The changes will be evaluated based on the post survey in the pilot area. The results shall be visible by the end of the pilot period. • <u>Integrating micromobility solutions with public transport modes:</u> The integration of micromobility into the public transport network will be enabled through physical access at selected hubs and digital connectivity through a journey planner. The goal is to have one multimodal passenger hub installed and a full integration of micromobility vehicles in the journey planner by the start of the pilot period. • <u>Improving the user experience by simplifying transfers between different journeys:</u> The user experience will be enhanced by

	providing reliable, real-time transfer information to users at the info screens installed at the multimodal hub. The objective is measurable through the post survey and the number of multimodal routes planned during the pilot. The objective is relevant as it aligns with SUMP goals for digital transition and multimodal connectivity. The results will be provided by the end of the pilot period. • <u>Expanding the multimodal functions of the public transport hub:</u> New functionality of the locations will be added by physical and digital elements that support multimodal travel (e.g., bike racks, info screen), which is measurable by the number of new components installed. The aim is achievable, since infrastructure upgrades are planned during the pilot, and the objective is relevant as it aligns with SUMP goals for digital transition and multimodal connectivity. • <u>Increasing the number of residents using the info screen in selected peak hours:</u> The objective can be measured through system usage data collected during the pilot period. Moreover, it is achievable, since infrastructure upgrades are planned during the pilot. The objective is relevant for promoting mode shift and achieving the overall goals of the project. • <u>Increasing the number of micromobility devices utilizing the smart hub:</u> The objective can be measured through system usage data collected during the pilot period (e.g., number of vehicles docked at the hub). Moreover, it is achievable, since physical infrastructure is planned during the pilot. The objective is relevant for promoting micromobility adoption and supporting the overall goals of sustainable urban mobility. The results will be presented by the end of the pilot period.
--	--

What: The Concept, Location, and Infrastructure

Use Case Code	● MK-UC01
Use Case Title	● Multimodal passenger hub
! Use Case Concept Definition	● The planned pilot aims to enhance an existing public transport hub by transforming it into an integrated multimodal mobility hub that connects buses, trams, micromobility options, and private transport modes within a unified physical and digital infrastructure. Unlike traditional hubs that operate as separate systems, this concept focuses on seamless integration to support convenient and sustainable travel. This hub will serve as a multimodal information point, providing users with essential information services. These services will not only guide commuters on transport options but offer updates on public transport information. Physical

	integration of various transport modes at the extended multimodal transport hub will streamline access, encouraging their use as a convenient last-mile solution. The core innovation lies in integration of different functions, as the hub will include bike racks, urban furniture, and a digital passenger information display. These elements will create a user-friendly environment that encourages multimodal travel. Another key component is the integration of micromobility that ensures flexibility for users and maximizes the hub's functionality as a last-mile solution. While the hub will serve as a multimodal information point offering real-time updates on public transport schedules, the primary function is to physically connect different transport modes in one accessible location. Through this initiative, the pilot will promote sustainable transport alternatives, improve the efficiency of the public transport system, and foster a more connected urban ecosystem that prioritizes user-friendly mobility solutions.
! Location (and its influence area)	● The Tapolca elágazás (Tapolca junction) is strategically situated on the southern outskirts of Miskolc, serving as a vital link between the city center and the popular tourist destination of Miskolctapolca, known for attractions like the Cave Baths. This route experiences heavy traffic, particularly during the tourist season, highlighting its significance for visitors. The transport hub not only facilitates easy access to various parts of Miskolc but also ensures tourists can reach key attractions throughout the city conveniently. Additionally, the junction connects the center of Miskolc to the motorways and Miskolctapolca, enhancing overall mobility. Local bus services further support public transport in the area, making it an integral part of daily commutes. The junction's closeness to the M30 motorway and main road 3 allows for swift connections to other cities, including Budapest and Kassa, further emphasizing its importance in regional travel. The main innovation is the transformation of this location into a multimodal hub through the integration of micromobility and digital services. This location was selected because of its high passenger volumes and strategic position, which creates strong potential for users to adopt micromobility for first- and last-mile connectivity. The physical integration will include installing bike racks, urban furniture, and a digital passenger information display. These elements will enable seamless transfers between public transport and micromobility, making multimodal travel practical and attractive.

	As an alternative site Bagolyvár is proposed as a backup location due to permit request documents and power supply constraints related to public utility services. Both sites represent one of the busiest transport hubs in Miskolc, where most of the city's bus routes converge, where local and regional buses stop and/or terminate, and which are located in proximity to major urban roads and residential areas. The selection of these sites was justified by the following factors: • Direct connection to the city's main public transport lines. • High passenger traffic volumes. • Suitable conditions for the safe placement and the potential of charging of micromobility devices. • Proximity to Park and Ride facilities. Map: 
Which (physical and digital) infrastructure is needed?	Physical components: Installation of bike racks, urban furniture, and a digital passenger information display. The infrastructure will include some of the following items: visual information system, bicycle storage facilities, surveillance camera, USB charger with solar panels, measurement of temperature and air pollution.

	Digital components: Integration with the MobilON system, data provision from public transport timetables and vehicle systems, and potentially deployment of environmental data monitoring. The digital infrastructure will connect the visual information system with specific data sources. The platform should eventually compare travel times and display emission savings by sustainable transport modes compared to car travel. The system should show the number of available e-scooters nearby (through operator APIs, if provided). Furthermore, it should include public transport travel and transfer times (through GTFS data). In addition, travel times and intercity bus schedules should be displayed (through intercity bus APIs and timetables, if provided), alongside weather information (through meteorological APIs, if provided). The system could also provide aggregated statistics and emission summaries.
! Who will be responsible for developing and managing this new infrastructure?	● • MVK – Bus and tram infrastructure • Municipality of Miskolc – Land use and permitting • Lime – Micromobility infrastructure • HC Linear – Integration, testing and operation of digital systems, including troubleshooting (MobilON platform)
! What (physical & digital) infrastructure needs to be modified	● • Installation of bike racks, platforms and urban furniture. • Deployment of digital passenger information displays. • Provision of electricity to power the display.
! Who will be responsible for these infrastructure modifications?	● • MVK – Operation and implementation • Municipality of Miskolc – Permitting and public space management • HC Linear – Operation of digital passenger information displays
! Which metaInnovation technology (WP2) is being tested linked to this UC?	● Manage & Operate: Framework for setting up and operating mobility hubs along with the incorporation of micromobility.

How: Operation, Management and Stakeholder Interaction

! How the Service will function (under normal	● Within this use-case a frequent junction will be upgraded into a multimodal hub, where the main components are racks for storing micromobility vehicles, renewed infrastructure including street furniture, and a digital passenger information display. The
--	---

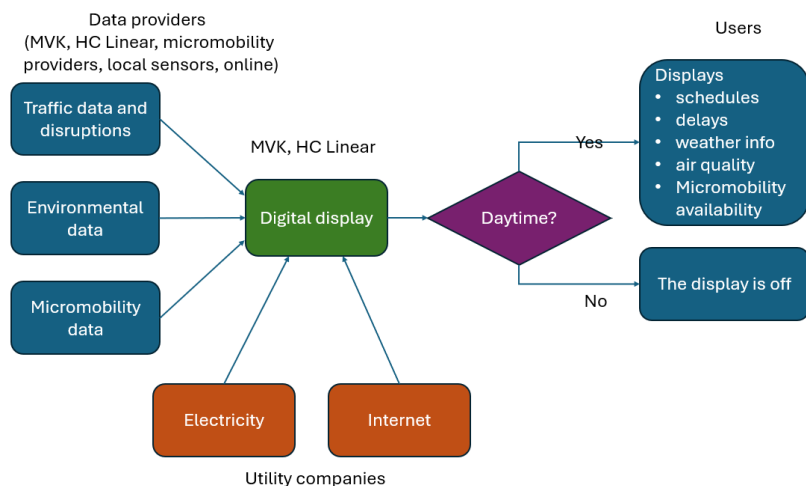
conditions - operation on a daily basis)

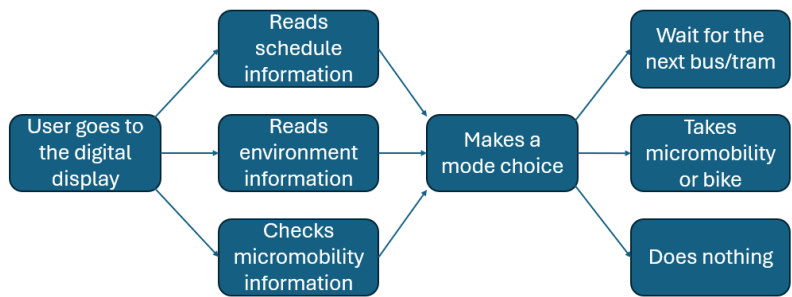
multimodal hub integrates public transport, micromobility, and passenger information, ensuring seamless travel planning and environmental awareness.

The bike racks and street furniture are static elements, and they are functioning all year round without supervision. The system will display information through screens based on the time of day and user needs. During peak hours, it will prioritize public transport information to support efficient travel, while during off-peak periods, it will provide supplementary content, such as local updates or environmental data. At night the system will automatically turn off to minimize light pollution. A stable internet connection is required for updates and seamless functionality.

MVK manages bus and tram traffic based on real-time data, potentially integrating micromobility services. Traffic and environmental data are continuously analysed via digital systems operated by HC Linear and are displayed on the digital screen in the multimodal hub. This enables passengers to plan their journeys using the information from the multimodal hub displays, while MVK and its partners use the data to optimize operations and reduce environmental impacts.

All functions will be managed and maintained by MVK, ensuring consistent operation and data accuracy. Moreover, MVK is responsible for the structural integrity and cleanliness of the display and the street furniture, while HC Linear ensures data pipeline integrity, error handling, and notifications, if there are problems with the display.



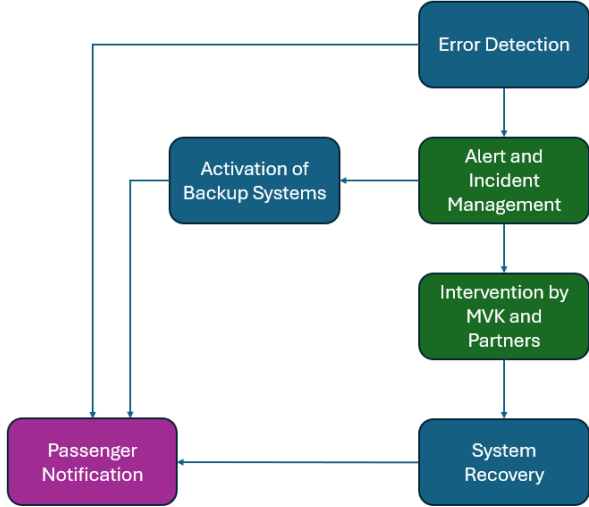
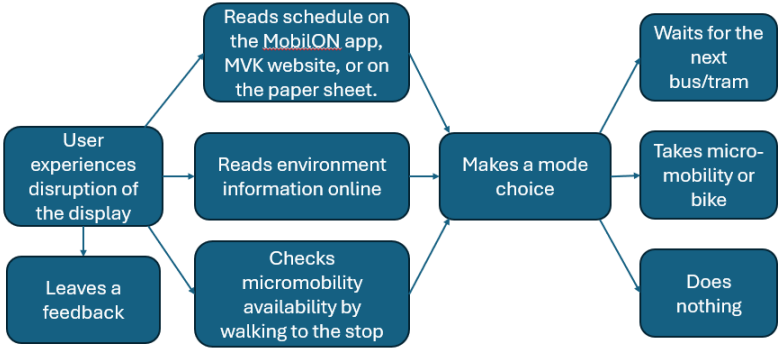
❗ How the User will interact (under normal conditions - operation on a daily basis)	● In the Multimodal hub, the users consult with the information display before travelling, where they will be able to see the traffic data and can decide which mode to take from the hub on their journey. The users will perceive the multimodal hub as an increased and enhanced liveability in the area. They will directly interact with the bike racks by docking/undocking micromobility vehicles, where no difficulties are foreseen by using the infrastructural elements. The main user benefit is that they will receive up-to-date information and gain more confidence in taking public transport. The difficulties are minor, for example for international tourists some inconvenience would arise from language barriers.  <pre> graph LR A[User goes to the digital display] --> B[Reads schedule information] A --> C[Reads environment information] A --> D[Checks micromobility information] B --> E[Makes a mode choice] C --> E D --> E E --> F[Wait for the next bus/tram] E --> G[Takes micromobility or bike] E --> H[Does nothing] </pre>
❗ Please review the Prototype stakeholder map and make changes	● • Operational stakeholders: MVK, data providers, digital system/data platform operator. HC Linear has a distinct role beyond simple data provision, including data analysis, pipeline integrity, error handling, and system notifications. • Infrastructure stakeholders: MVK, electricity company, internet provider, surveillance camera system operator. • Regulatory and support stakeholders: municipality. • Beneficiary stakeholders: local citizens, public transport users.

Second Stage of Why – What – How Framework

What: Foreseen Internal Risks and Mitigation Actions

Internal Risk (Technical issues, operability, service reliability):			
Scenario	Severity	Likelihood	Mitigation action
Electricity outage	high	low	Back-up battery.

Loss of data connection	moderate	moderate	Temporary message to use mobile devices for real-time information.
Agreement between MVK and data providers	low	moderate	Prepare potential alternatives.
! How the Service will function (under the anomalous scenario)	● MVK ensures the continuity of public transport services even under abnormal circumstances by following the steps below: <u>Step 1: Error Detection</u> • The system automatically detects technical failures (e.g. software malfunction, hardware failure, network outage). • External anomalies (e.g. power outage, extreme weather, vandalism) may also trigger protective protocols. • Disruptions to public transport services or availability are detected by the respective dispatchers. <u>Step 2: Alert and Incident Management</u> • Upon error detection, the MVK control center sends alerts to maintenance and IT teams. • The MobilON application and urban displays automatically notify passengers (if the issue is not with the display). <u>Step 3: Activation of Backup Systems</u> • The system switches to offline mode. • Basic information remains available with reduced functionality. <u>Step 4: Passenger Notification</u> • Displays show messages or go blank in case of a power outage. <u>Step 5: Intervention by MVK and Partners</u> • Technical partners and HC Linear begin diagnostics and troubleshooting, including remote restart or physical repairs. • Manual control may be initiated if necessary. <u>Step 6: System Recovery</u> • Normal operation is gradually restored after the incident. • The system logs the event and analyses root causes to prevent future occurrences.		

	 <pre> graph TD ED[Error Detection] --> AIM[Alert and Incident Management] AIM --> IBVP[Intervention by MVK and Partners] IBVP --> SR[System Recovery] SR --> PN[Passenger Notification] SR --> ABS[Activation of Backup Systems] ABS --> ED </pre> (blue: Display, green: MVK, purple: Passenger)
❗ How the User will interact (under the anomalous scenario)	● The users will experience minor inconveniences if the display is not operating. In such cases, they will have to find alternative solutions to access the information that would otherwise be displayed, for example by using the MVK website for schedules. For other information, they can rely on alternative websites, such as those providing weather or air quality data. In addition, paper-based timetables placed at the stops can be used for timetable information. If there are issues with micromobility services, users can plan their trips accordingly by using public transport or walking as fallback options. Passenger Feedback - Passengers can submit feedback via the MobilON app regarding experienced issues. - MVK and its partners incorporate this input into service development.  <pre> graph LR UED[User experiences disruption of the display] --> R1[Reads schedule on the MobilON app, MVK website, or on the paper sheet.] UED --> REO[Reads environment information online] UED --> LFB[Leaves a feedback] REO --> MCC[Makes a mode choice] R1 --> MCC MCC --> WBT[Waits for the next bus/tram] MCC --> TMB[Takes micro-mobility or bike] MCC --> DN[Does nothing] </pre>

What: Foreseen External and Other Risks and Mitigation Actions

External Risk (user acceptance: complex interface, trust,):			
	Severity	Likelihood	Mitigation action
Citizen acceptance	moderate	low	Marketing campaign to present the benefits of the new solution.
Potential future expansion of traffic lanes	moderate	moderate	The design of the multimodal passenger transport hub allows the system to be relocated to a new site at minimal cost, if needed.
Permitting issues related to utility service providers	moderate	moderate	In case of force majeure, implementation will take place at the designated backup location near the Bagolyvár transport hub.
Other external risks (Legislation, competitors (others))			
	Severity	Likelihood	Mitigation action
Regulatory changes	moderate	low	Close coordination with the city's legal department.
Vandalism	High	low	Operating surveillance camera.

How: Investment, Costs, and Pricing

What kind of initial investment might be anticipated?	● Budget for the multimodal passenger hub: Infrastructure: • Components: hardware and installation • Responsible: MVK Software: • Components: system integration and data processing • Responsible: HC Linear
What is included in this budget? (technology-based, consider running the service)	● In the budget both the installation of the display and surrounding elements is included. Moreover, the operation during the project.
How was the project funded? Under which funding schemas and co-financing?	● Project funding and local funding.
What is the cost per unit?	● A new multimodal hub will be realized, where several transport modes will be part of the framework. There will be one display deployed and one street furniture element.

Do you need any human resources? If yes, what type of human resources are needed?	● The implementation and maintenance of the project can be ensured through the adequate training of existing staff, thus no external hiring costs will occur.
Please specify any additional costs not outlined above	-
Was the pricing of the proposed service defined? If yes, what is the pricing of the proposed service (for the user)	● The transport service does not generate direct revenue for the company. Its primary objectives are to enhance customer satisfaction, improve passenger information, and promote environmental awareness.
Are there any incentives planned? If yes, would they motivate users to prefer this mobility solution more frequently? Why?	● No incentives are planned for this service. The focus is on providing reliable, real-time information to support informed travel decisions, rather than offering financial or reward-based motivation.

3.7.2. Metadesigned BIGM

Table 21: MK-UC01 Summary of BIGM

SECTION	DESCRIPTION
Summary of the BIGM	The BIGM for MK-UC01 organises MVK as the Focal Operator, supported by HC Linear and the Municipality (Core partners) to co-produce integrated information and safe, user-friendly public space at Tapolca junction. Investment comes from MVK and project funds, while ongoing costs are modest and sustained mainly by MVK, justified by expected increased gains in PT ridership, micromobility uptake and progress toward climate-neutrality targets.
Governance Model	Governance is centred on MVK and the Municipality, who jointly steer design, location and operation in line with SUMP and CCC, with structured involvement of BME, HC Linear and other stakeholders through mini-dialogue style co-creation and risk management processes. Operational governance relies on MVK's control centre and procedures for normal and anomalous conditions, complemented by agreements with data providers, micromobility operators and utilities to ensure reliable data, connectivity and safety at the hub. (Figure 1).
Business Innovation Model	A Radar Business Model is most suitable, as MK-UC01 is a public-service multimodal hub where MVK and the Municipality coordinate infrastructure and data, while technical partners and utilities co-produce a non-priced information service used by passengers and other city actors. This fits the Radar pattern with a

focal public operator, core digital and infrastructure partners, enriching stakeholders, such as utilities and universities, and end users as customers benefiting from improved information and intermodality.

Co-Created Value in Use	The hub provides real-time multimodal information (PT, micromobility, weather, emissions), physical integration of bus, tram and micromobility, and a safe, convenient waiting area, enabling users to choose faster and lower-emission trips and improving the attractiveness of public transport.
--------------------------------	---

Table 22: MK-UC01- List of stakeholders and roles

STAKEHOLDER TYPE		IDENTIFIED STAKEHOLDER	ROLE	STATUS
Focal	Public transport agency	MVK	Provides and operates bus and tram services at the hub; manages day-to-day operation and maintenance of the hub and digital displays; coordinates with other stakeholders and ensures service continuity in normal and anomalous	 Confirmed
	Municipality	Miskolc Mayor's Office	Provides legal framework, land use and permitting, and overall governance for public space and modal hub integration into SUMP and CCC	 In Discussion
Core	Data providers / Digital systems integrator	HC Linear	Develops, integrates and operates the digital passenger information system, including data connections and screen logic	 Confirmed
	University	Budapest University of Technology and Economics (BME)	Provides expertise from previous projects (e.g. journey planning, utility models) and supports cooperation and evaluation of user needs and behaviour around the hub	 Confirmed

STAKEHOLDER TYPE	IDENTIFIED STAKEHOLDER	ROLE	STATUS
Other	Electricity company	Electricity company	Supplies and connects electricity for the digital display, lighting, and any powered hub elements (e.g. scooter charging, USB chargers)
Other	Internet provider	Internet provider	Provides stable internet connection for real-time data updates and screen operation
Other	Surveillance camera system operator	(e.g. MVK city security)	Installs and operates CCTV around the hub to mitigate vandalism and improve safety
Customer	Users	Public transport passengers, micromobility users, visitors	Use the hub to transfer between modes, consult the screen for real-time and environmental information, and select routes accordingly

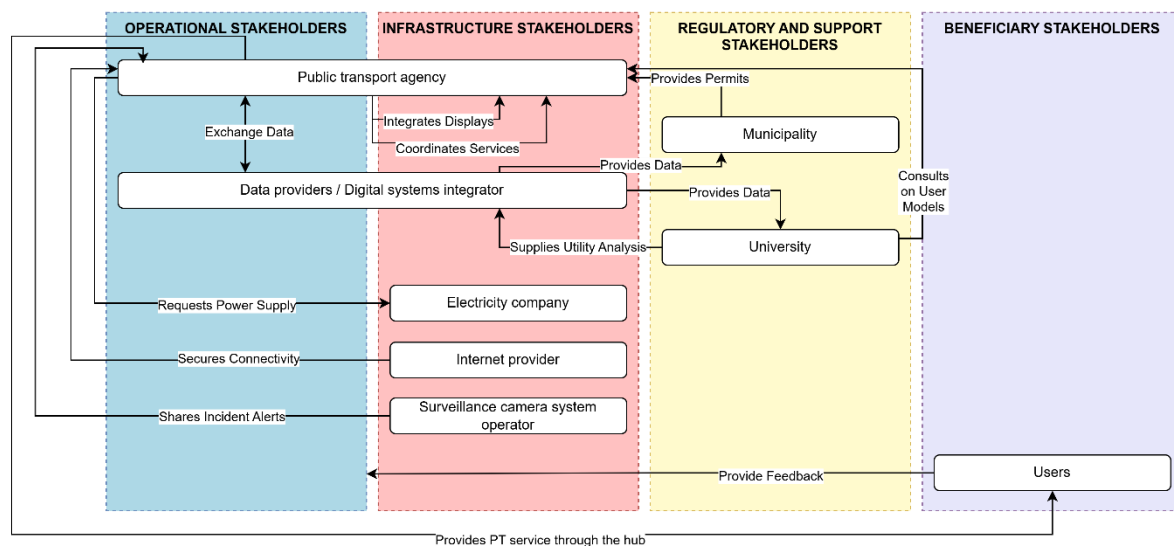


Figure 7: MK-UC01 Governance Model

Table 23: MK-UC01 - Business Model

STAKEHOLDER TYPE	COST (–) / BENEFIT (+)	CO-PRODUCTION ACTIVITY	VALUE PROPOSITION
Public transport agency	– Investment in display, share of street furniture, staff time, annual O&M including electricity, internet and repairs, participation in risk management and communication + Higher PT attractiveness and ridership, better use of infrastructure, improved passenger satisfaction and environmental image, access to operational data for optimisation	Define service concept and operational procedures; host and manage display; coordinate data flows from partners; implement backup and incident protocols	Reliable, user-friendly multimodal hub that supports MVK's mission and strengthens its role as integrated mobility provider
Municipality	– Administrative effort for permitting, coordination with utilities and police, integration into city planning + Progress toward CCC actions on integrated hubs, micromobility and traffic calming; improved public space quality and tourist accessibility	Approve location (Tapolca/Bagolyvár), manage public space rules, align hub design with wider urban and climate strategies	A visible flagship of green, multimodal mobility supporting climate-neutral city goals and local development at a key junction
Data providers / Digital systems integrator	– Development and integration effort, server and connectivity tasks, troubleshooting and maintenance + Reference implementation of integrated multimodal info solution, opportunity to reuse platform in other deployments, learning	Design and run the back-end and data interfaces; connect MobilON and other APIs; manage data analytics and content scheduling on the screen	Robust back-end enabling rich, real-time information and statistics, improving both user experience and city decision-making

