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# LIVING LABS SETUP, SPACES DEFINITION AND EVALUATION MODELS

Project deliverable D2.2

HORIZON Research and Innovation Action | 101203465 |
Call HORIZON-CL5-2023-D6-01

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# DELIVERABLE ADMINISTRATIVE INFORMATION

| | |
|---|---|
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| **WORK PACKAGE** | WP2 |
| **TYPE OF DELIVERABLE** | R — Document, report |
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| | Name | Organisation | Date |
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| Peer review | Andrea Porcelluzzi | City of Reggio Emilia | 12/05/2026 |
| Peer review | Gernot Lenz | City of Vienna | 14/05/2026 |
| Quality control | Nikolaos Chondrogiannis | ERTICO | 28/05/2026 |
| Final review and proofread | Roozbeh Mohammadi | ERTICO | 29/05/2026 |



## VERSION HISTORY

| Version | Date | Author | Summary of changes |
|---|---|---|---|
| 01 | 05/05/2026 | MLC-ITS Euskadi & FRONTIER Innovations | First delivered version |
| 02 | 21/05/2026 | MLC-ITS Euskadi & FRONTIER Innovations | Second delivered version |
| 03 | 29/05/2026 | ERTICO | Final Version |

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# LIST OF ABBREVIATIONS AND ACRONYMS

| Acronym | Meaning |
|---|---|
| AI | Artificial Intelligence |
| AIS | Automatic Identification System |
| API | Application Programming Interface |
| ATA | Actual Time of Arrival |
| ATD | Actual Time of Departure |
| BKK | Centre for Budapest Transport (Budapesti Közlekedési Központ) |
| C-ITS | Cooperative Intelligent Transport Systems |
| DRT | Demand Responsive Transport |
| EC | European Commission |
| ECDIS | Electronic Chart Display and Information System |
| EDC | Eclipse Dataspace Connector |
| EI | Expected Innovation |
| ETA | Estimated Time of Arrival |
| ETD | Estimated Time of Departure |
| EU | European Union |
| FEDORA | Federation of network optimisation services, simulation foresights, and data alchemy for adaptable, agile, secure, and resilient multimodal traffic management. |
| GA | Grant Agreement |
| GDPR | General Data Protection Regulation |
| GPS | Global Positioning System |
| ICT | Information and Communications Technology |
| ITS | Intelligent Transport Systems |
| IWT | Inland Waterway Transport |
| JRC | Joint Research Centre |





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| | |
|---|---|
| KPI | Key Performance Indicator |
| LEZ | Low Emission Zone |
| LLM | Large Language Model |
| MaaS | Mobility as a Service |
| MoSCoW | Must Have, Should Have, Could Have, Won't Have (prioritisation framework) |
| NDA | Non-Disclosure Agreement |
| ODRL | Open Digital Rights Language |
| RAG | Retrieval-Augmented Generation |
| RIS | River Information Services |
| SUMO | Simulation of Urban MObility |
| TCS | Tradable Credit Schemes |
| TRL | Technology Readiness Level |
| TSP | Telematics Service Provider |
| UAS | Unmanned Aircraft System |
| UAV | Unmanned Aerial Vehicle |
| WP | Work Package |





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# PROJECT EXECUTIVE SUMMARY

Lack of orchestration structured and standardized integration protocols and metadata descriptors, incorporation of real-world traffic complexities and nuances, underutilization of valuable resources, model uncertainties and integration of micro-mobility services and VRUs result in suboptimal performance in addressing complex issues related to the management of mobility services and infrastructure and a divergence from EU's sustainable mobility targets. FEDORA aims to pave the way towards advanced traffic and network management through the development of a federated spaces platform offering a holistic framework of innovative solutions and services that enable precise and proactive sensing of supply and demand, facilitate optimal operation of transport services and advance learning and evolution in complex environments. At the operational level, FEDORA offers a collaborative space of data that can realize advanced data alchemy processes using interconnected services and tools, a space of advanced traffic management optimisation services and a multi-modal simulation space to create and assess future mobility scenarios. The approach is validated in six thematic demonstrations in Vienna (Austria), the Basque Country (Spain), Reggio Emilia (Italy), Nicosia (Cyprus), Budapest (Hungary) and Greater Copenhagen (Denmark), covering varying EU urban and rural contexts, infrastructure maturity levels, multimodal mobility services availability, organisation/operational structures and social conditions. Interaction with existing programmes on road mapping and recommendations at national, EU and global level will be promoted, allowing a multiplication effect of project's results.

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# DELIVERABLE EXECUTIVE SUMMARY

This deliverable (D2.2 Living Labs Setup, Spaces Definition and Evaluation Models) documents the outputs of Task 2.2 (Living Labs Setup, Requirements and Stakeholders Co-creation Activities) and Task 2.3 (Spaces Definition, Evaluation Models and Framework Architecture) as defined in the FEDORA Grant Agreement (Horizon Europe, Grant Agreement No. 101203465).

Part I covers the full co-creation cycle completed during the first year of the project across the six FEDORA pilot sites: the Living Lab methodology adopted by the consortium, the engagement of local stakeholders through Workshop 1 (held individually at each pilot site between January and February 2026) and Workshop 1.1 (the internal cross-pilot alignment session held in March 2026), the consolidation of requirements and needs, and the initial identification and validation of use cases for each pilot. This work was led by MLC-ITS Euskadi as Task 2.2 leader, with each pilot lead responsible for the engagement of their local stakeholder ecosystem.

Part II covers the outputs of Task 2.3, led by FRONTIER Innovations, including the conceptual framework architecture for the FEDORA spaces, the spaces definition and component specifications, and the evaluation models for the assessment of network management solutions.

The co-creation process successfully engaged stakeholders across all six pilot sites, generating a consistent and rich picture of operational challenges, data gaps and governance conditions that FEDORA solutions will need to address. Use cases have been identified and initially validated for each pilot, connecting local operational needs to the Expected Innovations defined in the Grant Agreement. The cross-pilot alignment carried out in Workshop 1.1 confirmed shared dependencies across pilots and identified areas of complementarity that will inform the demonstration preparation phase through WP6. Where some pilot scope could be adapted since the Grant Agreement in response to practical constraints, these changes are documented transparently and flagged accordingly. This deliverable provides the methodological and operational foundation for Year 2 of the project.

# 1 INTRODUCTION

This deliverable is submitted at Month 12 of the project, capturing the state of co-creation and technical development activities at the end of the first project year, ahead of the start of the demonstration preparation phase. Part II, covering the outputs of Task 2.3, has been contributed by FRONTIER Innovations as Task 2.3 leader.

The content of this deliverable reflects work in progress. Use cases and data strategies will continue to evolve as technical development in WP3-WP5 matures and as pilot-specific governance frameworks and data partnerships are established. Where pilot scope has been adapted since Workshop 1 (as in the case of the Basque Country pilot), this is documented transparently and the updated framing will be incorporated in subsequent versions of this deliverable and in the outputs of Tasks 6.1 and 2.2.

## 1.1 MAPPING FEDORA OUTPUTS

This section maps the FEDORA Grant Agreement commitments, both the formal Deliverable and Task descriptions, against the work performed and documented in this deliverable. The table below maps the GA commitments against the work documented in this deliverable.

| FEDORA ga component title | FEDORA GA COMPONENT OUTLINE | RESPECTIVE DOCUMENT CHAPTER(S) | JUSTIFICATION |
|---|---|---|---|
| | | **DELIVERABLE** | |
| D2.2 | Living Labs Setup, Spaces Definition, and Evaluation Models (T2.2, T2.3) | Parts I and II | Part I covers T2.2 outputs (Living Labs, workshops, requirements). Part II covers T2.3 outputs (spaces definition, evaluation models). |
| | | **TASKS** | |
| T2.2 | Living Labs Setup, Requirements and Stakeholders co-creation activities | Chapters 2.1-2.6 | Chapters 2.1-2.6 cover the full T2.2 scope: methodology, stakeholder engagement, workshop outcomes, requirements and use cases. |
| T2.3 | Spaces definition, evaluation models and framework architecture | Chapters 3.1-3.2 | Covered in Chapters 3.1–3.2. Covers the evaluation models and spaces definition and provides an initial view for the framework architecture at the conceptual level. |

Table 1: Adherence to FEDORA GA Deliverable & Tasks Descriptions

## 1.2 DELIVERABLE OVERVIEW AND REPORT STRUCTURE

This deliverable is organised in two main parts, reflecting the two tasks it covers, followed by a set of annexes containing the primary source materials produced during the co-creation process.

Part I (Chapters 2.1-2.6) documents the outputs of Task 2.2, led by MLC-ITS Euskadi. It covers the Living Lab methodology, the stakeholder engagement process, the outcomes of Workshop 1 and Workshop 1.1, the consolidation of requirements and needs, and the initial identification of use cases for each pilot site. The use cases presented reflect the state of co-creation at the time of submission and are expected to be refined progressively through Tasks 2.2 and 6.1.

Part II (Chapters 3.1-3.2) covers most of the outputs of Task 2.3, led by Frontier Innovations. It covers the Spaces Definition and the Network Management Evaluation Models for the FEDORA platform, and it provides an initial overview of the high-level conceptual architecture. The complete version for the framework architecture will be included in future deliverables (D2.3 and D2.4), as the project matures and the platform architecture solidifies during the implementation stages.

The annexes contain the full source materials supporting the deliverable: Annex I includes the stakeholder mapping per pilot; Annex II contains the requirements and needs tables; Annex III provides the co-creation planning guidelines used across all pilots; Annex IV compiles the Workshop 1 Outcomes Reports produced by each pilot lead; Annex V provides the technical component specification template.

# 2 PART 1: LIVING LABS SETUPS & CO-CREATION

## 2.1 METHODOLOGY

This chapter describes the methodological approach adopted for the Living Labs setup and co-creation process across the six FEDORA pilot sites. It explains how the co-creation framework was designed, how it aligns with the project objectives, and how it was operationalised through a structured workshop process that engaged local stakeholders, captured requirements and generated the foundational inputs for the FEDORA demonstration phase.

### 2.1.1 LIVING LAB APPROACH AND CO-CREATION FRAMEWORK

The FEDORA Living Labs are established as structured spaces for multi-actor engagement, designed to bridge the gap between technological development and real-world deployment in the context of multimodal traffic and network management. The Living Lab model adopted in FEDORA draws on established co-creation principles (openness, iterative validation and multi-actor participation) and adapts them to the specific needs of a research and innovation project operating across six geographically and operationally diverse pilot sites.

The logic for the Living Lab approach is rooted in the recognition that effective traffic and mobility management solutions cannot be developed in isolation from the actors who will ultimately use, govern and be affected by them. Local stakeholders (public authorities, transport operators, logistics companies, technology providers and, where applicable, citizens) hold knowledge about operational realities, governance structures and data conditions that cannot be captured through research alone. The co-creation process is therefore not a validation exercise conducted after the fact, but an integral part of how FEDORA defines its objectives, requirements and use cases.

Each pilot site has established a local Living Lab, with actors drawn from industry, academia, city and administrations, mobility service providers and, where relevant, logistics and freight operators. The composition of each Living Lab reflects the specific typology and operational context of the pilot (urban mobility, multimodal logistics, UAV integration, demand management or inland waterway transport), while following a common methodological framework that ensures comparability and facilitates cross-pilot learning.

The overarching goals of the co-creation process, as defined in Task 2.2, are: to engage stakeholders in identifying local needs, barriers and opportunities; to collectively generate guidelines for the long-term adoption of FEDORA solutions and to support the validation of FEDORA's effectiveness as solutions mature through subsequent project phases.

## 2.1.2 WORKSHOP STRUCTURE AND PROCESS

The co-creation process in FEDORA was operationalised through a structured sequence of workshops designed to capture requirements, validate use cases and ensure progressive alignment between local stakeholder needs and the technical development work across WP3–WP5. Two distinct workshop formats were used, each serving a specific purpose within the overall co-creation cycle.

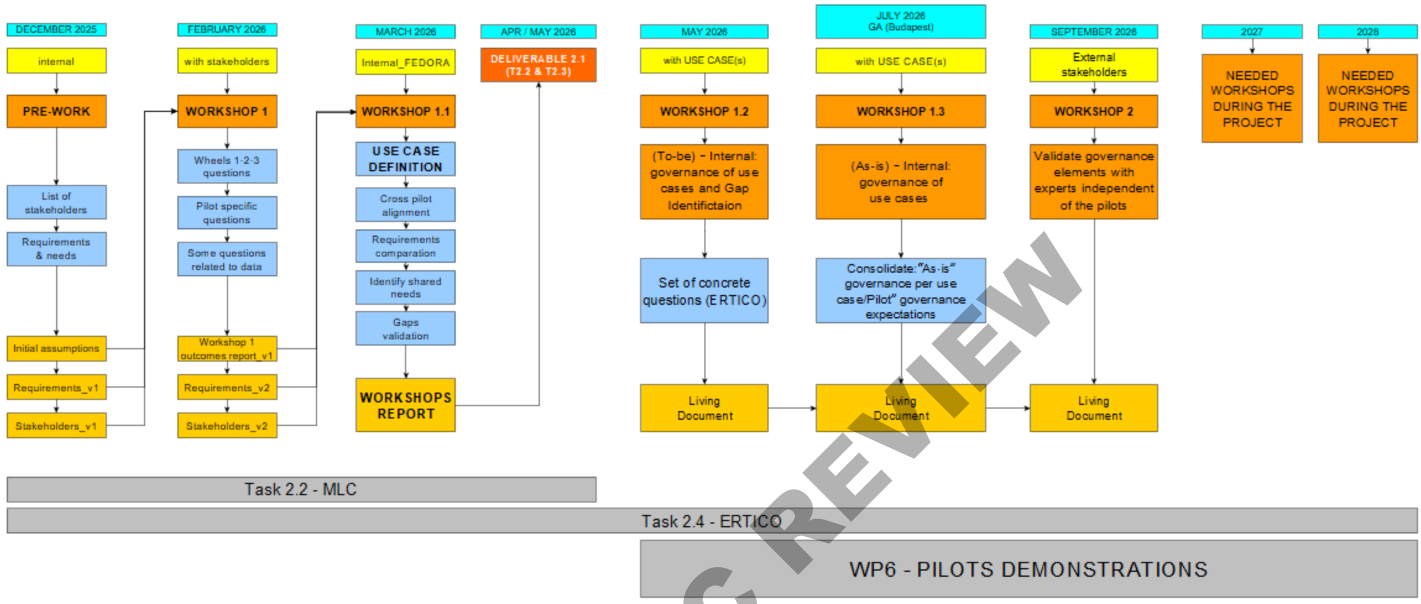



Figure 1: Co-creation-workshops structure flow-diagram



### 2.1.2.1 WORKSHOP 1: CO-CREATION WITH LOCAL STAKEHOLDERS

"Workshop 1" was the primary co-creation event at each pilot site, bringing together local stakeholders for the first time within the FEDORA framework. Each workshop followed a common facilitation approach based on the *Three Wheels methodology*, a co-creation facilitation framework developed specifically for the FEDORA project, structured around three thematic blocks:

- **Wheel 1: Current situation and pain points**: stakeholders identified the main operational inefficiencies, manual processes and data gaps affecting their domain. This block was designed to generate a grounded understanding of the problem space without pre-framing it around any specific technological solution.
- **Wheel 2: Tools and technological capabilities**: stakeholders explored existing digital tools and capabilities available in their context, identified automation needs and discussed how technology could address the pain points raised in Wheel 1. This block served to connect the problem diagnosis with potential solution directions.
- **Wheel 3: Data exchange and governance**: stakeholders examined the conditions under which data sharing could take place, identified trust barriers and competitive sensitivities and mapped the key actors with formal decision-making power over data governance. This block was essential for understanding the institutional and regulatory prerequisites for any data-driven intervention.

A common set of templates was used across all pilots to capture the outputs of each workshop in a structured and comparable format:

- **Template 1 (Stakeholder Mapping)**: documented the actors involved, their roles, their interest in the project and any gaps in stakeholder coverage identified during the workshop.
- **Template 2 (Requirements and Needs)**: consolidated the requirements emerging from the Three Wheels discussion, prioritised using the MoSCoW framework (Must Have, Should Have, Could Have, Won't Have).

Each "Workshop 1" was facilitated by the pilot leader in coordination with MLC-ITS Euskadi as Task 2.2 leader, using a common facilitation guide prepared in advance. The outputs were documented in a Workshop 1 Outcomes Report per pilot, which served as the primary input for the subsequent consolidation and cross-pilot analysis. The full Outcomes Reports are provided in Annex IV.

#### 2.1.2.2 WORKSHOP 1.1: INTERNAL CROSS-PILOT ALIGNMENT

"Workshop 1.1" was an internal cross-pilot alignment session, held online, recorded and organized by MLC-ITS Euskadi. It was designed to have a different purpose from "Workshop 1". While "Workshop 1" focused on local stakeholder engagement, "Workshop 1.1" brought together pilot leaders and FEDORA technical partners to consolidate findings, present emerging use case directions and begin the alignment with the Expected Innovations defined in the Grant Agreement.

The use cases presented at this session represent a first iteration, consistent with the early TRL context of the project. Their progressive refinement is planned through WP6 and subsequent co-creation rounds as technical development matures. They are not expected to be fully developed at this stage. Their progressive refinement will be carried out through Task 6.1 (Pilots Orchestration) and WP6 as technical development matures and stakeholder engagement deepens. The primary objective of this session was to give technical partners sufficient visibility of each pilot's direction so that they could reorient their development work if necessary, and to open a structured dialogue that had not yet taken place at this level of detail.

The session also served as the first formal occasion for technical partners to provide feedback on the feasibility and orientation of the proposed use cases, and to identify areas where further alignment between pilot requirements and WP3-WP5 development plans was needed. "Workshop 1.1" acted as a catalyst for bilateral engagement: following the session, several pilots initiated direct conversations with the relevant WP4 and WP5 task leaders to clarify technical dependencies, explore data approaches and refine their use case framing. A number of clarifications and adjustments were agreed during or following the session.

Finally, Task 6.1 will build on the foundations to explore synergies between use cases and Expected Innovations across pilots, working jointly with technical partners to identify where common components can serve multiple pilots simultaneously and to facilitate a coordinated approach to the FEDORA demonstration programme.



### 2.1.3 CROSS-COUNTRY LIVING LAB ACTIVITY PLAN

In line with the Task 2.2 mandate to create a supportive structure accommodating shared agendas across Living Labs, a cross-country activity plan has been developed to organise joint co-creation activities across all six FEDORA pilot sites. This plan ensures that findings from individual pilots are systematically shared, compared and integrated into a common cross-pilot vision, while respecting the specific context and pace of each local Living Lab.

The activity plan follows a structured progression across the project lifetime, aligned with the phased implementation approach described in the Grant Agreement:

| Activity | Purpose |
|---|---|
| **Workshop 1 (local)** | Co-creation with local stakeholders: requirements capture, pain point identification, data governance mapping. |
| **Workshop 1.1 (cross-pilot)** | Internal alignment: use case presentation, validation with technical partners, Expected Innovations alignment. |
| **Pilot factsheet validation** | Each pilot validates their use case factsheet; technical partners review and raise questions. |
| **Iterative co-creation activities** | Ongoing bilateral and multilateral engagement with pilots and technical partners as FEDORA solutions develop including bilateral meetings, use case refinement sessions and structured reviews aligned with WP3-WP5 milestones. |
| **Evidence collection and final assessment** | Collection of stakeholder feedback and evidence of FEDORA's effectiveness throughout the pilot demonstration phase, feeding into final deliverable versions. |

Table 2: Cross-country Living Lab activity plan: FEDORA T2.2



The cross-country dimension of the activity plan is not limited to the scheduled workshops. MLC-ITS Euskadi, maintains ongoing coordination with pilot leaders and ensures that relevant findings from individual pilots are shared across the consortium through consolidated outputs, including the pilot factsheets, the cross-pilot analysis of Expected Innovations and the use case synthesis documented in section 2.6.3.

The subsequent validation workshops will focus on presenting the FEDORA solutions developed in WP3–WP5 to local stakeholders and collecting their feedback. These workshops will serve as the primary vehicle for validating FEDORA's effectiveness, one of the core objectives of T2.2. In parallel, Task 6.1 will coordinate the cross-pilot dimension of this process, exploring synergies between use cases and Expected Innovations and ensuring that the co-creation findings are systematically fed into the demonstration and orchestration activities of WP6.

## 2.2 PILOT SITES OVERVIEW

This section provides an overview of each of the six FEDORA pilot sites, covering the pilot typology and location, its main objective, the key actors in the local ecosystem, the dependencies with other FEDORA tasks, and the Expected Innovations from the Grant Agreement assigned to each pilot. Where applicable, bilateral engagement activities carried out prior to or following "Workshop 1" are also referenced.

The six pilot sites represent a diverse set of transport contexts, operational environments and governance structures, spanning urban mobility, multimodal logistics, urban air mobility, demand management simulation and inland waterway transport. This diversity is a deliberate feature of the FEDORA design, ensuring that the solutions developed are tested and validated across a wide range of real-world conditions.

<u>Overview table:</u>

| # | Location | Typology | Task | Leader |
|---|---|---|---|---|
| 1 | Vienna, Austria | Urban Mobility | T6.2 | ITS Vienna Region (ITS-VIE) |
| 2 | Basque Country, Spain | Multimodal Logistics | T6.3 | MLC-ITS Euskadi (MLC) |
| 3 | Nicosia, Cyprus | Urban Air Mobility + Traffic Management | T6.5 | University of Cyprus (UCY) |
| 4 | Greater Copenhagen, Denmark | Simulation: Demand Management | T6.7 | Technical Univ. of Denmark (DTU) |
| 5 | Reggio Emilia, Italy | Urban Mobility: Demand Management | T6.4 | Comune di Reggio Emilia (CRE) |
| 6 | Budapest, Hungary | Inland Waterway Simulation | T6.6 | Budapest Univ. of Technology (BME) |

Table 3: FEDORA pilot sites overview



### 2.2.1 PILOT 1: VIENNA

- Pilot leader: ITS Vienna Region (ITS-VIE).
- FEDORA task: T6.2: Multimodal model services optimisation for equitable future mobility (M15-M35).
- Partners in T6.2: ITS-VIE (lead), AIT (Austrian Institute of Technology), VIE (City of Vienna) and FRONTIER.
- Pilot typology: Urban Mobility.
- Demonstration area: Praterstraße corridor and Danube Canal (Donaukanal), central Vienna, Austria.

**Pilot context and objective**

The Vienna pilot focuses on the optimisation of traffic signal management in a dense urban corridor. The current traffic light system in Vienna does only have sensors to collect real-time data for private motorised traffic and public transport, leaving pedestrians and cyclists outside the real-time control loop. This results in inequitable distribution of green time across modes and does only partially reflect the priorities set out in the Vienna Urban Development Plan, which foresees the prioritisation of non-motorised and public transport.

The pilot objective is to integrate non-motorised road users into the traffic light control system through the deployment of a Social Optimum Model (EI3.1), developed by AIT under T4.1. The model will receive real-time data from multiple sources (traffic counts, pedestrian and cyclist detection (AI-based cameras already installed on the Donau Kanal) and C-ITS CAM messages) and calculate the optimal distribution of green phases across all transport modes. The resulting signal plans will be fed into the existing traffic controllers operated by MA33. The pilot will work exclusively with temporary modifications, which eliminates the need for formal approval from the traffic authority MA46.

**Key actors in the local ecosystem**

- ITS Vienna Region: pilot leader, real-time traffic data provider, AI-based pedestrian/cyclist detection.
- AIT (Austrian Institute of Technology): Social Optimum Model development (T4.1); FEDORA partner.
- City of Vienna MA33 (Wien Leuchtet): operates the traffic controllers; plans signal phases.
- Mobilitätsagentur Wien: perspective of pedestrians and cyclists.

- Wiener Linien: public transport operator; timetable data provider.
- FRONTIER: FEDORA technical development.

**Dependencies with other FEDORA tasks**

- T4.1: Social Optimum Model: core dependency; provides the model integrated into the traffic controller.
- T2.5: FEDORA integrated platform: potential mobile app for 50 cyclist users via the Mega-Bicycle-Highway.
- T3.6: Data space implementation: mechanism for moving data between ITS-VIE, AIT and City of Vienna MA33.
- T5.6: Foresight analysis: evaluation of the social optimum under different scenarios.
- T6.1: Pilots orchestration: unified approach and comparable results across pilots.

**Expected Innovations (Grant Agreement)**

- EI3.1: Social optimum model for multimodal nodes and corridors - T4.1
- EI3.3: Mobility hub & corridor optimisation / UAV path planning - T4.3 (tentative: pending clarification of scope)
- EI3.4: Complex event processing - incident detection - T4.4
- EI3.5: Synchromodal optimisation algorithms - T4.5 (tentative: pending clarification of scope)
- EI3.6: Real-time network response planning - T4.6
- EI4.1: Simulation framework - T5.1
- EI4.2: Agent-based demand generation models - T5.2 (Tentative (pending clarification); the use of agent-based models depends on the implementation of the social optimum model (T4.1).
- EI4.6: Foresight analysis scenarios generator - T5.6

### 2.2.2 PILOT 2: BASQUE COUNTRY



- Pilot leader: MLC-ITS Euskadi
- FEDORA task T6.3: Sustainable and efficient multimodal logistics hubs (M15–M35)
- Partners in T6.3 MLC-ITS Euskadi (lead), FRONTIER.
- Pilot typology: Multimodal Logistics
- Demonstration area: Port of Pasaia logistics ecosystem, Gipuzkoa, Basque Country, Spain

**Pilot context and objective**

The Basque Country pilot addresses the fragmentation of information and coordination across the multimodal logistics chain connecting maritime, road and rail freight movements in the Basque Country. The region occupies a strategic position on the Atlantic corridor, with two main ports (Bilbao and Pasaia), three airports and four major logistics platforms, making it a representative and operationally rich testbed for multimodal logistics optimisation.

The core operational challenge identified through the co-creation process is the absence of a shared operational picture across the logistics chain: maritime events are not propagated in real time to terrestrial operators, data exchange between port actors is largely manual, and there is no coordination mechanism connecting port operations with road and rail movements at the relevant logistics nodes. The consequence is a reactive logistics chain where disruptions cascade unpredictably and operators cannot plan ahead.

The pilot objective is to demonstrate the potential of a FEDORA integration and orchestration layer that transforms this reactive model into a predictive one: detecting key maritime and logistics events and propagating them automatically to all relevant actors in the terrestrial chain, enabling more efficient multimodal routing and coordination. The specific demonstration site and use case are being defined through ongoing engagement with port authorities, logistics operators and technical partners, and will be formalised. The approach will combine simulation with progressively integrated real data, depending on the data governance frameworks and partnerships that develop over the course of the project.

**Key actors in the local ecosystem**

- Autoridad Portuaria de Bilbao (APB).
- Autoridad Portuaria de Pasaia (APP).
- Toro y Betolaza, Artaza: stevedoring and port operations.
- Algeposa, Bergé: road and multimodal logistics operators.
- Railsider: rail freight operator.
- Zaisa: inland logistics platform.
- Colegio Oficial de Agentes de Aduanas: customs agents.
- Adur Software Productions and NemoSoft: technology provider.

**Dependencies with other FEDORA tasks**

- T4.3: Multimodal hub optimisation (EI3.3): hub interactions at nodal level and slot management.
- T4.4: Complex event processing (EI3.4): maritime event detection and downstream propagation.
- T4.5: Synchro modal freight solutions (EI3.5): multimodal optimisation and truck slot routing.
- T5.3: Freight controllers (EI4.3): demand and supply simulation at larger scale.
- WP3: Data space: data sharing infrastructure for port actors.
- T2.5: FEDORA integrated platform: deployment environment for both use cases.
- T6.1: Pilots orchestration: unified approach and comparable results across pilots.