STAKEHOLDER TYPE	COST (–) / BENEFIT (+)	CO-PRODUCTION ACTIVITY	VALUE PROPOSITION
	on metaInnovation “Manage & Operate Framework for mobility hubs”		
University	– Expert time for analysis, surveys and contribution to models, without direct infrastructure funding + Research data, case study for multimodal hubs, and inputs for future AI-based planning tools in Miskolc	Support design of user surveys, utility models and impact analysis; advise on integrating hub data with journey planning research	Evidence base and methodological support to continuously improve the hub and related digital services
Electricity company	– Connection costs, operational energy supply, possible upgrades; coordination on outages and backup + Stable long-term client, contribution to visible low-carbon mobility project, reputational benefits	Provide grid connection, ensure reliability and support backup power solutions for outages	Reliable power enabling continuous information provision and safe public space at the hub
Internet provider	– Connectivity costs, service level commitments and troubleshooting + Service contract revenue and demonstration of reliable connectivity for smart city applications	Ensure continuous connectivity, support redundancy for data connection failures	Stable data link that keeps real-time information and dashboards functioning for users and operators
Surveillance camera system operator	– Investment in cameras and integration; operational monitoring, data storage and maintenance + Reduced vandalism risk for hub assets, improved perception of	Deploy and operate surveillance system; share relevant alerts with MVK and municipal services	Safer hub environment supporting wider city objectives on security and walkability

STAKEHOLDER TYPE	COST (–) / BENEFIT (+)	CO-PRODUCTION ACTIVITY	VALUE PROPOSITION
	safety, richer security ecosystem		
Users	– No direct monetary cost; time and attention to consult information; potential behavioural change and adaptation to new hub + Shorter and more reliable trips, safer and more comfortable waiting environment, ability to choose lower-emission or healthier modes based on clear	Daily use of the hub; indirect feedback via behaviour surveys and MobilON ; potential participation in co-creation and communication	Accessible, integrated place to change modes and obtain real-time, comparative information on options, emissions and

3.8. Multimodal journey planner in Miskolc (MK-UC02)

3.8.1. Metadesigned Use Case

First Stage of Why – What – How Framework

Why: Challenges and Objectives

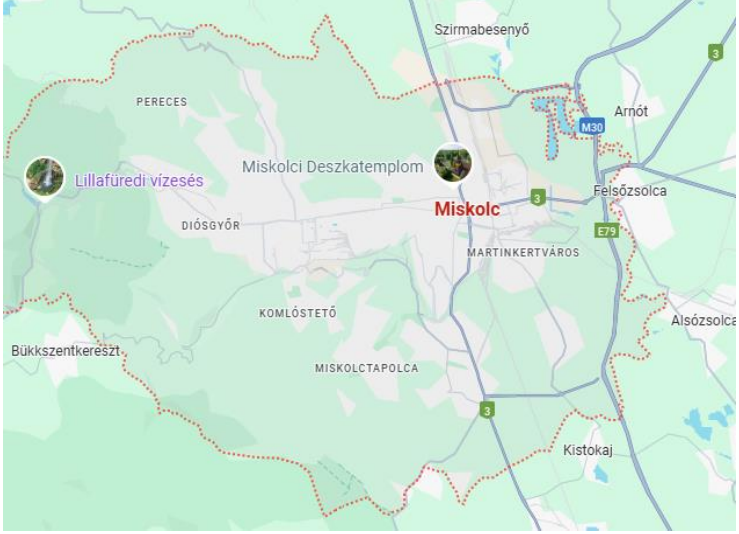
Questions	Considerations
! What specific challenges faced by the city will this Use Case address?	● One of the key challenges within Miskolc's public transport system lies in enhancing the interoperability among various transport modes (bus, tram, micromobility, and private car) and ensuring the spatial and temporal coordination of these services. However, even when all these transport modes exist, the users often struggle to plan efficient trips that can combine these modes. The currently available tools provide only basic public transport schedules and do not allow travellers to compare options across different modes or optimize routes based on

	personal priorities, such as cost, travel time, or environmental impact. This lack of integrated journey planning creates uncertainty, discourages multimodal travel, and limits the adoption of sustainable mobility options. The multimodal journey planner addresses this gap by offering a single platform, where users can plan complex trips involving multiple transport modes, including micromobility. It uses AI-based optimization algorithms to provide tailored recommendations, helping users to choose routes that fit their preferences and sustainability goals. By simplifying decision-making and improving convenience, the planner encourages a shift away from private car use toward greener transport alternatives. Planning and executing multimodal trips will encourage users to reduce emission, and the elaborated digital innovations will seamlessly integrate micromobility into the city's transport system.
Which (at least 5) objectives does the city aim to achieve through this Use Case?	● • <u>Reducing the dependence on private car usage and supporting the achievement of climate neutrality goals:</u> The objective is to encourage multimodal travel and reduce reliance on private cars during the pilot phase. The achievements will be evaluated through user surveys and trip planning data collected via the MobilON app. The results will be visible by the end of the pilot period, supporting CCC and SUMP goals for sustainable mobility. • <u>Integrating micromobility solutions with public transport modes:</u> The goal is to integrate micromobility options into the journey planner and ensure connectivity between transport modes. The success of the tool will be measured by the integration of micromobility options in the MobilON app and the number of planned multimodal trips. • <u>Improving the user experience by simplifying transfers between different journeys:</u> The objective is to provide multimodal route information via the app. The results will be measured through user feedback collected via the MobilON app and the number of multimodal routes planned during the pilot period. • <u>Expanding the multimodal functions of the journey planning application (MobilON):</u> The goal is to upgrade the MobilON app to include multimodal route planning with sustainability parameters, such as cost, emissions, and health impact. This will enable the assessment of emission reduction with multimodal trips. The objective will be measured by the number of new features and user engagement with these functionalities during the pilot period. • <u>Increasing the number of users registered for the trip planner:</u> The objective is to grow the user base of the MobilON app

	during the pilot phase. The outcomes will be measured by the number of new registrations recorded in the app analytics. The process will be encouraged by advertising the new features of the application. • <u>Increasing the number of planned trips utilizing the multimodal journey planner:</u> The goal is to increase the number of trips planned to use the multimodal journey planner compared to the baseline usage. The numbers will be measured by app analytics counting the number of multimodal route planning requests during the pilot period.
--	--

What: The Concept, Location, and Infrastructure

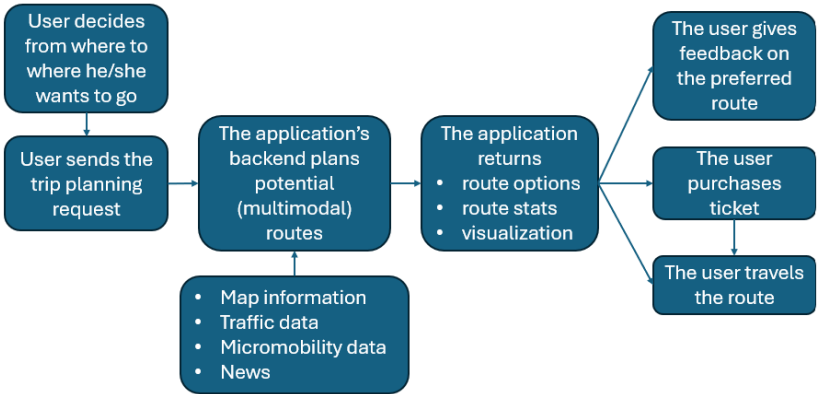
Use Case Code	● MK-UC02
Use Case Title	● Multimodal journey planner
! Use Case Concept Definition	● The planned pilot activity for digital innovation aims to enhance the journey planning system by incorporating a multimodal route planner that integrates various transport modes into the current local journey planner. This initiative responds to the growing need for sustainable and efficient transport solutions in urban environments. By allowing users to customize their travel parameters, such as the relevance of travel time, cost, CO2 emissions, and even health effects, the system empowers individuals to make informed choices that align with their personal preferences. A key innovation of this pilot is using artificial intelligence methods. These methods will optimize activity chains, enabling the system to analyze different travel combinations and deliver tailored recommendations. This means that users can receive guidance not only on the fastest or cheapest routes but also on options that have a lower environmental footprint or are more beneficial for their health. By prioritizing sustainability in travel planning, the pilot aligns with broader environmental goals and encourages a shift towards greener transport modes.
! Location (and its influence area)	● The application will be available in the administrative area of Miskolc and the operational area of MVK. Map:

	
! Which (physical and digital) infrastructure is needed?	● Miskolc is teaming up with the micromobility service provider, which company has an e-scooter service. They already have vehicles in place across the city, which enables the widespread usage of sustainable transport modes. Based on this cooperation the service provider agreed to share their service data, including the location of the stations, the capacity and the battery status of the vehicles. • Physical: servers, data connections, IT back-end system • Digital: MobilON application, Lime data
! Who will be responsible for developing and managing this new infrastructure?	● • HC Linear – application • Lime – micromobility service
! What (physical & digital) infrastructure needs to be modified	● As a digital infrastructure, an advanced route planner will be developed to plan journeys based on multiple parameters, taking into account not only travel time but also cost, health impact, and environmental aspects. We aim to utilize alternative transport modes by integrating them into the journey planner system. Through efficient cooperation with MVK the passenger information application, which is developed and operated by HC Linear, will be renewed and extended. Furthermore, BME's multimodal journey planning algorithm with awareness parameters and activity chain optimization will be also included.
! Who will be responsible for these infrastructure modifications?	● • HC Linear – the digital part for the passenger information application

	• BME – the multimodal journey planning algorithm with the extended parameters
! Which metaInnovation technology (WP2) is being tested linked to this UC?	● Harmonize: AI-models based on city data

How: Operation, Management and Stakeholder Interaction

! How the Service will function (under normal conditions - operation on a daily basis)	● The multimodal route planner operates as an extension of the existing local journey planner. It integrates public transport, micromobility, and walking routes, providing personalized travel recommendations based on user preferences such as time, cost, emissions, and health impact. In addition, the planner is capable of optimizing activity chains. The route planning algorithm uses utility calculations created by BME and provides the result of multimodal trips, showing the best possible transport mode while considering user preferences and environment friendliness. The results are visualized in the application, and feedback is collected from the users about their choices. The application will be available in the administrative area of Miskolc and the operational area of MVK. Passengers use the MobilON passenger information application, where they look for the closest transportation stops and plan routes or activity chains with different transport modes. MKV is responsible for running the buses and trams and for organizing the whole public transportation system. Lime is responsible for operating the e-scooters. HC Linear is responsible for running, maintaining, and developing the application. Software updates will be done via the application store, and for updates and status of the application, users are notified via app notifications. To access the mobile application, users need a smartphone with an internet connection. Users also need to register and specify their preferences for accurate trip planning and evaluation. The application will be integrated with the public transit feed (GTFS) and the micromobility status feed (GBFS), both of which are publicly available.
! How the User will interact (under normal conditions - operation on a daily basis)	● The user would like to travel in the city to a specific location. They use the passenger information application on their phone to plan their trip. They can set the parameters which help to define the optimal route. When the attributes are not filled, then the application uses default values.

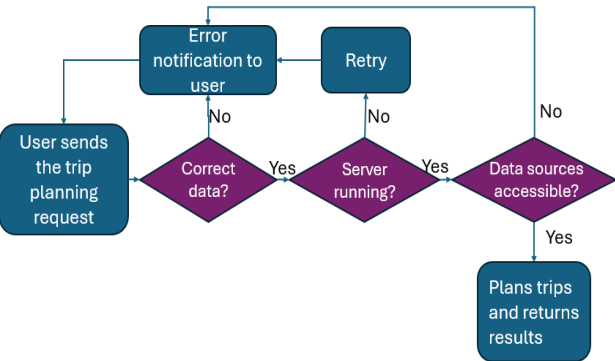
	The user selects an origin and a destination and sets personal preferences, such as travel time, cost, emissions, and health impact. This input forms the trip planning request. The request is sent to the backend route planning system, which combines public transport, micromobility, and walking options. The backend uses utility-based calculations to evaluate different multimodal routes and, if needed, to optimize activity chains. The planning relies on external data sources, including public transport schedules (GTFS), micromobility availability (GBFS), and map data. The backend returns multiple route options to the application. Each option includes indicators, such as travel time, cost, emissions, and health effects. These results are visualized in the application so that the user can easily compare alternatives. Then the user can purchase a ticket for the selected route, or if they have a pass, they can directly travel the route. Finally, the user can provide feedback about the choices that are logged by the system and can be used for further evaluation and improvements.  <pre> graph TD A[User decides from where to where he/she wants to go] --> B[User sends the trip planning request] B --> C[The application's backend plans potential multimodal routes] D["• Map information • Traffic data • Micromobility data • News"] --> C C --> E[The application returns route options, route stats, visualization] E --> F[The user gives feedback on the preferred route] E --> G[The user purchases ticket] E --> H[The user travels the route] </pre>
⚠ Please review the Prototype stakeholder map and make changes	BME: • Supports the cooperation between the stakeholders. • Focuses on extending functionalities of the journey planner. • Designs of the user surveys, utility models, and data analysis. HC Linear: • Developer and operator of the passenger information systems. • Technical supporter with various data available for journey planning. • Updates the functionalities of the journey planner. MVK: • Provides the public transport network and services.

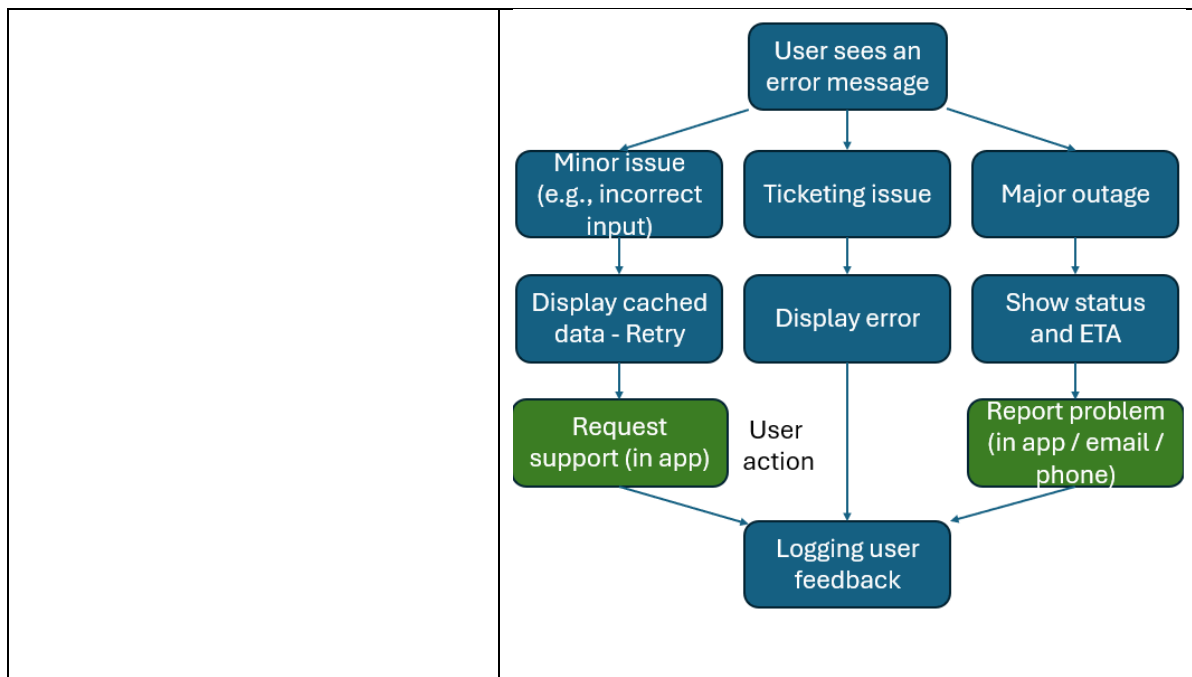
	• Support the realization of the activities and invites the citizens. • Enables the demonstration and the knowledge transfer processes. Lime: • Provides the e-scooter service in the city together with the data.
--	--

Second Stage of Why – What – How Framework

What: Foreseen Internal Risks and Mitigation Actions

Internal Risk (Technical issues, operability, service reliability):			
Scenarios	Severity	Likelihood	Mitigation action
Data connection	high	low	24/7 connection supervision and backup servers.
Server outage	high	low	24/7 connection supervision and backup servers.
Data quality	moderate	low	Identify alternative data sources.
⚠ How the Service will function (under the anomalous scenario)	● Three potential problems are considered: incorrect input to the server due to error information, connection issues to the server, and connection issues to the external data sources. When the user tries to plan a trip and the data entered is incorrect, an error message “Incorrect data” will be shown, and the user can restart entering the trip planning request data. • If the server is not accessible or not responding, the algorithms repeatedly try to reconnect to it until some timeout. While the application cannot connect to the application, “Connection lost” error message is shown, and the application works from cached data. If the server is not running, HC Linear tries to restart it or start fallback servers.		

	• If the data sources cannot be accessed by the server, it tries to reconnect internally and perform background system recovery. First, the user gets a “hourglass” display meaning that the server tries to plan the trip. If it cannot be planned due to missing data sources, eventually an error message will be displayed, e.g., “Data connection issue” and if possible cached data is also shown. • If an error message is shown to the user, the trip planning request has to be sent again.  <pre> graph TD Start([User sends the trip planning request]) --> D1{Correct data?} D1 -- No --> E1[Error notification to user] E1 --> R1[Retry] R1 --> D1 D1 -- Yes --> D2{Server running?} D2 -- No --> E2[Error notification to user] E2 --> R2[Retry] R2 --> D2 D2 -- Yes --> D3{Data sources accessible?} D3 -- No --> E3[Error notification to user] E3 --> R3[Retry] R3 --> D3 D3 -- Yes --> End([Plans trips and returns results]) </pre>
❗ How the User will interact (under the anomalous scenario)	🟢 When the user encounters an error message, their available actions depend on the type of issue. For minor issues, such as incorrect input or temporary connection problems, cached data is displayed to the user while the application attempts to resolve the issue automatically within a few seconds. If the issue is not resolved, the user can request assistance and provide feedback on the problem. In the case of a major system outage, the estimated recovery time is displayed to the user. The user can also report a new outage through the application or by contacting the developers via phone or email. All reported issues and user feedback are stored and used for the continuous improvement of the application.



What: Foreseen External and Other Risks and Mitigation Actions

External Risk (user acceptance: complex interface, trust,):			
Risk	Severity	Likelihood	Mitigation action
Citizen acceptance	moderate	low	Marketing campaign to present the benefits of the new solution.
User acceptance (dropout rate)	moderate	moderate	Reliable routing recommendations should be provided to enhance user trust and engagement.
Complaints against the service	low	low	Support and communication team should be set up to provide quick and efficient answers.
Other External Risks			
Risk	Severity	Likelihood	Mitigation action
N/A	N/A	N/A	N/A

How: Investment, Costs, and Pricing

What kind of initial investment might be anticipated?	● The proposed solution can be established using existing infrastructure in most cases. For new clients or deployments, where such infrastructure is not yet available, a dedicated server environment would be required. During the development and testing phase, HC Linear is responsible for providing temporary access to its internal server infrastructure to support setup and integration activities. This means no upfront hardware or installation costs for the client. For the live operational phase, the client is responsible for setting up and operating their own server environment that meets the defined performance and security requirements. This is considered part of operational expenditure rather than initial investment. It should be highlighted that the upfront cost is software development, which is carried out by HC Linear. No additional server extensions or hardware investments are required, as the server capacity for development and testing is fully covered by HC Linear. The personal of HC Linear of capable of carrying out the task, no further training is required. This approach ensures a scalable and secure architecture while keeping initial investment needs at a very manageable level.
What is included in this budget? (technology-based, consider running the service)	● The allocated budget is primarily dedicated to software development labor costs, covering the design, implementation, and testing phases of the application. The micromobility service provider will not receive any financial benefits, just the data is provided. However, certain system-related upgrades may also become necessary during the project lifecycle — for instance, memory allocation adjustments, server distribution optimization, or framework updates. At present, these technical requirements can be handled using our internal resources, without the need for external procurement. In some cases, temporary internal resource reallocation may be required to ensure optimal performance and continuity. This approach ensures efficient budget use, with flexibility to accommodate moderate infrastructure upgrades as the project evolves.
How was the project funded? Under which	● The project has been fully financed from the provided funds, without the need to involve any external financial sources or third-party investment.

funding schemas and co-financing?	All development, testing, and deployment activities are supported through the organization's own operational budget and resources, ensuring full flexibility and independence throughout the metaCCAZE project lifecycle. This self-funded approach also allows for greater control over priorities, timelines, and deliverables, while maintaining financial sustainability.
What is the cost per unit?	● The system has been designed to operate on existing infrastructure, ensuring both cost efficiency and sustainability. This means that no new hardware or equipment purchases are required, but the solution leverages the current fleet and the devices already installed. As long as standardized data sharing protocols are in place, the system can gather and process all necessary information to function effectively. By utilizing available assets, the project minimizes environmental impact and operational costs while maintaining full compatibility with the established ecosystem.
Do you need any human resources? If yes, what type of human resources are needed?	● The development tasks can be fully managed using our existing internal team, without the need for external recruitment or outsourcing. During the preparatory phase, the team became familiar with a new planner module, acquiring the necessary knowledge independently and within regular working hours, through internal learning and experimentation. This approach not only optimized costs but also strengthened internal competencies. The choice of this technology was driven by a commitment to sustainability, ensuring that future maintenance and expansion can also be handled effectively with internal expertise.
Please specify any additional costs not outlined above	● We have not encountered any additional or unforeseen costs during the project implementation, including the current stage of development.
Was the pricing of the proposed service defined? If yes, what is the pricing of the proposed service (for the user)	● The solution is exclusively available to public transport companies, as there are no for-profit operators in this sector within Hungary. At the same time the users can use the service free of charge. Regarding pricing, each implementation is based on individual discussions and customized agreements that take into account the specific needs, operational scope, and infrastructure of the transport provider. The software operates in compliance with GTFS and GBFS data standards, ensuring compatibility with any transport service provider capable of supplying standardized data. This flexibility

	allows for seamless integration across different mobility systems while maintaining fairness and technical neutrality.
Are there any incentives planned? If yes, would they motivate users to prefer this mobility solution more frequently? Why?	● This is a public service, designed for passengers to use for their own convenience and benefit. The promotion and communication of the application fall under the responsibility and interest of the local public transport operator, who will encourage its adoption among users. By using this digital solution, static passenger information boards can be gradually replaced, helping to reduce the ecological footprint and support environmentally sustainable communication practices. Risk consideration: during the App Store / Google Play review process, there is a potential risk that the publication might be delayed or rejected if the app contains any code segments flagged as potentially unsafe or non-compliant with platform policies. Continuous compliance review and adherence to best coding practices will help mitigate this risk.

3.8.2. Metadesigned BIGM

Table 24: MK-UC02 Summary of BIGM

SECTION	DESCRIPTION
Summary of the BIGM	The BIGM centers HC Linear as Focal Organisation, coordinating Core Partners (BME, MVK, Lime) for AI route optimization and data flows, with Municipality as Enriching Partner enabling governance. Funded via metaCCAZE with low ongoing costs using existing infra, it delivers free user access promoting sustainable trips.
Governance Model	MVK and HC Linear lead operations with BME design of algorithms; Municipality oversees permitting and alignment with SUMP/CCC goals. Decision-making via stakeholder coordination, with feedback loops from users and risks mitigated by backups/marketing. (Figure 1).
Business Innovation Model	Radar model is suggested for the Multimodal journey planner (MK-UC02) as it best captures the co-creation dynamics among multiple stakeholders providing data, development, and operations for enhanced journey planning, aligning with metaCCAZE prototype approaches in Miskolc use cases that emphasize collaborative value exchange and multi-actor roles.
Co-Created Value in Use	This BIGM facilitates co-created value through integrated AI-enhanced route planning in the MobilON app, enabling users to select multimodal trips (bus, tram, e-scooters) based on time, cost,

SECTION	DESCRIPTION
	emissions, and health impacts while optimizing city-wide sustainable mobility.

Table 25: MK-UC02- List of stakeholders and roles

	STAKEHOLDER TYPE	IDENTIFIED STAKEHOLDER	ROLE	STATUS
Focal	Technology provider	HC Linear	Developer/operator of passenger info systems; provides data for planning; updates functionalities	 Confirmed
	University	BME	Supports cooperation; extends journey planner functionalities; designs user surveys, utility models, data analysis	 Confirmed
Core	Public transport agency	MVK	Provides PT network/services; supports activities; enables demos/knowledge transfer	 Confirmed
	E-scooter provider	E-scooter provider	Provides e-scooter service and data (locations, capacity, battery)	 In Discussion
Enriching	Municipality	Miskolc Mayor's Office	Provides framework for mobility; enables data access	 In Discussion
	Users	Users	Use service for multimodal trips	 Future Engagement

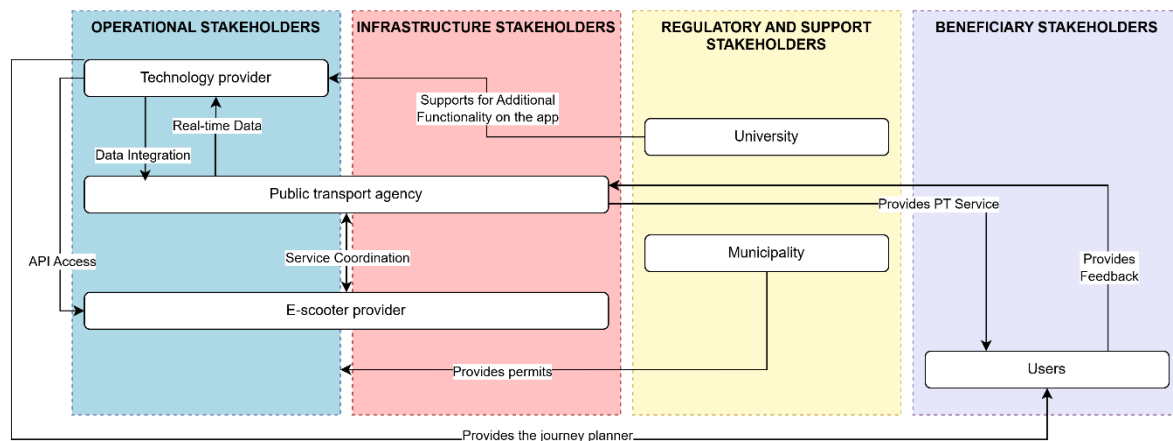


Figure 8: MK-UC02- Governance Model

Table 26: MK-UC02 - Business Model

STAKEHOLDER TYPE	COST (–) / BENEFIT (+)	CO-PRODUCTION ACTIVITY	VALUE PROPOSITION
University	– Development time, expertise + Enhanced algorithm adoption, research output	Algorithm design and utility modelling	Improved personalized, sustainable routing
Technology provider	– Software development, maintenance, server costs + Increased app usage, data insights	App integration, operation, updates	Reliable multimodal planning platform
Public transport agency	– Data sharing, promotion costs + Higher ridership, emission reductions	PT data provision, citizen invites	Optimized networks, user growth
Municipality	– Oversight, permitting + Climate goals achievement, better mobility	Regulatory support, data framework	Integrated urban transport system

STAKEHOLDER TYPE	COST (–) / BENEFIT (+)	CO-PRODUCTION ACTIVITY	VALUE PROPOSITION
E-scooter provider	– Data sharing + Visibility, usage boost	Data API provision	Expanded multimodal integration
Users	– None (free) + Efficient, eco-friendly trips	Feedback provision	Personalized, low-emission journeys

3.9. Intelligent road and smart traffic management in Poissy, Yvelines (Paris Region) (PO-UC01)

3.9.1. Metadesigned Use Case

First Stage of Why – What – How Framework

Why: Challenges and Objectives

Questions	Considerations
What specific challenges faced by the city will this Use Case address?	1. Traffic and congestion challenges There are significant challenges in the immediate vicinity of and within the mobility hubs. Despite the prior implementation of roundabouts as an accessibility and congestion mitigation measure, persistent bottlenecks indicate structural limitations in the current traffic layout and management approach. These congestion issues negatively affect travel time reliability, passenger accessibility (Pedestrian and motorized vehicles), and overall hub connectivity, during peak hours. 2. Interactions between multiple mobility services Poissy, Yvelines (Paris Region)'s rail station is a major mobility hub attracting and generating over 10 million passengers per year. The station offers connections to

	neighboring areas (14 bus lines) & Paris (2 train lines: RER A and Transilien J) and surrounding feeder hubs (e.g. Triel-sur-Seine). However: • The absence of advanced, real-time traffic and flow management limits the city's ability to dynamically monitor, predict, and manage interactions between available services, and provide evidence-based decision on the design of interoperable services both within the hub and in surrounding streets. • The mobility hub is not managed as a single system. There is limited monitoring across bus operations, traffic conditions, parking occupancy, incidents and real-time conditions, and shared mobility. Without a reliable monitoring system and an evidence-based decision process, the city and service operators cannot adjust services to real demand. As a result, the city struggles to manage the hub properly during both peak and off-peak periods. When passenger and traffic flows change, the mix of services should also change (for example, parking management, or shared-mobility supply), but decisions are often made without reliable data. This also means the hub lacks a clear way to assess which service arrangements are most reliable and efficient for passengers under different flow conditions, so improvements are difficult to justify and scale. •  A further challenge is the trip chain. These two Mobility hubs are going to be more attractive if they support a complete trip chain smoothly. Passengers cannot plan, book, then arrive, and transfer with certainty. In practice, trip chains break because main hubs (Poissy, Yvelines (Paris Region)) and feeder hubs (Triel-sur-Seine) are not well presented to passengers. Users face limited coordination between modes (Particularly between public transport, Parking services and Shared mobility). For park-and-ride users, the chain fails when parking occupancy and shared mobility service availability are not predictable. Therefore, passengers cannot rely on the whole trip chain and avoid using the hub for transfers and are less likely to shift to public transport and shared mobility, because the perceived risk (missed connections, extra time, lack of information) becomes too high.
--	---

! Which (at least 5) objectives does the city aim to achieve through this Use Case? <i>Use SMART objectives – Specific, Measurable, Achievable, Relevant, Time-Bound – giving example: increase by % the use of X in N by Y)?</i> 👁️ <i>Feel free to consider the data or evidence supports these challenges (e.g., surveys, reports, or statistics)?</i>	Objective 1 – Improve Traffic Performance through C-ITS including V2X Scientific: Design and validate a smart mobility hub management pipeline that models and analyses cooperative traffic behaviours enabled by C-ITS in a high-density multimodal environment. Technical: Deploy and integrate a sensing and communication stack combining roadside sensors, cameras, V2X (V2V, V2I, V2P), and drone-based traffic observation to enable real-time traffic supervision. Therefore, equipping road infrastructure across Poissy, Yvelines (Paris Region), and Triel-sur-Seine with sensing, V2X communication, and drone-enabled monitoring systems. Objective 2 – Demonstrate an Interoperable Intelligent Mobility Hub Architecture Scientific: Demonstrate an interoperable intelligent mobility hub management architecture that enables data fusion and decision-making across sensing, communication, and service layers. Technical: Implement an interoperability pipeline linking the sensing stack (sensors, cameras), third-party real-time data (e.g. Île-de-France Mobilités PRIM API), V2X communication assets, and end-user applications. Objective 3 – Assess the Impact of V2X on Traffic Operations Scientific: Quantify the effects of cooperative vehicle–infrastructure interactions on traffic efficiency and conflict reduction at mobility hubs. Also study transferability of smart mobility hub management concepts across multiple hubs. Technical: Enable V2X base communication between connected vehicles, infrastructure to support cooperative traffic management. User-oriented: Support city authorities in evidence-based decision-making and enhance passenger safety and service reliability through anticipatory traffic information and supervisions. Objective 4 – Implement a Phased and Scalable Deployment Strategy
--	---

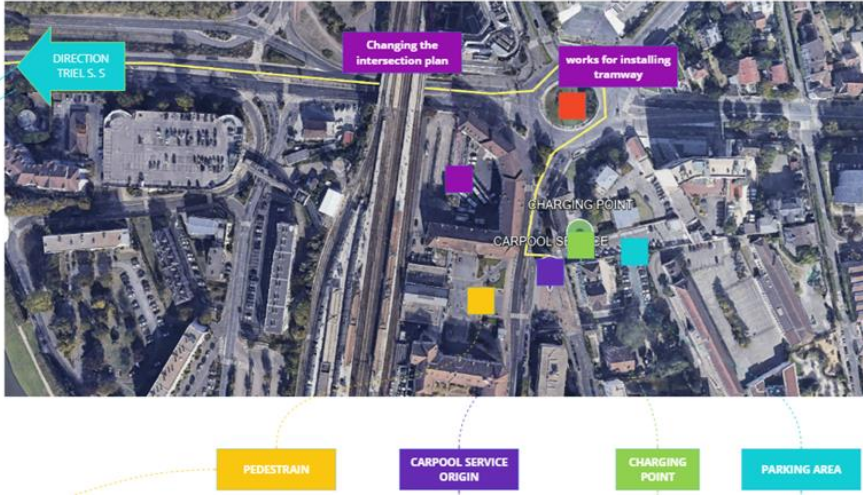
	• Technical: Execute a 4-phase deployment in terms of equipment of mobility hubs with sensing and V2X, and their connection with connected vehicles (3 conventional electric vehicles and 1 automated vehicle) for baseline vs after deployment of smart/intelligent mobility hub system management framework. • Demonstrate to local authorities the impacts of deploying the smart mobility hub management architecture by designing an architecture Interoperability pipeline between (i) sensing stack (including Sensors, Cameras) through dedicated API, (ii) third party data providers (Real time Public transport information incl Il-de-France Mobilite PRIM API) with (iii) advanced communication assets (V2X) and (iv) End User Applications (In this case Passenger Carpooling App), supported by bird-eye drone solution to collect video-based traffic data, all which enables C-ITS to function based on its objective. 5. Objective 5 – Measure Impact through Key Performance Indicators (SIEF) • Scientific: Establish evidence-based performance assessment of smart mobility hub management aligned with SIEF/KPI library identified.
--	--

What: The Concept, Location, and Infrastructure

Use Case Code	● UC01
Use Case Title	● Intelligent Road and Smart Traffic Management
! Use Case Concept Definition	● UC01 provides the technical foundation of a real-time supervision system for smart mobility hubs by integrating detection, data treatment, communication, and application enablers into a harmonised orchestration, monitoring, and decision-support framework for hub management. UC01 therefore aims to consolidate heterogeneous sensing, analytics, and connectivity components into a unified operational layer to support continuous monitoring, real-time supervision, and actionable interventions for mobility hub operations. (1) Detection (Floware, Mobilysis): UC01 deploys a multi-source sensing stack to detect, in real time: • Traffic flow, disaggregated by device types and transport modes

	• Accessibility conditions (incl. disruptions impacting access to hub) • Parking management, including parking occupancy • UC01 also leverages bird-eye drone solutions to collect video-based traffic data. Extracted trajectories and flow metrics are transformed into decision-grade supervision inputs and ingested into the smart hub management framework. (2) Data Treatment (VEDECOM, Floware): UC01 develops an enhanced local machine-learning data treatment pipeline based on Deep Reinforcement Learning, building on a Spatio-Temporal Graph Attention Network (ST-GAT) for short-term demand prediction in heterogeneous urban mobility networks. • ● Capturing spatial interdependencies across the network • Capturing temporal dynamics of demand and congestion • ● Capturing cross-modal interactions between mobility services • The pipeline also incorporates exogenous factors (e.g., weather) and disruptive events that affect accessibility and operational conditions at and around mobility hubs. (3) Communication stack (VEDECOM): UC01 leverages V2X/5G network functions (as defined in previous European work) to support distributed, configurable, and low-latency data delivery. It applies service slicing for data delivery based on IoT architectures and technologies; capturing, processing and delivering in a distributed and configurable manner the data coming from vehicles that are publishing driving dynamics and position, road environment, driver behavior and passenger services activity from sensors and devices. It includes: • Vehicle dynamics and position • ● Driver behavior indicators (where applicable and compliant) • Passenger-service activity derived from onboard/edge sensors • The V2X communication layer relies on C-V2X radio units, enhancing Telematics Control Unit (TCU) capabilities, supported by a V2X gateway module enabling edge/cloud deployments.
--	---

	● UC01 also integrates an ETSI V2X message standard into the V2X module to enable smart parking management and related hub services. (4) ● Application: The real-time supervision system supports three user groups: ● Authorities: A monitoring and decision-support to help cities assess operational needs and implement measures to improve multi-mobility hub performance (capacity, accessibility, safety, and traffic flow diagnosis). ● Operators: Real-time supervision of fleet operations using V2X-based KPIs to support service allocation at mobility hubs, and to provide real-time visibility on park-and-ride parking availability and utilization, synchronized with public transport services. ● Passengers: Situation-aware supervision to enable more efficient use of the hub (e.g., service availability, parking occupancy, and real-time accessibility conditions).
! Location (and its influence area)	● The Paris/Yvelines LL focuses on Poissy, Yvelines (Paris Region) (as Main mobility hub) and Triel-sur-Seine (as feeder mobility hub) which are a commune in the Yvelines department in the Île-de-France region in north-central France, north-west of Paris.  Area of Influence: The Living Lab forms around two mobility hubs; Poissy, Yvelines (Paris Region) (as Main mobility hub) and extends to two neighboring cities: 1. Carrières-sous-Poissy, Yvelines (Paris Region) (as corridor connection in between 2nd hub) 2. Triel-sur-Seine (as feeder mobility hub)

	Mobility Hub Details: 1. Poissy, Yvelines (Paris Region) (as Main mobility hub) - Poissy, Yvelines (Paris Region)'s rail station serves as a main local mobility hub, attracting and generating more than 10 million passengers per year Connections: includes (1) 14 bus lines to neighbouring areas and (2) Two train lines to Paris (RER A and Transilien J) (3) Main road axes: D190 and D308  2. Triel-sur-Seine (as feeder mobility hub) 
Which (physical and digital) infrastructure is needed?	A. ● Physical Infrastructure: - Connected Vehicle Fleet: (Serving as Carpooling services) - 3 conventional electric vehicles - ● 1 automated vehicle (Level of Autonomy to be defined) - Drone-Based Traffic Monitoring:

	- Bird-eye drone solutions to collect video-based traffic data - Used for trajectory-based traffic monitoring - Framework extended to: (i) improve detection and distinction between soft modes, (ii) efficiently operate in more diverse traffic environments 3. Multi Source Sensor Stack Infrastructure: - Multi-technology mobility sensors (Bluetooth, etc.) - Roadside units (RSU) for V2X communication - Computer vision capabilities 4. Road Infrastructure: - Equipment of sections of the actual road with sensing stack (Phase 1) - Equipment of sections of actual road with communication stack (Phase 2) B. Digital Infrastructure: 1. V2X Communication Systems: - ● V2V (Vehicle-to-Vehicle) protocols - V2I (Vehicle-to-Infrastructure) protocols - Telematics Control Units (TCU) on vehicles - Advanced V2X Gateway deployed on MEC (Multi-access Edge Computing) 2. C-ITS Services: - ● Cooperative Awareness - ● Decentralized Event Notification (DENM) - ● Collective Perception (CPM) - ● Traffic signal pre-emption (SREM/SSEM V2X protocols) 5. Communication Technologies: - LTE and 5G connectivity - New Radio V2X (NR-V2X) for lower latency and higher reliability
! Who will be responsible for developing and managing this new infrastructure?	● VEDECOM will be the main responsible party for: • Planning, design, deployment, and continuous management of both the physical (installation of detection and communication stack) and digital layers of the shared vehicle infrastructure (digital mobility hub)

	- Managing the mobility orchestration platform (Digital Hub) and fleet operations - Overseeing the AI-based demand prediction engine for dynamic vehicle allocation - Managing V2X integration and communication architecture between roadside units and shared vehicles (UC02) Floware will handle: - Deployment and calibration of traffic sensors - Real-time monitoring of vehicle flow - Integration with the existing IoT network - Providing real-time traffic data via sensor deployment and API Mobilysis will provide: - Aerial traffic insights via Bird-eye drone solution deployment to collect video-based traffic data. - Data calibration and analysis from aerial monitoring Local Authorities CD78 (Département des Yvelines) and Ville de Poissy, Yvelines (Paris Region) serve as: - Project sponsors - Providers of infrastructure and regulatory support - Facilitates engagement with local authorities - Facilitates engagement with local citizens (if needed)
! What (physical & digital) infrastructure needs to be modified 👁️ Consider these points while you are answering: <i>modifications needed to make infrastructure more accessible (e.g., ramps, elevators, signage)</i> <i>management and maintenance of the</i>	🟢 Mobility Hub Enhancements: - Co-design the necessary digital infrastructure for smart mobility hub management orchestration framework - EV charging stations - Dedicated carpooling service location at Poissy, Yvelines (Paris Region) hub and satellite zones (business parks, residential districts) connecting to Triel Sur Scene - Parking facilities with smart parking sensors for real-time occupancy (Probability Based) Monitoring Systems:

<i>modified infrastructure?</i> • <i>Involvement and coordination with other departments, agencies, or private entities</i>	• Drone swarm infrastructure for aerial traffic and flow monitoring • IoT-based traffic sensors on selected road segments (D190 and D308)
! Who will be responsible for these infrastructure modifications? 👁️ Please indicate the stakeholder/authority/department responsible for any infrastructure modifications.	Technical Partners: • VEDECOM: Manages the mobility orchestration platform, AI engines, and overall digital infrastructure • Floware: Responsible for sensor deployment, calibration, and ongoing monitoring • Mobilysis: Manages drone-based traffic monitoring systems Local Authority: • CD78 (Département des Yvelines) - Mobility Direction: Provides infrastructure support and coordinates with regional entities
! Which metaInnovation technology (WP2) is being tested linked to this UC? 👁️ Please consider these points while you are answering: • <i>Involvement of the responsible partner (from metaCCAZE)</i> • <i>another agent (internal) will be involved (e.g: digital twin within the Smart City department)</i>	1. Manage & Operate: Drone-based traffic data collection and analysis; 2. Connect: Development of V2I and V2V protocols (V2X). 3. Harmonize: AI-models based on city data.

How: Operation, Management and Stakeholder Interaction

! How the Service will function (under normal conditions -	🟢 The service is an Intelligent Road and Smart Traffic Management, designed to run daily within the specified operational area. Its functionality relies on the combined efforts of the three partners: Floware (Infrastructure & Data),
--	--

operation on a daily basis)

MOBILYSIS (Location/Drone Data), and VEDECOM (Service Operations & V2X/AV Systems).

Data Collection:

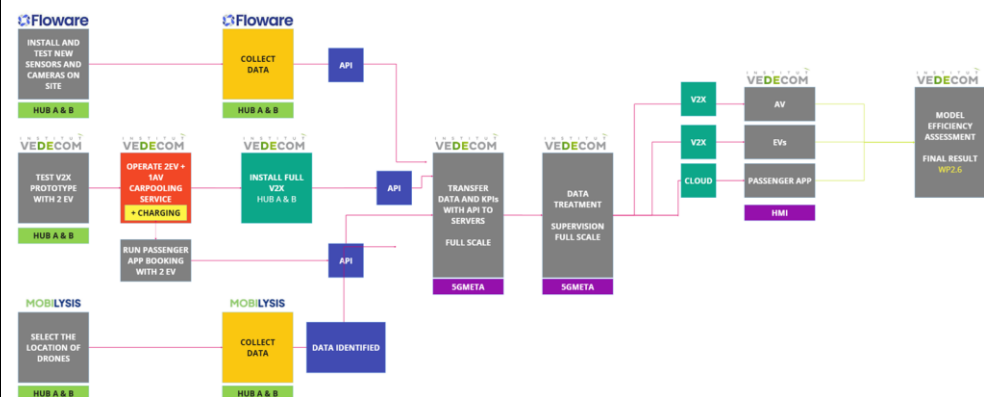
- Floware collects data from installed sensors and cameras
- Mobilysis collects data from drone
- VEDECOM operates the V2X Infrastructure for the connected services including carpooling services and park and ride services.