**Expected Innovations (Grant Agreement)**

- EI3.3: AI-driven mobility hub & corridor optimisation- T4.3
- EI3.4: Complex event processing for incident/bottleneck detection - T4.4
- EI3.5: AI synchromodal optimisation algorithms - T4.5
- EI4.3: Freight controllers for demand/supply simulation - T5.3



### 2.2.3 PILOT 3: NICOSIA

- Pilot leader: University of Cyprus (UCY)
- FEDORA task T6.5: Integration and traffic management of aerial and road services (M15–M35)
- Partners in T6.5: UCY
- Pilot typology: Hybrid: Urban Air Mobility + Road Traffic Management
- Demonstration area: Greater Nicosia urban corridor: Mall of Cyprus, Nicosia General Hospital, University of Cyprus

**Pilot context and objective**

The Nicosia pilot is the only FEDORA pilot with a genuine urban air mobility dimension. It addresses two distinct but complementary challenges in the city's transport system: the absence of real-time multimodal coordination across fragmented data sources, and the opportunity to integrate UAVs as both a new transport mode and a sensing tool.

The pilot objective is to demonstrate an integrated optimisation layer that combines UAV-based traffic sensing with multimodal routing and Park & Fly services. UAV deployment is planned, subject to regulatory authorisation from the Department of Civil Aviation for Park & Fly passenger operations and for aerial traffic monitoring. The pilot will be first modelled in the SUMO-based ITS testbed at UCY (T5.6), with field trials compared against simulation outcomes. Optimal vertiport locations will be identified using UCY's hub optimisation algorithms (T4.3, which UCY leads).

A key feature of this pilot is that UCY leads both T6.5 (the pilot itself) and T4.3 (hub optimisation) and T5.6 (foresight analysis), which significantly reduces external dependencies for the core technical components. The main risks are regulatory: UAV authorisation in Cyprus is more complex than anticipated due to military geofencing zones linked to the island's political status. GDPR compliance for aerial data collection also requires a formal anonymisation procedure before operations can begin.

**Key actors in the local ecosystem**

- Nicosia Municipality (local authority).
- Public Works Department (PWD): main road network authority.
- Department of Civil Aviation: UAV mission authorisation (critical dependency).
- Department of Land and Surveys: infrastructure and cadastral datasets.
- Bolt (e-scooters) and NEXTbike (bike share): mobility service providers.
- Ministry of Transport, Communications and Works: to be engaged in later phases for scalability and regulatory dialogue.

**Dependencies with other FEDORA tasks**

- T4.3: UAV path planning and vertiport location optimisation (EI3.3).
- T4.4: Complex event processing for aerial incident detection (EI3.4).
- T4.6: Response planning: propagation of paths to drones (EI3.6).
- T5.6: Foresight analysis scenarios for evaluation of UAV integration.
- T3.2: Data discovery and cataloguing: sharing of hub locations, bus schedules and UAV data.
- T6.1: Pilots orchestration: unified approach and comparable results across pilots.

**Expected Innovations (Grant Agreement)**

- EI3.3: UAV path planning & vertiport location optimisation - T4.3
- EI3.4: High-resolution incident data collection via UAVs - T4.4
- EI3.6: Response planning: propagate paths to drones - T4.6
- EI4.3: Simulation platform for emerging mobility services - T5.3

## 2.2.4 PILOT 4: COPENHAGEN

- Pilot leader: Technical University of Denmark (DTU)
- FEDORA task T6.7: Foresight analysis using network-wide simulations (M15–M35)
- Partners in T6.7: DTU
- Pilot typology: Simulation: Demand management and foresight analysis.
- Demonstration area: Greater Copenhagen metropolitan area, Denmark.

**Pilot context and objective**

The Copenhagen pilot is a large-scale simulation pilot (not a field deployment). It addresses a critical gap in the transport planning tools available to Danish national and regional authorities: current official models lack the capability to evaluate demand management strategies such as congestion pricing, tradable credits and MaaS integration.

This gap is particularly timely given that Denmark has recently completed a large-scale road pricing field experiment with 2.000 drivers (GPS and app data) and is considering extending the existing truck pricing policy towards passenger vehicles. The pilot objective is to develop and integrate dynamic pricing, tradable credits and MaaS controllers into the open-source SimMobility simulation model for the Greater Copenhagen area, calibrated against the field experiment data. Scenario exploration will be tested to showcase benefits to policy makers. The ambition is that the open-source implementation can serve as a feature testing bed for transfer to the official national transport model.

**Key actors in the local ecosystem**

- Vejdirektoratet (Danish Road Directorate): national road authority; owner of the official large-scale transport model.
- Region Hovedstaden (Capital Region of Denmark): regional mobility planning and policy decisions.
- Kobenhavn Kommune (Municipality of Copenhagen): transport planning; engaged at a later stage when results are available.
- Sund & Bælt: responsible for the road pricing pilot; key data source.
- DTU: model development; leads all technical work in T6.7.
- Movia (buses), DSB (trains) and Metroselskabet (metro): to be involved when initial results are available.

**Dependencies with other FEDORA tasks**

- T4.2: Dynamic pricing and artificial currencies (EI3.2): external dependency shared with Reggio Emilia.
- T5.2: Agent-based demand prediction models: demand-side simulation changes.
- T5.3: Controllers for MTM services: supply-side simulation changes including MaaS and pricing controllers.
- T5.6: Foresight analysis scenarios generator: scenario generation for prospective analysis.
- T6.1: Pilots orchestration: unified approach and comparable results across pilots.

**Expected Innovations (Grant Agreement)**

- EI3.2: Dynamic pricing & incentivisation using artificial currencies - T4.2
- EI3.6: Network response planning - T4.6
- EI4.2: Agent-based demand representation models - T5.2
- EI4.3: Passenger and demand management controllers - T5.3
- EI4.6: Foresight analysis scenarios generator - T5.6

### 2.2.5 PILOT 5: REGGIO EMILIA

- Pilot leader: Comune di Reggio Emilia (CRE)
- FEDORA task T6.4: Field and Simulation of Demand Management Strategies (M15–M35)
- Partners in T6.4: CRE (leader), FRONTIER, DTU
- Pilot typology: Urban Mobility: Demand management via tradable mobility credits

- Demonstration area: Reggio Emilia urban road network, Italy

**Pilot context and objective**

The Reggio Emilia pilot addresses urban air quality problems through a demand management approach based on tradable mobility credits. The pilot objective is to deploy the first tradable mobility credits system at real scale in Europe: GPS black boxes will be installed in 500 vehicles to track driving behaviour, and users will receive mobility credits that they spend when travelling on certain roads according to their emission profile. Unused credits can be sold on a marketplace, creating direct economic incentives for behaviour change.

The political context is favourable: the new road traffic plan for Reggio Emilia is currently being finalised, opening a concrete and time-sensitive window for FEDORA results to directly inform policy decisions. The pilot also provides the first empirical evidence of a tradable mobility credits mechanism at real scale in Europe, making it a significant research contribution beyond its local impact.

A major change occurred during the preparation phase initially, the pilot aimed to create synergies with MOVE-IN, a regional experimental telematics system, as the basis for participant recruitment. However, this option was ultimately considered unfeasible and formally abandoned: Move-In had an insufficient user base in Reggio Emilia, an incompatible privacy framework and misaligned objectives. The pilot will proceed with an independent technical implementation, requiring a new TSP, a new GDPR framework and a new recruitment process.

**Key actors in the local ecosystem**

- Comune di Reggio Emilia: pilot leader, regulator and primary data owner.
- Emilia-Romagna Region: regional governance and reference for the Move-In system.
- TSP provider (to be confirmed): black box data provider; critical for participant recruitment and data collection.
- DTU: pilot design and simulation for extrapolation of results at larger scale.
- FRONTIER: software development (app/web and backend).
- JRC ISPRA: research support.
- Privacy Authority: formal GDPR framework approval required before data collection can begin.

**Dependencies with other FEDORA tasks**

- T4.2: Dynamic pricing and artificial currencies (EI3.2): critical external dependency shared with Copenhagen.
- T5.2: Agent-based demand prediction models: behavioural simulation for extrapolation.
- T5.1: Simulation framework: extrapolation of real-world findings to larger scale.
- T5.6: Foresight analysis: prospective evaluation of the tradable credits scheme.
- T3.2: Data discovery and cataloguing: TSP data cataloguing and publication.
- T6.1: Pilots orchestration: unified approach and comparable results across pilots.

**Expected Innovations (Grant Agreement)**

- EI3.2: Dynamic pricing & incentivisation using artificial currencies - T4.2
- EI3.3: Multimodal journey planner - T4.3
- EI4.1Simulation framework - T5.1
- EI4.2: Agent-based demand models - T5.2
- EI4.6: Foresight analysis scenarios generator - T5.6

### 2.2.6 PILOT 6: BUDAPEST

- Pilot leader: Budapest University of Technology and Economics (BME)
- FEDORA task T6.6: Traffic Flow Simulation in inland waterways (M15–M35)
- Partners in T6.6: BME
- Pilot typology: Inland waterway traffic simulation + integration with road transport
- Demonstration area: Budapest section of the Danube River, Hungary

**Pilot context and objective**

The Budapest pilot investigates the integration of inland waterway transport with road transport through real-time traffic monitoring and multimodal journey planning. The Danube is a key corridor through the city, used by a growing number of sightseeing, event and hop-on/hop-off passenger vessels; passenger vessel numbers on the Budapest Danube have grown significantly in recent years. However, vessel arrival and departure times are not accurately known beyond static schedules and informal VHF radio communication between skippers, AIS data is not trusted due to quality issues, and tourists have no multimodal journey planning tool that integrates waterway transport. In addition, Budapest Municipality is planning to change the Danube Bank Building Regulations (DÉSZ) from 2027 without impact studies on waterway traffic, a specific opportunity for FEDORA to provide simulation-based evidence.

The pilot has identified four interrelated use cases: regulatory impact assessment (DÉSZ), real-time vessel ETA/ETD service, AIS data consolidation, and multimodal tourist journey planning. Use Cases 2 and 3 are directly dependent: without reliable AIS data, the real-time ETA service cannot function accurately.



**Key actors in the local ecosystem**

- Budapest Police, Ministry of Construction and Transport (Transportation Safety Bureau), Central Danube Valley Water Management Directorate: public authorities.
- Armada Budapest Kft., Európa Rendezvényiroda Kft., Scenic & Emerald Luxury Cruises, Legenda Kft. — vessel operators.
- BKV Zrt.: public transport operator.
- RSOE: Hungarian River Information Services (RIS) provider; official AIS data handler.
- HUNPASS (Federation of Hungarian Passenger Vessel Operators): represented absent vessel operators.
- Centre for Budapest Transport (BKK): BME maintains direct contact with BKK. While BKK has expressed interest in future waterway integration into BudapestGO!; this is expected beyond the FEDORA project timeframe.

**Dependencies with other FEDORA tasks**

- WP3: Data space architecture: AIS data is not standard transport data; data space architecture is needed.
- T4.3: Multimodal journey planner (EI4.3): cross-modal routing including inland waterway.
- T4.4: Collision event detection and processing (EI4.4).
- T5.1: Multimodal simulation engines framework (EI4.1).
- T6.1: Pilots orchestration: unified approach and comparable results across pilots.

**Expected Innovations (Grant Agreement)**

- EI4.1: Waterborne and land simulation models - T5.1
- EI4.3: Passenger journey planning-cross-modal - T4.3
- EI4.4: Complex event processing-collision detection - T4.4

- EI4.6: Cross-modal network management services - T5.6

## 2.3 STAKEHOLDER ENGAGEMENT

This chapter provides an overview of the stakeholder engagement activities carried out across the six FEDORA pilot sites as part of Task 2.2. It covers the actors engaged in each local Living Lab, the governance dimensions identified during the co-creation process, and the conditions for data sharing that emerged from "Workshop 1". Detailed stakeholder mapping per pilot is provided in Annex I.

### 2.3.1 OVERVIEW ACROSS PILOTS

Across the six FEDORA pilot sites, "Workshop 1" engaged a total of approximately 50 individual stakeholder organisations, representing a diverse set of actor categories: public authorities and municipalities, transport operators (road, rail, maritime, waterway and air), logistics companies, technology providers, research institutions and advocacy associations. Table 5 provides a comparative summary.

| Pilot | Organisations engaged | Workshop date | Key actor categories | Absences |
|---|---|---|---|---|
| Vienna | 5 | January | City authority, mobility agency, public transport operator, ITS provider, research. | None identified. |
| Basque Country | 9 | February | Port authority, stevedoring, road/rail logistics, customs, technology providers. | Rail infrastructure operators. |
| Nicosia | 6 | February | Municipalities, road authority, civil aviation, shared mobility providers. | Public transport operator (NPT): to be engaged. |
| Copenhagen | 5 | Jan-Feb | National road authority, regional authority, municipality, road pricing operator. | Movia, Metroselskabet: engaged at later stage. |
| Reggio Emilia | 5 | January | Municipality, region, TSP providers, research centres. | None: insurance companies explicitly ruled out. |
| Budapest | 8 | February | Public authorities, vessel operators, public transport, river info services, associations. | BKK, MAHART Passnave, Shipping Authority: to be engaged. |

Table 4: Stakeholder engagement summary across FEDORA pilots.

A number of cross-pilot patterns emerge from this overview. First, public authorities are present across all pilots, either as city administrations, transport agencies or regulatory bodies, and consistently emerge as the most legitimate actors to lead data governance frameworks at local level. Second, the engagement of technology providers and research institutions alongside operational actors reflects the Living Lab model's intent to bridge the gap between technological development and real-world deployment. Third, the most common type of absence across pilots involves private operators who are relevant for later stages but were either unavailable for the initial workshop or chose to wait for initial results before engaging.

### 2.3.2 PARTICIPATION AND KEY ABSENCES PER PILOT

This section documents, for each pilot, the actors who attended “Workshop 1”, those who were identified as relevant but absent, and the mitigation strategies planned to engage missing actors in subsequent project phases.

**PILOT 1: VIENNA**

“Workshop 1” in Vienna was held across two sessions in January and February 2026 at the Verkehrsverbund Ost-Region facilities. All invited organisations attended: the City of Vienna Public Lighting Department (MA33), Mobilitätsagentur Wien, Wiener Linien, ITS Vienna Region and AIT. No critical absences were identified. The workshop achieved full representation of the relevant actor groups for the pilot scope. A constructive and collaborative atmosphere was reported, with only minor differences of opinion on priorities. The Traffic Authority MA46 was not invited to “Workshop 1”, as their involvement is only required for permanent changes to signal plans, which this pilot does not foresee.

**PILOT 2: BASQUE COUNTRY**

“Workshop 1” in the Basque Country was held on February 2026 at the facilities of the Port Authority of Pasaia. Nine organisations attended: Port Authority, Toro y Betolaza (stevedoring), Artaza (port operations), Algeposa (logistics), Bergé (maritime and logistics), Railsider (rail freight), Zaisa (inland logistics platform), Colegio Oficial de Agentes de Aduanas (customs agents) and Adur Software Productions and NemoSoft (technology provider).

Two relevant actor groups were absent. Rail infrastructure operators (Renfe and Adif) were not present; rail-port coordination was identified as a significant pain point during the workshop, and bilateral outreach to these actors has been planned.

**PILOT 3: NICOSIA**

“Workshop 1” in Nicosia was held across two sessions on 2 and 9 February 2026, combining in-person and online formats. The participants included the Municipalities of Nicosia, Egkomi, Aglantzia and Strovolos, the Public Works Department, the Department of Civil Aviation, the Department of Land and Surveys, and two shared mobility providers: Bolt (e-scooters) and NEXTbike (bike share). This represented strong coverage of the public authority and urban mobility dimensions.

The main gap identified was the absence of the public transport operator (Nicosia Passenger Transport - NPT), which is relevant for multimodal routing but was not formally engaged during “Workshop 1”. The Ministry of Transport, Communications and Works was also absent; UCY has since shared the “Workshop 1” findings with the Ministry and received feedback (validating the finding). The plan is to also involve them in later phases when scalability and regulatory questions become relevant.

**PILOT 4: COPENHAGEN**

“Workshop 1” in Copenhagen was held across two sessions on 30 January and 2 February 2026. The participants included Vejdirektoratet (Danish Road Directorate), Region Hovedstaden (Capital Region of Denmark), Kobenhavn Kommune (Municipality of Copenhagen) and Sund & Bælt. DTU attended as both workshop facilitator and project partner.

Two groups were invited but declined to participate at this stage: Movia (bus operator) and Metroselskabet (metro operator), who requested to be engaged once initial simulation results are available. This is not a critical absence for the current phase of the pilot, which focuses on model development rather than operational deployment. Both operators will be contacted again once the first simulation outputs are ready.

**PILOT 5: REGGIO EMILIA**

“Workshop 1” in Reggio Emilia was held on 15 January 2026 in online format. Participants included the Comune di Reggio Emilia, the Emilia-Romagna Region, two Telematics Service Providers (OCTO Telematics (TSP provider, attended as potential data partner) and AIR), and two research organisations (JRC ISPRA and DTU). No critical absences were identified. Insurance companies were explicitly considered as potential stakeholders but were ruled out during the workshop, as their data access conditions and objectives are not aligned with the pilot's needs.

**PILOT 6: BUDAPEST**

“Workshop 1” in Budapest was held in February 2026. The participants included Budapest Police, the Ministry of Construction and Transport (Transportation Safety Bureau), the Central Danube Valley Water Management Directorate and four vessel operators (Armada Budapest Kft., Európa Rendezvényiroda Kft., Scenic & Emerald Luxury Cruises, Legenda Kft.), BKV Zrt. (public transport), RSOE and NAVINFO (Hungarian River Information Services), and HUNPASS (Federation of Hungarian Passenger Vessel Operators).

Three relevant actors were absent: the Centre for Budapest Transport (BKK), MAHART Passnave and the Shipping Authority Department.). BKK is a key actor for the multimodal journey planning use case and potential integration with the Budapest GO! application (BME maintains direct contact with BKK representatives, and they will be informed continuously and use FEDORA development to demonstrate that IWW traffic can be involved into BudapestGO!). MAHART Passnave holds the schedule data for cruise vessel arrivals and departures (currently not publicly available). A bilateral engagement and formal data agreement with MAHART Passnave is planned as a priority. The Shipping Authority Department (Ministry) was also absent; however, communication between BME and the Ministry on AIS data legal and regulatory questions is ongoing.

### 2.3.3 GOVERNANCE AND TRUST CONSIDERATIONS

Across all six pilot sites, “Workshop 1” generated valuable insights into the governance and data-sharing conditions that will shape the feasibility and design of FEDORA interventions. While the specific institutional contexts differ significantly across pilots, a number of common themes emerged that have direct implications for the project's data space work and platform architecture.

**DATA SHARING CONDITIONS**

In all pilots, stakeholders expressed willingness to participate in data sharing under specific conditions. The most consistently cited condition was the requirement for mutual benefit: actors are not willing to share data simply because it is technically feasible. They need to understand what they will gain from the exchange, either operationally (better information, reduced costs) or reputationally (positioning as an innovative actor). This finding reinforces the importance of the FEDORA use case design as a mechanism for making the value proposition of data sharing explicit and concrete for each actor.

A second common condition was the requirement for formal governance frameworks (either data agreements, consortium agreements, or regulatory instruments) before operational data sharing can begin. This was particularly evident in the Basque Country pilot (where the port authority's role as governance anchor was explicitly recognised), in Reggio Emilia (where the GDPR framework requires formal Privacy Authority approval) and in Nicosia (where GDPR compliance for UAV-based data collection requires a formal anonymisation procedure). In Vienna and Copenhagen, the main governance mechanism identified was the FEDORA data space infrastructure developed in T3.6, which provides the technical and organisational layer for data movement between actors.

The distinction between open data and restricted data also emerged consistently. Most pilots reported that static infrastructure data (road networks, timetables, annual counts) is either open or accessible through standard channels. The more sensitive categories (real-time operational data, commercially sensitive logistics data, and individually traceable movement data) are subject to restrictions that must be addressed through the governance frameworks described above.

## TRUST BARRIERS AND COMPETITIVE SENSITIVITIES

Trust barriers were identified in several pilots, though their nature and intensity varied significantly. In the Basque Country logistics pilot, cybersecurity concerns and commercial sensitivity were explicitly raised as barriers to data sharing between port operators — actors who are both potential collaborators and commercial competitors. The port authority was identified as the most legitimate neutral coordinator, capable of holding the governance role without creating competitive distortions. Similar dynamics were observed in Budapest, where the anonymisation of AIS data was described as a legal requirement rather than a matter of trust between operators.

In Nicosia, the main trust-related issue was not between operators but between the project and the regulatory environment: the military geofencing zones that restrict UAV airspace in Cyprus create a structural barrier that goes beyond the project's ability to resolve through stakeholder engagement alone. Similarly in Reggio Emilia, the Privacy Authority approval process represents a formal institutional barrier rather than a relationship-based one.

Vienna was the only pilot where no trust issues or competitive sensitivities were raised. This is consistent with the urban mobility context, where most relevant data is either government-owned or managed by public operators with no commercial conflict of interest.

## KEY ACTORS WITH FORMAL DECISION-MAKING POWER

Each pilot identified one or more actors with formal authority over the key decisions that will shape the pilot's implementation. These actors are essential partners for the governance of the Living Lab and, in several cases, for the regulatory approvals needed before demonstrations can begin. Table 6 summarises these key decision-makers per pilot.

| Pilot | Key decision-maker(s) | Decision scope |
|---|---|---|
| Vienna | City of Vienna MA46 (traffic authority); local government | Approval of permanent traffic measures; representation of public interest, funding of traffic measures and infrastructure. |
| Basque Country | Port Authorities | Data governance framework for the port logistics ecosystem; access control data. Primary engagement ongoing with APB Bilbao for Round 1 demonstrations. |
| Nicosia | Department of Civil Aviation | UAV mission authorisation within Nicosia airspace; critical prerequisite for field trials |
| Copenhagen | Vejdirektoratet (National Road Directorate) | Official transport model; formal validation of simulation transferability |
| Reggio Emilia | Comune di Reggio Emilia; Privacy Authority | Regulatory framework for the credit scheme; GDPR approval for data collection |
| Budapest | ÉKM Shipping Authority Department (Ministry) | Formal authority over waterway navigation regulations; to be engaged when legal questions arise |

Table 5: Key actors with formal decision-making power per pilot.

These actors represent dependencies for the project's demonstration phase. Their engagement must be maintained and formalised through data agreements or other instruments, as the project progresses towards the demonstration tasks. MLC-ITS Euskadi, as T6.1 lead, will track the status of these formal engagements as part of the pilots' orchestration work.

## 2.4 "WORKSHOP 1" OUTCOMES

This chapter summarises the main findings from "Workshop 1" across all six FEDORA pilot sites, as documented in the Workshop 1 Outcomes Reports produced by each pilot leader. It provides a cross-pilot comparative analysis of the pain points, data gaps and requirements identified, highlighting both common themes and pilot-specific findings. Full "Workshop 1" Outcomes Reports per pilot are provided in Annex IV. Updated stakeholder mapping and requirements tables are provided in Annexes I and II respectively.

### 2.4.1 SUMMARY OF FINDINGS ACROSS PILOTS

"Workshop 1" was conducted across all six pilot sites between January and February 2026, following the *Three Wheels methodology* described in section 2.1.2.1. The sessions generated a consistent and rich picture of the operational challenges, digital maturity gaps and governance conditions that FEDORA solutions will need to address. Several common themes emerged across pilots, despite the significant differences in transport context, geography and institutional structure:

- **Information fragmentation**: all pilots identified the absence of a shared, real-time operational picture as a fundamental problem. Whether in port logistics (Basque Country), urban traffic management (Vienna, Nicosia), demand modelling (Copenhagen) or waterway navigation (Budapest), actors operate with incomplete and disconnected information. This fragmentation drives reactive rather than anticipatory behaviour across the entire chain.
- **Manual processes and digitalisation gaps**: every pilot reported significant manual processes in areas where digital integration would be both feasible and valuable, from paper delivery notes and phone-coordinated nautical services in Pasaia, to manually estimated berth occupancy and VHF radio vessel ETAs in Budapest, to expert-dependent scenario configuration in Copenhagen. These gaps represent both the challenge and the opportunity for FEDORA.
- **Data availability vs data accessibility**: in most pilots, the relevant data either exists or could be generated. The barrier is not technical but organisational and institutional: conditions for sharing have not been agreed, governance frameworks are absent, and actors are unwilling to commit without a clear value proposition and a trusted intermediary.
- **Simulation as a prerequisite**: several pilots (Copenhagen, Basque Country, partially Nicosia) identified simulation as the necessary first step, either because real operational data is not yet accessible, or because the political or regulatory environment requires evidence before committing to real deployments.
- **Political windows and urgency**: multiple pilots identified specific policy processes or institutional changes that create a time-sensitive opportunity for FEDORA to generate relevant evidence (the Vienna Urban Development Plan, the Danish road pricing agenda, the finalisation of the Reggio Emilia's Road Traffic Plan, and the Budapest Danube Bank Building Regulation revision).

### 2.4.2 PAIN POINTS AND DATA GAPS. COMPARATIVE

This section presents a structured comparative analysis of the operational pain points and data availability gaps identified across pilots. The analysis is organised thematically, drawing on the Three Wheels outputs from each "Workshop 1" report. Table 7 (below) maps the primary pain points identified per pilot, grouped by operational domain.

<u>**OPERATIONAL PAIN POINTS**</u>

| Pilot | Primary pain points | Domain |
|---|---|---|

| | | |
|---|---|---|
| Vienna | Inequitable green time distribution; no monitoring of signal plans; incidents not detected automatically; missing data on pedestrians/cyclists. | Urban traffic signal control |
| Basque Country | No shared operational picture across port; nautical services coordinated by phone/manually; truck congestion at port access; manual vessel arrival recording. | Multimodal port logistics |
| Nicosia | Limited real-time traffic visibility; delayed incident detection; no integration between vertiport locations and existing hubs; fragmented data sources. | Urban traffic + UAV integration |
| Copenhagen | Simulation models lack demand management capabilities; calibration costly and manual; scenario configuration requires expert knowledge; no MaaS data in large-scale models. | Transport modelling and policy |
| Reggio Emilia | Drivers use residential streets instead of main corridors; no mechanism to dynamically orient driver behaviour; rigid, unidirectional policy instruments (ZTL, LEZ). | Urban demand management |
| Budapest | Vessel ETAs unknown beyond static schedules; AIS data not trusted (frequency, false data); tourists cannot plan multimodal routes; DÉSZ regulatory change without impact studies. | Inland waterway + multimodal |

Table 6: Primary pain points identified across FEDORA pilots. Workshop 1



## DATA GAPS AND AVAILABILITY

"Workshop 1" identified a consistent pattern across pilots: the most valuable data for FEDORA interventions is also the most difficult to access. Static infrastructure data is generally available as open data or through standard administrative channels. Real-time operational data, commercially sensitive logistics data, and individually traceable movement data are subject to access restrictions that require governance frameworks to resolve.

Specific data gaps by pilot include:

- **Vienna**: real-time pedestrian and cyclist detection data (to be generated via AI-based cameras already installed); C-ITS data access pending confirmation from infrastructure provider.
- **Basque Country:** vessel ETAs and nautical service status in real-time; berth occupancy; truck arrival times at port; stevedore shift data, most currently manual or non-existent.
- **Nicosia**: UAV-based traffic observations pending authorisation; updated cadastral datasets from the Land and Surveys Department; passenger counts by mode.
- **Copenhagen**: MaaS and shared mobility data (pickups and drop-offs) not yet integrated in large-scale models; freight movement data explicitly descoped.
- **Reggio Emilia**: individual driver trip data via black boxes, dependent on TSP agreements and GDPR framework; data format and transmission frequency not yet agreed.
- **Budapest**: consolidated AIS data, (currently low frequency), false positives and missing data; departure/arrival schedule data not digitally integrated; no multimodal journey data including waterway.

## REQUIREMENTS CONSOLIDATION AND MOSCOW PRIORITISATION

"Workshop 1" generated a comprehensive set of requirements across all pilots, captured using Template 2 (Requirements and Needs). Requirements were prioritised using the MoSCoW framework: Must Have (M), Should Have (S), Could Have (C) and Won't Have (W). The full requirements tables per pilot are provided in Annex II. This section presents a consolidated view of the Must Have requirements, which represent the minimum conditions for each pilot to proceed with its planned demonstrations.

Several Must Have requirements appear consistently across pilots, reflecting shared structural dependencies. Three cross-cutting themes stand out:

- **Real-time data access**: all pilots require some form of real-time operational data as a core input. Whether it is traffic counts and signal plans (Vienna), vessel ETAs and nautical service status (Basque Country), traffic and UAV data (Nicosia), field experiment GPS data (Copenhagen), driver trip data (Reggio Emilia) or consolidated AIS data (Budapest), the ability to access, process and act on timely data is a fundamental prerequisite.
- **Data governance frameworks**: five of the six pilots explicitly listed a data governance or data sharing framework as a Must Have requirement. This reflects the consistent finding that technical integration is blocked less by capability gaps than by the absence of agreed conditions for sharing. The FEDORA data space work is therefore an enabler for the entire demonstration programme.
- **Integration with existing systems**: all pilots require integration with at least one existing operational system or platform: the Sitraffic Scala controller (Vienna), the Puertos del Estado portal (Basque Country), the SUMO simulation environment (Nicosia), the official national transport model (Copenhagen), TSP telematics platforms (Reggio Emilia) and the River Information Services (Budapest). This integration layer is both a technical challenge and a governance one, requiring formal agreements with system owners.

| Pilot | Key Must Have requirements | Dependency |
|---|---|---|
| Vienna (VIE-001-006) | Real-time signal optimisation incl. pedestrians/cyclists; integration into existing traffic controllers; continuous monitoring; C-ITS CAM data; pedestrian/cyclist detection | C-ITS data access with infrastructure provider pending confirmation |
| Basque Country (BCO-001-013) | Real-time vessel ETA visibility; nautical service status; data governance framework; truck slot coordination mechanism | Real data commitments required |
| Nicosia (R-001–006) | Real-time traffic data; UAV airspace authorisation; mobility provider data integration; updated infrastructure datasets; anonymisation mechanism | UAV authorisation from Dept. of Civil Aviation — critical regulatory risk |
| Copenhagen (CPH-001–005) | Calibrated simulation with pricing & credit modules; automated calibration; user-friendly scenario tool; computational efficiency; MaaS framework | DTU leads T4.2 implementation; ETH Zurich contributes comparative analysis. Coordination framework to be confirmed. |
| Reggio Emilia (RE-001–007) | TSP partnership framework; GDPR-compliant architecture; 500 participant recruitment; token marketplace; user platform; backend system | GDPR framework and Privacy Authority approval on critical path |

| | | |
|---|---|---|
| Budapest (B-001–005) | DÉSZ impact simulation; AIS data consolidation; real-time ETA sharing; multimodal journey planning incl. vessels; tourist pier information | AIS data can only be used in anonymised form per Ministry regulations; MAHART Passnave data agreement needed for hotel vessel schedules |

Table 7: Must Have requirements summary and critical dependencies per pilot. Workshop 1

The full requirements tables, including Should Have, Could Have and Won't Have items, with justifications, are provided in Annex II. These tables will be updated progressively as the pilot use cases are refined through subsequent co-creation rounds.

## 2.5 "WORKSHOP 1.1" OUTCOMES

This chapter documents the outcomes of "Workshop 1.1", the internal cross-pilot alignment session held online on March 2026. The session brought together all six pilot leaders and FEDORA technical partners to present the "Workshop 1" findings, propose use cases and assess alignment with the Expected Innovations defined in the Grant Agreement. The session was recorded and fully transcribed.

"Workshop 1.1" represented the first formal occasion for pilot leaders and technical partners to jointly review the proposed use cases and assess their feasibility and alignment with the FEDORA toolbox. It is important to note that the use cases presented at this stage are a first vision, not a final definition. Use cases will evolve and be progressively refined throughout Task 6.1 (Pilots Orchestration) and WP6, as technical development matures and stakeholder engagement deepens. The purpose of "Workshop 1.1" was to give technical partners sufficient visibility of the pilots' direction to allow them to reorient their development work if necessary, and to open a structured dialogue between pilots and technical partners that had not yet taken place at this level of detail.

This workshop also served as a catalyst for bilateral engagement between pilots and technical partners. Following the session, several pilots initiated direct conversations with the relevant task leaders to clarify technical dependencies, explore data approaches and refine their use case framing. These exchanges are an integral part of the co-creation process and will be tracked as the project progresses.



### 2.5.1 CROSS-PILOT ALIGNMENT

The cross-pilot patterns and complementarities described in this section represent a first reading of the pilot landscape as it stood at the time of "Workshop 1.1". They are necessarily preliminary: pilots are at an early stage of use case definition, and both the technical scope and the data strategies of individual pilots are expected to progress as the project progresses. The identification of synergies and shared dependencies will be developed progressively through Task 6.1, which will maintain a live view of cross-pilot alignment and document it in Deliverable 6.1. What is presented here is therefore an initial mapping; a basis for coordination rather than a definitive characterisation.

**COMMON APPROACH: SIMULATION**

The most consistent cross-pilot theme that emerged from "Workshop 1.1" was the adoption of a simulation approach. Copenhagen and Reggio Emilia had already defined their pilots as simulation or field experiments respectively, with a clear phasing between data-driven simulation and real-world integration. The Basque Country pilot confirmed that its use cases would proceed in simulation mode at least in the first demonstration round, with real data integration explored progressively in Phase 2. Nicosia similarly identified simulation via the SUMO testbed at UCY as the starting point before field trials.

This convergence around simulation as a first step is not a limitation of the project's ambition; it reflects a mature understanding of the conditions for responsible deployment. Simulation allows pilots to demonstrate the value of FEDORA interventions, calibrate models and build the evidence base needed to engage data holders and regulatory bodies before committing to live data integrations. It also creates a natural coordination point with WP5, which provides the simulation frameworks and tools that all pilots will draw on.

This approach is also fully consistent with the project's positioning along the Technology Readiness Level scale: FEDORA pilots operate at TRL 3-5, where demonstrating feasibility and validating concepts in simulated or controlled environments is both the appropriate and expected mode of work at this stage of the research cycle.

## SHARED DEPENDENCIES ON TECHNICAL COMPONENTS

"Workshop 1.1" also made visible the degree to which pilots share dependencies on the same WP4 and WP5 components. Table below summarises the Expected Innovations that appear across multiple pilot use cases, as confirmed or tentatively confirmed during "Workshop 1.1".

| EI | Description | Pilots where relevant (Workshop 1.1) |
|---|---|---|
| EI3.3 | Mobility hub & corridor optimisation / UAV path planning | Vienna (tentative), Basque Country, Nicosia, Copenhagen (tentative), Reggio Emilia: 5 of 6 pilots |
| EI4.6 | Foresight analysis scenarios generator | Vienna, Copenhagen, Reggio Emilia, Budapest: 4 of 6 pilots |
| EI4.3 | Passenger/freight controllers and journey planning | Basque Country, Nicosia, Copenhagen, Budapest: 4 of 6 pilots |
| EI3.2 | Dynamic pricing & incentivisation using artificial currencies | Copenhagen, Reggio Emilia: shared dependency on ETH (T4.2) |
| EI4.2 | Agent-based demand generation models | Vienna (tentative), Copenhagen, Reggio Emilia: 2 pilots |
| EI3.4 | Complex event processing: incident/event detection | Vienna, Basque Country, Nicosia: 3 pilots |

Table 8: Expected Innovations confirmed as relevant across multiple pilots. Workshop 1.1

EI3.3 stands out as one of the most transversal innovations in the project, appearing across multiple pilots in different forms: hub and corridor optimisation (Basque Country, Reggio Emilia), UAV path planning and vertiport optimisation (Nicosia), and tentatively in Vienna and Copenhagen pending scope clarification. Its breadth of application underlines the importance of a robust and flexible implementation in T4.3.

## CROSS-PILOT USE CASE COMPLEMENTARITIES

Beyond shared dependencies, a first reading of the Workshop 1.1 outputs suggests several potential complementarities between pilot use cases. These are identified here as areas to explore further, not as confirmed synergies:

- **Demand management (Copenhagen and Reggio Emilia):** both pilots address demand management through pricing and tradable credits, one through large-scale simulation (Copenhagen) and one through real-world deployment (Reggio Emilia).

The simulation results from Copenhagen could inform the design of the Reggio Emilia field trial, and the empirical evidence from Reggio Emilia could validate and enrich the Copenhagen model. Both share a dependency on Task 4.2.

- **Vessel arrival data (Basque Country and Budapest):** both pilots require reliable vessel arrival and departure data as a core input. The Basque Country use case depends on reliable vessel arrival and departure data as a core input for its multimodal orchestration layer; the Budapest use case addresses exactly the challenge of making vessel ETA data accurate and accessible through AIS consolidation. A common approach to vessel data integration could benefit both pilots and reduce duplication of effort.
- **Simulation frameworks (multiple pilots):** Copenhagen, Nicosia and the Basque Country all rely on simulation as Phase 1. Coordination through WP5 on data formats, simulation environments and synthetic data generation approaches could generate efficiencies across these three pilots.

## 2.6 USE CASES

The use cases presented in this chapter represent the first iteration of the FEDORA demonstration scenarios, as identified through the co-creation process described in the preceding sections. They have emerged from "Workshop 1", where local stakeholders articulated their operational pain points, data gaps and governance constraints and have been refined and presented to technical partners at "Workshop 1.1".

These are exploratory-first version use cases, framed at a level consistent with the current stage of the project and the TRL at which FEDORA operates. They are not final specifications. They will continue to evolve as technical development in the different work packages, as data strategies are confirmed or adapted at each pilot site, and as the dialogue between pilot leads and technical partners increases.

The development of these use cases (including the identification of shared Expected Innovations, the exploration of cross-pilot synergies, the alignment with the FEDORA toolbox and the progressive integration of real operational data) will be a core activity of Task 6.1 and will be documented in Deliverable 6.1.

It is important to note that these use cases have not been defined top-down from the Grant Agreement. They have been shaped by the actors who experience the operational problems daily (operators, transport authorities, logistics companies, municipalities…) through a structured co-creation process that is at the core of the FEDORA Living Lab methodology.

### 2.6.1 USE CASE IDENTIFICATION METHODOLOGY

The use cases presented in this deliverable emerged from a structured co-creation process in which local stakeholders were the primary source of problem definition, and technical partners contributed by mapping those problems against the FEDORA toolbox and the Expected Innovations defined in the Grant Agreement. The identification process followed three sequential steps:

The first step was initial requirements gathering. Previous to workshops each pilot lead conducted preparatory work within their own ecosystem to identify the key actors to be engaged and gather a first set of operational needs and constraints. MLC-ITS Euskadi supported this process by providing common templates and guidelines to ensure consistency across pilots. This preparatory phase ensured that Workshop 1 was grounded in the specific reality of each pilot site and that stakeholders arrived with a clear sense of what the co-creation process was expected to produce.

The second step was problem articulation. Each pilot site held a local co-creation workshop, bringing together the relevant stakeholders from their ecosystem. The workshops were designed to surface operational pain points, identify data gaps and map governance constraints, without proposing solutions in advance. This approach ensured that use cases would be grounded in real operational needs rather than in what was technically convenient or already available.

The third step was use case framing. Following the first workshop, each pilot lead developed a proposed use case framing based on the outputs of their local workshop. This framing connected the pain points identified by stakeholders to the potential contribution of FEDORA's integration and orchestration capabilities and mapped the relevant Expected Innovations from the Grant Agreement. MLC-ITS Euskadi, as leader of the task, reviewed and consolidated these proposals to ensure consistency of format and language across pilots, and to prepare them for presentation at “Workshop 1.1”.

The fourth step was cross-pilot validation at “Workshop 1.1”. The proposed use cases were presented by each pilot to the full group of pilot leads and technical partners. This session served three purposes: to validate the use case framing with the actors who will be responsible for technical implementation, to identify shared dependencies on WP4 and WP5 components, and to begin mapping cross-pilot complementarities. The outcomes of this session are documented in section 2.5.

The use cases are scoped and described using the following common structure across all pilots: problem statement, FEDORA's potential contribution, data required, actors involved, Expected Innovations covered, and “Must-Have” requirements. This structure is designed to be directly usable as input for Task 6.1 and for the technical development work in WP3-WP5.

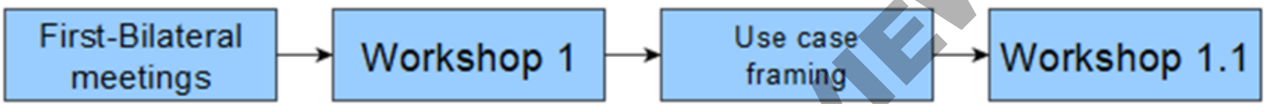



Figure 2: First use cases identification process



## 2.6.2 USE CASE PER PILOT

The use cases presented in this section represent a first iteration emerging from “Workshop 1” and “Workshop 1.1”. They are not final definitions. The detailed use case specification will be developed progressively in coordination with WP4 and WP5 as technical development matures and WP6 as continuous work from the pilot and stakeholders. For pilots where the operational context has evolved since Workshop 1, the use case framing is being actively adapted through Task 6.1 and bilateral engagement with technical partners and will be updated in subsequent deliverables.

### 2.6.2.1 PILOT 1: VIENNA

**Socially balanced traffic signal optimisation: integration of non-motorized road users into real-time signal management.**

The Vienna pilot addresses a structural inefficiency in the city's traffic management system: signal plans are designed and optimised primarily for private motorised traffic and and public transport, leaving pedestrians and cyclists systematically underrepresented in dynamic green time allocation. The consequence is a system that does not fully meet the city's own mobility objectives (the Vienna Urban Development Plan explicitly prioritises non-motorised transport and public transport) while generating unnecessary waiting times for non-motorized road users and failing to adapt dynamically to incidents or disruptions.

FEDORA's potential contribution is the development and integration of a Social Optimum Model (EI3.1) into Vienna's existing traffic light control system. The model would receive real-time data from multiple sources and calculate an optimised distribution of green phases across all transport modes. Optimised signal plans would be sent to the traffic controllers as temporary modifications. A continuous monitoring module would record the impact of active plans and alert on anomalies or gradual degradation.

The data required includes real-time traffic counts and traffic situation data (available from ITS-VIE), real-time detection of pedestrians and cyclists via AI-based cameras already installed on the Donaukanal corridor (AI model in development), public transport timetables from Wiener Linien, and current signal plans from MA33. Access to C-ITS CAM messages is pending confirmation with the infrastructure provider.

The Expected Innovations confirmed as relevant are EI3.1 (core of the pilot), EI3.4, EI3.6, EI4.1 and EI4.6. EI3.3 is marked as tentative pending clarification of scope. EI3.5 has been descoped: no freight operator is involved in this pilot, and the synchromodal dimension is not applicable to the Vienna urban mobility context.

The Must-Have requirements identified are: real-time optimised signal phase plans integrating pedestrian and cyclist preferences (VIE-001), integration into the traffic light control system (VIE-002), continuous monitoring of signal plan impacts (VIE-003), real-time detection of pedestrians and cyclists (VIE-004), real-time traffic situation data (VIE-005) and current signal plans (VIE-006).

#### 2.6.2.2 PILOT 2: BASQUE COUNTRY

**Use case: Multimodal logistics optimisation in the Basque Country port ecosystem.**



The Basque Country pilot addresses a structural information fragmentation problem across the multimodal logistics chain connecting maritime, road and rail freight movements in the Basque Country. The operational challenges identified through the co-creation process are consistent across the ecosystem: vessel arrivals are communicated manually, nautical services are coordinated by phone, there is no shared operational picture available to logistics operators, and the coordination between port operations and terrestrial transport modes is largely reactive. The consequence is a logistics chain where disruptions cascade unpredictably and operators cannot plan ahead effectively.

A second dimension of the problem concerns the optimisation of modal choice for cargo movements. Logistics operators handling freight through the port ecosystem face decisions about whether to route cargo by road, rail or a combination of both; decisions that are often made with incomplete information about timing, availability and relative efficiency of each mode. Historical operational data on cargo movements, handling times and modal transitions exists but is fragmented across actors and not currently used for optimisation purposes.

FEDORA's potential contribution is the development of an integration and orchestration layer that addresses both dimensions. The system would detect key maritime and logistics events and propagate them to the relevant actors in the terrestrial chain, enabling anticipatory rather than reactive behaviour. It would also support the optimisation of multimodal logistics decisions by leveraging available operational data to identify inefficiencies, analyse modal routing options and generate actionable recommendations for logistics operators.

The primary demonstration site is the Port of Bilbao ecosystem, where data availability and stakeholder readiness allow for a first demonstration round. The use case is being developed in coordination with a local technology stakeholder with access to historical operational data from a major logistics operator active in the port, covering cargo traceability, movement types, handling times and modal transition data. This dataset provides a realistic and concrete foundation for the first demonstration round without requiring real-time data integration from the outset. Maritime arrival data (vessel ETAs, port calls, tidal data…) is publicly available through the Port of Bilbao website and Puertos del Estado, so they could complement the traceability dataset.

The demonstration will focus on the Port of Bilbao ecosystem, with potential expansion to Pasaia Port, depending on data availability and stakeholder engagement as the project progresses. The Basque Country has a strong industrial base, particularly in the steel sector, which generates significant freight volumes through its port ecosystem, including industrial coils as a dominant cargo typology. This provides a rich and representative operational context for demonstrating FEDORA's multimodal logistics optimisation capabilities.

The specific use case design and data strategy are being finalised in coordination with technical partners and will be updated in this deliverable before final submission.

The Expected Innovations identified as potentially relevant are EI3.3 (hub and corridor optimisation), EI3.4 (complex event processing), EI3.5 (synchromodal algorithms, subject to confirmation with technical partners) and EI4.3 (freight controllers). Their specific scope and application will be confirmed through WP6 tasks in coordination with technical partners

The Must-Have requirements identified at Workshop 1 remain valid as a first baseline. They will be reviewed and updated as the use case definition progresses through the ongoing co-creation process.

#### 2.6.2.3 PILOT 3: NICOSIA

**UAV-enhanced multimodal corridor: Park & Fly integration and aerial traffic sensing**

The Nicosia pilot addresses two interconnected challenges in urban mobility management:

- The first is the absence of real-time network visibility: traffic management in Nicosia relies on ground-based monitoring that is slow to detect incidents and unable to provide a comprehensive operational picture across the city's fragmented transport network.
- The second is the lack of integration between existing multimodal transport services and emerging aerial mobility options, which prevents the development of seamless multimodal journeys and limits the potential of new mobility technologies to contribute to congestion reduction.

FEDORA's potential contribution combines two complementary roles for UAVs.

- In the first role, UAVs would act as airborne traffic sensors, providing real-time network visibility and enabling dynamic route optimisation and improved incident detection and response.
- In the second role, UAVs would be integrated as a new transport mode through Park & Fly vertiport operations, connecting key urban destinations and allowing part of a journey to shift to the air.

Both roles feed into a unified multimodal optimisation layer that coordinates routing across buses, bikes, scooters and aerial segments. Pilot operations will first be modelled within the SUMO-based ITS testbed at UCY before progressing to field trials, subject to regulatory clearance.

It should be noted that the feasibility of real-time dynamic rerouting, where a UAV-detected incident triggers immediate route changes communicated to passengers already in the network, remains to be confirmed with technical partners. The simulation-first approach at UCY's SUMO testbed is therefore not only a TRL consideration but also a prerequisite for assessing what can realistically be demonstrated in the field.

The data required includes real-time traffic data from ground sensors and public works authorities, UAV-based monitoring data (aerial traffic observations and incident detection), public transport and shared mobility data from bus and micromobility operators, infrastructure and mobility demand data for road network and vertiport location modelling, and updated cadastral datasets from the Department of Land and Surveys, whose current records were identified at Workshop 1 as outdated.

The Expected Innovations confirmed as relevant are EI3.3 (UAV path planning and vertiport location optimisation, EI3.4 (high-resolution incident data collection via UAVs), EI3.6 (response planning and drone path propagation) and EI4.3 (passenger journey planning and cross-modal integration; UAV segments included in multimodal routing).

The Must-Have requirements identified at Workshop 1 are: access to real-time traffic data (R-001), UAV operational authorisation within Nicosia airspace from the Department of Civil Aviation (R-002-identified as a critical risk given the complexity of military geofencing zones linked to Cyprus's political status), access to and integration of data from mobility providers (R-003), accurate road network, hub location and infrastructure datasets (R-004), access to UAV sensing data (R-005) and mechanisms for data anonymisation and secure sharing in compliance with GDPR (R-006).

#### 2.6.2.4 PILOT 4: COPENHAGEN

**Demand management impact assessment: simulation of congestion pricing, tradable credits and MaaS in Greater Copenhagen**

The Copenhagen pilot addresses a gap in the decision-making tools available to national and regional transport authorities. Denmark is considering advancing towards road pricing for passenger vehicles, but the official transport models used by authorities do not currently have the capability to evaluate the impacts of demand management strategies (congestion pricing, tradable mobility credits or MaaS integration) before committing to deployment. The result is that policy decisions of significant economic and social consequence must be made with insufficient evidence. A large-scale field experiment has recently been completed in Denmark, generating a rich behavioural dataset, but no tool currently exists to extrapolate those findings to the Greater Copenhagen network and assess full system-level impacts.

FEDORA's potential contribution is the development and integration of demand management modules (dynamic pricing, tradable credits and MaaS controllers) into the open-source SimMobility simulation model for Greater Copenhagen. There is no activity-based model in the literature that has developed such features and tested in large-scale realistic setting. The system would be calibrated against the Danish road pricing field experiment data, incorporate agent-based demand models capturing how users respond to pricing and credit mechanisms, and provide a scenario configuration and results visualisation accessible to non-expert stakeholders. KPI outputs would cover congestion, mode shares, accessibility, equity and emissions impacts across different policy scenarios.

The data required includes travel survey data and insights from app data collected in the Danish road pricing field experiment, traffic counts and public transport ridership data for model calibration, origin-destination flows and travel times from the existing national transport model, and existing MaaS and shared mobility open data.

The Expected Innovations confirmed as relevant are EI3.2 (dynamic pricing and incentivisation using artificial currencies), EI4.2 (agent-based demand representation models), EI4.3 (passenger and demand management controllers) and EI4.6 (foresight analysis scenarios generator). EI3.3 (multimodal hub optimisation) has been explicitly descoped and EI3.6 is marked as tentative by DTU given the network-wide scale.

The Must-Have requirements identified are: a fully calibrated Greater Copenhagen simulation with congestion pricing and tradable credit modules (CPH-001), calibration against traffic counts and public transport ridership (CPH-002), scenario configuration and results visualisations for stakeholders (CPH-003), a framework for MaaS integration in large-scale simulations (CPH-005) and the evaluation of computational performance to compare against current performance, estimated at approximately four days per full cloud run (CPH-004).

#### 2.6.2.5 PILOT 5: REGGIO EMILIA

**Tradable mobility credits: dynamic pricing and behavioural change for sustainable urban mobility**

The Reggio Emilia pilot addresses persistent air quality problems caused by private vehicle traffic using residential streets instead of main traffic corridors. The Municipality invests in main corridors that operate below capacity while residential areas suffer from congestion not intended for through traffic. Current policy instruments (access restrictions, low emission zones, static signage) communicate rules but do not interact with individual users, do not provide personalised feedback and do not create adaptive economic incentives linked to actual behaviour. The new road traffic plan for Reggio Emilia is currently being finalised, creating a concrete and time-sensitive window for FEDORA to provide empirical evidence that can directly inform policy decisions before the plan is adopted.

FEDORA's potential contribution is the deployment of the first tradable mobility credits system at real scale in Europe. Users would receive credits and spend them based on the kilometres travelled on different types of streets (main corridors versus residential streets). Unused credits could be sold on a marketplace, creating direct economic incentives to shift behaviour towards main corridors. The system would include GPS-based data collection via black boxes installed in 500 participating vehicles, a credit allocation and charging engine, a token trading marketplace, and a user-facing platform, which may be implemented as a web application as well as or instead of a mobile app, through which participants interact with the scheme. The Municipality would retain the ability to adjust scheme parameters and intervene in the market as a governance backstop.

It should be noted that the Move-In regional telematics system was initially explored as a possible baseline for participant recruitment, but was later abandoned due to the low number of users in Reggio Emilia and an incompatible privacy framework. The pilot will proceed with an independent technical implementation, with new TSP partnerships, a new GDPR framework and a new recruitment process. The pilot concept and its final objective remain unchanged. Three further changes compared to the GA description were confirmed during Workshop 1.1: credits will be calculated based on kilometres travelled rather than on the vehicle's emission profile, in order to avoid disadvantaging lower-income groups who typically own older vehicles; the user-facing platform may be a web application in addition to or instead of a mobile app; and ANPR systems have been discarded as a data source, with GPS/GNSS-based black boxes used exclusively.

The data required includes trip data from GPS black boxes installed in participant vehicles, TSP technical specifications for data collection and transmission, and a GDPR-compliant data processing framework, currently in development and subject to formal Privacy Authority review before data collection can begin.

The Expected Innovations confirmed as relevant are EI3.2 (dynamic pricing and incentivisation using artificial currencies), EI3.3 (multimodal journey planner), EI4.1 (simulation framework), EI4.2 (agent-based demand models) and EI4.6 (foresight analysis scenarios generator).

The Must-Have requirements identified at Workshop 1 are: a formal partnership framework with TSP providers for participant recruitment and data access (RE-001), a GDPR-compliant data processing architecture (RE-002), technical specifications for TSP data collection and transmission (RE-003), recruitment of 500 participants with black boxes regularly travelling in Reggio Emilia (RE-004), a token trading marketplace with market rules engine (RE-005), a user-facing platform (RE-006) and a backend system for TSP data processing and market transaction management (RE-007).



#### 2.6.2.6 PILOT 6: BUDAPEST

The Budapest pilot stands out within FEDORA for the breadth of its co-creation outputs: Workshop 1 identified four distinct and interrelated use cases, more than any other pilot site. The four use cases form a coherent and progressive stack, from data infrastructure to operational services to policy support.

**Use Case 1: Danube Bank Building Regulation impact assessment Simulation-based evidence to support the Municipality's regulatory process for the planned changes to Danube Bank Building Regulations from 2027, which could significantly reduce available moorings for sightseeing vessels.**

**Use Case 2: Real-time vessel ETA/ETD service Accurate and accessible departure and arrival times for passenger vessels on the Budapest Danube, based on consolidated AIS data and shared with all relevant actors in real time.**

**Use Case 3: AIS data consolidation Improvement of AIS data quality through frequency enhancement, missing data estimation and false data filtering (a prerequisite for Use Case 2 and a foundation for the other use cases).**

**Use Case 4: Multimodal tourist journey planner Integration of sightseeing and hop-on/hop-off Danube vessels into a multimodal journey planner combining river services with bus, metro and micromobility, with potential integration into the future Budapest GO! application.**

The breadth of the use case portfolio (four interrelated use cases) was discussed during Workshop 1.1. The pilot lead acknowledged that covering all four use cases in full may require significant technical resources. The prioritisation of use cases will be defined in coordination with technical partners, with Use Cases 2 and 3 (the ETA service and AIS consolidation, which are directly interdependent) likely forming the core of the first demonstration round.

The pilot addresses the operational isolation between inland waterway transport on the Danube and the city's road and public transport network. Vessel departure and arrival times are communicated informally between skippers via VHF radio, with no structured digital record accessible to downstream actors. AIS data (the primary source of vessel position information) is not trusted by operators due to insufficient update frequency, false readings and missing data points. Tourists cannot plan multimodal journeys that include Danube vessels, as no integrated journey planner exists. At the same time, the Budapest Municipality is preparing a change to the Danube Bank Building Regulations from 2027 that could significantly reduce available moorings, without any simulation-based evidence to inform the decision.

FEDORA's potential contribution addresses these challenges through the four use cases described above. Use Case 1 would provide simulation-based impact analysis to support the regulatory process, giving vessel operators and authorities data-backed evidence for a decision currently guided only by experience. Use Case 2 would deliver a real-time vessel ETA and ETD service accessible to all relevant actors (vessel operators, tourist agencies, event organisers and public transport coordinators) based on consolidated AIS data. Use Case 3 addresses the root cause of the ETA service limitations through the consolidation and improvement of AIS data, creating a more reliable data foundation for all other use cases. Use Case 4 would integrate sightseeing and hop-on/hop-off vessels into a multimodal journey planner with potential integration into the future Budapest GO! application.