Data Processing:

- All collected data flows through APIs to central servers
- VEDECOM transfers data and KPIs via API to servers operating at full scale
- Data undergoes treatment and supervision processes using queuing technology

Service Delivery:

- V2X communication channels provide real-time information to the electric vehicles (EVs)
- sensors and cameras provide real-time the information to the treatment layer to process these data and supervise the service.



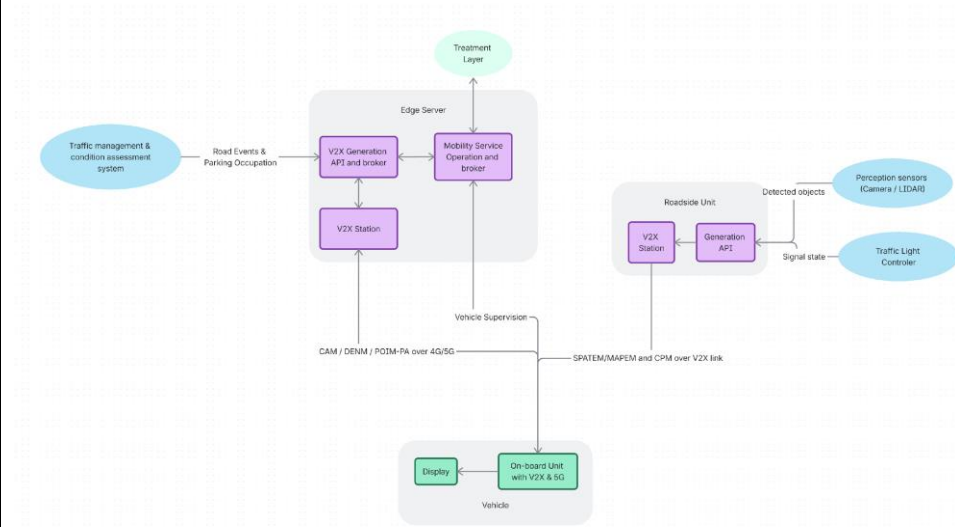
The flowchart shows the interaction between V2X (Vehicle-to-Everything) communication system with the sensor collection system and traffic light in three main layers:

Top - Edge Server: Hosts V2X message generation and mobility service brokers, plus a treatment layer for processing.

Middle - Roadside Infrastructure: V2X stations that connect to traffic management systems, perception sensors (cameras), and traffic light controllers.

Bottom - Vehicles: Equipped with on-board V2X/5G units.

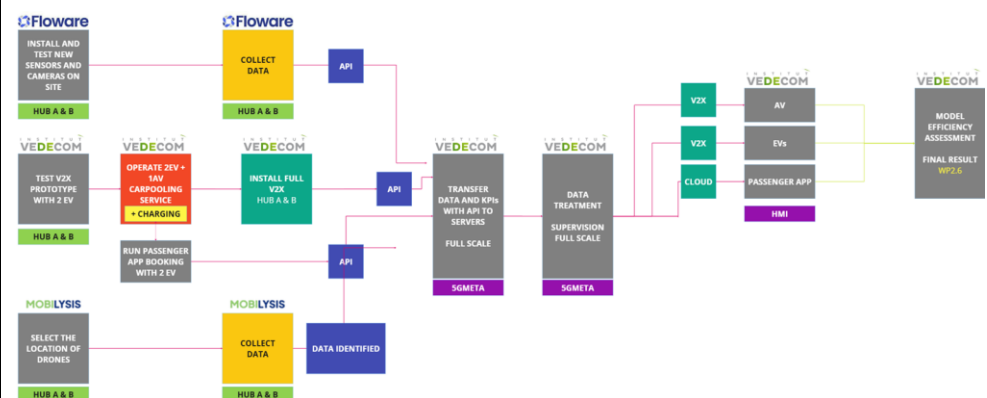
The system uses multiple protocols (CAM, DENM) over 4G/5G and V2X links to enable communication between vehicles, roadside infrastructure, and cloud services.



How the User will interact (under normal conditions - operation on a daily basis)

The users are vehicles

1. Data Collection (Trip): Sensors/cameras (Floware) and Drones (MOBILYSIS) continuously collect and identify data during the trip. Floware, MOBILYSIS, Data transfer via API to VEDECOM/Cloud systems.
2. Data Transfer & Treatment: All collected data (trip, infrastructure, V2X) is transferred via API to servers for treatment and KPI generation. Floware, MOBILYSIS, VEDECOM, Dependency on stable API connections and Server/Cloud infrastructure.
3. Supervision & Assessment, Data is supervised, and the operational model is assessed for efficiency (Final Result). VEDECOM, Feedback loop for continuous service optimization.



! List of stakeholders and their roles.	● 1. Department of Yvelines (CD78) - Lead Follower City Authority • Policy maker and regulator • Facilitator of links with territorial actors • Provider of authorizations • Co-definition of research and market needs 2. INSTITUT VEDECOM • Technology developer (V2X equipment and protocols) • Development of V2X Gateway • Extension of TCU capabilities • Development of configuration profile for RSU • Integration of new radio V2X (NR-V2X) Technical Contributions: • V2X communication systems • Connected vehicle technologies • Traffic management solutions 3. FLOWARE • Development and deployment of sensor prototypes • Integration of anonymized Bluetooth scan • Computer vision capabilities Technical Contributions: • Multi-technology mobility sensors • Traffic flow detection and analysis • Speed measurement systems 4. MOBILYSIS: Role: • Technology developer (Drone-based data collection) • Development of framework for collecting video data from traffic streams
--	---

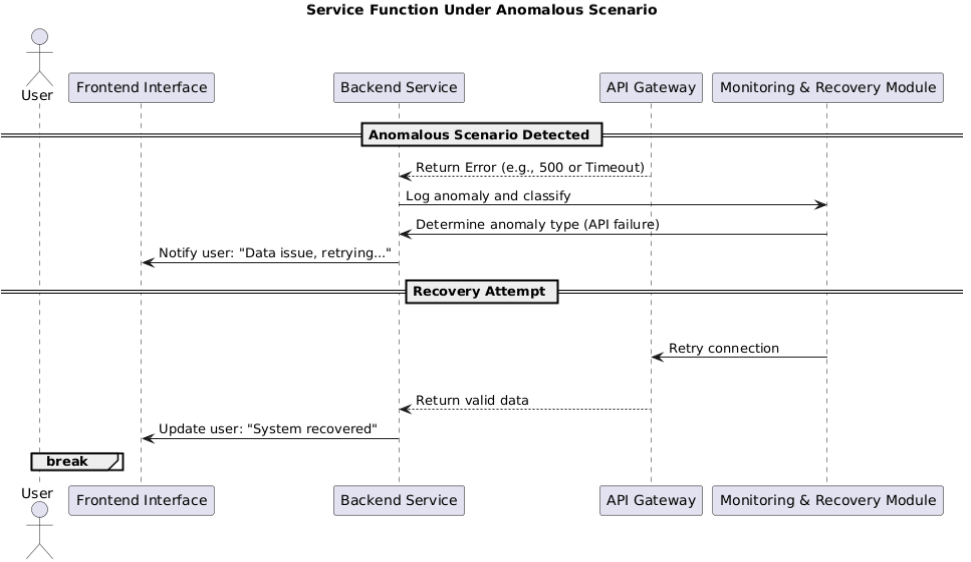
	• Processing data to detect traffic congestion • Providing evidence-based solutions Technical Contributions: • Drone swarms for traffic monitoring • Video data analysis • Congestion detection
--	---

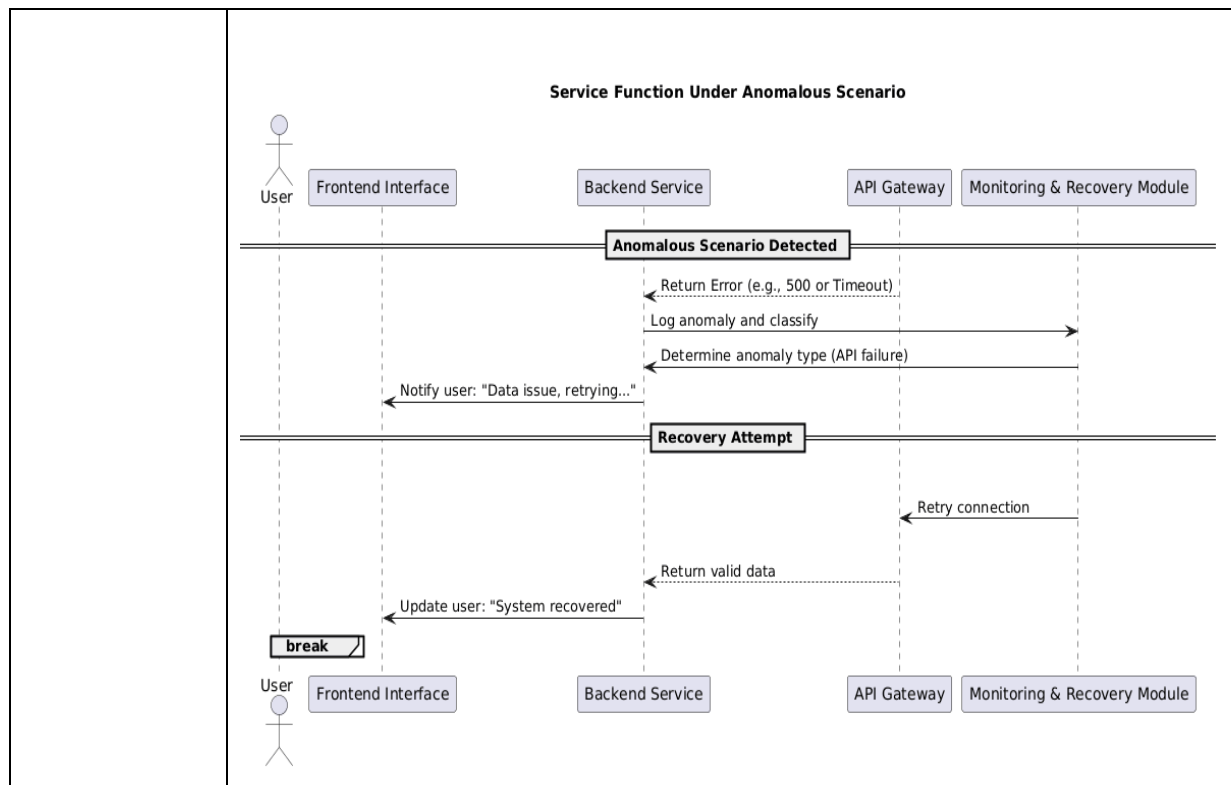
Second Stage of Why – What – How Framework

What: Foreseen Internal Risks and Mitigation Actions

Internal Risk (Technical issues, operability, service reliability):			
Scenario	Severity	Likelihood	Mitigation action
● Risk of insufficient space to install all required roadside units (RSU), sensors, and V2X equipment	High	Moderate	LL4 engagement with local authorities to co-define the implementation pathway of the plan: including installation of sensing stack, communication stack and definition of appropriate locations of devices. In worst case, consider temporary installation solutions (temporary masts - "vins temporaires") Early site surveys to identify optimal installation points Coordination with local authorities for space allocation
● Software errors or compatibility issues	Low	Low	Implement regular remote software updates and patches. Conduct comprehensive testing before deployment. Maintain version control and rollback procedures.

● Hardware failure (sensors, batteries, charging systems)	High	Low	Use reinforced protection for hardware components against power surges. Maintain spare parts and replacement devices. Include hardware monitoring in predictive maintenance schedule.
● Power supply instability / electrical network failure	Medium	Moderate	Install surge protectors and UPS systems for sensor equipment. Establish communication protocols with local power utility managers. Regular monitoring and maintenance of electrical connections
● Latency issues in V2X communications	High	Moderate	5G connectivity deployment
● Weak performance of the network (coverage gap, interference)	high	low	Multiple communication media (LTE, 5G, V2X)
● Weather conditions	Moderate (depend on the season)	Low	Test flights agreement with drivers
! How the Service will function (under the anomalous scenario) ● Defined Anomalies: the API of the V2X gateway on RSUs returns errors while connecting to it from the user side. The service will identify the anomalies and respond to it in two phases the first correspond to identification and the second is the recovery attempts that the backend will try after 2 to 10 seconds. Phase 1: Error Identification and Classification When an anomaly occurs, the system immediately captures the failure event as the API Gateway query times out without receiving a response from the backend services. The Monitoring & Recovery Module logs this error with detailed metadata including timestamp, affected endpoints, and request parameters. The logged error is then classified using predefined error patterns, in this case identified as a "Backend Timeout" based on the response characteristics and timeout duration. This classification triggers a monitoring alert that notifies system administrators while simultaneously initiating the			

	automated recovery protocol without human intervention, ensuring rapid response to minimize service disruption. PHASE 2 of Response to Anomalies: AUTO-RECOVERY The system then enters the Recovery Attempt phase, where the Monitoring & Recovery Module actively works to retry the connection with the API Gateway. Once the retry is successful and valid data is retrieved from the Backend Service, this data flows back through the API Gateway to the Frontend Interface. Finally, the user receives an update message confirming "System recovered," indicating that the anomaly has been resolved and normal service operation has been restored. The entire process is represented as a continuous loop with a break point at the end, demonstrating the system's ability to handle failures gracefully and return to stable operation without requiring manual user intervention.  <pre> sequenceDiagram actor User participant FI as Frontend Interface participant BS as Backend Service participant AG as API Gateway participant MR as Monitoring & Recovery Module Note over BS: Anomalous Scenario Detected BS-->>AG: Return Error (e.g., 500 or Timeout) BS->>MR: Log anomaly and classify BS->>MR: Determine anomaly type (API failure) MR->>FI: Notify user: "Data issue, retrying..." Note over BS: Recovery Attempt MR->>AG: Retry connection AG-->>BS: Return valid data BS->>FI: Update user: "System recovered" Note over User: break </pre>
! How the User will interact (under the anomalous scenario)	● What the User Experiences: The user initially encounters a brief service interruption but receives immediate feedback that the system is addressing the issue. Rather than being left with a dead-end error, they see a transparent "retrying" notification, The user Response to the anomalies: ERROR OCCURS in API gateway • API-Gateway query times out (no response) • Error logged and detected • Error classified as "Backend Timeout" • Monitoring alert triggered • Recovery protocol starts automatically



What: Foreseen External and Other Risks and Mitigation Actions

External Risk (user acceptance: complex interface, trust,):			
Scenarios	Severity	Likelihood	Mitigation action
Citizens may be hesitant to use new technologies (automated vehicles, connected services)	High	Moderate	User-centric design approach Clear communication about data privacy and security Training and awareness campaigns Accessibility features for diverse user groups (elderly, disabled) Demonstration of tangible benefits
Permission to use drones in public space	High	Moderate	Mobylisis investigates the regulatory pathway and uses professional drone riders to ensure adherence to regulations. Discussion with Yvelines

			Prefecture may facilitate the progress
Other external risks (Legislation, competitors (others))			
Scenarios	Severity	Likelihood	Mitigation action
Authorization for infrastructure modifications	High	Moderate	Early engagement with regulatory authorities Department of Yvelines role in facilitating authorizations Compliance with upcoming regulation for automated transport

How: Investment, Costs, and Pricing

What kind of initial investment might be anticipated?	This information was marked as confidential by the partners.
What is included in this budget? (technology-based, consider running the service)	This information was marked as confidential by the partners.
How was the project funded? Under which funding schemas and co-financing?	● Primary Funding Schema • Horizon Europe Framework Programme • Grant Agreement Number: 101139678 • Funding Programme: Horizon Europe (HORIZON-MISS-2023-CIT-01) • Call Type: Research and Innovation Actions (HORIZON-IA) • Duration: 48 months • Action Type: Budget-based mixed actual cost grant
What is the cost per unit?	-
Do you need any human resources? If yes, what type of human resources are needed? 👁️ <i>Please consider these points while you are answering:</i>	Remember: this is just an estimate and subject to change ● "Potential Hiring Cost" question, though it is "Potential" is asking for confidential and against regulations. Human resources are needed for: 1. (Developers) Designing the back end of the sensing and communication stacks

• <i>potential hiring costs</i> • <i>salaries of employees directly involved in the project</i> • <i>costs related to training or upskilling employees to meet project-specific needs</i>	2. Installation of devices at pilot sites 3. (Traffic Modellers) Scientific and <i>technical employees to design, develop and monitor</i>
Please specify any additional costs not outlined above	-
Was the pricing of the proposed service defined? If yes, what is the pricing of the proposed service (for the user)	Remember: this is just an estimate and subject to change The pricing system considered is based on the financial diagnosis model mentioned earlier.
Are there any incentives planned? If yes, would they motivate users to prefer this mobility solution more frequently? Why?	Remember: this is just an estimate and subject to change 🟡 For UC01 There is no incentive planned. For UC02 the incentive is as free carpooling services for passengers during the pilot.

3.9.2. Metadesigned BIGM

Table 27: PO-UC01 Summary of BIGM

SECTION	DESCRIPTION
Summary of the BIGM	The BIGM orchestrates a sensing–communication–application stack in which multi-source sensing from sensors, cameras, drones, and public transport APIs is fused through machine learning–based predictive models, enabling real-time, V2X-enabled supervision and C-ITS decision-making. It supports authorities, operators, and passengers with monitoring, KPIs, and predictive analytics for scalable traffic operations.
Governance Model	Department of Yvelines leads as Focal Organisation, coordinating Core Partners (VEDECOM, FLOWARE, MOBILYSIS) for tech deployment under regulatory oversight. (Figure 1).
Business Innovation Model	This radar business model is a digital orchestration framework that integrates a multi-source sensing–communication–application stack to establish a multi-stakeholder ecosystem in which public authorities, technology developers, and end-users co-create

intelligent traffic management via V2X gateways, sensors, cameras and drones, with collaborative value exchange in Paris–Yvelines.

Co-Created Value

Real-time traffic supervision, data fusion, and decision-support for smarter mobility hubs, improving efficiency, safety, and multimodal coordination via integrated sensing, V2X, and analytics.

Table 28: PO-UC01- List of stakeholders and roles

	STAKEHOLDER TYPE	IDENTIFIED STAKEHOLDER	ROLE	STATUS
Focal	Public Authority / Municipality	Department of Yvelines (CD78)	Policy maker, regulator, facilitator of links with territorial actors, provider of authorizations	 Confirmed
	V2X Technology provider	INSTITUT VEDECOM	V2X developer, gateway extension, TCU/RSU integration	 Confirmed
	Sensors Technology provider	FLOWARE	Sensor deployment, Bluetooth/computer vision integration	 Confirmed
	Drone Data Provider	MOBILYSIS	Drone-based data collection, video analysis	 Confirmed
Customer	End Users	Users	Utilize managed traffic flows	 Future Engagement

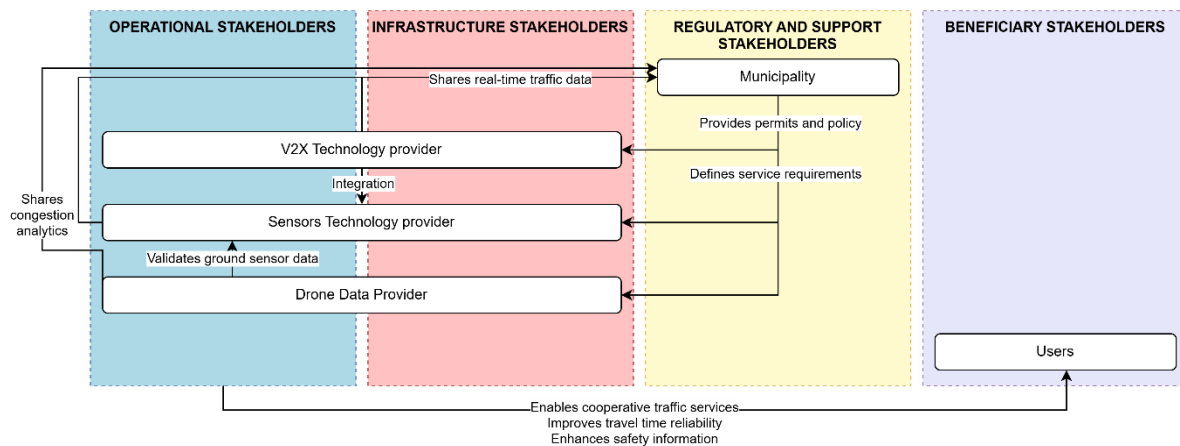


Figure 9: PO-UC01- Governance Model

Table 29: PO-UC01 - Business Model

STAKEHOLDER TYPE	COST (—) / BENEFIT (+)	CO-PRODUCTION ACTIVITY	VALUE PROPOSITION
Municipality	— Infrastructure provision, personnel + Evidence-based decisions, improved hub performance, reduce congestion and CO2 emissions	Defines needs, provides regulatory support	Enhanced traffic management, safety, multimodal integration
V2X Technology provider	— Development, deployment costs + Tech validation, market expansion, selling the communication stack	Develops V2X systems, integrates communication	Advanced C-ITS for cooperative traffic
Sensors Technology Provider	— Sensor hardware, calibration + Data revenue, tech deployment, selling the sensors	Deploys multi-source sensors for flow detection	Real-time traffic analytics
Drone Data Provider	— Drone operations, framework development + Aerial insights sales	Provides drone swarms for monitoring	Congestion detection, evidence-based solutions

STAKEHOLDER TYPE	COST (–) / BENEFIT (+)	CO-PRODUCTION ACTIVITY	VALUE PROPOSITION
End Users	– N/A + Reliable access, reduced congestion	Provide usage data via vehicles/apps	Safer, efficient hub usage

3.10. Shared vehicle services for enhanced mobility in Poissy, Yvelines (Paris Region) (PO- UC02)

3.10.1. Metadesigned Use Case

First Stage of Why – What – How Framework

Why: Challenges and Objectives

Questions	Considerations
! What specific challenges faced by the city will this Use Case address?	● Poissy, Yvelines (Paris Region)'s rail station and Triel sur Seine are local mobility hubs that attracts and generates a large number of trips offering connections to neighboring areas (> 14 bus lines) and Paris (> 2 train lines). The challenges regarding this use case are mainly about UC01 applicability. This Use Case addresses the city's operational challenge of: • Limitations cities face in deploying communication stacks capable of disseminating time-critical information such as congestion levels, incidents, dynamic routing recommendations, and parking availability to vehicles and passenger in and around mobility hubs.

! Which (at least 5) objectives does the city aim to achieve through this Use Case?	● UC02 serves as the validation layer for UC01 by demonstrating how UC01's sensing and predictive analytics can be operationalised end-to-end into an implementation-grade traffic and mobility hub management system. It will assess the interoperability of V2X technologies with connected vehicles and shared mobility services and validate the system's ability to exchange real-time decisions across multiple interaction levels: vehicle-to-vehicle, vehicle-to-infrastructure, infrastructure-to-passenger, and driver/vehicle-to-passenger. This directly supports improved hub access, coordinated multimodal operations, and more efficient use of park-and-ride and shared vehicle services. Objective 1: Operationalise UC01 supervision through connected shared-vehicle services 1.1.1. Deploy shared vehicle services (carpooling EV/AV operations) as a live validation environment for UC01, ensuring that UC01's smart real-time mobility hub supervision outputs (traffic flow, accessibility, parking occupancy, disruption signals) are converted into service-level decisions (routing, fleet allocation, and user guidance) for mobility hub operations in Poissy, Yvelines (Paris Region) (Hub A) and Triel-sur-Seine (Hub B). Objective 2: Implement V2V/V2X-enabled supervision-to-vehicle loop for cooperative driving and access management - Establish a V2V/V2X integration layer that connects UC01's monitoring and predictive analytics to connected vehicles' on-board systems (via C-V2X/TCU + V2X gateway), enabling cooperative functions such as: - Access guidance to hubs (including congestion-aware entry/exit management), - Real-time safety and operational messages (e.g. speed supervision), - Coordinated drop-off/pick-up and smart parking compliance, thereby demonstrating a closed-loop "supervision-to-vehicle" operational capability.
--	---

	Objective 3: Deliver an end-user shared mobility application for routing, booking, and supervised trip execution • Pilot a user application that provides real-time, situation-aware mobility assistance for shared vehicle services, including: ○ Routing (carpool/shared EV/AV), ○ Booking and service confirmation, ○ Real-time hub state information (accessibility, parking availability, disruption events), ○ Guidance for pickup/drop-off and park-and-ride usage, so that passengers can execute supervised and coordinated trips across the hub (Trip Chain Validation). Objective 4: Integrate shared services with park-and-ride and public transport for multimodal coordination • Enable interoperability between shared vehicle services and the park-and-ride system, synchronised with public transport services (IDFM network), to support: • Allocation of parking resources for carpool users, • Timed transfers to/from rail/bus services to shared mobility, Objective 5: Validate performance gains of communication stack (V2X) using measurable KPIs across efficiency, energy, and user experience • Assess UC02 outcomes using a KPI framework, quantifying improvements in: ○ Operational efficiency of V2X enabled system (low latency thresholds), ○ Network/hub performance (congestion impact around D190/D308, parking occupancy management), ○ Energy efficiency of EV vehicles (energy-efficient routing, eco-routing),
--	---

	○ User experience (Perceived accessibility, service clarity). As a means of verification and validation of UC01, the UC02 therefore, operationalize electric and automated vehicle services under carpooling setup. The service is run using three conventional electric vehicles and one automated vehicle and the ride is free for the passenger to incentivize shared mobility with support of advanced traffic management system
--	---

What: The Concept, Location, and Infrastructure

Use Case Code	● UC02
Use Case Title	Shared Vehicle Services for Enhanced Mobility
! Use Case Concept Definition	● The UC02 – Shared Vehicle Services for Enhanced Mobility use case operationalizes the Orchestration framework (UC01) by testing the integration of shared electric and automated vehicle services (three conventional electric vehicles and one automated vehicle) with real-time supervision, predictive analytics, and multimodal coordination. The long-term expected impact of this integration is to assess the effectiveness of sensing and V2X stack supported by advanced traffic management system. Its uniqueness lies in its holistic and data-driven approach: it bridges the gap between vehicle-centric services (EVs, AVs, and shared fleets) and infrastructure-based intelligence developed in UC01. This use case transforms traditional carpooling and on-demand services into a connected, adaptive, and energy-efficient mobility system, coordinated through a digital mobility hub.
! Location (and its influence area)	● The UC02 pilot is deployed within the Ville de Poissy, Yvelines (Paris Region) Hub A and gare of triel-sur-seine Hub B: The area of influence covers: • The Poissy, Yvelines (Paris Region) multimodal hub, connecting RER A, Transilien J, regional bus lines, and future tramway extensions (2028). • Main road axes D190 and D308, linking Poissy, Yvelines (Paris Region) with neighboring communes such as Carrières-sous-Poissy, Yvelines (Paris Region), Achères, and Saint-Germain-en-Laye. • Residential, industrial, and commercial areas generating high commuter and freight flows. Reasons for location selection:

	• High concentration of commuting flows and mobility bottlenecks, offering a realistic testing environment. • Existing public transport connectivity through IDFM networks, enabling seamless multimodal integration. 
! Which (physical and digital) infrastructure is needed?	● Required Physical and Digital Infrastructure The deployment of shared and automated vehicle services requires both physical mobility assets and digital coordination layers, integrated with PO-UC01's connected infrastructure. Physical Infrastructure • Shared EV and AV fleets: shared electric vehicles • Dedicated carpooling parking spots at both mobility hubs • EV charging points at the mobility hub • Parking infrastructure equipped with smart parking sensors for real-time occupancy. Digital Infrastructure • Mobility orchestration platform (Digital Hub): Integrates data from sensing stack, drones, connected vehicles (carpooling), and public transport systems (open source IDFM data). • AI-based demand prediction engine (VEDECOM): Anticipates trip requests and dynamically reallocates vehicles. • IoT and fleet monitoring systems: Real-time vehicle diagnostics, location tracking, and V2X efficiency analytics.
! Who will be responsible for developing and managing this new infrastructure?	● VEDECOM will be responsible for the planning, design, deployment, and continuous management of both the physical and digital layers of the shared vehicle infrastructure. This includes the integration of connected and automated vehicle technologies, smart charging systems, and the digital orchestration platform enabling real-time supervision and fleet coordination.

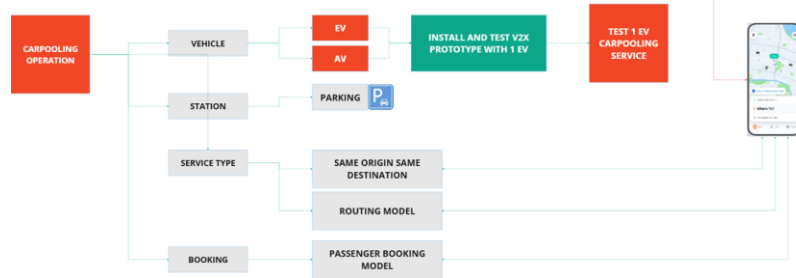
! What (physical & digital) infrastructure needs to be modified	● For the Shared Vehicle, no major modifications to existing infrastructure are required. The pilot primarily leverages the connected infrastructure and digital ecosystem already developed under UC01. The only necessary modification concerns roadside and traffic infrastructure to enable seamless interaction between shared vehicles and the existing network: Roadside and Traffic Modifications: Selected Road segments will be equipped with V2X roadside units, IoT-based traffic sensors, and adaptive signalling systems to allow real-time communication between shared vehicles and road infrastructure.
! Who will be responsible for these infrastructure modifications?	● The responsibility for the infrastructure modifications under UC02 – Shared Vehicle Services for Enhanced Mobility will be shared between Floware, VEDECOM and Mobilysis. • Floware will be responsible for the deployment and calibration of traffic sensors, ensuring accurate real-time monitoring of vehicle flow and integration with the existing IoT network. • Mobilysis will be responsible for extracting drone data and the analysis of the images collected and send them to use of the carpooling platform • VEDECOM will oversee the V2X integration, managing the communication architecture between roadside units and shared vehicles to guarantee interoperability and system reliability.
! Which metaInnovation technology (WP2) is being tested linked to this UC?	● The core WP2 technologies are the same as UC01, applied to the shared vehicle context: 1. Manage & Operate: Drone-based traffic data collection and analysis. 2. Connect: Development of V2I and V2V protocols. 3. Harmonize: AI-models based on city data.

How: Operation, Management and Stakeholder Interaction

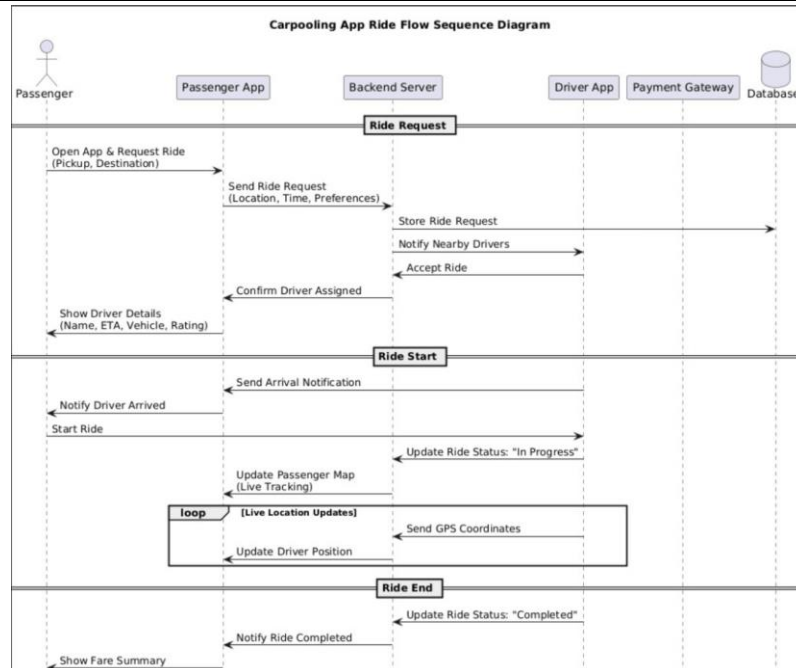
! How the Service will function (under normal conditions - operation on a daily basis)	● 1. Booking & Request, User books a ride via the Passenger App (requesting a carpool/EV/AV ride), VEDECOM, Dependency on Internet Connectivity and Passenger App availability.
---	--

2. Trip Assignment, VEDECOM's central system assigns the nearest available EV/AV based on real-time data (location, battery status, V2X data), VEDECOM, Dependency on real-time V2X data from Floware and Cloud connectivity.

3. Vehicle Operation: EV/AV operates the carpooling service, navigating the route automatically (AV) and communicating via V2X and Floware's installed sensors and V2X infrastructure for real-time traffic/safety data.



How the User will interact (under normal conditions - operation on a daily basis)



The user opens the carpooling application and enters their destination.

- The system processes the request and automatically matches the user with an available driver.
- The application displays key trip details, including the driver's estimated time of arrival (ETA), vehicle information, and the estimated travel time.

	• The user is picked up at a designated, convenient meeting point and transported to an assigned drop-off location. • The user gets the fare summary on the app
! List of stakeholders and their roles.	● VEDECOM (Institut VEDECOM) ○ Leads planning, design, deployment, and continuous management of physical and digital infrastructure for shared vehicle services ○ Manages platform, fleet, and AI-based demand prediction engine ○ Oversees V2X integration and communication architecture between roadside units and shared vehicles • Floware ○ Deploys and calibrates traffic sensors for accurate real-time monitoring of vehicle flow ○ Integrates sensors with existing IoT network ○ Provides real-time traffic data via sensor deployment • Mobilysis ○ Provides aerial traffic insights via drone deployment, calibration, and data analysis ○ Collects video data from traffic streams using swarms of drones ○ Delivers trajectory-based traffic monitoring and congestion analysis • Public Authorities: Department of Yvelines (CD78) ○ Provides regulatory framework and infrastructure support ○ Facilitates links with territorial actors ○ Assist to obtain permissions for infrastructure modifications and pilot operations

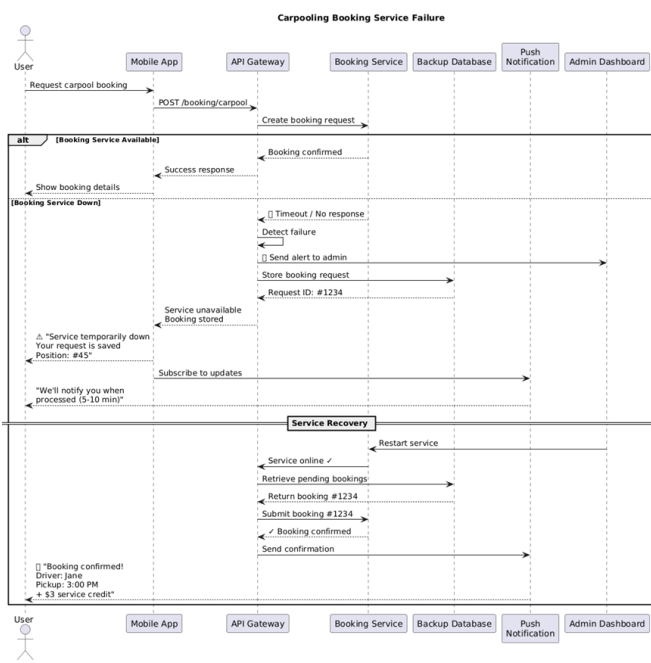
	○ Supports multimodality development and sustainable transport promotion
--	--

Second Stage of Why – What – How Framework

What: Foreseen Internal Risks and Mitigation Actions

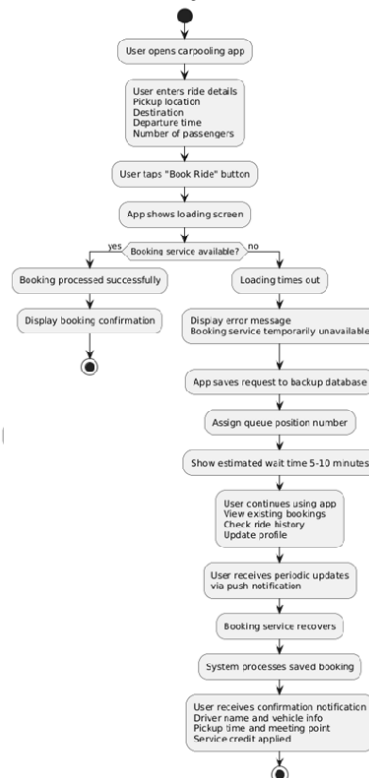
Internal Risk (Technical issues, operability, service reliability):			
Risk	Severity	Likelihood	Mitigation action
AI Demand Prediction Inaccuracy - Poor trip forecasting leading to inefficient vehicle allocation	Medium	Medium	Continuous algorithm learning from operational data
Risk of insufficient space to install all required roadside units (RSU), sensors, and V2X equipment	High	Moderate	Find compromise solutions with suboptimal installation angles if needed In worst case, consider temporary installation solutions (temporary masts - "vins temporaires") Early site surveys to identify optimal installation points Coordination with local authorities for space allocation This has been discussed during LL4 activities, and the space insufficiency is discussed and agreed upon a feasible solution and discuss in LL5.
Software errors or compatibility issues	Low	Low	Implement regular remote software updates and patches. Conduct comprehensive testing before deployment. Maintain version control and rollback procedures.

Hardware failure (sensors, batteries, charging systems)	High	Low	Use reinforced protection for hardware components against power surges. Maintain spare parts and replacement devices. Include hardware monitoring in predictive maintenance schedule.
Software errors or compatibility issues	Low	Low	Implement regular remote software updates and patches. Conduct comprehensive testing before deployment. Maintain version control and rollback procedures.
Hardware failure (sensors, batteries, charging systems)	High	Low	Use reinforced protection for hardware components against power surges. Maintain spare parts and replacement devices. Include hardware monitoring in predictive maintenance schedule.
Power supply instability / electrical network failure	Medium	Moderate	Install surge protectors and UPS systems for sensor equipment. Establish communication protocols with local power utility managers. Regular monitoring and maintenance of electrical connections
Latency issues in V2X communications	High	Moderate	5G connectivity deployment
Weak performance of the network (coverage gap, interference)	high	low	Multiple communication media (LTE, 5G, V2X)
Weather conditions	Moderate (depend on the season)	Low	Test flights agreement with drivers

! How the Service will function (under the anomalous scenario)	● The Scenario of booking service anomaly of the carpooling app: The booking service for the carpooling platform becomes completely unavailable due to technical failures such as server crashes, database connectivity issues, or software bugs. When users attempt to book a carpool ride through the mobile app, their requests fail to process, preventing them from securing seats in available vehicles. The system detects this failure through automated health checks and timeout monitoring. Upon detection, the platform immediately activates a degraded mode where booking requests are temporarily stored in a backup database for later processing. Users are notified of the service disruption and presented with alternative options including phone-based booking through a call center or the ability to join a waitlist that will automatically process their booking once the service recovers. Meanwhile, system administrators are automatically alerted and work to restore the booking service. During the outage, existing confirmed bookings remain unaffected, and drivers can continue their scheduled trips. Once the service is restored, all stored booking requests are processed in order, users receive confirmation notifications, and service credits are automatically applied to affected accounts as compensation for the inconvenience.  <pre> sequenceDiagram actor User participant MobileApp as Mobile App participant APIGateway as API Gateway participant BookingService as Booking Service participant BackupDatabase as Backup Database participant PushNotification as Push Notification participant AdminDashboard as Admin Dashboard User->>MobileApp: Request carpool booking MobileApp->>APIGateway: POST /booking/carpool APIGateway->>BookingService: Create booking request alt (Booking Service Available) BookingService-->>APIGateway: Booking confirmed APIGateway-->>MobileApp: Success response MobileApp-->>User: Show booking details else (Booking Service Down) BookingService-->>APIGateway: Timeout / No response APIGateway->>AdminDashboard: Detect failure APIGateway->>AdminDashboard: Send alert to admin APIGateway->>BackupDatabase: Store booking request BackupDatabase-->>APIGateway: Request ID: #1234 APIGateway-->>MobileApp: Service unavailable Booking stored MobileApp-->>User: "Service temporarily down Your request is saved Position: #45" MobileApp->>PushNotification: Subscribe to updates PushNotification-->>User: "We'll notify you when processed (5-10 min)" and ServiceRecovery as Service Recovery AdminDashboard->>BookingService: Restart service BookingService-->>APIGateway: Service online ✓ APIGateway->>BackupDatabase: Retrieve pending bookings BackupDatabase-->>APIGateway: Return booking #1234 APIGateway->>BookingService: Submit booking #1234 BookingService-->>APIGateway: Booking confirmed ✓ APIGateway-->>PushNotification: Send confirmation PushNotification-->>User: "Booking confirmed! Driver: Jane Pickup: 3:00 PM + \$3 service credit" end </pre>
! How the User will interact (under the anomalous scenario)	● User Interaction During Booking Service Failure: When the booking service fails, the user opens the app and attempts to book a carpool ride by entering their pickup location, destination, and time. After tapping "Book Ride," the

app displays a loading screen that times out after a few seconds. The user then sees an error message stating "Booking service temporarily unavailable" with their request automatically saved to a backup database. The app assigns them a queue position number and shows an estimated wait some time. The user receives a push notification when the service recovers and their booking is successfully processed, showing driver details, pickup time, and a compensatory service credit added to their account. Throughout this experience, the user remains informed through clear status updates and maintains access to their existing bookings and ride history.

User Interaction - Booking Service Failure Scenario



What: Foreseen External and Other Risks and Mitigation Actions

External Risk (user acceptance: complex interface, trust,):			
Risk	Severity	Likelihood	Mitigation action
Low Perceived Value - Users don't see benefits over existing options	Medium	High	Before booking show clear communication of cost/time savings Competitive pricing and incentives Free trial periods

			Segmented messaging: Provide messaging during the service to commuters such as “You saved X€” / “You saved Y minutes/” You saved Z energy or Co2”
Other External Risks			
Risk	Severity	Likelihood	Mitigation action
Competition from Existing Services - Taxis, ride-hailing competition	Low	High	Competitive pricing Superior public transport integration Environmental benefits messaging

How: Investment, Costs, and Pricing

What kind of initial investment might be anticipated?	<i>Remember: this is just an estimate and subject to change</i> ● The budget allocated to Metacaze is estimated as initial investment requirement for 2 RUSs, 1 Software licence, V2X units for 4 vehicles, Lidars and cloud storage for real time data storage and data fusion.
What is included in this budget? (technology-based, consider running the service)	● UC02 shares the overall project budget framework with UC01.
How was the project funded? Under which funding schemas and co-financing?	● UC02 shares the overall project budget framework with UC01.
What is the cost per unit?	● UC02 shares the overall project budget framework with UC01.
Do you need any human resources? If yes, what type of human resources are needed?	● UC02 shares the overall project budget framework with UC01.
Please specify any additional costs not outlined above	● UC02 shares the overall project budget framework with UC01.
Was the pricing of the proposed service defined? If yes, what is the pricing of the proposed service (for the user)	● UC02 shares the overall project budget framework with UC01.

Are there any incentives planned? If yes, would they motivate users to prefer this mobility solution more frequently? Why?	● UC02 shares the overall project budget framework with UC01.
--	---

3.10.2. Metadesigned BIGM

Table 30: PO- UC02 Summary of BIGM

SECTION	DESCRIPTION
Summary of the BIGM	This Radar BIGM operationalizes carpooling EVs/AVs with V2X supervision at hubs, validating PO-UC01 via dynamic allocation. Funded by Horizon Europe, it scales via stakeholder contributions for zero-emission replication.
Governance Model	Department of Yvelines leads as Focal Organisation, coordinating Core Partners (VEDECOM, FLOWARE, Mobilysis) for infrastructure /technology via APIs/V2X. (Figure 1).
Business Model Innovation Model	The Radar model fits PO-UC02 as it captures multi-stakeholder co-creation in shared vehicle services, emphasizing value exchange among tech providers, municipality, and users.
Co-Created Value	Shared vehicle services deliver enhanced mobility via EV/AV carpooling integrated with V2X for real-time supervision, reducing congestion and enabling multimodal trips at Poissy, Yvelines (Paris Region)/Triel Sur Scene hubs. Users gain reliable, free pilot rides and supervision on smart parking management (for Park and Ride); operators optimize fleets; authorities advance sustainable goals.