Use Cases 2 and 3 are directly interdependent: without reliable consolidated AIS data (UC3), accurate real-time ETAs (UC2) cannot be provided. UC3 is therefore a prerequisite for UC2, and both feed into UC4.

The data required across the four use cases includes inland AIS data from Hungarian River Information Services, vessel schedule and operational data from vessel operators, public transport and micromobility data from BKK and mobility operators, and infrastructure and regulatory data from the Budapest Municipality and relevant public authorities.

The Expected Innovations confirmed as relevant are EI4.1 (waterborne and land simulation models - UC1 and UC3), EI4.3 (passenger journey planning and cross-modal integration - UC2 and UC4), EI4.4 (complex event processing for missing and false AIS data estimation - UC3) and EI4.6 (foresight analysis and cross-modal network management - UC1 and UC4).

The Must-Have requirements identified at Workshop 1 are: simulation-based support for the Danube Bank Building Regulation change process (B-001), AIS data consolidation including frequency improvement, missing data estimation and false data filtering (B-002: prerequisite for UC2, UC3 and UC4), real-time vessel departure and arrival data sharing with all relevant actors (B-003), integration of sightseeing and hop-on/hop-off vessels into multimodal route planners (B-004) and tourist information on pier locations, bus parking and nearest public transport and micromobility connection points (B-005).

### 2.6.3 VALIDATION WITH TECHNICAL PARTNERS

Use case validation with technical partners is an ongoing process that began at Workshop 1.1 and will continue throughout the project through the subsequent co-creation rounds. It is not a single event but a progressive dialogue between pilot leads, who bring operational knowledge and stakeholder perspectives, and technical partners, who contribute expertise on what the FEDORA toolbox can realistically deliver at each stage of development.

### 2.6.4 COMPLEMENTARY AND CROSS-PILOT USE CASES

The use cases identified represent a first iteration. As the project progresses, they are expected to evolve; they may be refined in scope, subdivided into more specific sub-cases as technical development clarifies what is feasible, or expanded to incorporate new data sources and partnerships as they are confirmed. In some cases, complementarities between pilots may give rise to shared approaches or coordinated demonstrations that were not visible at this stage of the project. This is inherent to the Living Lab methodology and to the TRL at which FEDORA operates.

The cross-pilot complementarities identified in this section should therefore be read as areas of potential coordination rather than as confirmed synergies. Their formalisation and progressive development is part of the ongoing work of WP6 and will be documented in the Deliverables. This section complements the cross-pilot analysis presented in section 2.5, adding a use-case-oriented reading of the patterns identified there.



<u>Demand management and pricing mechanisms: Copenhagen and Reggio Emilia</u>

The most direct complementarity identified across pilots connects Copenhagen and Reggio Emilia, both of which address demand management through pricing and tradable credits. Copenhagen approaches this through large-scale simulation of Greater Copenhagen, while Reggio Emilia deploys a real-world field experiment with 500 participants. The two pilots are not duplicating effort; they are operating at different scales and with different methodologies, but their shared dependency on Task 4.2 artificial currency models, creates a natural coordination point. The simulation results from Copenhagen could inform the design parameters of the Reggio Emilia experiment, and the empirical behavioural evidence from Reggio Emilia could validate and enrich the Copenhagen model. As both pilots mature, there is potential to develop shared KPI frameworks and comparable evidence on how users respond to tradable credit mechanisms across different European urban contexts.

<u>Vessel arrival data and maritime event management: Basque Country and Budapest</u>

A second complementarity connects the Basque Country and Budapest pilots around a shared operational challenge: the availability and reliability of vessel arrival and departure data. Both pilots depend on structured maritime event data as a key input, and both face similar technical challenges in making that data reliable, accessible and actionable for downstream actors. While the two pilots operate in very different port contexts (a major maritime port in the Atlantic and an inland waterway in Central Europe) the approaches being developed in Budapest for AIS consolidation could inform data integration strategies in the Basque Country, and vice versa.

<u>Simulation frameworks and synthetic data generation: Copenhagen, Nicosia, Basque Country and Budapest</u>

A third complementarity cuts across three pilots that share a dependence on simulation as their primary mode of operation in the first demonstration round. Copenhagen relies on SimMobility for large-scale agent-based simulation, Nicosia uses the SUMO-based ITS testbed at UCY and the Basque Country will generate port logistics data to demonstrate its use cases before real data integration becomes possible. All three pilots will draw on WP5 simulation frameworks and tools, and all three face the challenge of generating synthetic or calibrated data that is realistic enough to produce meaningful results. Coordination through WP5 on data formats, simulation environments and data generation methodologies could generate significant efficiencies across these three pilots and avoid each one solving the same problem independently. Budapest also relies on simulation as part of its Use Case 1, which requires the modelling of demand scenarios for inland waterway transport. Its inclusion in this coordination effort is therefore relevant, particularly in relation to the simulation environments and synthetic data generation methodologies developed under WP5.

Shared Expected Innovations across multiple pilots

Beyond these thematic complementarities, section 2.5 has documented the degree to which individual Expected Innovations are shared across pilots, reflecting the breadth of application of the FEDORA toolbox across very different operational contexts. The identification and monitoring of these shared dependencies will be an important activity of WP6, ensuring that technical development priorities are informed by the full picture of pilot needs rather than by individual requests. The mapping of Expected Innovations to pilots will be progressively refined as use cases are finalised.

# 3 PART 2: SPACES DEFINITION & EVALUATION MODELS

## 3.1 SPACES DEFINITION AND FRAMEWORK ARCHITECTURE

This section presents the overall architecture for the technical work of the FEDORA project. Two distinct approaches have been followed regarding the technical work during this initial design and definition phase, working complementary to each other: on the one hand, we provide a top-down view of the overall architecture that offers a high-level conceptual understanding of how all the technical elements of the project are meant to come together into coherent complex solutions; and on the other hand, we present a bottom-up approach that begins at the technical component level with each individual component being defined in isolation via its scope, functionality, inputs, and outputs.

At the core of this dual process lies the interface between the two approaches, which is identified here as each component being required to only provide a definition for its core functionality, inputs, and outputs at this point, without considering dependencies with other components. This interface provides increased flexibility for both approaches, allowing the top-down approach to consider the optimal overall framework for information flow without significant restrictions since no dependencies exist between specific components, while also allowing each technical partner to focus their expertise on their particular components and describe how they work, without restricting their work due to dependencies.

In the following section we will be presenting both the conceptual high-level architecture, as well as the technical component definitions in their current form. This report will not go into detail on how specific components will combine into more complex solutions or their implementation for particular pilots and use cases. That process will be presented in future deliverables, when the technical work has matured more and once solutions have begun forming for the pilots.



### 3.1.1 CONCEPTUAL FRAMEWORK ARCHITECTURE

At this point in the project work progress, we present the conceptual architecture at a high-level using general principles, without the inclusion of technical details on how specific components combine into full-fledged solutions. This choice is motivated by two main reasons: first, to make it accessible and comprehensible to external audiences, without requiring extensive technical knowledge; and second, to offer an overview to FEDORA technical partners in future months during the design, development, and implementation of the various FEDORA tools and solutions, providing them with high-level understanding of how each component will fit in the overall picture. Future reports and deliverables will focus more on the technical implementation of the solutions (D3.1/2, D4.1/2, D5.1/2 on Month 15).

FEDORA categorizes its technical work into three distinct groups, called Spaces. A Space contains a range of tools, solutions and components, each with distinct functionality and aims, all of them related to the containing Space's overarching responsibility. Furthermore, each Space has a clear goal that all its components share and contribute towards, as well as clear inputs and outputs. The three Spaces of the FEDORA project are: the Data Space, the Network Management Services Space, and the Simulations Space. A summary description of their functionality as well as inputs and outputs are shown in Table 10.

| Name | Functionality | Input | Output |
|---|---|---|---|

| | | | |
|---|---|---|---|
| **Data Space** | Facilitating secure and trusted data sharing within the FEDORA platform | Raw data from external sources | Harmonized and enriched data |
| **Network Management Services Space** | Generating traffic network optimization solutions | Data for analysis | Optimization strategies |
| **Simulations Space** | Providing simulation testbeds for exploring scenarios and solutions | Data and optimization strategies for simulation setup | Scenario simulation results |

Table 9: FEDORA Spaces functional characteristics

All components identified within each of the three FEDORA Spaces are designed in an autonomous manner. Each component defines its inputs, outputs, processes, and characteristics, without having explicit dependencies on other FEDORA components where possible. This approach enables for components to be re-used in different contexts without significant modification. This modularity allows for increased flexibility in combining various components from multiple Spaces together into the more complex solutions that will ultimately be deployed and evaluated during the pilot phase of the project.

In addition to the three Spaces defined above, we also consider a fourth functional element at the conceptual level of the architecture, that of the Facilitator. The Facilitator is the framework that enables the various FEDORA components to communicate with one another, and includes any additional systems and interfaces needed to connect the FEDORA components together into full solutions. These additional systems and interfaces may take any form as needed, including catalogues, APIs schemas, databases, and UI interfaces that are being designed and developed as part of T2.5, and as such the particular details of these are not relevant in this deliverable and will be presented in future deliverables (D2.3, D2.4). We highlight the consideration of the Facilitator at this point only to clarify that each of the three FEDORA spaces and their components are designed as stand-alone systems, and it will be the responsibility of external systems to facilitate the connections between them; at this stage we group all of these external systems and frameworks under the term Facilitator, however we expect that the term may be updated/refined in the future. Each distinct deployment of a FEDORA solution will require the deployment of a Facilitator, set up according to the needs of each pilot use case, that will be tasked with routing information from one component to another, and to the final users via user interfaces where needed. The Facilitators used for each use case will be set up in an ad-hoc manner with the user interfaces provided in different formats according to use case needs, including mobile applications, web interfaces, and others, as needed.

A diagram of the full conceptual architecture of the FEDORA Spaces system is presented in Figure 3. This architecture, where each component defines its functionality, inputs, and outputs provides the flexibility to build more complex solutions: for each unique Use Case a solution is built without having to develop bespoke components each time, but rather by combining the base components in different configurations as needed. This results in components being re-used in multiple use cases and in different combinations each time, allowing for extensibility and interconnection between Spaces, as dictated by each use case requirements.

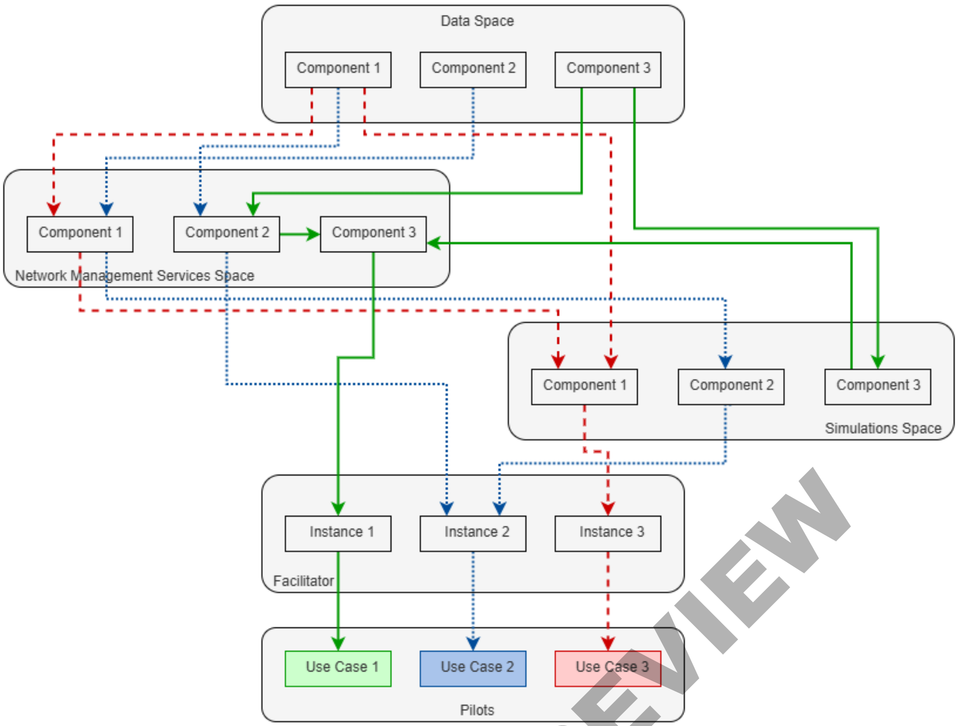



Figure 3: FEDORA Spaces Conceptual Architecture

### 3.1.2 SPACES DEFINITION

Following on the principle of clear aims and interactions of each Space as defined above, this section will go into more detail regarding each Space.

#### 3.1.2.1 DATA SPACE

The Data Space provides the framework through which all data sharing within FEDORA will take place. The workflow of the FEDORA Data Space is to first receive datasets from relevant trusted sources; secondly to enrich and harmonize all data sets so that they are available at the FEDORA standards; and finally, to make them available to the various FEDORA solutions in the appropriate data formats.

The Data Space is the Space within the FEDORA system that connects most with systems external to FEDORA, identified mainly as the various data sources that feed into the various FEDORA solutions. Additionally, it provides traffic and other relevant data to the Network Management Services Space to be used for analysis and optimization strategy calculation, and it feeds data (geospatial, traffic, and others as needed) to the Simulations Space, to be used for the set up and calibration of simulation tools and models.

The components identified and defined thus far in the Data Space are the following:

1. FEDORA Public Catalogue.
2. Mobility Data Harmonisation, Enrichment & Synthetisation Engine.
3. RAG Search System.
4. Smart Data Contracts Module.
5. Dataspace Connector.

### 3.1.2.2 NETWORK MANAGEMENT SERVICES SPACE

The Network Management Service Space collects all services and algorithms whose aim is to calculate network optimization strategies in one form or another. Each component receives a number of relevant traffic datasets as input, analyses them, and generates a set of strategies or solutions that aim to improve some aspect in the traffic network.

The Network Management Services Space as a whole receives inputs in the form of data sets via the Data Space. Occasionally data sets may also be received via the Simulations Space when real-world data is not available. Its main outputs are toward the Simulations Space, in the form of strategies and solutions to be deployed and evaluated in a simulation environment, and towards the Facilitator instances to be forwarded to the final recipients, when only analysis results are required.

The Network Management Services Space has the following components identified and defined thus far:

1. Traffic signal timings optimizer using a social optimum model.
2. Traffic counters using computer vision.
3. Dynamic pricing and incentivization models.
4. UAV path-planner.
5. Multimodal journey planner.
6. Multimodal hub location optimization.
7. Time-series analysis tools (Complex Event Processing Engine).
8. Synchromodal freight routing optimization.
9. Dynamic incident response planner.



### 3.1.2.3 SIMULATIONS SPACE

The Simulations Space contains all the simulation tools and supporting functionality that will be used to explore and evaluate scenarios and strategies in silico. As a broad guideline, components in the Simulations Space will be set up and calibrated on relevant datasets received via the Data Space, will receive a strategy or scenario from the Network Management Services Space and execute it within a simulated controlled environment, and will make available the results for further analysis or decision-making.

The Simulations Space receives input in two major ways: first, in the form of data sets (geospatial, traffic, demographic, and others as needed) from the Data Space to be used for setting up and calibrating the various simulation models deployed within the FEDORA system; and second, potential optimization strategies and solutions from the Network Management Services Space, whose impacts will be evaluated in a controlled environment.

The various tools in the Simulations Space are the following:

1. Multimodal simulation engines framework
2. ABMs for user behaviour
3. Controllers for multimodal services
4. Model-agnostic modular simulation platform
5. Sim2Real techniques
6. Foresight scenario generation and evaluation

## 3.1.3 COMPONENT SPECIFICATIONS

This section includes the component specifications for each component developed in the FEDORA system. Specifications in this section are provided as a high-level overview, with each component describing its core functionality and characteristics, and outlining its expected inputs and outputs with specific formats where known. Detailed technical descriptions of the components will be provided in future deliverables from WP3, WP4, and WP5. The technical component descriptions presented here have been defined using a technical components specification sheet, standardized across the FEDORA project. The technical component specifications template that has been shared to technical partners is included in Annex V, for reference.

The component definition process is still at an initial stage, and therefore some information is still to be determined (marked as TBD). Additionally, there are components that have not been defined to an adequate degree yet and therefore do not have a component specification sheet included in this section. Finally, component specifications are expected to change and adapt to practical needs as identified during the implementation phase, and for this reason the component specifications sheet includes versioning, to account for this need.

#### 3.1.3.1 FEDORA PUBLIC CATALOGUE

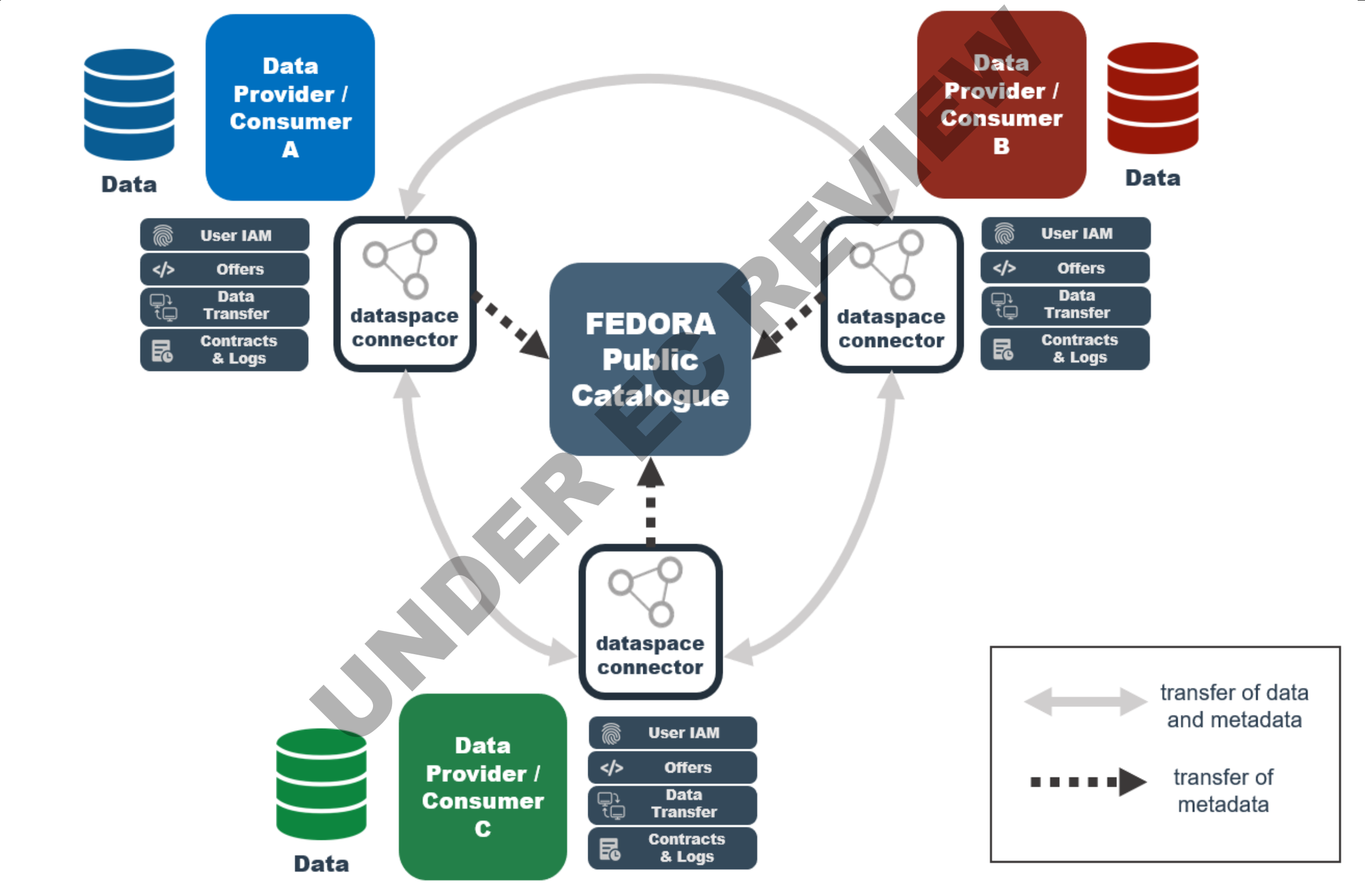
| **Overview** | | | |
|---|---|---|---|
| Component name: | FEDORA public catalogue – T3.2 | | |
| Created by: | AKKODIS - AKKIS | Document version: | 0.3.x |

| **Purpose** |
|---|
| **The FEDORA Public Catalogue** is a publicly accessible catalogue that lists all the data available within the data space. It serves as a central component, providing a single, publicly visible point of access, in contrast to decentralized connectors that operate behind the scenes. |
| **Description** |
| Data providers can specify whether a particular dataset should be publicly visible. Datasets marked as public appear in the public-facing catalogue, allowing any user to see what data is available, without disclosing which participant provides each dataset. This "honeypot" approach is intended to attract potential participants to the data space. Access to these datasets requires joining the data space, thereby converting interested users into active members.<br><br>**<u>Synchronisation with Data Offers and Harvested Metadata</u>**<br><br><u>- Connector Data Offers</u><br>The catalogue synchronizes with data offers from decentralized connectors within the data space.<br>When a data provider registers or updates a dataset via a connector, the public-facing catalogue automatically reflects its metadata if the dataset is marked as publicly visible. This ensures consistency between the source connectors and the public catalogue, avoiding outdated or incomplete information.<br><br><u>- Harvested Open Data Metadata</u><br>The catalogue can ingest metadata from external open data portals through harvesting mechanisms (e.g., using CKAN-to-CKAN harvesting, or DCAT feeds). Harvested datasets are normalized and integrated into the catalogue, providing users with a unified view of both internal and external data offerings. Metadata from harvested sources can be enriched or tagged to align with the data space taxonomy.<br><br><u>- Automated Update and Validation</u><br>Synchronisation processes run on a scheduled basis or trigger-based updates to ensure that any changes in source datasets are reflected in the public catalogue. Validation checks ensure metadata completeness and quality, maintaining a reliable user experience.<br><u>- Visibility and Access Control</u> |

| |
|---|
| Even after synchronization, the catalogue enforces visibility rules: only datasets approved for public display appear. Users are not able to see provider identities unless explicitly permitted, maintaining the “honeypot” functionality.<br><br>- Unified Search and Discovery<br>All synchronized datasets, whether from connectors or harvested sources—are available in the same search interface. This allows seamless exploration and discovery without differentiating the source, while still ensuring metadata provenance is traceable internally. |
| **Interfaces** |
| How the Public-Facing Catalogue fits in the Data Space Architecture<br><br>- Central Entry Point: The public-facing catalogue acts as the primary interface for discovering datasets in the data space. It provides a unified, user-friendly view of available datasets, whether they originate from internal data offers or harvested external sources.<br>- Interface Between Public and Private Layers: While connectors and internal services manage private or restricted datasets, the public catalogue exposes only datasets marked as publicly visible. This separation allows safe exploration without compromising access control or participant confidentiality.<br>- Synchronization Hub: The catalogue synchronizes automatically with decentralized connectors and harvested metadata sources. It ensures that public users see up-to-date information, acting as the “face” of the data space.<br>- Onboarding and Participant Attraction: By showing public datasets without revealing provider identities, the catalogue serves as a “honeypot” to attract new participants. Interested users must join the data space to access full datasets, helping grow the community and encourage active participation.<br>- Interoperability: The catalogue supports metadata standards (e.g., DCAT-AP and mobilityDCAT-AP) to maintain interoperability across the data space and outside.<br>- Search, Discovery, and Analytics Layer (cf. T3.4): Provides advanced search, filtering, and navigation for all publicly visible datasets. |
| **Dependencies and assumptions** |

| | |
|---|---|
| Input Data | - Dataset Metadata from Connectors<br>- Harvested Open Data Metadata<br>- System Metadata (e.g. Connector sync status, Harvesting job logs, Metadata validation reports)<br>- Reference / Enrichment Data<br>- Spatial / Geographical Data (optional), supporting map-based search or geospatial filtering. |
| Output Data | - Public Dataset Listings: display all publicly visible datasets for browsing and discovery.<br>- Metadata Records: provide structured metadata for external integration and machine consumption.<br>- Search Results: provide filtered datasets based on user queries.<br>- Dataset Previews / Sample Data: give users a glimpse of the dataset content without full access. |
| Assumptions | - CKAN compatibility: The CKAN software solution is broadly compatible with the core requirements of the public-facing FEDORA data space catalogue, including discovery, metadata standards, access control, and harvesting.<br>- Dataset Visibility Choice by Providers: All data providers will correctly indicate which datasets can be made public. |

| | |
|---|---|
| | - Metadata Completeness and Quality: Datasets synced from connectors or harvested from external sources contain sufficient and accurate metadata (title, description, keywords, formats, spatial/temporal coverage).<br>- Synchronization Reliability: Connectors and harvesting mechanisms will reliably push or pull updated metadata on a regular basis.<br>- Standardization of External Metadata: Harvested open data metadata from external portals will follow compatible standards (DCAT-AP, CKAN JSON) or can be normalized without major loss of information.<br>- Metadata Update Frequency: Updates to datasets (new versions, corrections) will be reflected promptly in the public catalogue. |
| **Diagrams** | |




| Non-functional requirements | | |
|---|---|---|
| Operational Performance | Availability | TBD |
| | Frequency | Metadata Synchronization from Connectors |

| | | |
|---|---|---|
| | | • Frequency: near real-time or scheduled hourly/daily depending on connector capabilities<br>Harvesting of External Open Data Metadata<br>• Frequency: Daily or weekly depending on external portal update frequency.<br>• Purpose: Keep harvested datasets from open data portals current without overloading source systems.<br>Search Index Updates<br>• Frequency: Near real-time to hourly, depending on CKAN's search backend (Solr).<br>• Purpose: Ensure that any new or updated datasets are immediately searchable by users. |
| | Latency | TBD |
| Manageability and Maintainability | Monitoring | To be defined |
| | Extensibility | CKAN supports standard metadata schemas and UI extensions |
| Security | Authorization and Authentication | - General Public (Unauthenticated Users)<br>Access Level: Read-only access to public metadata.<br>- Administrators / System Operators<br>Access Level: Full system-level access.<br>Manage users, roles, and permissions. |



| **Additional Information** | |
|---|---|
| Notes and Issues | In summary, this centralized public-facing metadata catalogue should synchronize with decentralized dataspace connectors on the one hand and external harvested sources on the other. This approach is a hybrid architecture combining a central discovery index with distributed data ownership. In this model, connectors would actively push metadata updates to CKAN via calls to the CKAN API, enabling near real-time synchronization. This push-based mechanism can be contrasted with the harvesting approach (pull-based) traditionally used by CKAN for collecting open data from data portals - such as the National Access Points (NAPs).<br>The advantages of a push-based approach are freshness, reduced latency, and better alignment with dataspace event-driven paradigms, but there are drawbacks related to reliability (what if CKAN is down), authentication, versioning, and schema alignment (the CKAN metadata model might differ from the connector's one).<br>An important aspect that emerged during the Advisory Board meeting, is the alignment with EMDS Interlinking Layer as a conceptual component within European dataspace architectures. Even though this interlinking layer does not currently exist as an operational software component, its concept is already rather well defined. The Interlinking Layer extends beyond simple indexing to include semantic alignment and relationship discovery |

| | |
|---|---|
| | between datasets. In contrast, the CKAN-based central catalogue defined here acts as a metadata indexing and search layer and would represent only a partial implementation of the broader interlinking functions envisioned in EMDS.<br><br>This means that, depending on the progress of the interlinking layer at the European level, the concept described here will need to be adapted, potentially by adding this layer as an intermediary between the connector and the catalogue. By the way, the Task 3.3 "Dataset harmonisation and enrichment for complex data exchanges" seems to correspond broadly to the interlinking layer in its harmonisation and enrichment aspects (even though it extends beyond it when it includes synthetisation), and the potential connections could be further examined as part of this task.<br><br>The term "(Metadata) Synchronisation Hub" we proposed here seems a suitable designation for the functionality we intend to deliver, as it reflects a central coordination role between connectors and the catalogue while remaining compatible with both push and potential hybrid synchronization models. However, renaming may be considered at a later stage in case an alignment with the EMDS interlinking layer is achieved, in order to avoid confusion. |

#### 3.1.3.2 MOBILITY DATA HARMONISATION, ENRICHMENT & SYNTHETISATION ENGINE



| **Overview** | | | |
|---|---|---|---|
| Component name: | [MDHESE] Mobility Data Harmonisation, Enrichment & Synthetisation Engine – T3.3 | | |
| Created by: | Eider Irigoyen – VICOM | Document version: | 0.3.0 |

| **Purpose** |
|---|
| To provide a unified operational component that harmonises, enriches, and synthesises heterogeneous mobility-related datasets in order to enable seamless, interoperable, and high-quality data exchanges across the mobility data space.<br>**TBD**: *To be confirmed in D2.3 will it be a service offered by the data space marketplace? Will it be the data provider using this component to publish "clean" data? Or will it be the data consumer using the component to "clean" the data they have received? --> Perhaps Akkodis or Front, who have a more global view of the dataspace, have a clearer idea or can help define this.* |
| **Description** |
| The Mobility Data Harmonisation, Enrichment & Synthetisation Engine (MDHESE) is a configurable and extensible component responsible for transforming heterogeneous datasets into harmonized, enriched, and synthetically augmented data products.<br><br>**1. Dataset Harmonisation**<br>• Normalisation of formats, units, semantics, and metadata.<br>• Resolution of ambiguities in data representation (e.g., naming conflicts, schema variations, inconsistent codifications).<br>**2. Dataset Enrichment**<br>• Integration of contextual metadata (e.g., geospatial context, timestamps, provenance). |

- Linking and fusion with external or complementary datasets.
- Rule-based or AI-driven augmentation of missing fields.