Table 31: PO-UC02- List of stakeholders and roles

	STAKEHOLDER TYPE	IDENTIFIED STAKEHOLDER	ROLE	STATUS
Focal	Regional authority	Department of Yvelines (CD78)	Policy maker, regulator, infrastructure support	 Confirmed
Core	V2X Technology provider	Institute VEDECOM	V2X integration, platform management, fleet operations, provide the app	 Confirmed
	Sensors Technology provider	FLOWARE SAS	Sensor deployment, traffic monitoring	 Confirmed

Drone Data Provider	Mobilysis SARL	Drone data collection, analysis	Confirmed 
Customer	Users	Users	Book shared vehicle-carpool via app  Future Engagement

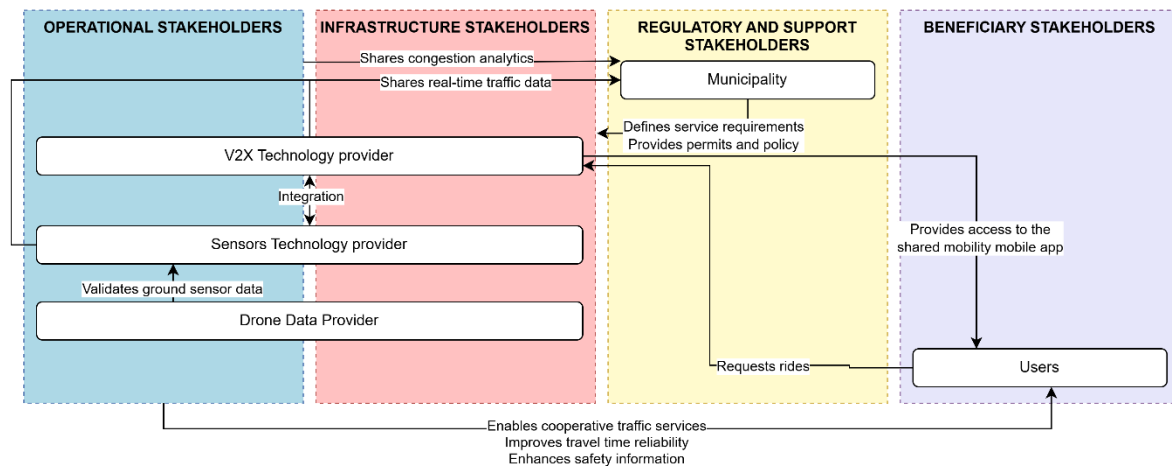


Figure 10: PO-UC02 Governance Model

Table 32: PO-UC02 - Business Model

STAKEHOLDER TYPE	COST (–) / BENEFIT (+)	CO-PRODUCTION ACTIVITY	VALUE PROPOSITION
Municipality	– Infrastructure provision, authorizations + Sustainable transport promotion, multimodality	Facilitate links with actors, permissions	Evidence-based hub management, emission reduction
V2X Technology provider	– Deployment, AI development + Tech validation, data insights	Manage orchestration platform, demand prediction, develops the mobile app	Interoperable V2X/AV ecosystem
Sensors Technology provider	– Sensor calibration, data provision + Real-time flow data	Integrate IoT, provide APIs	Accurate vehicle flow analytics
Drone Data Provider	– Aerial monitoring ops + Traffic insights	Deploy drones, analyse video	Congestion detection via trajectories

STAKEHOLDER TYPE	COST (–) / BENEFIT (+)	CO-PRODUCTION ACTIVITY	VALUE PROPOSITION
Users	– Time for booking + Convenient, free rides, and real time parking occupancy	Use app for booking/routing and Park&Ride	Reliable multimodal access

4. Conclusions and next steps

The D1.5 deliverable details the design and planning of ten transferable ZESM use cases for six follower cities: Athens, Krakow, Gozo, Milan, Miskolc, and Poissy, Yvelines (Paris Region). The central objective is to adapt the experiences and methodologies validated in Trailblazer Living Labs specifically those detailed in D1.4 to create solutions that are locally relevant and deployment ready. These use cases include e-bus fleet integration and optimization, C-ITS/V2X traffic management, and automated on-demand services. The methodology is anchored in the WHY-WHAT-HOW framework and Business Innovation and Governance Models to ensure long-term sustainability.

The following conclusions can be drawn:

1. **Importance of Co-creation Ecosystems:** Utilizing the Service-Dominant Business Model Radar (SDBMR), the project demonstrates that governance must be a multi-actor partnership. Success requires value co-production between municipal authorities, who provide infrastructure and policy alignment, and private technology providers, who manage operational data and services.
2. **Digitalization as a Driver of Intermodality:** The success of mobility hubs depends on digital orchestration, using AI-based demand prediction and real-time monitoring tools like drones and IoT sensors. These technologies, particularly V2X communication, enable cooperative vehicle-infrastructure interactions that optimize traffic flow and charging reliability in high-density areas.
3. **Effectiveness of Methodological Transfer:** The application of a structured, multidimensional framework allows follower cities to proactively mitigate barriers and align innovations with local regulatory and social contexts. By utilizing the SIEF the project ensures that lessons from the twelve Trailblazer use cases are consistently applied to monitor performance and guarantee methodological continuity.

Across these cities, **transferability and scalability** are achieved by tailoring governance and business models to reflect each follower city's specific **institutional capacity and market conditions**. This structured transfer approach ensures that mobility solutions are not only technically robust but also **contextually appropriate** for diverse urban environments.

5. Literature /References

- CIVITAS SATELLITE (2021), CIVITAS evaluation framework – Deliverable 2.3 - <https://civitas.eu/resources/civitas-evaluation-framework>
- CIVITAS MUSE (2024). CIVITAS MUSE updated Evaluation Framework - Deliverable 5.1. <https://civitas.eu/coordination/muse>
- FAME project (2024). European Common Evaluation Methodology for CCAM - D4.2: EU-CEM Handbook. https://www.connectedautomateddriving.eu/wp-content/uploads/2024/05/EU-CEM-Handbook_DRAFT_240502.pdf
- Le Mesurier project (2024). Measuring the Value of the Key Performance Indicators (KPI) of the 2ZERO Partnership - D1.1 – Methods, frameworks & baselines to assess the direct KPIs. <https://ec.europa.eu/research/participants/documents/downloadPublic?documentIds=080166e5100a13ba&appId=PPGMS>
- CEN (2019), CWA 17381:2019 – *The Description and Assessment of Good Practices for Smart City Solutions*, European Committee for Standardization, Brussels.
- SMARTER TOGETHER (2021), *Review of the CWA 17381 development – Interview Guideline*, Horizon 2020 project document. Published to support the uptake and evaluation of CWA 17381.
- metaCCAZE (2024). D1.1. Status Quo Map, Prototype ZESM Use Cases for Passengers and Freight
- metaCCAZE (2025). D1.3. Follower cities: status quo map and prototype ZESM use cases
- metaCCAZE (2024). D1.4. MetaDesigned ZESM use cases for the trailblazer LLs and the SIEF.

Annex I - SIEF KPIs final table for T-LLs and F-LLs

Impact monitoring and Evaluation: SIEF

For the F-LLs, the definition and operationalisation of the SIEF builds directly on the methodology developed for the T-LLs and described in Section 2.4 of Deliverable D1.4. The F-LLs follow the same step-by-step SIEF process, ensuring methodological consistency and comparability across LLs, while supporting the assessment of transferability across different urban contexts and allowing for context-specific adaptation.

As for the T-LLs, the selection of KPIs for each F-LL was carried out through an analysis of the local context and of the impacts expected from each Use Case. This process builds on the Status Quo Maps prepared for each city (D1.3) and on the specific characteristics of the Use Case descriptions presented in the following chapters of this deliverable. F-LLs defined their expected impacts and selected their indicators by drawing from the core set of **project-wide** and **solution-wide** KPIs already defined for the T-LLs. In parallel, additional **context-specific** indicators were identified to capture impacts that are particularly relevant to the local conditions, objectives, and constraints of the Follower cities. This process resulted in an extended SIEF KPI set comprising a total of 82 indicators, covering both T-LLs and F-LLs.

The KPI definition process was carried out in close collaboration with the Task 1.4 leaders. Initial KPI proposals were jointly developed with the cities and subsequently refined through the LL5 metadesign workshops, ensuring alignment with the SIEF logic and data availability. The outcomes of the LL5 workshops, including the final list of KPIs defined for each Use Case and their corresponding data sources, are presented in Annex 2 of this deliverable.

Analysis: Social Embracement

The definition of the Social Embracement tools is still ongoing and will be further refined in the coming months. Nevertheless, an initial alignment between the Social Embracement framework and the SIEF has already been established. As described in the methodology presented in Deliverable D1.4, the Social Embracement tools also serve as a key source of data for several KPIs included in the SIEF.

For this reason, particular attention has been paid to ensuring coherence between the selection of KPIs within the SIEF and the data collection mechanisms foreseen through the Social Embracement activities. This alignment ensures that the indicators selected for impact evaluation can be effectively monitored and measured through the planned surveys and qualitative tools, avoiding gaps between KPI definition and data availability.

T. D.* Thematic domain	
T	Transport System
Env	Environment
Ene	Energy
V	vehicle and automation
S	Social
E	Economy

H* (hierarchy)
PW: Project wide
SW: Solution wide
CS: context specific

Level:
FL: First Level
SL: Second Level

Scale:
Pilot area
Whole city



D1.5 – MetaDesigned transferable ZESM use cases for the follower LLs

H*	T. D.*	impact category	Expected impact	Level	Indicator	unit	MU-UC01	MU-UC02	TA-UC01	TA-UC02	LI-UC01	LI-UC02	LI-UC03	LI-UC04	AM-UC01	AM-UC02	AM-UC03	AM-UC04	AT-UC01	AT-UC02	GM-UC01	KR-UC01 - A-A&B	MI-UC01	MK-UC01	MK-UC02	PO-UC01	PO-UC02
PW	T	Congestion	Reducing road congestion	SL	Number of motorised vehicles on a sample of roads (Traffic counts in peak time of a sample day)	n of vehicles / h	x				x	x	x	x								x					
PW	T	Congestion	Reducing road congestion	SL	Average travel time by a vehicle (car/vessel) for a sample of OD pairs	minutes					x	x														x	x
CS	T	Congestion	Reducing road congestion	SL	Average speed on samples of roads (district/streets where the system is implemented)	km/h	x	x																			
CS	T	Congestion	Reducing road congestion	SL	Average number of veh. (traffic) stops in the zone (district/streets where the system is implemented)	stops/time unit	x																				
PW	T	Congestion	Reducing Perceived road congestion	SL	Congestion perception of residents/Local community/visitors/users	weighted average (scale from 1 to 5)	x	x			x	x	x									x	x		x		
SW	T	Congestion	Reducing motorised freight vehicles activity	SL	Number of road freight vehicles on a sample of roads	n of vehicles / h		x																			
CS	T	Congestion	Reducing motorised freight vehicles activity	SL	Amount of trucks that would replace the amount of freight carried by the vessel	n of vehicles / day									x												
CS	T	Congestion	Reduction of the time/distance searching for a parking spot (for delivery companies)	FL	Average time searching for a parking spot (for delivery vehicles)	minutes	x																				
PW	T	Perceived car dependency	Decrease perceived car dependency	SL	Share of a representative sample of inhabitants/users reporting to be fully or highly dependent on car for their daily urban mobility	%			x	x	x	x	x				x				x	x	x	x	x		
SW	T	Competitive speed	Increasing Speed of public transport (Reduction of travel times with public transport)	FL	Observed travel time of PT between sample stops in sample periods in the experiment area for each involved route	minutes			x	x	x																
SW	T	Competitive speed	Improving speed of driverless bus service compared to conventional bus service	FL	Ratio of between Travel time between sample stops in sample periods in the experiment area for each involved route of driverless bus compared to conventional bus services	Ratio			x	x											x						
SW	T	Reliability of PT	Improving reliability of public transport	SL	Share of services arriving at a sample stops more than 20% of headway delayed	%			x	x	x		x						x		x		x				



D1.5 – MetaDesigned transferable ZESM use cases for the follower LLs

H*	T. D.*	impact category	Expected impact	Level	Indicator	unit	MU-UC01	MU-UC02	TA-UC01	TA-UC02	LI-UC01	LI-UC02	LI-UC03	LI-UC04	AM-UC01	AM-UC02	AM-UC03	AM-UC04	AT-UC01	AT-UC02	GM-UC01	KR-UC01 - A-A&B	MI-UC01	MK-UC01	MK-UC02	PO-UC01	PO-UC02
SW	T	Accessibility to PT	Increasing perceived accessibility to public transport	FL	Share of users perceiving an increase in the accessibility to public transport	%			x	x	x		x						x		x		x	x			x
SW	T	Accessibility to PT	Increase number of passengers in public transport	FL	Number of bus (or mini-bus) passengers in specific stops	n of pax				x	x		x								x		x				
CS	T	Accessibility to PT	minimizing the passengers' waiting time at each pickup point.	FL	average waiting time at each pickup point	minutes			x		x								x		x		x				x
CS	T	Intermodality	minimizing the passengers' waiting time at the station (after drop-off for intermodal trips)	FL	average waiting time at the station/stop (after drop-off for intermodal trips)	minutes				x																	
CS	T	Intermodality	improve physical integration between transport modes	FL	Ratio between the number of cargobikes interchanging at multimodal hubs and population	n/share per population																x					
CS	T	Intermodality	improve physical integration between transport modes	FL	Ratio between the number of passengers interchanging at multimodal hubs and population (or number of survey respondents)	n/share per population							x									x		x			x
CS	T	Intermodality	improve physical integration between transport modes	FL	Ratio between the number of passengers interchanging at tram stop (with the automated service) and population of the experiment area	n/share per population				x																	
CS	T	Intermodality	improve physical integration between transport modes	FL	Number of sharing stations in the city that can be reached from PT stop/stations in the experiment area in a 5 min walk	n						x															
CS	T	Intermodality	Increasing the usage of multimodal trip planner	FL	Number of trips planned	n																			x		
CS	T	Intermodality	Increasing number of trip planner users	FL	Number of users registered for the trip planner	n																			x		
PW	T	Modal shift	Modal shift towards public transport for commuting trips	SL	Share of public transport on generated commuting trips in the pilot area	%			x	x	x		x					x					x	x			



D1.5 – MetaDesigned transferable ZESM use cases for the follower LLs

H*	T. D.*	impact category	Expected impact	Level	Indicator	unit	MU-UC01	MU-UC02	TA-UC01	TA-UC02	LI-UC01	LI-UC02	LI-UC03	LI-UC04	AM-UC01	AM-UC02	AM-UC03	AM-UC04	AT-UC01	AT-UC02	GM-UC01	KR-UC01 - A-A&B	MI-UC01	MK-UC01	MK-UC02	PO-UC01	PO-UC02
PW	T	Modal shift	Modal shift towards active modes for commuting trips	SL	Share of active modes on generated commuting trips in the pilot area	%						x	x					x				x		x	x		
PW	T	Modal shift	Modal shift towards lighter and electrified vehicles (cargo bikes and cargo ships) in freight (or waste collection)	FL	Modal shares on trips (delivering goods or collecting waste) done by lighter and electrified vehicles (cargo bikes and cargo ships)	%		x														x					
PW	T	Modal shift	Modal shift towards shared modes for commuting trips	FL	Share of shared vehicle usage on generated commuting trips in the pilot area	%																					
CS	T	Accessibility to city functions	Improving accessibility to city functions through bike sharing facilities	FL	Number of bike sharing stations that can be reached within 10, minutes starting from schools in the pilot area	n						x															
SW	T	Use of shared mobility	Increasing use of shared mobility	FL	Number of usages of shared vehicles (cars, bikes, scooters, ...) per (week/month/year) per inhabitant	n of pax/share per population						x	x					x				x		x	x		
CS	T	Use of Active modes	Increasing use of active modes (bikes and cargo-bikes)	SL	Number of bikes/cargo-bikes on a sample of roads (Traffic counts in peak time of a sample day)	n of vehicles / h																x					
CS	T	Efficiency	Reduction of total km driven by the On Demand mobility fleet to transport the same amount of people	FL	Vehicle-Km-Travelled (VKT) of an On-Demand-Mobility Service to transport the same amount of people	Vkm	x				x																
CS	T	Efficiency	Maximizing efficiency of waste collection	FL	Distance traveled per unit of waste collected	km/kg											x										
SW	T	Efficiency	Minimization of deadhead distances	FL	Kms run by PT with less than 15% passenger load capacity/Passengers traveling by PT by time of day	km/pax			x	x	x			x										x			
CS	T	Efficiency	Minimization of deadhead distances	FL	Total EV vehicle-kilometers run by PT with zero passenger load capacity per day	Km/vehicle													x								
CS	T	Efficiency	Maximizing efficiency of carpooling service by reducing single vehicle occupancy rate	FL	Share of single-occupancy trips using carpooling service	%																					x



D1.5 – MetaDesigned transferable ZESM use cases for the follower LLs

H*	T. D.*	impact category	Expected impact	Level	Indicator	unit	MU-UC01	MU-UC02	TA-UC01	TA-UC02	LI-UC01	LI-UC02	LI-UC03	LI-UC04	AM-UC01	AM-UC02	AM-UC03	AM-UC04	AT-UC01	AT-UC02	GM-UC01	KR-UC01 - A-A&B	MI-UC01	MK-UC01	MK-UC02	PO-UC01	PO-UC02
SW	T	Efficiency	Minimization of deadhead distances (freight)	FL	Average loading capacity (freight)	freight/km travelled		x									x										
CS	T	Efficiency	Maximizing efficiency of waste collection	FL	Amount of waste collected per unit time or amount of households served per unit time	households / hour (kg/hour)											x										
CS	T	Efficiency	Optimize charging grid increasing use during non-peak hours	FL	Time charging on peak hours over time charging on non-peak hours	minutes/ratio								x						x							
CS	T	Efficiency	Enhance data interoperability across systems	FL	Number of data sources integrated via API	n																				x	
CS	T	Efficiency	Reduce block completion failures	FL	Operational resilience of the electric-bus system during disruptions in the network or the charging grid	%													x	x							
CS	T	Efficiency	Reduced downtime and improved fleet scheduling efficiency during charging operations	FL	Charging session duration in minutes/operational time across all buses	minutes														x							
CS	T	Reducing Parking occupancy rate	% utilisation of smart parking lots	FL	% utilisation of smart parking lots	%																				x	
CS	T	User perception of Efficiency	User perception of the time needed to find a parking spot	FL	Share of users perceiving a reduction on the time needed to find a parking spot	%	x																				
CS	T	Real-time information	Improving Real-time information about disruptions	FL	Share of transport operators whose services are covered by a multimodal trips planning application considering real time disruptions	n							x														
CS	Env	Liveability of urban space	Reduce illegal double-lane parking	FL	Frequency (events/h) of double parking in selected streets in the pilot area	events/h	x																				
CS	Env	Liveability of urban space	Reduce standing time of motorized vehicles in the public space	SL	Observed standing time of vehicles at a complete stop (e.g. due to congestion or road blockages)	minutes		x																			
PW	Env	Liveability of urban space	Improving urban environmental	FL	Reported environmental liveability (perception)	Weighted average	x	x	x	x	x	x	x	x	x	x					x	x	x	x			



D1.5 – MetaDesigned transferable ZESM use cases for the follower LLs

H*	T. D.*	impact category	Expected impact	Level	Indicator	unit	MU-UC01	MU-UC02	TA-UC01	TA-UC02	LI-UC01	LI-UC02	LI-UC03	LI-UC04	AM-UC01	AM-UC02	AM-UC03	AM-UC04	AT-UC01	AT-UC02	GM-UC01	KR-UC01 - A-A&B	MI-UC01	MK-UC01	MK-UC02	PO-UC01	PO-UC02
			liveability perception of selected target groups																								
CS	Env	Liveability of urban space	Reduce noise of public transport	SL	Noise estimate of total bus fleet before and after the introduction of Evs	Decibel (dB)													x								
CS	Env	Awareness of climate impact	Increasing awareness of generated emission, and health effects	FL	Reported awareness of generated emission, and health effects by app users/survey respondents	Weighted average																			x		
PW	Env	Climate impact	Reducing Climate impact	FL	Average CO2 emission per vkm of road vehicles in the fleet	kg CO2-eq / vkm or per unit time	x	x	x	x	x	x	x	x	x			x	x	x	x	x	x	x	x	x	x
PW	Env	Pollution impact	Reducing Pollution impact	FL	Total pollutants emissions (produced by all vehicles circulating in the area) expressed in tonnes/year, for three pollutants: Particulate Matter (PM), Nitrogen Oxides (NOx), Volatile Organic Compounds (VOC).	tonnes/year	x	x	x	x	x	x	x	x					x	x			x			x	
PW	Ene	Energy demand	Reducing transport energy demand	FL	Modelled energy demand (3 separated numbers on Gasoline, Diesel, Electricity)	litres (Gasoline, Diesel) and Kwh (elect.)	x	x			x	x	x	x	x					x	x		x	x			x
PW	Ene	Energy demand	Reducing transport energy demand	FL	Energy supplied at fuelling/recharging	litres (Gasoline, Diesel) and Kwh (elect.)			x	x					x		x			x	x						
CS	Ene	Energy demand	Reducing transport energy demand	FL	Stations using inductive changing with respect to manual charging	Kwh, %, Ratio			x	x																	
SW	V	Improve technical functioning.	Reduce frequency of system failures	FL	Frequency of system failures	Count per km driven and their description			x	x					x						x		x			x	x
SW	V	Improve technical functioning.	Reduce disengagement rate	FL	disengagement rate	Count per km driven			x	x					x								x				
CS	V	Improve technical functioning	Improve system response time	FL	Average communication delay between vehicle and infrastructure.	minutes																				x	



D1.5 – MetaDesigned transferable ZESM use cases for the follower LLs

H*	T. D.*	impact category	Expected impact	Level	Indicator	unit	MU-UC01	MU-UC02	TA-UC01	TA-UC02	LI-UC01	LI-UC02	LI-UC03	LI-UC04	AM-UC01	AM-UC02	AM-UC03	AM-UC04	AT-UC01	AT-UC02	GM-UC01	KR-UC01 - A-A&B	MI-UC01	MK-UC01	MK-UC02	PO-UC01	PO-UC02
SW	V	Driving behaviour	Acceleration sum	FL	Sum of positive accelerations per 100 km, in free driving and in car following	m/s2			x	x																	
SW	V	Driving behaviour	Harsh braking events	FL	Number of ego vehicle decelerations over X m/s ² for at least Y s, per distance driven	Number/km or number/h			x	x											x						x
SW	V	Driving behaviour	Improving Speed of AV	FL	Observed travel time of AV between sample segments in sample periods in the experiment area	m/s	x																				x
CS	S	Safety	Increase transport related safety	SL	Incident rates of Automated Electric Waterborne Vessels compared to conventional vessels.	On field									x												
PW	S	Safety	Increase transport related safety	SL	Total number of traffic accidents per inhabitant in pilot/experiment area	n			x	x	x	x	x	x		x										x	
PW	S	Perceived safety	Increase perceived safety of mobility in the experiment area	SL	Reported road safety (perception)	Weighted average	x	x	x	x	x	x	x		x	x			x		x		x				
PW	S	Increasing acceptance	Increasing perception of positive impact (or benefit) on day to day life	FL	Reported perception of positive impact (or a benefit) on day to day life by selected group	Weighted average	x	x	x	x	x	x	x	x	x	x	x	x	x					x	x	x	x
PW	S	Increasing acceptance	Increasing acceptance of implemented measures	FL	Reported score of respondents considering acceptable the implemented measures	Weighted average	x	x	x	x	x	x	x		x	x		x	x	x	x	x	x	x	x	x	
SW	S	Increasing acceptance	Acceptability of being next to the automated vehicle	FL	Share of respondents that would support: Driving/Walking/Cycling next to the AV	%	x	x	x	x					x						x						
SW	S	Increasing acceptance	Acceptability to hop on an automated vehicle	FL	Share of respondents that would use an AV as passengers	%	x	x	x	x											x						
PW	S	Increasing acceptance	Increase Customer satisfaction	FL	Level of satisfaction of the respondents (residents/users/stakeholders) with the service	Weighted average			x	x	x	x	x		x	x			x		x	x	x	x	x		x
CS	S	Increasing acceptance	Increasing number of employees participating in the TMC scheme	FL	Number of employees participating in the TMC scheme over total of employees in the companies	n												x									
CS	S	Increasing awareness	Increasing awareness of service and time-schedules	FL	Share of (Students/users) that aware of service and time-schedules	%					x														x		

D1.5 – MetaDesigned transferable ZESM use cases for the follower LLs

H*	T. D.*	impact category	Expected impact	Level	Indicator	unit	MU-UC01	MU-UC02	TA-UC01	TA-UC02	LI-UC01	LI-UC02	LI-UC03	LI-UC04	AM-UC01	AM-UC02	AM-UC03	AM-UC04	AT-UC01	AT-UC02	GM-UC01	KR-UC01 - A-A&B	MI-UC01	MK-UC01	MK-UC02	PO-UC01	PO-UC02
PW	S	Propensity towards sustainable mobility behaviours	Increasing propensity to adopt sustainable mobility behaviors (change mobility patterns)	FL	Share of respondents (stakeholders/citizens/students/employees/relevant group of people) ready to adopt sustainable mobility behaviours	%			X	X	x	x	x					x				x	x	x	x		x
CS	S	Equitable access for all user	Fainess of credit allocation across different demographics within the company	FL	Share of users/stakeholders that find the credit allocation fair	%												x									
SW	S	Equitable access for all user	Increasing perceived accessibility of vulnerable groups	FL	Perceived level of accessibility by vulnerable groups	Weighted average			X	X	x	x											x				
CS	S	Improve working experience and conditions	Improve working experience and conditions for workers	FL	Perceived level of working experience and conditions for workers	Weighted average													x	x							
CS	S	Respect of speed limits	Respect of speed limits by relevant transport mode	FL	Share of bicycles/relevant transport mode exceeding speed limits	%										x											
CS	E	Economic efficiency	Reduce operational cost	FL	Average operational costs per parcel	€/parcel		x							x							x					
CS	E	Economic efficiency	Reduce operational cost	FL	Average Delivery time per parcel	minutes/parcel		x							x							x					
SW	E	Economic efficiency	Reduce operational cost	FL	Operational costs using (automated vehicles/electric mini-buses), compared to Operational costs using convensional vehicles	%			x	x	x				x					x	x			x			x
CS	E	Economic efficiency	Reduce operational cost	FL	Average total daily charging cost	Euro														x							
CS	E	Economic efficiency	Reducing planning costs	FL	Planning effort (hours/week, iterations, staff) required by the operations-planning team	%													x								
CS	E	Economic efficiency	Reducing rostering costs	FL	Rostering costs using electric buses, compared to rostering costs using conventional vehicles	%													x								
SW	E	Economic efficiency	Reduce operational cost	FL	Monetarised value of travel time	€	x		x	x	x				x								x				



D1.5 – MetaDesigned transferable ZESM use cases for the follower LLs

H*	T. D.*	impact category	Expected impact	Level	Indicator	unit	MU-UC01	MU-UC02	TA-UC01	TA-UC02	LI-UC01	LI-UC02	LI-UC03	LI-UC04	AM-UC01	AM-UC02	AM-UC03	AM-UC04	AT-UC01	AT-UC02	GM-UC01	KR-UC01 - A-A&B	MI-UC01	MK-UC01	MK-UC02	PO-UC01	PO-UC02
PW	E	Economic viability	Economic viability of the system	FL	Share of stakeholders that consider the system will be / is economically viable	%	x	x	x	x	x	x			x			x	x		x	x	x				
CS	E	Economic viability	Willingness to pay	FL	Share of users that are willing to pay for the service	%					x										x	x	x				
TOTAL of KPIs per UC							20	18	29	31	28	20	21	9	17	7	6	11	19	11	18	18	23	14	11	10	12

Annex II – KPIs details for the Followers and LL5 workshop details

KPIs details for the Followers

T. D.* Thematic domain	
T	Transport System
Env	Environment
Ene	Energy
V	vehicle and automation
S	Social
E	Economy

H* (hierarchy)
PW: Project wide
SW: Solution wide
CS: context specific

Level:
FL: First Level
SL: Second Level

Scale:
P: Pilot area
C: Whole city

AT-UC01

H*	T.D.	Expected impact	Level	Indicator	unit	Data sources		Scale		Additional information/Clarification
						Source 1	Alternative Source (if needed)	P	C	
SW	T	Improving reliability of public transport	SL	Share of services arriving at a sample stops more than 20% of headway delayed	%	OASA - Transport operator			X	

D1.5 – MetaDesigned transferable ZESM use cases for the follower LLs

SW	T	Increasing perceived accessibility to public transport	FL	Share of users perceiving an increase in the accessibility to public transport	%	OASA - Transport operator	Task 1,5 - surveys		x	
CS	T	minimizing the passengers' waiting time at each pickup point.	FL	average waiting time at each pickup point	minutes	Task 1,5 - surveys			x	
CS	T	Minimization of deadhead distances	FL	Total EV vehicle-kilometres run by PT with zero passenger load capacity per day	Km/vehicle	OASA - Transport operator			X	
CS	T	Reduce block completion failures	FL	Operational resilience of the electric-bus system during disruptions in the network or the charging grid	%	OASA - Transport operator	OSY		x	number of EB blocks that fail to complete due to insufficient battery energy
CS	Env	Reduce noise of public transport	SL	Noise estimate of total bus fleet before and after the introduction of Evs	Decibel (dB)	Technical specifications of the electric buses			X	
PW	Env	Reducing Climate impact	FL	Average CO2 emission per vkm of road vehicles in the fleet	kg CO2-eq / vkm or per unit time	OASA - Transport operator	OSY		X	
PW	Env	Reducing Pollution impact	FL	Total pollutants emissions (produced by all vehicles circulating in the area) expressed in tonnes/year, for three pollutants: Particulate Matter (PM), Nitrogen Oxides (NOx), Volatile Organic Compounds (VOC).	tonnes/year	OSY			X	Types of pollutants available to be confirmed
PW	Ene	Reducing transport energy demand	FL	Modelled energy demand (3 separated numbers on Gasoline, Diesel, Electricity)	litres (Gasoline, Diesel) and Kwh (elect.)	digital monitoring systems OASA	digital monitoring systems OSY		X	
PW	Ene	Reducing transport energy demand	FL	Energy supplied at fuelling/recharging	litres (Gasoline, Diesel) and Kwh (elect.)	OASA - Transport operator			X	
PW	S	Increase perceived safety of mobility in the experiment area	SL	Reported road safety (perception)	Weighted average	Task 1,5 - surveys			X	
PW	S	Increasing perception of positive impact (or	FL	Reported perception of positive impact (or a benefit) on day-to-day life by selected group	Weighted average	Task 1,5 - surveys			X	

D1.5 – MetaDesigned transferable ZESM use cases for the follower LLs

		benefit) on day-to-day life								
PW	S	Increasing acceptance of implemented measures	FL	Reported score of respondents considering acceptable the implemented measures	Weighted average	Task 1,5 - surveys			X	Measured for operators and drivers
PW	S	Increase Customer satisfaction	FL	Level of satisfaction of the respondents (residents/users/stakeholders) with the service	Weighted average	Task 1,5 - surveys	OASA's Marketing team		X	Level of User Satisfaction and Quality of Service with the Integration of Electric Buses into Public Transport
CS	S	Improve working experience and conditions for workers	FL	Perceived level of working experience and conditions for workers	Weighted average	Bus operator	Task 1.5 - Survey		X	This indicator will be calculated in the following forms: - drivers' experience with EBs, given the improved duties from optimized rostering - Less effort and better work experience for the station master of OASA/OSY
SW	E	Reduce operational cost	FL	Operational costs using (automated vehicles/electric mini-buses), compared to Operational costs using conventional vehicles	%	OASA	OSY		X	This type of data exist for the difference in consumption of energy (fuel vs. electricity). OASA and OSY are currently collecting data on maintenance costs of the electric buses, which will be available in the next few months.
CS	E	Reducing planning costs	FL	Planning effort (hours/week, iterations, staff) required by the operations-planning team	%	Bus operator	Task 1.5 - Survey		X	
CS	E	Reducing rostering costs	FL	Rostering costs using electric buses, compared to rostering costs using conventional vehicles	%	OSY			X	OSY can provide cost data related to bus energy/fuel (electricity for electric buses and diesel for conventional buses). Additional cost components (i.e., vehicle spare parts costs and driver rostering costs) are more difficult to access; however,

D1.5 – MetaDesigned transferable ZESM use cases for the follower LLs

									efforts will be made to collect them.
PW	E	Economic viability of the system	FL	Share of stakeholders that consider the system will be / is economically viable	%	Task 1,5 - surveys		X	Measured through targeted questions for stakeholders.

AT-UC02

H*	T.D.	Expected impact	Level	Indicator	unit	Data sources		Scale		Additional information/Clarification
						Source 1	Alternative Source (if needed)	P	C	
CS	T	Optimize charging grid increasing use during non-peak hours	FL	Time charging on peak hours over time charging on non-peak hours	minutes/ratio	OSY			x	
CS	T	Reduce block completion failures	FL	Operational resilience of the electric-bus system during disruptions in the network or the charging grid	%	OASA - Transport operator	OSY		x	Number of service interruptions due to charging
CS	T	Reduced downtime and improved fleet scheduling efficiency during charging operations	FL	Charging session duration in minutes/operational time across all buses	minutes	OASA - Transport operator	OSY		x	
PW	Env	Reducing Climate impact	FL	Average CO2 emission per vkm of road vehicles in the fleet	kg CO2-eq / vkm or per unit time	OASA - Transport operator	OSY		x	
PW	Env	Reducing Pollution impact	FL	Total pollutants emissions (produced by all vehicles circulating in the area) expressed in tonnes/year, for three pollutants: Particulate Matter (PM), Nitrogen Oxides (NOx), Volatile Organic Compounds (VOC).	tonnes/year	OSY			x	Types of pollutants available to be confirmed
PW	Ene	Reducing transport energy demand	FL	Modelled energy demand (3 separated numbers on Gasoline, Diesel, Electricity)	litres (Gasoline, Diesel) and Kwh (elect.)	digital monitoring systems OASA	digital monitoring systems OSY		x	

D1.5 – MetaDesigned transferable ZESM use cases for the follower LLs

PW	Ene	Reducing transport energy demand	FL	Energy supplied at fuelling/recharging	litres (Gasoline, Diesel) and Kwh (elect.)	OASA - Transport operator		x	
PW	S	Increasing acceptance of implemented measures	FL	Reported score of respondents considering acceptable the implemented measures	Weighted average	Task 1,5 - surveys		x	Measured for operators and drivers
CS	S	Improve working experience and conditions for workers	FL	Perceived level of working experience and conditions for workers	Weighted average	Bus operator	Task 1,5 - surveys	x	Station/depot masters/drivers' experience regarding the coordination of charging at depots
SW	E	Reduce operational cost	FL	Operational costs using (automated vehicles/electric mini-buses), compared to Operational costs using conventional vehicles	%	OASA	OSY	x	
CS	E	Reduce operational cost	FL	Average total daily charging cost	Euro	OASA - Transport operator		x	

KR-UC01 - A-A&B

H*	T.D.	Expected impact	Level	Indicator	unit	Data sources		Scale		Additional information/Clarification
						Source 1	Alternative Source (if needed)	P	C	
PW	T	Reducing road congestion	SL	Number of motorised vehicles on a sample of roads (Traffic counts in peak time of a sample day)	n of vehicles / h	MobiLysis swarm of drones		x		
PW	T	Reducing Perceived Road congestion	SL	Congestion perception of residents/Local community/visitors/users	weighted average (scale from 1 to 5)	Task 1.5 - Survey		x		
PW	T	Decrease perceived car dependency	SL	Share of a representative sample of inhabitants/users reporting to be fully or highly dependent on car for their daily urban mobility	%	Task 1.5 - Survey		x		This KPI will be measured for all multimodal hub users / city users
CS	T	improve physical integration between transport modes	FL	Ratio between the number of cargobikes interchanging at multimodal hubs and number of survey respondents)	n/share per population	Task 1.5 - Survey		x		This KPI will be measured for all multimodal hub users / city users
CS	T	improve physical integration between transport modes	FL	Ratio between the number of passengers interchanging at multimodal hubs and population (or number of survey respondents)	n/share per population	Task 1.5 - Survey		x		This KPI will be measured for all multimodal hub users / city users

D1.5 – MetaDesigned transferable ZESM use cases for the follower LLs

PW	T	Modal shift towards active modes for commuting trips	SL	Share of active modes on generated commuting trips in the pilot area	%	Task 1.5 - Survey		x	This KPI will be measured for all multimodal hub users / city users
PW	T	Modal shift towards lighter and electrified vehicles (cargo bikes and cargo ships) in freight (or waste collection)	FL	Modal shares on trips (delivering goods or collecting waste) done by lighter and electrified vehicles (cargo bikes and cargo ships)	%	Cargo bike operator	Freight companies (users)	x	Modal shares on trips (delivering goods) done by lighter vehicles (cargo bikes)
SW	T	Increasing use of shared mobility	FL	Number of usages of shared vehicles (cars, bikes, scooters, ...) per (week/month/year) per inhabitant	n of pax/share per population	E-scooter operator (if available)	Municipal sharing system	x	
CS	T	Increasing use of active modes (bikes and cargo-bikes)	SL	Number of bikes/cargo-bikes on a sample of roads (Traffic counts in peak time of a sample day)	n of vehicles / h	MobiLysis swarm of drones		x	Measured separately for bicycles and cargo bikes
PW	Env	Improving urban environmental liveability perception of selected target groups	FL	Reported environmental liveability (perception)	Weighted average	Task 1.5 - Survey	morning photos	x	Indicator supported by comparative morning photos of the First Ring Road — with and without delivery vans — taken from the same location and at the same time
PW	Env	Reducing Climate impact	FL	Average CO2 emission per vkm of road vehicles in the fleet	kg CO2-eq / vkm or per unit time	Task 1.5 - Survey	JRC (Last update 2021) - CO2 estimation by vehicle-km	x	Estimated CO ₂ emissions savings will be calculated based on the increased use of cargo bikes (instead of average vans). The indicator will be monitored through survey-based data collection (Or cargo bike usage if available by the operator)
PW	S	Increasing acceptance of implemented measures	FL	Reported score of respondents considering acceptable the implemented measures	Weighted average	Task 1.5 - Survey		x	This KPI will be measured twice. 1, targeted to users of the bicycle-rental systems 2, targeted to users of the hub
PW	S	Increase Customer satisfaction	FL	Level of satisfaction of the respondents (residents/users/stakeholders) with the service	Weighted average	Task 1.5 - Survey		x	This KPI will be measured twice. 1, targeted to users of the hub 2, targeted to companies using cargo bikes
PW	S	Increasing propensity to adopt sustainable	FL	Share of respondents (stakeholders/citizens/students/employees/relevant	%	Task 1.5 - Survey		x	Survey targeted to users of the bicycle-rental systems

D1.5 – MetaDesigned transferable ZESM use cases for the follower LLs

		mobility behaviors (change mobility patterns)		group of people) ready to adopt sustainable mobility behaviours						and future users of the hub
CS	E	Reduce operational cost	FL	Average operational costs per parcel	€/parcel	Cargo bike operator		x		Sensitive data. The possibility to collect this data is not certain. If this is not possible, we will measure this quantitatively in through the survey
CS	E	Reduce operational cost	FL	Average Delivery time per parcel	minutes/parcel	Cargo bike operator		x		Sensitive data. The possibility to collect this data is not certain. If this is not possible, we will measure this qualitatively in through the survey
CS	E	Willingness to pay	FL	Share of users that are willing to pay for the service	%	Task 1.5 - Survey		x		logistics companies and other institutional stakeholders only

GM-UC01

H*	T.D.	Expected impact	Level	Indicator	unit	Data sources		Scale		Additional information/Clarification
						Source 1	Alternative Source (if needed)	P	C	
PW	T	Reducing Perceived Road congestion	SL	Congestion perception of residents/Local community/visitors/users	weighted average (scale from 1 to 5)	Task 1.5 - Survey		x		Calculated among LOCAL COMMUNITY/VISITORS/USERS OF BUS
PW	T	Decrease perceived car dependency	SL	Share of a representative sample of inhabitants/users reporting to be fully or highly dependent on car for their daily urban mobility	%	Task 1.5 - Survey		x		
SW	T	Improving speed of driverless bus service compared to conventional bus service	FL	Ratio of between Travel time between sample stops in sample periods in the experiment area for each involved route of driverless bus compared to conventional bus services	Ratio	PT operator		x		
SW	T	Improving reliability of public transport	SL	Share of services arriving at a sample stops more than 20% of headway delayed	%	PT operator		x		Measured for fleet being tested in the LL

D1.5 – MetaDesigned transferable ZESM use cases for the follower LLs

SW	T	Increasing perceived accessibility to public transport	FL	Share of users perceiving an increase in the accessibility to public transport	%	Task 1.5 - Survey		x	Calculated among LOCAL COMMUNITY/VISITORS/USERS OF BUS
SW	T	Increase number of passengers in public transport	FL	Number of bus (or mini-bus) passengers in specific stops	n of pax	PT operator		x	
CS	T	minimizing the passengers' waiting time at each pickup point.	FL	average waiting time at each pickup point	minutes	Task 1.5 - Survey		x	
PW	Env	Improving urban environmental liveability perception of selected target groups	FL	Reported environmental liveability (perception)	Weighted average	Task 1.5 - Survey		x	Calculated among LOCAL COMMUNITY/VISITORS/USERS OF BUS
PW	Env	Reducing Climate impact	FL	Average CO2 emission per vkm of road vehicles in the fleet	kg CO2-eq / vkm or per unit time	PT operator		x	Measured for fleet being tested in the LL
SW	V	Reduce frequency of system failures	FL	Frequency of system failures	Count per km driven and their description	PT operator		x	Measured for fleet being tested in the LL. System Failure will be considered when the vehicle had to be switched to manual mode during the planned automated route
SW	V	Harsh braking events	FL	Number of ego vehicle decelerations over X m/s ² for at least Y s, per distance driven	Number/km or number/h	PT operator (TBC in case the vehicle software is able to record these on its own)		x	Number of deceleration events exceeding a defined threshold (X m/s ² sustained for at least Y seconds), per km or per hour. Metric: Number/km or number/h
PW	S	Increase perceived safety of mobility in the experiment area	SL	Reported road safety (perception)	Weighted average	Task 1.5 - Survey		x	Calculated among LOCAL COMMUNITY/VISITORS/USERS OF BUS
PW	S	Increasing acceptance of implemented measures	FL	Reported score of respondents considering acceptable the implemented measures	Weighted average	Task 1.5 - Survey		x	Calculated among LOCAL COMMUNITY/VISITORS/USERS OF BUS

D1.5 – MetaDesigned transferable ZESM use cases for the follower LLs

SW	S	Acceptability of being next to the automated vehicle	FL	Share of respondents that would support: Driving/Walking/Cycling next to the AV	%	Task 1.5 - Survey		x	Calculated among LOCAL COMMUNITY/VISITORS/USERS OF BUS
SW	S	Acceptability to hop on an automated vehicle	FL	Share of respondents that would use an AV as passengers	%	Task 1.5 - Survey		x	Calculated among LOCAL COMMUNITY/VISITORS/USERS OF BUS
PW	S	Increase Customer satisfaction	FL	Level of satisfaction of the respondents (residents/users/stakeholders) with the service	Weighted average	Task 1.5 - Survey		x	Calculated among LOCAL COMMUNITY/VISITORS/USERS OF BUS
PW	E	Economic viability of the system	FL	Share of stakeholders that consider the system will be / is economically viable	%	Task 1.5 - Interviews		x	Calculated among STAKEHOLDERS
CS	E	Willingness to pay	FL	Share of users that are willing to pay for the service	%	Task 1.5 - Survey		x	Calculated among LOCAL COMMUNITY/VISITORS/USERS OF BUS

MI-UC01

H*	T.D.	Expected impact	Level	Indicator	unit	Data sources		Scale		Additional information/Clarification
						Source 1	Alternative Source (if needed)	P	C	
PW	T	Decrease perceived car dependency	SL	Share of a representative sample of inhabitants/users reporting to be fully or highly dependent on car for their daily urban mobility	%	Task 1.5 - Survey		x		Calculated among FRIMBO users
SW	T	Improving reliability of public transport	SL	Share of services arriving at a sample stops more than 20% of headway delayed	%	Service platform		x		Will be calculated for delays of more than 5 minutes. Thus, "Share of services arriving at sampled stops with a delay of more than 5 minutes"
SW	T	Increasing perceived accessibility to public transport	FL	Share of users perceiving an increase in the accessibility to public transport	%	Task 1.5 - Survey		x		Calculated among FRIMBO users
SW	T	Increase number of passengers in public transport	FL	Number of bus (or mini-bus) passengers in specific stops	n of pax	Service platform		x		Calculated among FRIMBO users

D1.5 – MetaDesigned transferable ZESM use cases for the follower LLs

CS	T	minimizing the passengers' waiting time at each pickup point.	FL	average waiting time at each pickup point	minutes	Service platform		x	Calculated among FRIMBO users
PW	T	Modal shift towards public transport for commuting trips	SL	Share of public transport on generated commuting trips in the pilot area	%	Service platform	Task 1.5 - Survey	x	Calculated among FRIMBO users. The survey includes a question on the original transport mode, identifying users shifting from private car, bicycle, or traditional public transport.
SW	T	Minimization of deadhead distances	FL	Kms run by PT with less than 15% passenger load capacity/Passengers traveling by PT by time of day	km/pax	Service platform		x	Calculated on FRIMBO vehicles
PW	Env	Improving urban environmental liveability perception of selected target groups	FL	Reported environmental liveability (perception)	Weighted average	Task 1.5 - Survey		x	Calculated among FRIMBO users
PW	Env	Reducing Climate impact	FL	Average CO2 emission per vkm of road vehicles in the fleet	kg CO2-eq / vkm or per unit time	Service platform	Task 1.5 - Survey	x	Will estimate the reduction of CO2 emissions among FRIMBO users
PW	Env	Reducing Pollution impact	FL	Total pollutants emissions (produced by all vehicles circulating in the area) expressed in tonnes/year, for three pollutants: Particulate Matter (PM), Nitrogen Oxides (NOx), Volatile Organic Compounds (VOC).	tonnes/year	Service platform	Task 1.5 - Survey	x	Will estimate the reduction of pollution expressed in tonnes/year, for three pollutants: Particulate Matter (PM), Nitrogen Oxides (NOx), Volatile Organic Compounds (VOC) emissions among FRIMBO users
PW	Ene	Reducing transport energy demand	FL	Modelled energy demand (3 separated numbers on Gasoline, Diesel, Electricity)	litres (Gasoline, Diesel) and Kwh (elect.)	Service platform	Task 1.5 - Survey	x	Will estimate the reduction of Gasoline, Diesel, Electricity consumption among FRIMBO users
SW	V	Reduce frequency of system failures	FL	Frequency of system failures	Count per km driven and their description	Automated e-pod operator	Service platform	x	Calculated for the docking system