**3. Dataset Synthetisation**

- Generation of synthetic datasets through advanced techniques (simulation, generative models, statistical modelling).
- Creation of realistic synthetic mobility data to support testing, validation, and scenarios where real data is scarce or incomplete.
- Compatibility with static and dynamic data types, including network graphs, IoT/sensor data, and real-time streams.

| **Interfaces** |
|---|
| The component will expose a RESTful API providing multiple methods for dataset ingestion, harmonisation, enrichment, and synthetisation. Through this unified interface, external systems will be able to submit raw data, initiate transformation processes, and retrieve the resulting harmonised or synthetic datasets. The API will follow standard web protocols to ensure interoperability and seamless integration within the mobility data space. |

| **Dependencies and assumptions** | |
|---|---|
| Input Data | (Format TBD)<br>Heterogeneous mobility datasets, including, for example:<br>- Network graphs (transport networks, routes, nodes/edges)<br>- Sensor and IoT data (traffic, environmental sensors)<br>- Static datasets (infrastructure, registries, maps)<br>- Dynamic datasets (real-time traffic, vehicle telemetry)<br>- Semi-structured or unstructured data where applicable<br>Metadata describing schema, provenance, quality, and context. |
| Output Data | (Format TBD)<br>- Harmonized datasets.<br>- Enriched datasets with added context, metadata, and linked information<br>- Synthetic datasets simulating realistic mobility behaviour |
| Assumptions | - Datasets may arrive with incomplete, inconsistent, or ambiguous structures.<br>- Data providers expose minimum metadata for ingestion (source, timestamp, dataset type).<br>- The component is part of a wider mobility data space architecture that ensures secure and governed data exchange. |

| **Diagrams** |
|---|
| Conceptual Component Diagrams that can help in component understanding (if available)<br>TBD |

| **Non-functional requirements** |
|---|

| | | |
|---|---|---|
| Operational Performance | Availability: | The component is always running and publicly (in the scope of the Data Space) available at all times, listening for incoming requests. |
| | Frequency: | The component operates reactively, per request. There are no expected regular outputs |
| | Latency: | TBD |
| Manageability and Maintainability | Monitoring: | TBD |
| | Extensibility: | TBD |
| Security | Authorization and Authentication: | Access to the MDHESE will be available only to authorized users. Authorized users are generally expected to be all of the participants in the FEDORA Data Space (both as Data Providers and Data Consumers) |

| **Additional Information** | |
|---|---|
| Notes and Issues: | Any additional information |



### 3.1.3.3 RAG SEARCH SYSTEM

| **Overview** | | | |
|---|---|---|---|
| Component name: | RAG Search System – T3.4 | | |
| Created by: | AKKODIS - AKKIS | Document version: 0.1 | 0.2.0 |

| **Purpose** |
|---|
| This component provides a user-facing search and question-answering system using a Retrieval-Augmented Generation (RAG) approach. It allows users to interact with data from FEDORA. |
| **Description** |
| This RAG Search System uses a self-hostable, open-source, LLM application platform and RAG orchestration framework (e.g. *Dify*) to provide a conversational interface and manage retrieval workflows. It replaces/extends the CKAN dataset metadata search by redirecting the search queries to this system.<br><br>Main functions:<br><br>- Retrieve and rank relevant CKAN datasets using a hybrid approach (semantic + keyword search + knowledge graph) on the metadata.<br>- Store and manage embeddings using a Vector Database (embedded within the framework, i.e. Weaviate).<br>- Periodically synchronize data between CKAN and the Vector Database using scheduled scripts and the application framework API (CRON-based diff system).<br>- Allow direct chat-based interaction where users ask natural language questions, and the RAG system retrieves and generates responses. |

- Integrate VicomTech's Knowledge Graph API also based on the CKAN metadata datasets for better context before fusion ranking.

The system currently works with a RAG pipeline but may evolve into a more adaptive "agentic" pipeline where the LLM uses tools to dynamically decide retrieval and reasoning steps.

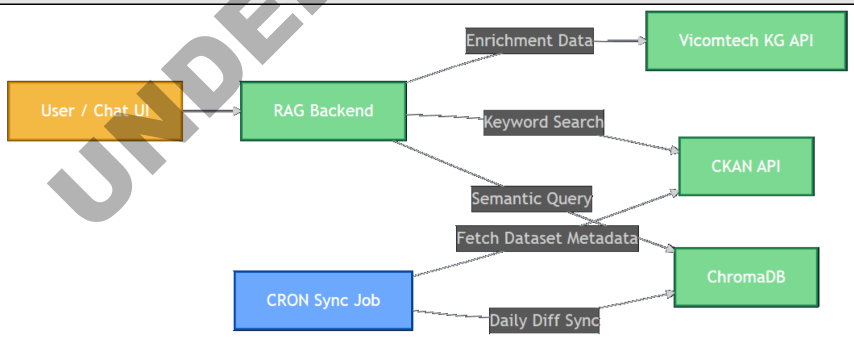
**Interfaces**

- Frontend interface: Web-based chat and search UI (provided by the RAG platform or a using a custom integration).
- Backend (internal): RAG orchestration system (API endpoints, workflow logic, and data retrieval).
- Database interface: Vector DB managed natively by the RAG framework.
- External APIs:
    - CKAN REST API: dataset metadata and search access.
    - Vicomtech's Knowledge Graph API: potentially REST, TBD.

**Dependencies and assumptions**

| | |
|---|---|
| Input Data | - Metadata retrieved from CKAN datasets (JSON format).<br>- User's query and historic (JSON format). |
| Output Data | - Ranked results and structured responses for user queries (JSON). |
| Assumptions | - Assumes CKAN instance and API is reachable and stable.<br>- Assumes Vicomtech's KG API is reachable and stable.<br>- Assume LLM API is available (model up and running).<br>- Availability of the Vector Database within the RAG framework.<br>- Assume consistent CKAN dataset metadata format for synchronization scripts. |

**Diagrams**




**Non-functional requirements**

| | | |
|---|---|---|
| Operational Performance | Availability | - The orchestration service is designed to run continuously, responding to user search/chat requests at any time.<br>- The periodic synchronization scripts run automatically without manual triggering. |
| | Frequency | - The RAG service operates on demand (when users query).<br>- The synchronization job runs periodically, default frequency TBD. |

| | | |
|---|---|---|
| | Latency | - Expected query response time < 5-8 seconds for simple queries under normal load; could increase depending on KG and CKAN API response time, and LLM availability. |
| Manageability and Maintainability | Monitoring | - System health checked can be done using logs, framework's API heartbeat endpoint, and CRON job status reporting. Errors and warnings logged in standard format. |
| | Extensibility | - The framework's architecture allows easy extension of retrieval sources, addition of new tools, or switching LLM providers.<br>- It is still reliant on the CKAN keyword search API. |
| Security | Authorization and Authentication | - End-user frontend access fully open (for now, could add framework-level authentication if necessary).<br>- Backend and admin platform not open to public; requires internal network access and secure credentials.<br>- KG API (VicomTech) is secured using authentication by token (Exact protocol TBD). |

| **Additional Information** | |
|---|---|
| Notes and Issues: | - Knowledge Graph integration awaits final API specification from VicomTech.<br>- Evaluation metrics and quality assessment pipeline are TBD.<br>- Deployment config (docker for the framework and databases) to be defined based on FEDORA infrastructure guidelines. |

#### 3.1.3.4 SMART DATA CONTRACTS MODULE

| **Overview** | | | |
|---|---|---|---|
| Component name: | Smart Data Contracts Module (SDCM) - T3.5 | | |
| Created by: | Kostas Cheliotis – FRONT | Document version: | 0.3.1 |

| **Purpose** |
|---|
| The Smart Data Contracts Module (SDCM) is a component embedded in the Data Space (WP3). Its primary objective is to record and verify all data-sharing activities between partners in the Data Space. |
| **Description** |
| The SDCM is tasked with keeping records of all data transactions taking place in the FEDORA Data Space, as well as providing data space participants with a method to verify transactions and agreements. The SDCM will be implemented via blockchain technology, establishing a decentralized system for data-sharing among partners.<br><br>The expected main tasks of SDCM are to:<br><br>1. Record all data-related transactions in an immutable and secure format<br>2. Verify dataset and transaction authenticity and integrity<br><br>Based on the required actions discussed above, the SDCM has the following two distinct sub-components: |

| |
|---|
| 1. The transaction history<br>2. The queries interface<br><br>The Transaction History component automatically records any data transaction that happens in the data space, in an immutable format. Furthermore, the transaction history is stored in a blockchain ledger shared by all data space participants, ensuring that no tampering may take place.<br><br>The Queries Interface provides an API for data space participants to request specific information regarding the history of transactions. It essentially provides a user-friendly interface to query the blockchain, to view and verify past transactions. |

| **Interfaces** | |
|---|---|
| - The SDCM will be developed using Hyperledger Fabric as the blockchain framework. Custom logic will be developed to couple the Fabric endpoints with the EDC connectors that will be used for the Data Space deployment.<br>- The technology for developing the queries interface is still TBD.<br>- The framework(s) that will be used to implement the SDCM is still TBD. | |
| **Dependencies and assumptions** | |
| Input Data | - EDC action (required): The Fabric endpoint will automatically receive information about a Data Space action and store this information on the blockchain.<br>- Query (required): A formatted query regarding transaction history. Format is still TBD |
| Output Data | - Query result: JSON or similar machine-readable format, containing the response to the query. |
| Assumptions | - This version of the SDCM assumes that the data space will never handle the data itself, but rather will facilitate connections between data partners, and thus any operations that require access to the datasets (e.g. for generating hash values for verification) will need to be performed client side. If this is not the case, then it is possible to move all SDCM operations central side, thus streamlining development, maintenance, and operation. |
| **Diagrams** | |
| Conceptual Component Diagrams that can help in component understanding (if available) | |

| **Non-functional requirements** | | |
|---|---|---|
| Operational Performance | Availability | All parts of the SDCM are always running and publicly (in the scope of the Data Space) available at all times, listening for incoming requests. |
| | Frequency | All parts of SDCM operate reactively, per request. There are no expected regular outputs. |
| | Latency | TBD |

| | | |
|---|---|---|
| Manageability and Maintainability | Monitoring | TBD |
| | Extensibility | TBD |
| Security | Authorization and Authentication | Access to the SDCM will be available only to authorized users. Authorized users are generally expected to be all of the participants in the FEDORA Data Space (both as Data Providers and Data Consumers) |

| **Additional Information** | |
|---|---|
| Notes and Issues: | Any additional information |

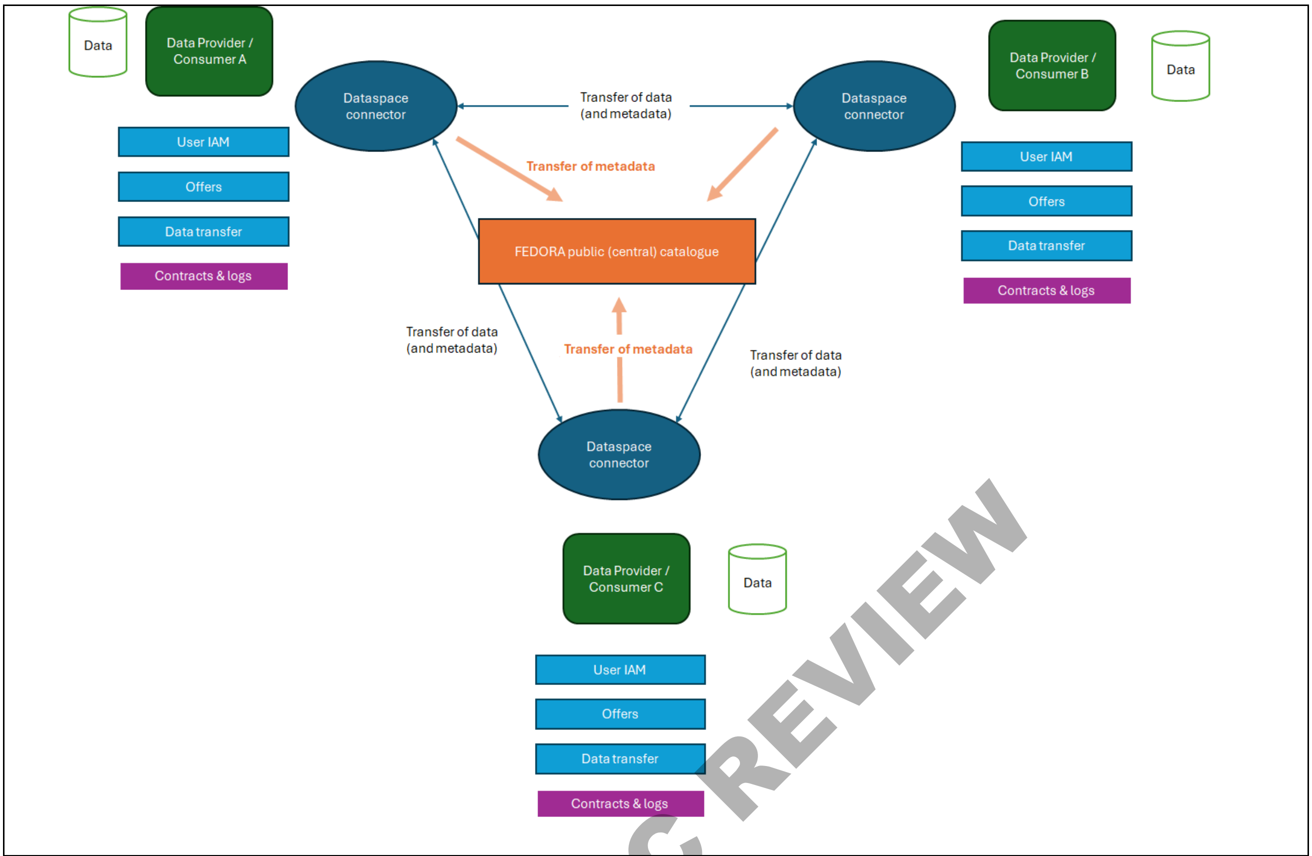
### 3.1.3.5 DATASPACE CONNECTOR

| **Overview** | | | |
|---|---|---|---|
| Component name: | Dataspace Connector – T3.6 | | |
| Created by: | AKKODIS - AKKIS | Document version: | 0.2.x |

| **Purpose** |
|---|
| **The FEDORA Data Space Connector** is the core technical component that enables organisations to participate in the FEDORA Data Space. It is a small software component installed on a participant's own systems that makes it possible to interact with other members of the Data Space in a secure, standardised, and automated way. |
| **Description** |
| Primary Functions of the Data Space Connector:<br>- Participation in the Data Space: the connector enables organisations to join the FEDORA Data Space and perform all key operations related to data sharing.<br>- Publication and Discovery: It allows providers to publish metadata and offerings (datasets, language models, etc.) to the FEDORA Data Space catalogue. Consumers can search and discover those offerings via their own connector.<br>- Negotiation and Enforcement of Use Policies: The connector manages the exchange of information about data offers, including terms and conditions of use. It enforces the data provider's conditions (e.g., usage policies, licence requirements, payment terms), helping ensure agreements are honoured<br>- Secure Data Transfer: Once a negotiated agreement is reached, the connector handles the secure transfer of data assets between participants. It logs contracts and transactions locally for transparency and traceability. |

| **Interfaces** |
|---|
| **How the Connector Fits in the Architecture**<br>- Decentralised Peer-to-Peer Model: Each participant runs their own connector, which interacts with others directly - there's no single central server hosting the data itself. |

| | |
|---|---|
| - Standards-Based: The connector is built on recognised data space technologies like Eclipse Dataspace Components (EDC) and supports metadata and policy standards such as DCAT-AP and ODRL. | |
| **Dependencies and assumptions** | |
| Input Data | - Participant Identity & Access Management (IAM) Inputs: Organisation Identity, Connector credentials<br>- User Identity: User accounts and roles inside the connector<br>- Asset Descriptions & Metadata Inputs: Asset Metadata<br>- Policy & Contract Inputs (cf. T3.5): Usage Policies, ODRL policy expressions,<br>- Contract Offers & Agreements<br>- Discovery & Catalogue Inputs: Crawled metadata from other connectors |
| Output Data | - Published Asset Catalogue Entries: Asset metadata records (DCAT/DCAT-AP or JSON-LD), enables discovery in federated catalogues and searches.<br>- Contract and Negotiation Outputs (cf. T3.5): Contract offers, Contract agreements<br>- Data Transfer Invocation Details: e.g. Data transfer status events<br>- Activity & Audit Logs: Connector logs, Transaction records |
| Assumptions | - FEDORA will fully adopt the Eclipse Dataspace Components (EDC) as its base connector framework<br>- Core interoperability formats will be DCAT-AP (metadata) and ODRL (policy)<br>- Connectors will operate in a fully decentralized, peer-to-peer model<br>- All participants will run connectors with stable reachable endpoints.<br>- If a participant cannot host or operate their own FEDORA dataspace connector, another partner can provide a hosted connector or connector-as-a-service, provided several governance and trust requirements are respected. -> to be discussed. |
| **Diagrams** | |
| | |




| **Non-functional requirements** | | |
|---|---|---|
| Operational Performance | Availability | The connector is expected to be continuously running during normal operation. It is not a “manual launch per request” application.<br>It is:<br>- Always-on<br>- Event-driven and reactive / The connector reacts to incoming requests: e.g., contract negotiation, data requests, metadata queries. |
| | Frequency | TBD? N/A? |
| | Latency | TBD? N/A? |
| Manageability and Maintainability | Monitoring | To be defined |
| | Extensibility | TBD? N/A? |

| | | |
|---|---|---|
| Security | Authorization and Authentication | The connector is designed to enforce strict access control in line with data space principles:<br>• Only authorized participants can access its services.<br>• All interactions are authenticated and verified.<br>• Public access is not allowed to internal connector services (e.g., contract negotiation, data transfer orchestration).<br>This ensures data sovereignty and compliance with policies and contracts. |

| **Additional Information** | |
|---|---|
| Notes and Issues: | Any additional information |

### 3.1.3.6 SOCIAL OPTIMUM MODEL

| **Overview** | | | |
|---|---|---|---|
| Component name: | Social optimum model - T4.1 | | |
| Created by: | Georg Brandstätter - AIT | Document version: | 0.3.0 |

| **Purpose** |
|---|
| This component computes an optimized traffic light schedule based on expected/forecasted traffic flows. The goal is to find a schedule that minimizes the (appropriately weighted) waiting times of all participating road users. |
| **Description** |
| This component consists of an optimization algorithm for traffic light schedule planning and a REST API for accessing it. The service is stateless and processes each optimization request separately (but not necessarily deterministically).<br><br>The algorithm's input consists mainly of a street network section and a forecast of how road users will travel within that network during the given planning horizon, as well as a specification of how existing traffic lights must be operated.<br><br>The street network is defined as a directed graph where nodes and arcs represent intersections and streets/lanes, respectively.<br><br>For each intersection with traffic lights, we're given a specification of how they must be operated during the planning horizon (sequence of traffic light phases, allowed start and end times of each phase, …)<br><br>We're also given a list of road users that will travel within the street network during the planning period. For each user, we know their arrival time and location within the network, as well as the (partial) route they want to take through the network.<br><br>Each user is assigned a priority based on factors like mode of transport, which can also vary depending on external conditions (like weather).<br><br>Our algorithm then computes a feasible traffic light schedule (consisting of the start and end time of each phase at each intersection) such that the overall waiting time of all users is minimized. Each user's priority is considered |

| |
|---|
| accordingly to ensure that higher-priority users (e.g., pedestrians during bad weather) have to wait proportionally less than lower-priority ones. |

| **Interfaces** | |
|---|---|
| This component will communicate via a REST API defined by an OpenAPI specification. Data is exchanged in JSON format. | |
| **Dependencies and assumptions** | |
| Input Data | - Planning horizon duration (number of traffic light cycles)<br>- Street network layout (relevant section)<br>- Expected traffic flows (route, arrival time) within the street network<br>- Default traffic light schedule for each intersection<br>- Allowed traffic light schedules for each intersection (start and end times of each block) |
| Output Data | - Optimized traffic light schedule |
| Assumptions | - An optimized schedule will only be generated if a feasible schedule exists (and can be computed within the set time limit). Otherwise, an error will be returned. Clients are expected to handle this appropriately (e.g., by falling back to some default strategy). |

| **Non-functional requirements** | | |
|---|---|---|
| Operational Performance | Availability | - The component will be running continuously. Whenever a request is received, it is immediately processed and the response is sent as soon as it is available (see below). |
| | Frequency | - This component only responds to requests.<br>- Requests are expected to be received approximately every 5 minutes.<br>- However, multiple requests can be processed in parallel as long as sufficient computational resources are available. |
| | Latency | - As part of their request, clients provide a time limit. All responses should be sent within the specified time limit.<br>- By default, the time limit should roughly correspond to the request frequency (e.g., 300 seconds if requests are sent every 5 minutes). |
| Manageability and Maintainability | Monitoring | - All requests, responses, warnings and errors will be logged.<br>- When no feasible schedule can be generated, an error response will be returned. Clients should handle this with a fallback strategy (e.g., falling back to a default schedule). |
| | Extensibility | - This component could be extended to use different algorithms (exact, heuristic and hybrid) for computing the optimized traffic light schedule, each with a different trade-off between solution quality and speed.<br>- Algorithm selection / parametrization would be handled as part of the request. |

| | | |
|---|---|---|
| Security | Authorization and Authentication | - This component does not perform any authentication or authorization itself. Any received request will be responded to.<br>- It should therefore be deployed within an internal network that is only accessible to other components interacting with it. |

| **Additional Information** | |
|---|---|
| Notes and Issues | This component will be deployed as a Docker container. |

### 3.1.3.7 ALGORITHM FOR TRAFFIC COUNTING VIA AI AND CAMERAS

| **Overview** | | | |
|---|---|---|---|
| Component name | Algorithm for Traffic Counting via AI and Cameras | | |
| Created by | Ida Hoenigmann – ITS-VIE | Document version: | 0.2.0 |

| **Purpose** |
|---|
| Supplies counting values for all traffic participants once per minute. Live video stream of cameras are analysed using AI, resulting in lane-specific counting values for various modes of transport. |
| **Description** |
| Publicly available low-resolution video streams are used to run an artificial intelligence object detection and classification algorithm. Traffic participants that can be detected by the AI include cars, trucks, buses, motorcycles and non-motorized private transport. By running this detection with 4fps and using a tracking algorithm, the average speed per lane is calculated. Additionally, a value representing the image quality is calculated from the blurriness, contrast and brightness. These values are output at a regular interval with one minute being the default. We plan to use the data generated by this component as part of the input into the algorithm developed in the Vienna pilot. |

| **Interfaces** | |
|---|---|
| This component uses video streams and makes the output available via database entries. | |
| **Dependencies and assumptions** | |
| Input Data | - Video streams of cameras (MJPG, with >= 4 fps) |
| Output Data | - Traffic counts<br>- Format: TBD (currently sqlite entries, but other output formats could be made available in the future) |
| Assumptions | - TBD |

| **Non-functional requirements** | | |
|---|---|---|
| | Availability | Expected to be always running and producing outputs. |

| | | |
|---|---|---|
| Operational Performance | Frequency | Continuously running. |
| | Latency | TBD (typically counting values older than 5-10 minutes do not provide sufficient information for a traffic model). |
| Manageability and Maintainability | Monitoring | TBD |
| | Extensibility | able to be extended: could include trams, trains and scooter drivers in future version, however training data would have to be generated for this. |
| Security | Authorization and Authentication | TBD |



#### 3.1.3.8 DYNAMIC PRICING AND INCENTIVISATION MODELS FOR TRAFFIC MANAGEMENT APPLICATIONS

| **Overview** | | | |
|---|---|---|---|
| Component name: | Dynamic Pricing and Incentivisation Models for Traffic Management Applications – T4.2 | | |
| Created by | Michail Makridis - ETH<br>Julius Schlapbach - ETH<br>Kevin Riehl - ETH | Document version: | 0.2.0 |

| **Purpose** |
|---|
| The main purpose of the dynamic pricing and incentivisation module is the exploration of novel economic instruments for traffic management, as well as their adaptation and application in real-world case studies. |
| **Description** |
| Task 4.2 will primarily focus on research activities related to novel dynamic pricing and incentivisation mechanisms for traffic management. This includes conducting research and publishing results on the use of non-tradable credit schemes (for example, the Karma mechanism) as fairness-enhancing instruments in traffic management applications.<br><br>In addition, the examination of non-monetary pricing schemes may be complemented by a comparative analysis of tradable and non-tradable currencies, thoroughly assessing the advantages and disadvantages of each approach (TBD, in collaboration with DTU).<br><br>Finally, the task seeks to investigate the individualization and mass customization of spatio-temporal resource allocation, as well as the applicability of these concepts in the real-world case study in Reggio Emilia (*) (CRE, in collaboration with DTU). |

| **Interfaces** |
|---|

| | |
|---|---|
| Since Task 4.2 focuses on the development and evaluation of novel dynamic pricing mechanisms, its primary outputs will be scientific publications. In addition, the planned investigation of formats for the real-world applicability of such mechanisms may inform the implementation of the pilot case study in Reggio Emilia in WP6 (*). | |
| **Dependencies and assumptions** | |
| Input Data | - Traffic and mobility data, including flow volumes, speeds, historical travel patterns, and user mobility behaviour. This encompasses both aggregated network-level data and individual travel profiles necessary for understanding current traffic conditions and user preferences.<br>- Pricing structures and transaction records, covering existing tariff schemes, credit allocation mechanisms, and both tradable and non-tradable currency transactions. These data sources may support the evaluation of novel pricing mechanisms and their economic impacts in comparison to existing solutions and could inform assessments of their potential applicability in real-world settings.<br>- Infrastructure, network, and event data, including system capacity, and operational constraints affecting traffic conditions. This information enables the adaptation of pricing mechanisms to real-world constraints and dynamic urban conditions. |
| Output Data | - Scientific publications detailing novel dynamic pricing and incentivisation mechanisms, including potential findings on non-tradable credit schemes and, if applicable, comparative studies of tradable versus non-tradable currencies.<br>- (*) Conceptual frameworks and application strategies for potential deployment of selected pricing mechanisms in the Reggio Emilia pilot, informing integration efforts in WP5 and WP6. |
| Assumptions: | - Availability and accessibility of sufficient traffic, mobility, and pricing data from relevant sources with adequate granularity and quality for mechanism evaluation.<br>- Willingness of users and stakeholders to engage with non-traditional pricing schemes (e.g., non-tradable credits) in pilot implementations.<br>- (*) Transferability of findings from theoretical models and simulations to real-world traffic management contexts in Reggio Emilia. |
| **Diagrams** | |
| Not applicable | |



| **Non-functional requirements** | | |
|---|---|---|
| Operational Performance | Availability | Not applicable |
| | Frequency | Not applicable |
| | Latency | Not applicable |
| Manageability and Maintainability | Monitoring | Not applicable |
| | Extensibility | Future research can build on the published outputs from this component, enabling further exploration of advanced pricing mechanisms, expanded data integration, and broader application contexts both within FEDORA and beyond. |

| | | |
|---|---|---|
| Security | Authorization and Authentication: | TBD |

| Additional Information | |
|---|---|
| Notes and Issues: | - |

### 3.1.3.9 MULTIMODAL HUB LOCATION & CAPACITY OPTIMISATION MODULE

| Overview | | | |
|---|---|---|---|
| Component name: | Multimodal Hub Location & Capacity Optimisation Module (T4.3) | | |
| Created by: | KIOS - UCY | Document version: | 0.3.3 |

<table>
<tr><th>Purpose</th></tr>
<tr><td>Select and size multimodal hubs (bus, micromobility, UAV taxi) based on demand coverage and feasibility constraints and provide hub capacity outputs to support simulation studies.</td></tr>
<tr><th>Description</th></tr>
<tr><td>This module formulates and solves a multi-hub location and capacity optimisation problem for integrated multimodal hubs to support EI 3.3 (Mobility hub & corridor optimisation).<br><br>Specifically, this module screens candidate sites and then runs a Mixed-Integer Linear Programming (MILP) model to select hubs (where applicable) and/or size capacities for pre-selected hubs (e.g., number of bus bays, UAV pads, micromobility docks).<br><br>This component is expected to:<br>1. Define the candidate hub set and apply primary site screening (e.g., area and power availability).<br>2. Solve a MILP to maximize captured OD demand subject to feasibility constraints and capacity limits.<br>3. Output hub selection results and/or recommended capacities per mode for pilot planning and downstream evaluation.<br>Hence, it is expected to include the following distinct sub-modules:<br>1. Data Preparation (candidate sites, attributes, etc).<br>2. MILP Model Builder (decision variables, objective, constraints).<br>3. Solver Interface (MILP solver configuration; open-source or licensed solver TBD).<br>4. Post-Processing (capacity sizing outputs, reporting, export to CSV/JSON).</td></tr>
</table>

| Interfaces |
|---|
| Implementation will be provided as a MILP-based optimisation tool (Python + MILP solver). Other partners can use it by providing candidate hub locations with attributes (area/power) and OD demand, then running the optimisation scripts to obtain hub capacities. |

| | |
|---|---|
| The optimisation module outputs can be used to define hub capacities for pre-installed hub locations (e.g., number of bus bays and UAV charging pads). These capacities can then be used as inputs for simulation experiments to test operational feasibility under different scenarios.<br><br>TBD: exact solver stack and packaging (e.g., Pyomo/PuLP + Gurobi). | |
| **Dependencies and assumptions** | |
| Input Data: | Full list of inputs for the whole component:<br>- Candidate hub locations and IDs. Format: CSV/GeoJSON (TBD).<br>- Candidate-site attributes (e.g., available area, power supply feasibility). Format: CSV.<br>- OD demand matrix (static or time-sliced). Format: CSV (TBD)<br>- Mode-specific travel-time matrices: access/egress (walk/bike/scooter) and trunk (bus/UAV).<br>Format: CSV.<br>- Policy/parameter settings: number of hubs n, capacity bounds, docking/bay requirements, optional cost weights. Format: JSON (TBD).<br>Inputs for specific sub-components:<br><br>MILP Model Builder:<br>- Variables, constraints, objective weights, capacity bounds per mode.<br>- Solver Interface:<br>- Solver name, time limit, optimality gap (TBD). |
| Output Data: | Expected outputs:<br>- Selected hubs (if hub selection is enabled) and assignment summary. Format: CSV.<br>- Recommended capacities per hub and per mode (bus bays, UAV pads/chargers, micromobility docks/slots). Format: JSON.<br>- Objective value and key KPIs (captured OD demand, coverage metrics). Format: CSV.<br>- Optional: solution reports for papers/deliverables. Format: PDF/Markdown (TBD). |
| Assumptions: | - Travel-time matrices represent average conditions.<br>- Candidate-site area and power attributes are accurate. If constraints are wrong, capacity recommendations may be infeasible (high severity).<br>- OD demand is assumed to be known (or generated) for the scenario. If OD demand is uncertain, sensitivity analysis will be required (medium severity). |
| **Diagrams** | |
| TBD (MILP decision flow and data pipeline diagram will be added in a next revision). | |

| **Non-functional requirements** | | |
|---|---|---|
| Operational Performance | Availability | Offline optimisation tool. It is executed when hub capacity planning is needed; it is not expected to run continuously. |

| | | |
|---|---|---|
| | Frequency | Reactive / per request (single run or parameter sweep over candidate solutions). |
| | Latency | TBD. Depends on problem size and solver; expected seconds to minutes for typical instances. |
| Manageability and Maintainability | Monitoring | Solver logs (status, optimality gap, infeasibility reports) and basic validation checks on inputs/outputs. |
| | Extensibility | Can be extended to additional modes, new constraints (e.g., emissions, equity), multi-period demand, and robust/sensitivity analysis. |
| Security | Authorization and Authentication | Access is intended for FEDORA consortium partners (authorized users). Input datasets may be restricted depending on data-sharing agreements. |

| **Additional Information** | |
|---|---|
| Notes and Issues: | |

### 3.1.3.10 MULTIMODAL JOURNEY PLANNER

| **Overview** | | | |
|---|---|---|---|
| Component name: | Multimodal journey planner - T4.3 | | |
| Created by: | Kostas Cheliotis - FRONT | Document version: | 0.3.1 |

| **Purpose** |
|---|
| The Multimodal journey planner component is a tool that provides route recommendations between origin and destination within a given transportation network, combining multiple mobility services and modes of transport. |
| **Description** |
| The Multimodal journey planner is set up as a service: It receives a request for a journey recommendation between from an origin to a destination, it calculates viable options, and it returns them to the requester.<br><br>Each instance of the multimodal journey planner convers one area/network. For different distinct locations, one instance of the journey planner needs to be deployed and set up per location.<br><br>The Multimodal journey planner has two distinct sub-components:<br>- The communication interface<br>- The journey calculator<br>The communication interface receives inputs as part of the external journey calculation request, forwards them to the journey calculator, collates and formats the journey calculator outputs, and returns the result back to the external caller.<br><br>The journey calculator receives the journey request parameters from the communication interface, calculates potential routes in the network that fulfil all parameters, and returns all viable routes back to the communication interface. |

| **Interfaces** |
| --- |
| The journey planner service is developed in Python 3.13, using the FastAPI library to expose the communication interface as a webAPI. The whole service is provided as a Docker container for straightforward deployment. |

| **Dependencies and assumptions** | |
| --- | --- |
| Input Data: | - Origin (required): the trip origin as lat-long coordinates<br>- Destination (required): the trip destination as lat-long coordinates<br>- Modes of transport to avoid (optional): a list of modes of transport to avoid during trip calculation.<br>- Modes of transport to include (optional): Forces the trip calculation to include the modes of transport provided here.<br>- Network graph (required): a graph representation of the location's transportation network. Required during initial set up.<br>- Current traffic conditions (optional): Optional real-time traffic conditions, allowing the journey planner to take current congestion into consideration. |
| Output Data: | - Routes list: A list of viable routes. Each route will be broken down into a sequence of trip legs. |
| Assumptions: | - None |

| **Diagrams** |
| --- |
| Conceptual Component Diagrams that can help in component understanding (if available) |



| **Non-functional requirements** | | |
| --- | --- | --- |
| Operational Performance | Availability | Once deployed, the journey planner is always online and accepts requests for journey calculations. |
| | Frequency | The journey planner will generate routes upon request, therefore will not run on a frequency. |
| | Latency | The expected latency between receiving a request and returning a response is a typical HTTP request operation, a few seconds at most. |
| Manageability and Maintainability | Monitoring | Requests that cannot be fulfilled will receive a failure response with an error description and additionally will be logged internally.<br><br>Service availability monitoring will be performed by pinging the service from an external source. |
| | Extensibility | TBD |
| Security | Authorization and Authentication | TBD |

| **Additional Information** |
| --- |

| | |
|---|---|
| Notes and Issues: | Any additional information |

### 3.1.3.11 UAV-BASED TRAFFIC MONITORING & ANOMALY DETECTION (UAV-CV)

| **Overview** | | | |
|---|---|---|---|
| Component name: | UAV-based Traffic Monitoring & Anomaly Detection (UAV-CV) (T4.4) | | |
| Created by: | KIOS - UCY | Document version: | 0.3.3 |

| **Purpose** |
|---|
| Provides UAV video-based vehicle detection and traffic indicators for Task T4.4, supporting usage patterns, bottlenecks, and anomaly detection (i.e., queue estimation for bottleneck detection) in the in-silico Nicosia pilot.<br><br>Emulates altitude-dependent detection accuracy and processing speed to enable realistic in-silico experiments and small pilot validation. |
| **Description** |
| The UAV-CV component supports Task T4.4 (and subsequently EI3.4 - Complex event processing) by providing computer-vision outputs from drone data that can be used to detect usage patterns, bottlenecks, and anomalies. It focuses on vehicle detection and traffic monitoring from UAV imagery, and it can operate in an emulation mode inside the Nicosia in-silico environment.<br><br>To make in-silico experiments realistic, the component includes an altitude-aware performance model of the study provided by patterns in [1] on aerial vehicle detection at 50–500 m altitudes. As illustrated in Figure 2 of the study, models trained at a single altitude perform best near that altitude and degrade when evaluated at different altitudes. Therefore, the component supports a mixed-altitude, single-model strategy and realistic performance curves (accuracy and FPS) as altitude changes.<br><br>The component is intended to feed the generative-AI complex event processing engine with drone-derived observations and features (not to replace it) and subsequently to support EI3.4 (Complex event processing)<br><br>Specifically, this component can output raw detections/tracks as well as aggregated traffic indicators (counts, speeds, density/occupancy proxies, queue evolution) that help classify incidents and bottlenecks.<br><br>Main sub-modules include:<br><br>1. Altitude-aware detection layer (single-model mixed-altitude profile; optional altitude-specific profiles; configurable inference input size).<br>2. Tracking and traffic feature extraction (per-ROI/segment counts, flow, speed proxies, queue length indicators over time).<br>3. Output adapter to T4.4 (events/features via JSON files). |

| **Interfaces** |
|---|
| UAV-CV is expected to be implemented as a software module (e.g., Python) that can run in the Nicosia in-silico stack (emulation mode), producing drone-like detections/features from simulation ground truth. Interfaces provided (TBD final selection). |

| Dependencies and assumptions | |
|---|---|
| Input Data: | Full list of inputs for the whole component:<br>- UAV telemetry: altitude (m) over time, timestamps; optional GPS/pose. Format: CSV/JSON.<br>- Camera parameters (optional): FOV, estimation of error. Format: JSON.<br>- In-silico emulation (optional): simulation ground truth objects/trajectories from SUMO or other sources. Format: TraCI stream / CSV / JSON (TBD). |
| Output Data: | - Detection stream: timestamp, detected objects (vehicle), confidence score. Format: JSON.<br>- Tracking stream (optional): track id, position/ROI, speed proxy. Format: JSON.<br>- Aggregated traffic indicators: vehicle counts/flow per ROI or road segment, speed proxies, density/occupancy proxies, queue growth indicators. Format: JSON/CSV.<br>- Candidate anomaly cues (optional): time-stamped flags such as sudden speed drop, stopped-vehicle cluster, abnormal queue growth. Format: JSON (event list).<br><br>Performance/meta outputs:<br>- Expected detection quality vs altitude (e.g., mAP/precision proxies) for the selected configuration. Format: JSON/CSV. |
| Assumptions: | - The altitude-dependent detection performance curves derived from the study in [1] that is representative enough to emulate realistic behaviour in Nicosia, as obtained from real traffic video-based data. Severity: Medium.<br>- The component provides observations/features; final incident/bottleneck classification is handled by the T4.4 CEP/GenAI pipeline. Severity: Low. |
| **Diagrams** | |
| TBD (conceptual flow):<br><br>telemetry (altitude) -> Altitude-aware detection/tracking -> Traffic indicators + candidate cues -> Event/feature stream -> T4.4 CEP/GenAI engine (FRONT) -> Incident/bottleneck labels & predictions | |



| Non-functional requirements | | |
|---|---|---|
| Operational Performance | Availability | Runs as a service during simulation sessions (in-silico). It can be launched on demand and does not need to be always-on outside these sessions. |
| | Frequency | Runs once per scenario and exports a results package. |
| Manageability and Maintainability | Monitoring | Logging of inputs, warnings/errors, and per-run summary metrics. |
| | Extensibility | Altitude/performance profiles can be updated as new datasets become available. |

| | | |
|---|---|---|
| Security | Authorization and authentication | Access restricted to FEDORA partners and authorized pilot operators. |

| Additional Information | |
|---|---|
| Notes and Issues | This component corresponds to UCY's contribution in Task T4.4 (computer vision techniques for usage patterns, bottlenecks, and anomaly detection using drone data).<br><br>Reference used for altitude-aware detection behaviour:<br><br>**[1]** Makrigiorgis, R., Kyrkou, C. and Kolios, P., 2023, June. How high can you detect? improved accuracy and efficiency at varying altitudes for aerial vehicle detection. In *2023 International Conference on Unmanned Aircraft Systems (ICUAS)* (pp. 167-174). IEEE. |

### 3.1.3.12 COMPLEX EVENT PROCESSING ENGINE



| Overview | | | |
|---|---|---|---|
| Component name: | Complex Event Processing Engine - T4.4 | | |
| Created by: | Kostas Cheliotis - FRONT | Document version: | 0.3.1 |
| **Purpose** | | | |
| The Complex Event Processing Engine component is a collection of tools that handle and analyze time series traffic data. It contains various relevant functionalities, including forecasting, predictions, anomaly detection, synthetic data generation, and data labelling. | | | |
| **Description** | | | |
| The Complex Event Processing Engine is provided as a collection of semi-independent services, all providing operations relevant to time series traffic data. Each instance of the Complex Event Processing Engine is calibrated for a single network based on historic data and can then provide outputs relevant to that network. The complete system is deployed as a single application, providing endpoints to access the various services. The different sub-component services are the following:<br><br>- Traffic predictor/synthetic data generator<br>- Network evolution forecaster<br>- Recurrent anomaly detection<br>- Non-recurrent event detection<br>- Data labeller<br><br>The Traffic Predictor/synthetic data generator is calibrated on historic traffic data and can be used to generate baseline traffic predictions based only on parameters external to the network such as date, time, and weather conditions.<br><br>The Network Evolution Forecaster takes into account the current traffic conditions and extrapolates to generate short-term forecasts. | | | |

| |
|---|
| The Recurrent Anomaly Detection system compares forecasts from the Network Evolution Forecaster to the baseline Traffic Predictor outputs to detect whether the current or expected conditions are outside the expected range of values for the given period, constituting an anomaly.<br><br>The Non-Recurrent Event Detection system employs Machine Learning processes to detect inconsistencies in traffic data and identify unexpected events.<br><br>The Data Labeller analyses incoming traffic data streams and auto-generates labels and categorizations for parts of the dataset, enriching the datasets to be used as input in other systems. |

| **Interfaces** | |
|---|---|
| The Complex Event Processing Engine is implemented in python 3.13 and provided as a Docker container for deployment. Each sub-service exposes a set of dedicated webAPI endpoints for accessing its functionality. | |
| **Dependencies and assumptions** | |
| Input Data: | <u>Traffic Predictor:</u><br>- Current conditions and predictors to generate a prediction for. Should be from the list of variables used during calibration.<br><br><u>Network Evaluation Forecaster:</u><br>- Current traffic conditions (required), to be used for extrapolating during short-term forecasting<br>- Baseline conditions (optional): To also include in the forecasting, such as weather/notable events etc.<br><br><u>Recurrent Anomaly Detection:</u><br>- Baseline traffic prediction from Traffic Predictor (required)<br>- Network evolution forecast (required)<br><br><u>Non-Recurrent Event Detection:</u><br>- Current traffic conditions (required) to analyze and detect non-recurrent events<br><br><u>Data Labeller:</u><br>- Time series traffic data to be labelled (required) |
| Output Data: | <u>Traffic Predictor:</u><br>- A prediction of expected traffic conditions for a given network based on the input external factors (date/time, weather, etc)<br><br><u>Network Evaluation Forecaster:</u><br>- A short-term forecast for traffic conditions in the network.<br><br><u>Recurrent Anomaly Detection:</u><br>- A boolean value on whether the forecast traffic conditions are within expected values for the given date/time. |

| | |
|---|---|
| Assumptions: | - Each of the sub-components has been calibrated on historic data in the same format as the one provided during operation. |
| **Diagrams** | |
| Conceptual Component Diagrams that can help in component understanding (if available) | |

| **Non-functional requirements** | | |
|---|---|---|
| Operational Performance | Availability | Once deployed, the Complex Event Processing Engine is always online and accepts incoming requests. |
| | Frequency | No fixed frequency, the component will provide outputs upon request. |
| | Latency | The component should provide a response within common HTTP request timeouts, i.e. within a few seconds. |
| Manageability and Maintainability | Monitoring | Failure to generate responses to incoming requests will be logged internally, failure to connect to the service from external callers will be monitored by regular health checks by pinging the service from an external source. |
| | Extensibility | Many of the sub-components are designed to be extendable by allowing additional models to be imported and afterwards be available for use. |
| Security | Authorization and Authentication | TBD |

| **Additional Information** | |
|---|---|
| Notes and Issues: | Any additional information |



#### 3.1.3.13 SYNCHROMODAL CONFLICT-FREE VEHICLE ROUTING OPTIMISER

| **Overview** | | | |
|---|---|---|---|
| Component name | Synchromodal Conflict-Free Vehicle Routing Optimiser – T4.5 | | |
| Created by | MJC$^2$ - MJC$^2$ | Document version: | 0.3.1 |

| **Purpose** |
|---|
| Logistics scheduling and planning solution that enables freight operations to be optimised taking into account information about congestion, freight flows and transport resources. |
| **Description** |

| |
|---|
| The T4.5 component will have the ability to plan and schedule freight movements through a complex transport network, aiming to optimise flows to reduce congestion and emissions. A detailed logistics scheduling model is used, modelling the transport network and resource availability and well as individual freight orders/movements. For example, the road network would typically be represented using open data such as OpenStreetMap, while vessel or rail connections can be modelled in terms of routes and service availability/times. The optimiser considers location and availability of road transport resources, constraints on freight movements (e.g. volume, times, routing constraints), and similar inputs for multimodal operations.<br><br>A flexible multi-layered optimisation architecture is proposed, which enables a wide range of logistics scenarios and networks to be considered following appropriate configuration. During FEDORA this optimisation toolset will be configured to model specific cases for the pilot exercises. The system optimises the allocation of freight orders to transport resources, routes and services, sequencing activities and flows to increase efficiency and reduce congestion and conflicts, and creating minute-by-minute schedules of movements, including for example ETA/ETD at hubs and terminals which can be used to determine and reduce the impact of anticipated queuing or bottlenecks. |

| **Interfaces** | |
|---|---|
| The component will be implemented using Java, C++, SQL, Javascript and HTML. Interfaces to other components if needed and possible are to be discussed. For example, a possible interface to the T4.1 component to receive traffic light/congestion data may be required, or it may be possible to simulate this interaction to demonstrate the innovations. | |
| **Dependencies and assumptions** | |
| Input Data | <u>Inputs may include:</u><br>- Road network data (probably MIF/MID format).<br>- Other transport network data e.g. vessel or rail service schedules, depending on the use case.<br>- Location and availability of road transport resources.<br>- Freight orders/volumes.<br>- Hub/terminal locations.<br>- Origin/destination locations.<br>- Road speed data.<br>- (TBC depending on the use case) |
| Output Data | <u>Outputs may include:</u><br>- Allocation of freight orders/movements to resources<br>- Sequencing and scheduling of freight movements<br>- Routes used<br>- ETA/ETD at main hubs and origin/destination locations<br>- (TBC depending on the use case) |
| Assumptions | It is assumed that suitable freight orders/volumes can be provided or estimated accurately, and that corresponding resource and service availability/schedules are available. If these are not available, it will compromise the accuracy of the results significantly. |
| **Diagrams** | |
| N/A | |

| Non-functional requirements | | |
|---|---|---|
| Operational Performance | Availability | This component is anticipated to be available as a software application running on a suitable server. Mostly functionality will be initiated by the user (e.g. updating the transport plan) but some background processes may run in an automated way. The mode of operation depends on the use case. |
| | Frequency | As above, certain functions will be user-initiated and therefore not on a fixed cycle, while other functions may run on a fixed schedule. Frequency depends on the use case. |
| | Latency | This depends on the use case but may range from seconds to minutes. |
| Manageability and Maintainability | Monitoring | If required, the user/planner will be presented with error/warning messages. |
| | Extensibility | The component will be adapted and enhanced during FEDORA in response to feedback from tests and trials. A flexible optimisation architecture is used, enabling further modifications and extensions after the end of the project (e.g. to accommodate new requirements from other operations/territories). |
| Security | Authorization and Authentication | Authorised users only will be able to access the system. Multiple authorisation levels can be defined if required, but for the purposes of the project it may not be necessary to implement multiple levels for test purposes – TBC. |

| Additional Information | |
|---|---|
| Notes and Issues | Functionality and specifications will be refined during the project in response to tests and trials. |



### 3.1.3.14 DYNAMIC RESPONSE PLANNER

| Overview | | | |
|---|---|---|---|
| Component name | Dynamic response planner – T4.6 | | |
| Created by | Kostas Cheliotis - FRONT | Document version: | 0.3.1 |
| **Purpose** | | | |
| The Dynamic Response Planner is a system that provides comprehensive mitigation measures in response to detected traffic degradations. | | | |
| **Description** | | | |
| The Dynamic Response Planner is an always-on service that continuously monitors a given network for traffic degradation and generates valid comprehensive response plans to mitigate the degradation. It consists of three main sub-components:<br>- The situation evaluator | | | |

| |
|---|
| - The response plan generator<br>- The response plan validator<br><br>The Situation Evaluator requests inputs from anomaly detection and forecasting services at fixed intervals and evaluates whether current and expected conditions warrant a mitigation response plan.<br><br>If a mitigation response plan is required, the Response Plan Generator requests inputs from various external dedicated optimization services, receiving mitigation plans for different aspects of the network (e.g. one optimization service may provide traffic signal timing optimizations, while another may provide suggestions for lane access changes). After collection, it collates the various optimizations into a unified response plan (or multiple response plans, if different configurations exist).<br><br>Once unified response plans are generated, they are passed to the Response Plan Validator, that forwards them to a simulation engine along with a baseline scenario (the do-nothing case, as received initially by the Situation Evaluator). The simulation engine executes the response plans and returns the output back to the Response Plan Validator that determines whether the response plans will provide a marked improvement and ranks them accordingly. Finally, it forwards the unified response plan to affected entities for implementation. |

| **Interfaces** | |
|---|---|
| The Dynamic Response Planner is implemented in Python 3.13, provided as a Docker container for straightforward deployment. The various services that are required should be provided as webAPI endpoints. | |
| **Dependencies and assumptions** | |
| Input Data | - Anomaly detection (required): A boolean value on whether an unexpected degradation in current or future traffic conditions has been identified.<br>- Baseline scenario (required if traffic degradation is detected): A forecast of traffic conditions for the near future in the case of degradation, if no measures are taken.<br>- Optimization strategies (required if traffic degradation is detected): Inputs from multiple network optimization services, each operating on a specific aspect.<br>- Expected traffic conditions for response plan (required if traffic degradation is detected): In the case of response plan evaluation, the simulation engine should return the expected traffic conditions if the response plan is implemented. |
| Output Data | - Unified response plan (required if traffic degradation is detected): a response plan covering multiple parameters and aspects of the given network. |
| Assumptions | - The Dynamic Response Planner depends on inputs from multiple external services, all focussing on the same transport network, in order to pass actions between them. As such it operates under the assumption that all external services have been set up and calibrated accordingly, and the provided endpoints of these services point to the correct instances. |
| **Diagrams** | |
| Conceptual Component Diagrams that can help in component understanding (if available) | |

| **Non-functional requirements** |
|---|

| | | |
|---|---|---|
| Operational Performance | Availability | After deployment of a Dynamic response planner instance, it runs continuously, monitoring and generating response plans at fixed interval. |
| | Frequency | The Dynamic response planner will check for traffic degradations at a fixed interval, every 5 minutes. If degradation is detected or forecast within the next 15-30 minutes, the response plan generation is automatically triggered; Otherwise, no response plan is generated. |
| | Latency | The Dynamic response planner should generate a validated response plan within 5 minutes of requesting a degradation check. |
| Manageability and Maintainability | Monitoring | The Dynamic response planner depends on multiple external services and will continuously monitor the health. If at any point they are unresponsive, this is logged internally.<br><br>Additionally an endpoint shall be made available to ping from an external source that will check whether the overall Dynamic response planner service is up and running. |
| | Extensibility | TBD |
| Security | Authorization and Authentication | TBD |

| **Additional Information** | |
|---|---|
| Notes and Issues: | Any additional information |



#### 3.1.3.15 MODEL-AGNOSTIC AND MODULAR SIMULATION PLATFORM

| **Overview** | | | |
|---|---|---|---|
| Component name: | Model-agnostic and Modular Simulation Platform – Task 5.4 | | |
| Created by: | Michail Makridis - ETH<br>Julius Schlapbach - ETH<br>Kevin Riehl - ETH | Document version: | 0.2.0 |

| **Purpose** |
|---|
| The main purpose of the interoperability framework is to enable seamless integration and communication of various optimisation modules, controllers, and software components within the FEDORA simulation environment through modular, agent-based interfaces. |
| **Description** |
| Task 5.4 will primarily focus on the development of a general agent-based interoperability framework that enables seamless integration and communication between various software components within the FEDORA simulation environment. This includes designing and implementing modular interfaces through dedicated interoperability agents, each facilitating specific connectivity for optimisation modules, controllers, simulation elements and other |

FEDORA

| |
|---|
| components. These agents will act as communication bridges, enabling flexible integration of diverse software modules without requiring extensive modifications, ultimately supporting the coordinated operation of multiple FEDORA services within an integrated workspace. |

<table>
<tr><th colspan="3">Interfaces</th></tr>
<tr><td colspan="3">The interoperability framework will be implemented as a modular, agent-based software platform that provides standardized communication interfaces for integration with FEDORA services and modules. Each interoperability agent will expose specific APIs and communication protocols that enable other components to connect and exchange data seamlessly. Further technical specifications and interface definitions will be refined and clarified during WP5 implementation activities.</td></tr>
<tr><th colspan="3">Dependencies and assumptions</th></tr>
<tr><td>Input Data:</td><td colspan="2">TBD</td></tr>
<tr><td>Output Data:</td><td colspan="2">TBD</td></tr>
<tr><td>Assumptions:</td><td colspan="2">TBD</td></tr>
<tr><th colspan="3">Diagrams</th></tr>
<tr><td colspan="3">TBD</td></tr>
<tr><th colspan="3">Non-functional requirements</th></tr>
<tr><td rowspan="3">Operational Performance</td><td>Availability</td><td>The interoperability framework is expected to be constantly available when running the FEDORA platform, operating as a persistent service that facilitates essential communication between relevant components. However, specific operational requirements and deployment configurations are subject to further clarification and refinement during ongoing WP5 development activities.</td></tr>
<tr><td>Frequency</td><td>The framework will run constantly as a persistent service but operate on-demand, processing communication requests from different components as they occur to facilitate data exchange between simulation elements, controllers, and other components of the FEDORA services suite. The exact request handling mechanisms and communication patterns are subject to further specification and potential adjustments during WP5 implementation.</td></tr>
<tr><td>Latency</td><td>TBD</td></tr>
<tr><td>Manageability and Maintainability</td><td>Monitoring</td><td>The framework will implement health checks and continuous heartbeat mechanisms to ensure ongoing service availability and monitor operational status. Logging of communication requests, connection states, warnings, and errors will provide visibility into component health and performance. Specific monitoring protocols and diagnostic mechanisms are subject to further specification during WP5 implementation.</td></tr>
</table>

| | | |
|---|---|---|
| | Extensibility | The framework will be implemented as general and flexible as possible, offering a common API for communication between diverse components within the FEDORA platform. It is designed to remain highly extensible, allowing for integration of additional new components developed later in the project or introduction of modularity in previously fixed elements (for example, replacing a fixed traffic demand module in the FEDORA simulation space with a modular demand component). This extensibility will support both ongoing FEDORA development and future applications beyond the project scope. |
| Security | Authorization and Authentication | TBD |

| **Additional Information** | |
|---|---|
| Notes and Issues: | Any additional information |



#### 3.1.3.16 FORESIGHT SCENARIOS GENERATION & EVALUATION MODULE

| **Overview** | | | |
|---|---|---|---|
| Component name: | Foresight Scenarios Generation & Evaluation Module (T5.6) | | |
| Created by: | KIOS – UCY | Document version: | 0.3.3 |

**Purpose**

Generate, run, and evaluate foresight "what-if" scenarios on the Nicosia pilot in-silico network to test FEDORA solutions beyond the baseline pilot conditions.