D1.5 – MetaDesigned transferable ZESM use cases for the follower LLs

SW	V	Reduce disengagement rate	FL	disengagement rate	Count per km driven	Service platform		x		
PW	S	Increase perceived safety of mobility in the experiment area	SL	Reported road safety (perception)	Weighted average	Task 1.5 - Survey		x		
PW	S	Increasing perception of positive impact (or benefit) on day-to-day life	FL	Reported perception of positive impact (or a benefit) on day-to-day life by selected group	Weighted average	Task 1.5 - Survey		x		Calculated among FRIMBO users
PW	S	Increasing acceptance of implemented measures	FL	Reported score of respondents considering acceptable the implemented measures	Weighted average	Task 1.5 - Survey		x		Calculated for the docking system. Measures the acceptability of the hypothetical case of an interchange carried out in motion.
PW	S	Increase Customer satisfaction	FL	Level of satisfaction of the respondents (residents/users/stakeholders) with the service	Weighted average	Task 1.5 - Survey		x		Calculated among FRIMBO users
PW	S	Increasing propensity to adopt sustainable mobility behaviours (change mobility patterns)	FL	Share of respondents (stakeholders/citizens/students/employees/relevant group of people) ready to adopt sustainable mobility behaviours	%	Task 1.5 - Survey		x		Sample of respondents TBD.
SW	S	Increasing perceived accessibility of vulnerable groups	FL	Perceived level of accessibility by vulnerable groups	Weighted average	Task 1.5 - Survey		x		Calculated among FRIMBO users
SW	E	Reduce operational cost	FL	Operational costs using (automated vehicles/electric minibuses), compared to Operational costs using conventional vehicles	%	Operator		x		
SW	E	Reduce operational cost	FL	Monetarised value of travel time	€	Scientific Literature	Automated e-pod operator/Platform	x		The monetised value of travel time savings generated by FRIMBO is calculated by

D1.5 – MetaDesigned transferable ZESM use cases for the follower LLs

										comparing users travel times before and after using the service. The total monthly time saved is estimated for the total number of users. This value is then converted into monetary terms using a literature-based value of time: MVTT (€/month) = Total time saved (h) × Value of time (€/h)
PW	E	Economic viability of the system	FL	Share of stakeholders that consider the system will be / is economically viable	%	Task 1.5 - Survey	workshops with operators and stakeholders	x		
CS	E	Willingness to pay	FL	Share of users that are willing to pay for the service	%	Task 1.5 - Survey		x		Calculated among FRIMBO users - Share of users that are willing to pay for the service in relation to the fare system

MK-UC01

H*	T.D.	Expected impact	Level	Indicator	unit	Data sources		Scale		Additional information/Clarification
						Source 1	Alternative Source (if needed)	P	C	
PW	T	Reducing Perceived Road congestion	SL	Congestion perception of residents/Local community/visitors/users	weighted average (scale from 1 to 5)	Task 1.5 - Survey		x		
PW	T	Decrease perceived car dependency	SL	Share of a representative sample of inhabitants/users reporting to be fully or highly dependent on car for their daily urban mobility	%	Task 1.5 - Survey		x		
SW	T	Increasing perceived accessibility to public transport	FL	Share of users perceiving an increase in the accessibility to public transport	%	Task 1.5 - Survey		x		
CS	T	improve physical integration between transport modes	FL	Ratio between the number of passengers interchanging at multimodal hubs and population (or number of survey respondents)	n/share per population	Task 1.5 - Survey		x		

D1.5 – MetaDesigned transferable ZESM use cases for the follower LLs

PW	T	Modal shift towards public transport for commuting trips	SL	Share of public transport on generated commuting trips in the pilot area	%	Task 1.5 - Survey		x		
PW	T	Modal shift towards active modes for commuting trips	SL	Share of active modes on generated commuting trips in the pilot area	%	Task 1.5 - Survey		x		
SW	T	Increasing use of shared mobility	FL	Number of usages of shared vehicles (cars, bikes, scooters, ...) per (week/month/year) per inhabitant	n of pax/share per population	sharing operator	Alternative source: Task 1.5 - Survey	x		Mitigation action in case the operator is unwilling to provide data: The indicator will be monitored through survey-based data collection, assessing changes in shared vehicle usage as self-reported by respondents.
PW	Env	Improving urban environmental liveability perception of selected target groups	FL	Reported environmental liveability (perception)	Weighted average	Task 1.5 - Survey		x		Focused on the quality of urban space
PW	Env	Reducing Climate impact	FL	Average CO2 emission per vkm of road vehicles in the fleet	kg CO2-eq / vkm or per unit time	Task 1.5 - Survey	EEA / Eurostat Pocketbook	x		Estimated CO ₂ emissions savings will be calculated based on the increased use of more sustainable transport modes (active mobility and public transport). The indicator will be monitored through survey-based data collection, estimating CO ₂ emission reductions based on self-reported changes in modal shift by respondents.
PW	S	Increasing perception of positive impact (or benefit) on day-to-day life	FL	Reported perception of positive impact (or a benefit) on day-to-day life by selected group	Weighted average	Task 1.5 - Survey		x		
PW	S	Increasing acceptance of implemented measures	FL	Reported score of respondents considering acceptable the implemented measures	Weighted average	Task 1.5 - Survey		x		
PW	S	Increase Customer satisfaction	FL	Level of satisfaction of the respondents (residents/users/stakeholders) with the service	Weighted average	Task 1.5 - Survey		x		
CS	S	Increasing awareness of service and time-schedules	FL	Share of (Students/users) that aware of service and time-schedules	%	Task 1.5 - Survey		x		

D1.5 – MetaDesigned transferable ZESM use cases for the follower LLs

PW	S	Increasing propensity to adopt sustainable mobility behaviours (change mobility patterns)	FL	Share of respondents (stakeholders/citizens/students/employees/relevant group of people) ready to adopt sustainable mobility behaviours	%	Task 1.5 - Survey		x	
----	---	---	----	---	---	-------------------	--	---	--

MK-UC02

H*	T.D.	Expected impact	Level	Indicator	unit	Data sources		Scale		Additional information/Clarification
						Source 1	Alternative Source (if needed)	P	C	
PW	T	Decrease perceived car dependency	SL	Share of a representative sample of inhabitants/users reporting to be fully or highly dependent on car for their daily urban mobility	%	Task 1.5 - Survey			x	
CS	T	Increasing the usage of multimodal trip planner	FL	Number of trips planned	n	planner app			x	
CS	T	Increasing number of trip planner users	FL	Number of users registered for the trip planner	n	planner app			x	
PW	T	Modal shift towards active modes for commuting trips	SL	Share of active modes on generated commuting trips in the pilot area	%	planner app			x	
SW	T	Increasing use of shared mobility	FL	Number of usages of shared vehicles (cars, bikes, scooters, ...) per (week/month/year) per inhabitant	n of pax/share per population	planner app	Task 1.5 - Survey		x	Mitigation action in case the operator is unwilling to provide data: The indicator will be monitored through survey-based data collection, assessing changes in shared vehicle usage as self-reported by respondents.
CS	Env	Increasing awareness of generated emission, and health effects	FL	Reported awareness of generated emission, and health effects by app users/survey respondents	Weighted average	Task 1.5 - Survey			x	
PW	Env	Reducing Climate impact	FL	Average CO2 emission per vkm of road vehicles in the fleet	kg CO2-eq / vkm or per unit time	Task 1.5 - Survey	EEA / Eurostat Pocketbook		x	Estimated CO ₂ emissions savings will be calculated based on the increased use of more sustainable transport modes (active mobility - shared modes). The indicator will be

D1.5 – MetaDesigned transferable ZESM use cases for the follower LLs

										monitored through survey-based data collection, estimating CO ₂ emission reductions based on self-reported changes in modal shift by respondents.
PW	S	Increasing perception of positive impact (or benefit) on day-to-day life	FL	Reported perception of positive impact (or a benefit) on day-to-day life by selected group	Weighted average	Task 1.5 - Survey			x	
PW	S	Increasing acceptance of implemented measures	FL	Reported score of respondents considering acceptable the implemented measures	Weighted average	Task 1.5 - Survey			x	
PW	S	Increase Customer satisfaction	FL	Level of satisfaction of the respondents (residents/users/stakeholders) with the service	Weighted average	Task 1.5 - Survey			x	
PW	S	Increasing propensity to adopt sustainable mobility behaviours (change mobility patterns)	FL	Share of respondents (stakeholders/citizens/students/employees/relevant group of people) ready to adopt sustainable mobility behaviours	%	Task 1.5 - Survey			x	

PO-UC01

						Data sources		Scale		
H*	T.D.	Expected impact	Level	Indicator	unit	Source 1	Alternative Source (if needed)	P	C	Additional information/Clarification
PW	T	Reducing road congestion	SL	Average travel time by a vehicle (car/vessel) for a sample of OD pairs	minutes	V2I based estimation	Sensor based	x		choosing different samples of OD pair, including targeted roundabouts
CS	T	Enhance data interoperability across systems	FL	Number of data sources integrated via API	n	API system dashboard		x		
CS	T	% utilisation of smart parking lots	FL	% utilisation of smart parking lots	%	Cameras and Sensors		x		Will be measured in 2 parking lots
PW	Env	Reducing Climate impact	FL	Average CO ₂ emission per vkm of road vehicles in the fleet	kg CO ₂ -eq / vkm or per unit time	Machine learning model		x		Will be measured for Carpooling fleet
PW	Env	Reducing Pollution impact	FL	Total pollutants emissions (produced by all vehicles circulating in the area) expressed in tonnes/year, for three pollutants: Particulate	tonnes/year	Carpooling fleet	Congestion estimation Drones / Sensors and Cameras	x		

D1.5 – MetaDesigned transferable ZESM use cases for the follower LLs

				Matter (PM), Nitrogen Oxides (NOx), Volatile Organic Compounds (VOC).					
PW	Ene	Reducing transport energy demand	FL	Modelled energy demand (3 separated numbers on Gasoline, Diesel, Electricity)	litres (Gasoline, Diesel) and Kwh (elect.)	Machine learning model		x	Will be measured for Carpooling 3 EV + 1 AV vehicles
SW	V	Reduce frequency of system failures	FL	Frequency of system failures	Count per km driven and their description	V2X network logs		x	Calculated for communication V2X and V2I
CS	V	Improve system response time	FL	Average communication delay between vehicle and infrastructure.	minutes	V2X network logs		x	
PW	S	Increase transport related safety	SL	Total number of traffic accidents per inhabitant in pilot/experiment area	n	Cameras		x	
PW	S	Increasing acceptance of implemented measures	FL	Reported score of respondents considering acceptable the implemented measures	Weighted average	Task 1.5 - Survey		x	Survey conducted to skaholders only

PO-UC02

						Data sources		Scale		
H*	T.D.	Expected impact	Level	Indicator	unit	Source 1	Alternative Source (if needed)	P	C	Additional information/Clarification
PW	T	Reducing road congestion	SL	Average travel time by a vehicle (car/vessel) for a sample of OD pairs	minutes	V2I based estimation	Sensor based	x		Calculated for peak and off-peak hours
SW	T	Increasing perceived accessibility to public transport	FL	Share of users perceiving an increase in the accessibility to public transport	%	Task 1.5 - Survey		x		To be calculated for carpooling users
CS	T	minimizing the passengers' waiting time at each pickup point.	FL	average waiting time at each pickup point	minutes	Cameras	V2X Carpooling Vehicle WT	x		
CS	T	improve physical integration between transport modes	FL	Ratio between the number of passengers interchanging at multimodal hubs and population (or number of survey respondents)	n/share per population	Cameras		x		
CS	T	Maximizing efficiency of carpooling service by	FL	Share of single-occupancy trips using carpooling service	%	Automated Vehicle Operator Data		x		To be calculated for carpooling service

D1.5 – MetaDesigned transferable ZESM use cases for the follower LLs

		reducing single vehicle occupancy rate								
SW	V	Reduce frequency of system failures	FL	Frequency of system failures	Count per km driven and their description	Automated Vehicle Operator Data		x		Calculated for communication V2V - automated vehicles
SW	V	Harsh braking events	FL	Number of ego vehicle decelerations over $X \text{ m/s}^2$ for at least $Y \text{ s}$, per distance driven	Number/km or number/h	Automated Vehicle Operator Data		x		Calculated for automated vehicle
SW	V	Improving Speed of AV	FL	Observed travel time of AV between sample segments in sample periods in the experiment area	m/s	Automated Vehicle Operator Data		x		Calculated for automated vehicle
PW	S	Increasing perception of positive impact (or benefit) on day to day life	FL	Reported perception of positive impact (or a benefit) on day-to-day life by selected group	Weighted average	Task 1.5 - Survey		x		To be calculated for carpooling users
PW	S	Increase Customer satisfaction	FL	Level of satisfaction of the respondents (residents/users/stakeholders) with the service	Weighted average	Task 1.5 - Survey		x		To be calculated for carpooling users
PW	S	Increasing propensity to adopt sustainable mobility behaviours (change mobility patterns)	FL	Share of respondents (stakeholders/citizens/students/employees/relevant group of people) ready to adopt sustainable mobility behaviours	%	Task 1.5 - Survey		x		To be calculated for carpooling users
SW	E	Reduce operational cost	FL	Operational costs using (automated vehicles/electric mini buses), compared to Operational costs using conventional vehicles	%	Operator		x		

LL5 workshop details

City	Date	Brief description	Format	Type of stakeholder involved	N* of people	Specific insights
Athens	27/11/2025	The Athens LL held an online meeting between the NTUA team and representatives from OASA (Athens PT operator). Ahead of the meeting, NTUA had prepared the SIEF Excel dataset following the 1:1 session with TRT (19/11/2025), specifying the	Online	National Technical University of Athens— (NTUA): 4 representatives, OASA—(Athens PT Operator): 2 representatives	6	The NTUA team and OASA confirmed all Impacts and Indicators that NTUA had identified as most relevant to the Athens UCs. OASA also confirmed the availability of data on: public transport reliability improvements, supplied energy for fueling/recharging, operational costs when using EBs versus conventional vehicles, EB charging times/sessions

D1.5 – MetaDesigned transferable ZESM use cases for the follower LLs

		Impacts and corresponding Indicators most relevant to the two Athens UCs and suitable for quantification. The discussion focused on the availability of input data—particularly from OASA and OSY—for the initially selected Impacts and Indicators, which were subsequently confirmed by OASA during the meeting.				during an operational day, charging-related costs, charging infrastructure characteristics, infrastructure maintenance times, and local grid loads (from OSY and/or OASA). For several other data types, OASA noted that confirmation is still needed from their side and/or from OSY and will follow up accordingly. Finally, regarding service interruptions due to EB system or charging malfunctions, OASA reported no recorded occurrences to date—even during the high-temperature periods of the last two summers (2024 & 2025) while EBs were in operation on Athens roads.
Krakow	26/11/2025	Mini-dialogue session with GLS representatives focused on validating proposed KPIs for last-mile delivery optimization in alignment with Kraków's Sustainable Urban Mobility Plan (SUMP) and Climate City Contract.	in-person	General Logistics Systems Poland – service provider	2	Feedback was collected on indicators such as reducing road congestion, promoting modal shift towards cargo bikes, and improving energy efficiency. The discussion emphasized that GLS's involvement helps confirm the feasibility of city KPIs while ensuring that their implementation delivers tangible benefits for residents—such as cleaner air, reduced congestion, and more efficient urban logistics. The topic of willingness to pay was also raised; however, GLS expressed limited enthusiasm, noting that in a similar project in Poznań they face higher operational costs and significant challenges in recruiting couriers. GLS committed to providing anonymized data on parcel traffic volumes and route choices to support future optimization and the development of an optimal route map through the city center, reinforcing consistency with Kraków's strategic frameworks. These conclusions will be reflected in the SIEF Excel file on proposed KPIs, noting that willingness to pay will likely be excluded due to limited stakeholder interest and high operational costs. Indicators such as reducing congestion, promoting modal shift, and improving energy efficiency remain prioritized for alignment with city-wide objectives.
Krakow	26/11/2025	Mini-dialogue session with VeloHub representatives focused on exploring practical possibilities for organizing essential infrastructure—such as video surveillance of the maneuvering area and dedicated hub facilities	in-person	VeloHub - Urban Logistics Innovator, project Lead for cargo bike logistics and microhub infrastructure, last-mile delivery optimization, multimodal hubs.	1	Session focused on practical infrastructure needs—such as video surveillance for maneuvering areas, dedicated hub facilities, and courier workflow organization—to better align operational aspects with KPI objectives: Enhanced delivery efficiency, Economic viability, Average delivery time per parcel, Revenue or savings from last-mile optimization, and Modal shift towards cargo bikes for last-mile deliveries. Comfort requirements for seasonal conditions were also raised (air conditioning for summer, heating deemed non-essential for winter). These insights will be reflected in the SIEF Excel file on proposed KPIs, noting that infrastructure-related indicators remain critical for achieving efficiency and economic viability
Krakow	11/12/2025	24th Session of the Task Force on the Development Direction of Bicycle Infrastructure in the City of Kraków	hybrid	Stowarzyszenia: Kraków Miastem Rowerów, Krakowski Park Rowerowy, Velo	14	Reviewed the plan to establish a transshipment point near Kraków Grzegórzki station under the MetaCCAZE program. Discussed infrastructure access, lack of bicycle parking spaces, and the need to relocate the bike path for improved service.

D1.5 – MetaDesigned transferable ZESM use cases for the follower LLs

				MałopolskaStowarzyszenie Kraków dla Mieszkańców Municipal Bodies of Kraków: Public Transport Authority Municipal Investment Board, Department of Municipal Economy and Infrastructure Traffic Management Unit, Metro Construction Preparation Unit		Attempted to define the importance of KPIs for the project from the perspective of social organizations and municipal institutions, including road management authorities.
Gozo-Malta	2/12/2025	An online meeting was organised with the GRDA representatives to discuss the KPIs and their relevance to the Gozo Regional Development Strategy and the Gozo Climate Neutral Plan.	Online	Government Authority (GRDA)	7	Feedback was collected on the overall plans for Gozo as a mission city and the upcoming release of the Climate Neutral Plan. The KPIs were discussed in light of this plan and the existing Gozo Regional Development Strategy. The recent Budget plans were also discussed including the plan to electrify all public transport in Gozo by next year. The KPI for the willingness to pay was highlighted as an important indicator to measure to ascertain any influence of the current free public transport offered in Malta and Gozo on this indicator.
	2/12/2025	An online meeting was organised with representatives from the Transport authority and ministry for transport to discuss the KPIs and their relevance to the National Transport Masterplan 2030, the national transport model and the Malta transport strategy.	Online	Government Authority and Ministry	9	Feedback was collected on the KPIs of the project and the recently published National Transport Masterplan. A discussion was held on the existing baseline data found in the Base year model report which will be requested. This will be an important step to ascertain if any pre-existing data sets exist and if they can be shared with the living lab.
Milan	9/1/2026	An online meeting was held with AMAT staff involved in the development and monitoring of the Sustainable Urban Mobility Plan (PUMS) and the Climate City Contract (CCC) of the city of Milan. The objective of the session was to ensure alignment between the metaCCAZE project indicators and those already adopted within the PUMS and CCC frameworks. During the meeting, we presented the current draft of the SIEF and discussed the selection of KPIs, focusing in particular on indicators related to mobility demand, sustainability, accessibility, and environmental impacts.	Online	Milan SUMP and CCC referents	3	The discussion highlighted the importance of carefully addressing social equity as a key element of a just mobility transition. Strong interest was also expressed in evaluating the transport impacts of scenarios involving a wide-scale adoption of the metaCCAZE solution, in order to benchmark their performance against the reference scenarios defined within the PUMS, particularly in terms of accessibility, efficiency, and distributional effects across different user groups.
Miskolc	11/26/2025	An online workshop was organized to collect the insights of the local stakeholders and project partners regarding the indicators in the SIEF. After	Online	Miskolc City Transportation Company (public transport provider), Miskolc Mayor's	8	All indicators were discussed in details. As a result no indicators were deleted from the suggested ones. The data collection through the survey were endorsed. There were additional comments regarding two

D1.5 – MetaDesigned transferable ZESM use cases for the follower LLs

		a short overview of the project and the introduction to the use cases each indicator was discussed. During the meeting first the multimodal mobility hub related indicators were listed, and after that the multimodal journey planners related indicators were listed. Several comments were realized and we agreed on every indicator.		Office (municipality), Hungarian Public Roads (infrastructure provider), HC Linear (application developer company), Budapest University of Technology and Economics (academia)		indicators, namely the road congestion and the climate impact. In the first case there are traffic counts in two main roads of the city that could potentially included, but they are not close to the use case locations. In the second case there is an external application measuring emission, but the service is not owned by any of the stakeholders and the data are not validated. It was agreed that only two additional indicators should be collected for the multimodal journey planner use case, such as the increasing number of conscious users and the increasing usage of multimodal trip planner.
Yvelines (Paris-Poissy, Yvelines (Paris Region))	3/12/2025	A joint on-site meeting was held at the Gare de Poissy, Yvelines (Paris Region) mobility hub with GPSE engineers and representatives of the City of Poissy, Yvelines (Paris Region). Partners from VEDECOM, FLOWARE, and the Département des Yvelines participated to assess deployment needs and coordinate the implementation plan for the use case. The discussion covered the deployment timeline, the regulatory and permitting requirements needed to proceed (including authorisations related to equipment installation and drone operations), and the number of installation points required across the hub for sensors, cameras, and V2X/RSU units. Furthermore, areal assessment has been done with the local authorities to understand the technical difficulties of managing mobility hub, particularly access points and accessibility constraints.	in-person	Local and Regional authorities and Engineers	11	1. Confirmed the most suitable locations for services within the hub and the operational allocation of the carpooling service. 2. The team reviewed EV charging constraints and practical considerations for integrating charging with carpooling parking areas. 3. Discussed operational and regulatory constraints related to drone usage at and around the hub. Recommendations are provided. 4. Installation points identified for sensors, cameras, and V2X/RSU units to ensure adequate coverage. 5. Carpooling service access, idle timing, local feasibility, service visibility and circulation considerations has been discussed in detail 6. Practical pathway to carry on installation of instruments on time, including permits, stakeholder responsibilities, and sequencing of works has been discussed and recommendation are provided 7. Electrical infrastructure requirements, with a focus on provisioning of power supply and cabling for devices has been discussed and reliable solution has been identified

www.metaCCAZE-project.eu



@metaCCAZE



metaCCAZE-project