**Description**

The T5.6 module prepares and evaluates foresight scenarios that extend beyond the baseline pilot conditions to support EI 4.6 (Foresight analysis scenarios generator).

Specifically, this module combines scenario definition (assumptions and parameter ranges) with simulation-based evaluation on the Nicosia in-silico network (SUMO-based), to assess how FEDORA solutions behave under different future conditions.

This task is expected to:

1. Define scenario assumptions, parameter ranges, and experiment design (controlled vs uncontrolled cases).
2. Generate scenario configurations and simulation inputs (demand, service levels, management/control policies).
3. Execute simulation runs and collect key performance indicators (KPIs) for mobility, congestion, and service performance.
4. Compare scenarios and quantify the efficiency and practical applicability of FEDORA solutions.
5. Provide scenario definitions, run configurations, and evaluation outputs to other WPs (e.g., WP5/WP6).

| |
|---|
| Hence, T5.6 is expected to include the following distinct sub-modules:<br>1. Scenario Definition Builder (scenario template + parameter sets).<br>2. Input Generator (demand/OD generation, multimodal service settings, UAV taxi parameters).<br>3. Simulation Runner (batch execution of SUMO runs with consistent configuration management).<br>4. KPI Extractor and Report Generator (KPIs to CSV + summary plots/tables).<br>5. Experiment Manager (parameters, scenario cataloguing, result comparison). |

| **Interfaces** | |
|---|---|
| - Implementation will be provided as a set of scripts and configuration files (Python + SUMO). Other partners can use the module by supplying a scenario configuration (e.g., JSON) and running the provided experiment scripts locally.<br>- Interfaces are expected to include: (i) a scenario configuration file interface, (ii) command-line execution for batch runs, and (iii) export of results in standard machine-readable formats (CSV/JSON) for downstream analysis and reporting.<br>- TBD: final packaging (repository structure, containerization, and exact API endpoints, if any). | |
| **Dependencies and assumptions** | |
| Input Data | Full list of inputs for the whole component:<br>- In-silico network model (SUMO .net.xml and related files).<br>- Demand inputs (OD matrices, trip demand, temporal profiles).<br>- Multimodal service definitions (bus lines/schedules, micromobility assumptions).<br>- UAV taxi parameters (speed, capacity, service availability, operating rules).<br>- Traffic management / control policy parameters (baseline and FEDORA solutions).<br>- Scenario configuration files (assumptions + parameter ranges).<br><br>Inputs for specific sub-components:<br>Scenario Definition Builder:<br>- Scenario templates, parameter ranges, controlled/uncontrolled case definitions TBD.<br>Input Generator:<br>- OD/demand matrices, service settings, UAV parameters.<br>Simulation Runner:<br>- SUMO configuration (.sumocfg), route/trip files, additional files.<br>KPI Extractor:<br>- SUMO outputs (e.g., tripinfo.xml, edge/lane measures). |
| Output Data | Expected outputs:<br>- Scenario catalog (scenario definitions + parameter sets). Format: JSON/YAML/CSV (TBD).<br>- Simulation run configurations and logs. Format: text/log files.<br>- KPI tables per scenario (travel time, delays, queues, utilization, etc.). Format: CSV. |

| | |
|---|---|
| | - Comparative evaluation summaries (controlled vs uncontrolled, baseline vs FEDORA). Format: CSV/PDF (TBD). |
| Assumptions | - The Nicosia in-silico network and basic demand inputs are available and consistent. If the network changes, scenario inputs and scripts may need re-generation (medium severity).<br>- UAV taxi and multimodal service models are simplified representations suitable for comparative evaluation, not fully operational certification (low/medium severity).<br>- Partners will be able to run SUMO locally (or via a shared environment) and access required inputs; otherwise, a shared execution environment will be needed (medium severity). |
| **Diagrams** | |
| TBD (conceptual workflow diagram will be added in a next revision). | |

| **Non-functional requirements** | | |
|---|---|---|
| Operational Performance | Availability | This is an offline analysis tool. It is launched when scenario generation or simulation evaluation is needed; it is not expected to run continuously as a service. |
| | Frequency | Reactive / per request. It can run single scenarios or batch experiments (parameter sweeps) when triggered. |
| | Latency | TBD. Depends on scenario size and number of runs (typical runs may take minutes to hours). |
| Manageability and Maintainability | Monitoring | Execution logs, run status summaries, and automated checks for missing/invalid outputs (e.g., failed SUMO runs). |
| | Extensibility | Designed to add new scenario dimensions (e.g., disruptions, new modes, additional controllers) and new KPIs with minimal changes. |
| Security | Authorization and authentication | Access is intended for FEDORA consortium partners (authorized users). If deployed centrally, access control will follow consortium credentials (TBD). |



| **Additional Information** | |
|---|---|
| Notes and Issues: | Current status: framework integration and scenario evaluation pipeline preparation are ongoing. Next: finalize scenario assumptions/parameter ranges, complete network integration, and start controlled/uncontrolled comparisons. |

# 3.2 NETWORK MANAGEMENT SOLUTIONS EVALUATION MODELS

The FEDORA project includes a series of network optimization systems that will be tasked with producing a wide range of solutions for increasing mobility performance, to be tested through diverse pilots. In this chapter we present the frameworks that will be used to evaluate the outcomes of these network optimizations both on their expected impact as well as their maturity level.

## 3.2.1 IMPACT-BASED EVALUATION SYSTEM

The primary evaluation system for network management solutions to be used in FEDORA will be based on established evaluation frameworks, and more specifically the CIVITAS evaluation framework developed as part of the EU-led CIVITAS Initiative (more information and resources on the CIVITAS project may be found on the project website here: https://civitas.eu/).

The main focus of the evaluation system in FEDORA is to characterize and rank network management solutions. This particular focus, combined with the fact that the majority of FEDORA solutions will be evaluated in simulation and not deployed in real-world pilots, means that the evaluation process will focus only on the expected impact of a proposed network management solution, rather than focus on other aspects of a proposed solution such as implementation process, communication strategies, etc. As such, for the purpose of evaluating network management solutions within FEDORA we will be using the "Impact evaluation" approach defined in the CIVITAS evaluation framework (Engels et al. 2017).



The CIVITAS impact evaluation framework employs a straightforward "before-and-after" analysis: by capturing well-defined metrics before and after a measure is implemented and comparing the difference between the two stages, the impact of the measure may be identified. Building on top of this core principle, the CIVITAS impact evaluation framework proposes additional steps to refine the process and help isolate the identified effects of the measure from other factors.

More specifically, the process identifies the following steps, also summarized in Figure 4:

1. Measure metrics before a measure is implemented, as the baseline
2. Conduct a 'business-as-usual' study to identify what would happen if no measure was implemented on baseline conditions
3. Identify other factors that may influence the result, that are not linked to the measure
4. Conduct a study by implementing the measure to baseline conditions
5. Evaluate the effect of measure compared to business-as-usual, excluding other factors

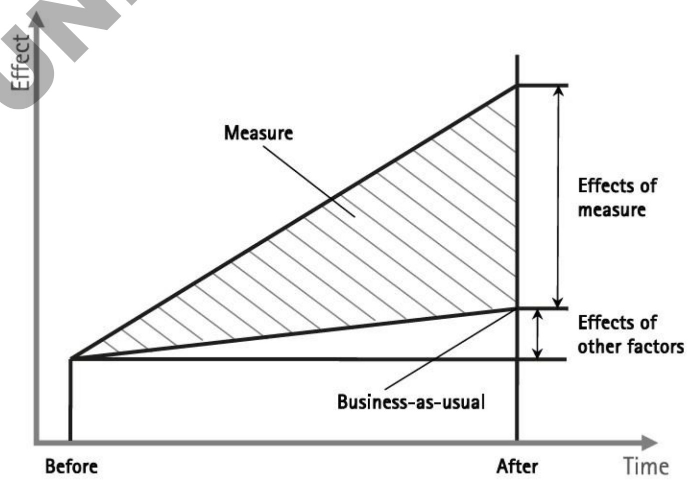



Figure 4: CIVITAS impact evaluation method. Figure from (Engels et al. 2017), original from (Dziekan et al. 2013)

In the context of FEDORA some minor adaptations are needed, to bring this evaluation framework more in-line with the FEDORA needs and characteristics. The main adaptation needed is due to the fact that the majority of pilots in FEDORA will significantly include simulations, and therefore network optimizations will be tested in a fully controlled environment in simulation, rather than the real world. This characteristic comes with both a benefit and a drawback: On the one hand, a simulated environment lacks some of the complex processes and systems that exist in the real-world and therefore may lack the fidelity to fully capture the impact of the measure in all aspects of a real-world system. However, this is an acceptable limitation, given the low TRLs of the FEDORA project that do not require real-world implementations. Additionally, the simulation environment provides a list of benefits as well: first, the fact that we have a fully controlled environment in which both the before and after phases can be captured in their entirety and replicated identically as needed, means that the process of measuring the necessary metrics is made significantly more straightforward; second, both the business-as-usual and the measure implementation studies can be performed on the exact same baseline scenario, avoiding inconsistencies that would be encountered in the real-world; and third, studies may be re-run as needed to identify and isolate external factors to a higher degree compared to a real-world study.

Applying the above process to the FEDORA systems, when a network optimization needs to be evaluated via simulation in a pilot, the following process will be followed: first, pilot stakeholders need to provide the datasets that identify and establish the baseline conditions, followed by the network optimization tools providing measures that are expected to improve those conditions. Next, a simulation will be set up on those baseline conditions and executed without the application of the proposed measures, at the end of which relevant metrics will be captured, defining the business-as-usual study. At the same time, another simulation will be set up on the same baseline conditions, but this time executed including the application of the proposed measure, capturing the relevant metrics at the end to define the implementation study. Both simulations will be executed for the same simulated duration.

At the end of the process described above, the comparison between business-as-usual and measure implementation may be performed, resulting in identifying the impact of the proposed measure. When multiple measures may be applied to one baseline, the effects of each measure in isolation as well as their compound effect should be measured. Given that FEDORA will employ simulations, this comprehensive evaluation process is considered to be feasible at least in principle and therefore should be explored.



### 3.2.2 MATURITY-BASED EVALUATION SYSTEM

In addition to the main Impact-based evaluation system presented above, we consider here a secondary evaluation system, based on the maturity of the evaluating process. This evaluation system is a conceptual framework that may be used to consider measures based on the maturity of the process that generated and validated them, signifying the degree of confidence one should have in the applicability of the measure if applied to a real-world system. The proposed evaluation scale ranges from theoretical abstract models and heuristics as the least mature, to repeated applications in real-world conditions being the most mature. In this regard it may be considered to map somewhat to the TRL scale, with least mature systems seen as closer to low TRLs (1-2) and most mature systems closer to high TRLs (7-9).

A full maturity-based scale is proposed here as follows, from least to most mature:

1. Heuristic
2. Theoretical abstract model and logic model
3. Logic model calibrated on real-world data
4. Simulation model tested on real-world data
5. Real-world application

This maturity-based evaluation system is not meant to be compared to the impact-based evaluation system and should not be considered as a potential replacement. Instead, we consider it here as complementary, only used to measure and evaluate the proposed network management solutions regarding their robustness and expected relevance to the real-world at their current maturity level. The general principle behind this framework is that at lower levels the processes that generate measures are built on more assumptions and are generally more abstract, and therefore lack the fidelity and nuisance that exists in real-world systems, whereas at higher levels the processes incorporate data and parameters more and more from the real-world and are expected to more accurately represent it. Thus, the more mature a system is, its outputs may be considered as more directly applicable to the real-world. A maturity-based metric should therefore also be included explicitly for the overall evaluation of a measure in combination with its impact evaluation; to make clearer to stakeholders both the expected impacts as well as the additional study needed before a measure is ready to be applied to the real-world. In the context of the FEDORA project where most of the pilots will involve simulation environments, we expect to see measures in the range 1-4 from heuristics and mathematical models to simulations calibrated to real-world data).

# 4 CONCLUSIONS AND NEXT STEPS

This deliverable marks the completion of the first co-creation cycle in FEDORA, covering the establishment of the Living Lab methodology, the engagement of local stakeholders across six pilot sites, and the initial identification and validation of use cases. It also presents the conceptual framework and evaluation models developed under Task 2.3 as the technical foundation for the FEDORA platform.

Regarding Part II, Task 2.3 has delivered the conceptual framework architecture for the FEDORA spaces, defining the three core spaces (the data space, the optimisation services space and the simulation space) and their interoperability principles. The evaluation models developed in this task provide a structured approach to assessing the maturity and impact of network management solutions across the six pilots, establishing a common baseline for the demonstration evaluation work that will follow in Year 2.

Several conclusions can be drawn from the work documented here. The co-creation process confirmed that the operational challenges identified in the Grant Agreement are real and felt by local stakeholders: all six pilots surfaced clear pain points around data fragmentation, governance gaps and the absence of integrated multimodal coordination tools. The Three Wheels methodology proved effective in structuring the co-creation dialogue and ensuring that use cases remained grounded in operational realities rather than technical convenience. The cross-pilot alignment session (Workshop 1.1) was particularly valuable in surfacing shared dependencies and areas of complementarity across pilots (notably around demand management, arrival data reliability and simulation frameworks) which will inform the coordination work of WP6.

At the same time, this deliverable reflects work in progress. Use cases will continue to evolve as technical development in WP3-WP5 matures and as pilot-specific data governance frameworks are established. For some pilots the scope has been adapted since Workshop 1 in response to practical constraints, without affecting the overall pilot concept or final objectives. This adaptability is consistent with the Living Lab approach and with the TRL context in which FEDORA operates.

The next steps flowing from this deliverable are the following. Task 6.1 will take the use case framings developed here as input for the Demonstrations Planning Guidelines, defining the specific activities, KPIs and evaluation approaches for each pilot site. Workshop 2, the second co-creation round, will present FEDORA's technical solutions to local stakeholders for validation and feedback, closing the loop between the needs identified here and the tools developed in WP3-WP5. The requirements and use cases documented in this deliverable will serve as the primary reference for that validation process. Following the second co-creation round as well as the definition of technical components in WP3-WP5, the full FEDORA system implementation architecture will be presented in D2.3, that will include the combinations of technical components for the different pilot implementations.

# 5 REFERENCES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# ANNEXES

# ANNEX I: STAKEHOLDER MAPPING

**Stakeholder identification file**

| Pilot 1 | Vienna | Stakeholder name | Target group | Project partner or external | Confirmed Participation / Contribution | Explanation of its main activity | Expected role in the project |
|---|---|---|---|---|---|---|---|
| | | AIT Austrian Institute of Technology GmbH | Research institution | Project partner | yes | research institution | Develops the social optimum algorithm |
| | | Stadt Wien (MA33) | Public Authorities (inc. national, regional and loc | Project partner | yes | infrastructur provider of traffic lights, traffic controller, ... | Provides infrastructure (including sensor data) and interfaces to the traffic management system |
| | | Verkehrsverbund Ost-Region (VOR) GmbH | Public Transport Operator | Project partner | yes | coordination of public transport operators, provider of traffic models | Provides traffic model and sensor data evaluations |
| | | Mobilitätsagentur Wien | Civil society representatives(e.g. VRUs associati | External | yes | representation of active mobility | input from active mobility point of view |
| | | Wiener Linien | Public Transport Operator | External | yes | public transport in vienna | input from public transport point of view |
| | | Frontier Innovations | Other | Project partner | yes | | develops app? (still unclear) |
| | | Stadt Wien (MA46) | Public Authorities (inc. national, regional and loc | External | n/a | traffic authority, approval of permanent traffic measures | N/A |
| | | Police | Public Authorities (inc. national, regional and loc | External | n/a | traffic control and traffic management | N/A |

| Pilot 2 | Basque Country | Stakeholder name | Target group | Project partner or external | Confirmed Participation / Contribution | Explanation of its main activity | Expected role in the project |
|---|---|---|---|---|---|---|---|
| | | Autoridad Portuaria de Pasaia (APP) | Public Authorities (inc. national, regional and loc | External | | Port authority managing the Port of Pasaia, responsible for port infrastructure, access control, vessel coordination and port services | Decision-making authority |
| | | NemoSoft | Service provider | External | | Primary data provider for maritime operational data; formal agreement pending | Provide data |
| | | Toro y Betolaza | Logistics operator | External | | Stevedoring and logistics operator at Port of Pasaia, handling cargo loading/unloading operations | Attend workshop |
| | | Artaza | Logistics operator | External | | Port operator at Pasaia involved in cargo handling and vessel operations | Attend workshop |
| | | Berge | Logistics operator | External | | Port and logistics operator providing cargo handling and transport coordination services | Prossible data provider |
| | | Algeposa | Logistics operator | External | | Logistics operator at Port of Pasaia managing container and cargo operations | Attend workshop |
| | | Railsider | Logistics operator | External | | Rail logistics operator based in Irún, managing rail freight movements connecting Port of Pasaia with inland platforms | Attend workshop |
| | | Zaisa | Logistics operator | External | | Logistics platform in Irún managing freight flows between the port and inland distribution nodes | Attend workshop |
| | | Colegio Oficial de Agentes de Aduanas | Sectorial associations | External | | Professional association of customs agents operating at Port of Pasaia and surroundings | Attend workshop |
| | | | | | | | |

| Pilot 3 | Nicosia | Stakeholder name | Target group | Project partner or external | Confirmed Participation / Contribution | Explanation of its main activity | Expected role in the project |
|---|---|---|---|---|---|---|---|
| | | BOLD | Service provider | External | YES | Micro-mobility representative | Provides infrastructure location and activity of shared e-scooters. |
| | | Department of Land and Surveys | Public Authorities (inc. national, regional and loc | External | YES | Public authority for infrastructure | Provide data related to road netowork and buildings location/ information. |
| | | NextBike | Service provider | External | YES | Micro-mobility representative | Provides infrastructure location and activity of shared e-bikes/ bikes. |
| | | Public Works Department (PWD) | Road operators/Infrastructure managers | External | YES | Main road network operator. | Provide data related to transport netowork, road infrastructure, and live measurements (passenger counts). PWD will be the user of the Pilot Area. |
| | | Unmanned Aircraft Systems Department of Civ | Public Authorities (inc. national, regional and loc | External | YES | Public authority for legal dimension regarding European rules for Unmanned Aircraft Systems (UAS) | Provide information about geo-fencing zones for operating UAS. |
| | | Police | Public Authorities (inc. national, regional and loc | External | YES | Public authority representative | Provide information about incidents on the road network and for the pilot excecution approvals |
| | | Municipalities (Nicosia, Aglantzia, Egkomi, Str | Public Authorities (inc. national, regional and loc | External | YES | Public authority representative | Provide approvals for the pilot excecution |
| | | | | | | | |

| Pilot 4 | Copenhagen | Stakeholder name | Target group | Project partner or external | Confirmed Participation / Contribution | Explanation of its main activity | Expected role in the project |
|---|---|---|---|---|---|---|---|
| | | Vejdirektoratet | Road operators/Infrastructure managers | External | Workshop + Follow up | Manages the national road network and traffic - owns national and regional simulat | Local workshop participation + Follow up one on one meetings on scenario development and results |
| | | Capital Region | Public Authorities (inc. national, regional and loc | External | Workshop | Regional policy and regulation in mobiity and sustainability | Local workshop participation |
| | | København Kommune | Public Authorities (inc. national, regional and loc | External | Not yet | Manages the local road network and traffic - owns amother regional simulation mo | Feedback to Results |
| | | Sund & Bælt | Service provider | External | Not yet | Company with stakeholder interests in pricing experimetns in denmark | Feedback to Results |
| | | Movia | Public Transport Operator | External | Not yet | Main Bus Operator in Zealand | Feedback to Results |
| | | Metroselskabet | Public Transport Operator | External | Not yet | CPH Metro Operator | Feedback to Results |
| | | | | | | | |
| | | | | | | | |

| Pilot 5 | Reggio Emilia | Stakeholder name | Target group | Project partner or external | Confirmed Participation / Contribution | Explanation of its main activity | Expected role in the project |
|---|---|---|---|---|---|---|---|
| | | Reggio Emilia Municipality | Public Authorities (inc. national, regional and | Project partner | yes | Pilot coordinator | Pilot leader |
| | | Emilia Romagna Region | Public Authorities (inc. national, regional and | External | yes | collaboration in the set up of the pilot (linked to MOVE IN infrastructure) | facilitating connections with MOVEIN project and other relevant actors; feedback and advisory |
| | | MYAIR | Service provider | External | Not yet | Black boxes installation and data collection | Technical service provier |
| | | DTU | Research institution | Project partner | yes | support in technical development of the pilot | input and coordination, support to technical implementation |
| | | ETH | Research institution | Project partner | yes | support in technical development of the pilot | input and coordination, support to technical implementation |
| | | JRC | Research institution | External | yes | advisory for pilot implementation | advisory pilot project implementation |
| | | FRONTIER | Research institution | Project partner | yes | support in technical development of the pilot | input and coordination, support to technical implementation |
| | | | | | | | |
| | | | | | | | |

| Pilot 6 | Budapest | Stakeholder name | Target group | Project partner or external | Confirmed Participation / Contribution | Explanation of its main activity | Expected role in the project |
|---|---|---|---|---|---|---|---|
| | | ÉKM HHF - Ministry of Construction and Tra | Public Authorities (inc. national, regional and | External | yes | Supreme regulatory authority in Hungarian inland navigation | Provides regulatory assessment criteria to project (pilot) results, gives permission to use AIS data |
| | | RSOE | Service provider | External | yes | Hungarian River Information Services (RIS) provider, historical AIS data mana | Historical AIS data provider for tests, possible AIS data provider,sharing IWT traffic management experiences and development suggestions, possible host of AIS based data hub |
| | | HFIP - Hungarian Federation of Danube Port | Sectorial associations | External | yes | Umbrella association of Hungarian inland ports for advocacy | Sharing port management experiences |
| | | HUNPASS - Federation of Hungarian Passen | Sectorial associations | External | yes | Umbrella association of Hungarian passenger vessel operators for advocacy | Sharing passenger vessel operational and traffic/transport management experiences and user needs. Partner in Budapest pilot organizing and evaluating results. |
| | | BKK - Centre for Budapest Transport | Public Transport Operator | External | yes | Responsible for the operation and development of Budapest public transport | Public transport data provider. Sharing deployEMDS experiences. Project results observer as transport organizer of Budapest. |
| | | HUI | Service provider | External | observer | Dataset developer for deploy EMDS in Budapest GO! pilot | Sharing deployEMDS experiences. |
| | | BKV - Budapest Transport Privately Held Co | Service provider | External | yes | Public transpor operator of Budapest, including waterway transport. | Sharing passenger vessel operational and transport management experiences and user needs. Possible ship operator in Budapest pilot. |
| | | Európa Rendezvényiroda Kft. | Service provider | External | yes | Passenger vessel operator (sightseeing and event cruises) | Sharing passenger vessel operational and transport management experiences and user needs. Possible ship operator in Budapest pilot. |
| | | MAHART Passnave | Service provider | External | not yet | Passenger vessel operator (sightseeing, event cruises, river cruising) | Sharing passenger vessel operational and transport management experiences and user needs. Possible ship operator in Budapest pilot. |
| | | Legenda Kft. | Service provider | External | yes | Passenger vessel operator (sightseeing and event cruises) | Sharing passenger vessel operational and transport management experiences and user needs. Possible ship operator in Budapest pilot. |
| | | Armada Budapest Kft. | Service provider | External | yes | Passenger vessel operator (sightseeing and event cruises) | Sharing passenger vessel operational and transport management experiences and user needs. Possible ship operator in Budapest pilot. |
| | | Scenic &Emerland Luxury Cruises | Service provider | External | yes | Passenger vessel operator (river cruising/ hotel vessels) | Sharing passenger vessel operational and transport management experiences and user needs. |
| | | ÉKM KBSz - Ministry of Construction and Tra | Public Authorities (inc. national, regional and | External | yes | Investigating/analysing accidents/incidents (including IWT), makes recomme | Sharing experiences in navigation and transport safety. |
| | | BRFK DVRK - Budapest Police, Danube Wat | Public Authorities (inc. national, regional and | External | yes | Performs water policing tasks, supervises ship traffic and enforces rules | Provides police assessment criteria to project (pilot) results. Sharing water police experiences in IWT. |
| | | KDVVIZIG - Central Danube Valley Water Ma | Public Authorities (inc. national, regional and | External | yes | Waterway and fairway maintenance, supports navigation by electronic naviga | Project observer, and hydrological (bathimetry, water level) data provider. |

# ANNEX II: REQUIREMENTS

| ID | Target group | Associated Pilot | Description | Cathegory | MoSCoW |
|---|---|---|---|---|---|
| VIE-001 | Social optimum service operator | Pilot 1: Vienna | Real-time traffic counts | Data Management | Should have |
| VIE-002 | Social optimum service operator | Pilot 1: Vienna | Real-time C-ITS CAM messages | Data Management | Could have |
| VIE-003 | Social optimum service operator | Pilot 1: Vienna | Public transport schedules | Data Management | Should have |
| VIE-004 | Social optimum service operator | Pilot 1: Vienna | Real-time detection of pedestrians and bicyclists | Data Management | Must have |
| VIE-005 | Social optimum service operator | Pilot 1: Vienna | Traffic demand data | Data Management | Should have |
| VIE-006 | Social optimum service operator | Pilot 1: Vienna | Real-time traffic situation data | Data Management | Must have |
| VIE-007 | City of Vienna | Pilot 1: Vienna | Real-time optimized signal phase plans including the preferences of pedestrians and bicyclists | Functional | Must have |
| VIE-008 | City of Vienna | Pilot 1: Vienna | Continuous monitoring of signal plan impacts (traffic situation, waiting times, ...) | Functional | Must have |
| VIE-009 | City of Vienna | Pilot 1: Vienna | Integration into traffic light control system | Functional | Must have |
| VIE-010 | City of Vienna | Pilot 1: Vienna | interoperability (OpenAPI?) | Operational | Should have |
| VIE-011 | City of Vienna | Pilot 1: Vienna | configurability | Operational | Should have |
| VIE-012 | City of Vienna | Pilot 1: Vienna | performance (every 5 min or even less?) | Operational | Should have |
| VIE-013 | City of Vienna | Pilot 1: Vienna | safety & security | Operational | Should have |
| VIE-014 | City of Vienna | Pilot 1: Vienna | observability | Operational | Should have |
| VIE-015 | Social optimum service operator | Pilot 1: Vienna | Signal plans | Data Management | Must have |
| BCO-001 | Logistics operators | Pilot 2: Basque Country | Real-time visibility of vessel arrival times (ETA) accessible to all port operators | Technical | Must have |
| BCO-002 | Logistics operators | Pilot 2: Basque Country | Real-time availability and status of port nautical services (tugboats, mooring, pilots) | Technical | Must have |
| BCO-003 | Logistics operators | Pilot 2: Basque Country | Truck slot management system for port access to reduce waiting times and congestion | Technical | Should have |
| BCO-004 | Logistics operators | Pilot 2: Basque Country | Real-time berth assignment and space optimisation at Port of Pasaia | Technical | Should have |
| BCO-005 | Logistics operators | Pilot 2: Basque Country | Container tracking from port departure to final delivery | Technical | Could have |
| BCO-006 | Road operators | Pilot 2: Basque Country | Digital integration between APP systems, stevedores and customs for cargo processing | Technical | Could have |
| BCO-007 | Road operators | Pilot 2: Basque Country | Digitisation of operational documentation (packing lists, delivery notes, customs summaries) | Operational | Could have |
| BCO-008 | Road operators | Pilot 2: Basque Country | Improved coordination between port and rail operators for freight movements | Operational | Could have |
| BCO-009 | Logistics operators | Pilot 2: Basque Country | Shared truck availability planning tool between logistics operators and port | Operational | Should have |
| BCO-010 | Public Authorities | Pilot 2: Basque Country | Data governance framework defining conditions and roles for data sharing among port actors | Organisational | Must have |
| BCO-011 | Public Authorities | Pilot 2: Basque Country | Cybersecurity standards and protocols for shared port data infrastructure | Organisational | Could have |
| BCO-012 | Sectorial associations | Pilot 2: Basque Country | Establishment of a border inspection facility at Port of Pasaia to avoid displacement to Bilbao/Irún | Regulatory / Legal | Won't have |
| BCO-013 | Logistics operators | Pilot 2: Basque Country | Access control system using licence plate recognition to manage vehicle entry and assign waiting zones | Technical | Should have |
| BCO-014 | Logistics operators | Pilot 2: Basque Country | Terminal lighting automation linked to operational schedules | Technical | Won't have |
| BCO-015 | Road operators | Pilot 2: Basque Country | Rail freight data sharing between operators to enable co-loading of wagons | Data Management | Could have |
| BCO-016 | Service provider | Pilot 2: Basque Country | Real-time maritime operational data feed covering vessel ETAs, ATA/ATD events, nautical services status, intra-port movements and incident registry | Data Management | Must have |
| NIC-001 | Public Works Department | Pilot 3: Nicosia | Bus Stops | Data Management | Must have |
| NIC-002 | Public Works Department | Pilot 3: Nicosia | Bus Routes and Timetables | Data Management | Must have |
| NIC-003 | Public Works Department | Pilot 3: Nicosia | Bus Routes Real Time | Data Management | Must have |
| NIC-004 | Public Works Department | Pilot 3: Nicosia | Bus Stations | Data Management | Must have |
| NIC-005 | Public Works Department | Pilot 3: Nicosia | Bus Lanes | Data Management | Must have |
| NIC-006 | Public Works Department | Pilot 3: Nicosia | Charging Stations | Data Management | Should have |
| NIC-007 | Public Works Department | Pilot 3: Nicosia | Cycleways | Data Management | Must have |
| NIC-008 | Public Works Department | Pilot 3: Nicosia | GTFS Schedule | Data Management | Must have |
| NIC-009 | Public Works Department | Pilot 3: Nicosia | Park & Ride | Data Management | Must have |
| NIC-010 | Public Works Department | Pilot 3: Nicosia | Parking Areas | Data Management | Should have |
| NIC-011 | Public Works Department | Pilot 3: Nicosia | Passenger Counts | Data Management | Must have |
| NIC-012 | Public Works Department | Pilot 3: Nicosia | Traffic Signals | Data Management | Must have |
| NIC-013 | Public Works Department | Pilot 3: Nicosia | Historical Traffic Data (Peak Hrs & Off-Peak Hrs) | Data Management | Must have |
| NIC-014 | Public Works Department | Pilot 3: Nicosia | Real Traffic Data | Data Management | Must have |
| NIC-015 | Public Works Department | Pilot 3: Nicosia | Incidents (e.g. road closures) | Data Management | Should have |
| NIC-016 | NextBike | Pilot 3: Nicosia | e-Bike Rental Stations | Data Management | Must have |
| NIC-017 | BOLD | Pilot 3: Nicosia | e-Scooter Geofencing Zones | Data Management | Must have |
| NIC-018 | BOLD | Pilot 3: Nicosia | e-Scooter Stations | Data Management | Must have |
| NIC-019 | Department of Land and Surveys | Pilot 3: Nicosia | Buildings | Data Management | Should have |
| NIC-020 | Department of Land and Surveys | Pilot 3: Nicosia | Urban Planning Zones | Data Management | Could have |
| NIC-021 | Department of Land and Surveys | Pilot 3: Nicosia | Transport Network | Data Management | Should have |
| NIC-022 | Unmanned Aircraft Systems Department of Civil Aviation | Pilot 3: Nicosia | UAS Geographical Zones | Regulatory / Legal | Should have |
| NIC-023 | Electricity Authority of Cyprus (EAC) | Pilot 3: Nicosia | EAC Charging Stations | Data Management | Should have |
| NIC-024 | Police | Pilot 3: Nicosia | Incidents (e.g. accidents, road condition etc) | Data Management | Should have |
| NIC-025 | Police (Traffic Department) | Pilot 3: Nicosia | Pilot excecution approvals | Data Management | Must have |
| NIC-026 | Nicosia Municipality | Pilot 3: Nicosia | Pilot excecution approvals | Data Management | Must have |
| NIC-027 | Aglantzia Municipality | Pilot 3: Nicosia | Pilot excecution approvals | Data Management | Must have |
| NIC-028 | Egkomi Municipality | Pilot 3: Nicosia | Pilot excecution approvals | Data Management | Must have |
| NIC-029 | Strovolos Municipality | Pilot 3: Nicosia | Pilot excecution approvals | Data Management | Must have |





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| | | | | | |
|---|---|---|---|---|---|
| CPH-001 | planners | Pilot 4: Copenhagen | modules | Technology | Must |
| CPH-002 | Data providers (road authority, Movia, DSB, freight operators) | Pilot 4: Copenhagen | Calibration against traffic counts and public transport ridership | Data / Validation | Must |
| CPH-003 | Road authority, regional planners, non-expert users | Pilot 4: Copenhagen | Scenario configuration and results visualisation for stakeholders | Tools / Interface | Must |
| CPH-004 | Funders, modelling team | Pilot 4: Copenhagen | Evaluation of computational performance to compare against current performance, estimated at approximately four days per full cloud run | Resources / Performance | Must |
| CPH-005 | MaaS operators, road authority | Pilot 4: Copenhagen | Establish a framework for MaaS integration in large-scale simulations | Governance / MaaS | Must |
| CPH-006 | Modelling team | Pilot 4: Copenhagen | Ensure the simulation platform can run partial-network or multi-scale simulations, reducing runtime and cost while maintaining accuracy | Performance / Scalability | Could Have |
| CPH-007 | Environmental planners | Pilot 4: Copenhagen | Develop advanced emission-modelling capabilities to assess environmental impacts of scenarios | Environment / Tools | Should Have |
| CPH-008 | Funders, modelling team | Pilot 4: Copenhagen | Funding & compute resources for regular model runs of existing model | Resources | Won't have |
| CPH-009 | Regional planners | Pilot 4: Copenhagen | Forecasting tools for bus hours, seat capacity & budgets | Planning / Tools | Should Have |
| CPH-010 | MaaS operators, road authority | Pilot 4: Copenhagen | Governance framework for MaaS integration & data sharing | Governance | Won't have |
| CPH-011 | Public / travellers | Pilot 4: Copenhagen | Gamified user-feedback mechanism for pricing schemes | Engagement / Tools | Could have |
| CPH-012 | Travellers | Pilot 4: Copenhagen | Mobile app for personalised travel incentives & dynamic pricing | Mobile / App | Could have |
| CPH-013 | Data providers (road authority, Movia, DSB, freight operators) | Pilot 4: Copenhagen | Data-sharing agreements and platform to integrate traffic, ridership, seat and freight data | Data / Governance | Could have |
| RE-001 | Municipality of Reggio Emilia/TSPs | Pilot 5: Reggio Emilia | Establish a formal partnership framework with TSPs | Organisational | Must have |
| RE-002 | Municipality of Reggio Emilia/Data Protection Officer | Pilot 5: Reggio Emilia | Establish a GDPR-compliant data processing architecture | Regulatory / Legal | Must have |
| RE-003 | TSPs | Pilot 5: Reggio Emilia | Define and formalise the technical specifications for TSP data collection and transmission | Data Management | Must have |
| RE-004 | Municipality of Reggio Emilia | Pilot 5: Reggio Emilia | Recruit 500 participants to install black boxes who regularly travel within the Reggio Emilia road network | Operational | Must have |
| RE-005 | Research institutions | Pilot 5: Reggio Emilia | Implement token trading marketplace with market rules engine | Technical | Must have |
| RE-006 | Research institutions | Pilot 5: Reggio Emilia | Provide participants with a user-facing platform (app or web-based) | Technical | Must have |
| RE-007 | Research institutions / TSP | Pilot 5: Reggio Emilia | A backend system capable of receiving and processing TSP trip data, managing credit balances and market transactions, enforcing market rules | Technical | Must have |
| RE-008 | Research institutions | Pilot 5: Reggio Emilia | market rules to prevent speculation and manipulation (transaction costs, per-trade limits, daily frequency caps, maximum token ownership) | Technical | Should have |
| RE-009 | All participants | Pilot 5: Reggio Emilia | Implement History & Statistics module showing individual trip history, token usage, personal performance indicators, and comparative statistics across the participant group | Technical | Should have |
| RE-010 | Research institutions | Pilot 5: Reggio Emilia | Implement push notification system to alert participants of charging scheme changes | Technical | Could have |
| RE-011 | All participants | Pilot 5: Reggio Emilia | Implement gamification features (e.g. badges, rankings, challenges) to enhance participant engagement with the platform | Technical | Won't have |
| RE-012 | Municipality of Reggio Emilia | Pilot 5: Reggio Emilia | Integrate with public transport ticketing systems | Technical | Won't have |
| BUD-001 | Budapest municipality, ship operators, sectorial associations | Pilot 6: Budapest | Danube Bank Building Regulations will be changed: Municipality want to reduce pier num | Governance | Should have |
| BUD-002 | Ship operators | Pilot 6: Budapest | Compliance with navigation rules to avoid safety risk situations on wateray | Operational | Must have |
| BUD-003 | Public authority | Pilot 6: Budapest | Mandatory use of ECDIS | Regulatory / Legal | Won't have |
| BUD-004 | Ship operators, River Information Service provider | Pilot 6: Budapest | Supporting navigation in rule-abiding behavior on ECDIS | Data Management | Could have |
| BUD-005 | Ship operators, River Information Service provider, water management authority | Pilot 6: Budapest | Supporting navigation with real time water depth data on ECDIS | Data Management | Could have |
| BUD-006 | Ship operators, River Information Service provider | Pilot 6: Budapest | Supporting navigation with real vessel departure and arrival data on ECDIS | Data Management | Should have |
| BUD-007 | Ship operators | Pilot 6: Budapest | Supporting navigation with real arrival/departure pier No. on ECDIS | Data Management | Should have |
| BUD-008 | Ship operators | Pilot 6: Budapest | Supporting navigation with expected vessel trajectories on ECDIS | Data Management | Could have |
| BUD-009 | Ship operators, River Information Service provider, sectorial associations | Pilot 6: Budapest | Sharing real time ship departure and arrival data (time, pier No.) with skippers, tourists and event organizers | Data Management | Must have |
| BUD-010 | Ship operators, River Information Service provider | Pilot 6: Budapest | Using a departure time registration system for vessels mooring in city center of Budapest | Organisational | Could have |
| BUD-011 | Ship operators, River Information Service provider | Pilot 6: Budapest | No trust in AIS data. Consolidation of AIS data: frequency of position data, estimation of missing data, refinement or filtering of fals data. | Functional | Must have |
| BUD-012 | Public authory, River Information Service provider | Pilot 6: Budapest | AIS data handling in compliance with RIS regulations | Regulatory / Legal | Must have |
| BUD-013 | Public transport operator (BKK) | Pilot 6: Budapest | Sharing of sightseeing and event ship PNT data should be harmonized so that it can be integrated into BKK's transport data systems. (Possible development of Budapest GO! applicarion) | Technical | Must have |
| BUD-014 | Ship operator, sectorial association | Pilot 6: Budapest | Reduce impact of international tourist agent online platforms. | Business / Financial | Could have |
| BUD-015 | Ship operator, sectorial association | Pilot 6: Budapest | Support of sightseeing tour planning of individual tourists with involving sightseeing and ho on-hop off ships into (public transport and mycromobility) route planner. | Operational | Should have |
| BUD-016 | Ship operators, public transport operator (BKK), | Pilot 6: Budapest | Support of tourists in finding pier numbers, tourist bus parking places, closest public/mycromobility connection points | Operational | Should have |
| BUD-017 | Ship operators, sectorial association | Pilot 6: Budapest | Schedule plan of sightseeing/hop on-hop off/event/cruiser (hotel) ships | Technical | Must have |
| BUD-018 | Ship operators, sectorial association | Pilot 6: Budapest | Pier numbers of vessels | Technical | Must have |
| BUD-019 | River Information Service provider | Pilot 6: Budapest | Consolidated AIS data | Technical | Should have |
| BUD-020 | Public transport operator (BKK) | Pilot 6: Budapest | Public transport traffic data | Technical | Must have |
| BUD-021 | Public transport operator (BKK)/ mycromobility operator | Pilot 6: Budapest | Mycromobility traffic data | Technical | Must have |

# ANNEX III: CO-CREATION GUIDELINES

This annex contains the co-creation guidelines developed for T2.2, defining the methodology, criteria and process followed to set up the Living Labs, engage stakeholders, and facilitate the co-creation workshops across the six FEDORA pilot sites.

## PURPOSE

This document provides a common methodology for planning and executing the **Pilot Co-Creation Workshops in WP2**, ensuring that all six FEDORA pilots follow a coherent, comparable and efficient process.

These guidelines aim to:

- Provide pilot leaders with a procedure to prepare and conduct the workshops.
- Define a set of common questions and outputs valid for all pilots, while allowing customisation according to pilot typology.
- Ensure transition of outputs from WP2 to WP6.

## HOW TO USE THIS DOCUMENT

This document is intended for all FEDORA pilot leaders and teams involved in WP2 (T2.2) and WP6. Its purpose is to provide a unified procedure for preparing, conducting and reporting the Pilot Co-Creation Workshops.

| | | | | | |
|---|---|---|---|---|---|
| CPH-001 | planners | Pilot 4: Copenhagen | modules | Technology | Must |
| CPH-002 | Data providers (road authority, Movia, DSB, freight operators) | Pilot 4: Copenhagen | Integrate traffic counts and public-transport ridership into an automatic validation procedure | Data / Validation | Must |
| CPH-003 | Road authority, regional planners, non-expert users | Pilot 4: Copenhagen | Provide a user-friendly scenario configuration and results-visualisation tool to enable non-experts to design and assess policy scenarios | Tools / Interface | Must |
| CPH-004 | Funders, modelling team | Pilot 4: Copenhagen | Showcase alternative computational architectures and resources to support regular model runs and experimentation, lowering the barrier to innovation | Resources / Performance | Must |
| CPH-005 | MaaS operators, road authority | Pilot 4: Copenhagen | Establish a framework for MaaS integration in large-scale simulations | Governance / MaaS | Must |
| CPH-006 | Modelling team | Pilot 4: Copenhagen | Ensure the simulation platform can run partial-network or multi-scale simulations, reducing runtime and cost while maintaining accuracy | Performance / Scalability | Could Have |
| CPH-007 | Environmental planners | Pilot 4: Copenhagen | Develop advanced emission-modelling capabilities to assess environmental impacts of scenarios | Environment / Tools | Should Have |
| CPH-008 | Funders, modelling team | Pilot 4: Copenhagen | Funding & compute resources for regular model runs of existing model | Resources | Won't have |
| CPH-009 | Regional planners | Pilot 4: Copenhagen | Forecasting tools for bus hours, seat capacity & budgets | Planning / Tools | Should Have |
| CPH-010 | MaaS operators, road authority | Pilot 4: Copenhagen | Governance framework for MaaS integration & data sharing | Governance | Won't have |
| CPH-011 | Public / travellers | Pilot 4: Copenhagen | Gamified user-feedback mechanism for pricing schemes | Engagement / Tools | Could have |
| CPH-012 | Travellers | Pilot 4: Copenhagen | Mobile app for personalised travel incentives & dynamic pricing | Mobile / App | Could have |
| CPH-013 | Data providers (road authority, Movia, DSB, freight operators) | Pilot 4: Copenhagen | Data-sharing agreements and platform to integrate traffic, ridership, seat and freight data | Data / Governance | Could have |

- **Who should use it**
  - ☐ Pilot leaders and technical partners in each pilot.
  - ☐ Teams responsible for stakeholder engagement.
  - ☐ WP2 and WP6 leaders for coordination.

- **How pilots must use it**
  - ☐ Follow the common structure for Workshop 1 described in Sections 3 and 4.
  - ☐ Use the templates provided (Stakeholder List and Initial Requirements) before the workshop.
  - ☐ Use the question sets provided.
  - ☐ Submit the required outputs after the workshop (Section 5).

- **Mandatory vs. flexible elements**
  - ☐ Mandatory: common agenda, common questions, use of templates, delivery of post-workshop outputs.

- Flexible: local adaptations, order of discussion, specific technical depth depending on pilot type.

- **Expected deliveries.** Pilots must deliver:

1. A stakeholder engagement summary.
2. Requirements Table.
3. A prioritised list of critical requirements in a report.

Methodology for Requirements Elicitation (WP2 → WP6)

The objective of this methodology is to ensure that all pilots follow a consistent and comparable process for identifying, refining and validating their requirements. This guarantees that the outputs of WP2 can be directly used by the technical work packages (WP3–WP6) and that FEDORA develops interoperable and coherent solutions across Europe.

**STEP 1 – Pre-workshop preparation**

Each pilot completes:

- Template 1 (Stakeholder Mapping)
- Template 2 (Initial Requirements & Needs)

Inputs may come from:

- Bilateral meetings,
- Existing mobility/logistics plans,
- Current operational challenges,
- Known data assets and barriers.

**STEP 2 – Co-creation "Workshop 1"**

During the workshop, the pilot:

- Validates its initial list of requirements,
- Collects additional inputs from stakeholders,
- Clarifies data needs and constraints,
- Identifies barriers and dependencies.

**STEP 3 – Consolidation of "Requirements Table v1"**

After the workshop, the pilot:

- Completes missing fields,
- Cleans duplicates,
- Assigns categories,
- Completes MoSCoW prioritisation,
- Documents data needs and constraints.

**STEP 4 – Internal Alignment Workshop ("Workshop 1.1")**

Pilots and MLC jointly:

- review similarities and differences between pilots,

- identify cross-pilot requirements,
- detect incompatibilities or missing elements,
- prepare the harmonised inputs for WP6.

**STEP 5 – MLC consolidation**

MLC merges all pilots' tables and information, ensuring:

- Unified naming practices/standards,
- Consistent categories,
- Comparable prioritisation,
- Preparation of the deliverable.

**STEP 6 – Transition to WP6**

The consolidated result becomes the baseline for:

- WP6 design and implementation,
- technical prioritisation,
- definition of KPIs,
- validation scenarios.

This process ensures coherence across pilots and a smooth transition into the technical work packages.

## PILOT TYPOLOGY AND IMPLICATION FOR WORKSHOPS

-To ensure that the co-creation workshops are adapted to the reality of each site, we have proposed a practical classification of the six pilots based on the descriptions provided in the Grant Agreement.

-Each pilot leader is invited to confirm whether this typology reflects their site adequately or to propose minor adjustments if needed. The goal is to ensure alignment while keeping a consistent structure across all workshops.

-The typology could change depending on the situation and will be evaluated with the leaders.

| Category | Pilots | What it means for the workshop |
|---|---|---|
| **Real logistics / industrial** | Basque Country (#2)<br>Budapest (#6) | ▪ **Stakeholders**: operators, ports, logistic-nodes, SMEs.<br>▪ **Focus** on requirements focused on digitalization, events, data, interoperability. |
| **Real urban mobility** | Vienna (#1)<br>Reggio Emilia (#5) | ▪ **Stakeholders**: city council, mobility operators, users.<br>▪ **Focus** on traffic management, incentives, social optimum, C-ITS. |
| **Hybrid / Novel modes** | Nicosia (#3) | ▪ **Stakeholders**: drone, authorities, operators.<br>▪ **Focus** on UAV + modes integration. |
| **Simulation / Foresight** | Copenhagen (#4) | ▪ **Stakeholders**: transport authorities, modelers.<br>▪ **Focus** on future scenarios, data and granularity. |

**PILOT #1 - Vienna: Multimodal services optimisation for equitable future mobility**

Objective: Optimise urban mobility services in Vienna by integrating pedestrians, bicycles, public transport, and private vehicles within a single, socially balanced traffic management system. The pilot aims to shift from motorised traffic-focused management to multimodal optimisation that balances efficiency, equity, and sustainability.

Description: The pilot will take place in central Vienna, where C-ITS units are already installed at traffic lights. The project will expand this infrastructure to integrate:

- Tram, bus, cyclist, and pedestrian data.
- Urban sensors and cameras.
- Users equipped with the FEDORA mobile app to collect real-time data.

Added value: Creation of a European reference model for socially balanced multimodal traffic management, combining physical infrastructure, digital technology, and simulation models.

**PILOT #2 - Basque Country: Seamless integration of logistics hubs for optimal door-to-door freight transport**

Objective: Develop a multimodal logistics ecosystem connecting ports, logistics platforms, railways, and road transport, focusing on process digitalisation and frictionless optimisation of the supply chain.

Description: The pilot will be located in the Basque logistics network: ports of Bilbao and Pasaia, airports, intermodal nodes (CTVi, Arasur, Aparkabisa, Zaisa), and road transport operators (Algeposa, GTO, etc.), aiming to facilitate data exchange between actors and develop predictive tools for door-to-door planning and synchronisation of operations.

Added value: Demonstrate how FEDORA solutions can be applied to real industrial logistics, advancing towards a digitised multimodal supply chain model without mode barriers.

**PILOT #3 - Nicosia: Integration and traffic management of aerial and road services**

Objective: Integrate urban air transport (drones for passengers and goods) into the existing mobility system, evaluating mode interaction and the potential of UAVs as urban traffic sensors.

Description: The pilot will use drones for two purposes:

- Urban "Park & Fly": integration of transport drones with vertiports connected to the ground network (P&R, public transport).
- Aerial monitoring: drones equipped with cameras to collect real-time traffic information and improve incident management.

Added value: Explore urban air mobility (UAM) and its integration with ground systems, offering an advanced vision of future multimodal management.

**PILOT #4 - Copenhagen: Foresight analysis using network-wide simulations of realistic multimodal services**

Objective: Assess demand management policies and future multimodal mobility strategies using a large-scale, high-resolution simulation model.

Description: Agent-based simulation that reproduces the multimodal network of the Copenhagen metropolitan region: car, bus, train, metro, shared bikes, car sharing, and on-demand transport. It will serve as a testbed for dynamic pricing policies, incentives, and Mobility as a Service.

Added value: Provides FEDORA's reference simulation laboratory, where mobility policies can be tested before real-world implementation.

**PILOT #5 - Reggio Emilia: Managing demand using incentivisation, nudging and artificial currencies**

Objective: Apply mobility currency mechanisms (mobility credits) and dynamic pricing to regulate access to low-emission zones and promote a modal shift towards more sustainable options.

Description: Users receive digital credits that they can spend or trade in a local market. The value depends on vehicle profile, distance, and time spent within the LEZ. A mobile app will allow users to check their balance, history, and redeem rewards.

Added value: First empirical demonstration in Europe of a cap-and-trade system for mobility, combining economics, sustainability, and user behaviour.

**PILOT #6 - Budapest: Traffic Flow Simulation in inland waterways**

Objective: Integrate river and land transport through simulations and IoT systems, improving coordination between them and reducing navigation risks and urban congestion.

Description: Based on traffic on the Danube, the pilot will enable real-time visualisation of routes, schedules, and estimated times of arrival (ETA) of vessels, and coordinate their connection with tourist and public land transport.

Added value: Demonstrates the integration of waterborne and land transport models under a single digital traffic management platform.

## PRE-WORKSHOP PREPARATION (by each pilot)

- Before the co-creation "Workshop 1" takes place, each pilot must complete a minimum level of preparation to ensure that the sessions are meaningful and not starting "from zero".

- MLC provides the structure, templates, and coordination, but each pilot team is responsible for filling in their own content based on their local ecosystem.

- Before "Workshop 1", each pilot will arrive with **an** initial set of preliminary requirements. These requirements come from the bilateral meetings already held with key stakeholders during November-December 2025, using both templates (stakeholder list and initial requirements table).

-These pre-inputs are not final: they serve as the starting point for the co-creation session.

-The goal of "Workshop 1" is to validate, refine and expand these initial requirements by involving the wider local ecosystem. This ensures that:

- Stakeholders do not start from a blank page.
- Discussions remain concrete and focused.

- The workshop builds on work already completed in T2.2.
- Pilots avoid duplicated efforts or parallel pre-workshops.

-After "Workshop 1", each pilot will produce a new "Requirements Table", which represents the consolidated version of all insights (pre-work + workshop contributions).

-MLC will gather all the information into a single document.

## Stakeholder List (Template 1 provided by MLC in the shared folder)

-Each pilot must update the stakeholder table using the common format shared by MLC.

-Deadline: 31/12/2025

-The purpose of this template is to ensure that all pilots enter the first workshop with a clear map of who they should involve.

-The table includes the following fields:

- Stakeholder name
- Role (e.g., operator, authority, logistics node, technology provider, user)
- Type (local / regional / industrial / public / private)
- Participation confirmed? (Yes / Not yet)
- Expected contribution (what type of input they can provide: requirements, barriers, data access, validation, etc.)

-This template was already shared with partners earlier, and each pilot is expected to fill it based on their initial contacts and first bilateral exchanges with stakeholders.

-The upcoming workshop will refine and complete the list, but it is essential that each pilot arrives with a preliminary version already filled.

### Initial Requirement Assumptions

-Each pilot must update the stakeholder table using the common format shared by MLC.

-Deadline: 31/12/2025

-This template, also shared by MLC, collects initial hypotheses on requirements and needs from the pilot.

- It is not expected to be complete yet (it will be refined in the workshop), but it avoids beginning the session from a blank page.

**-These initial assumptions should come from:**

- Internal knowledge of the pilot team
- Previous or ongoing projects
- Known bottlenecks or barriers
- First conversations with key stakeholders
- Existing strategic plans in the city/port/region

-These initial requirement entries are only a starting point. The purpose of the first workshop is precisely to validate, refine, and complete this list with stakeholders.

-After the workshop, we will obtain the official requirement set, which will later be communicated to technical partners.

Understanding requirement categories in template 2

Template 2 (“Requirements & Needs”) includes a predefined list of categories that all pilots must use when classifying each requirement. This section clarifies what each category means and provides guidance to ensure consistent interpretation across the six pilot sites.

The categories available in the template are:

**Technical:** This refers to requirements related to system capabilities, integration needs, technologies to be used, interoperability, performance, or any technical aspect required for the pilot.

Examples:

- Need for multimodal prediction algorithms
- Integration with existing traffic/light management systems
- APIs or data standards required

**Operational**: These describe needs directly related to the pilot’s day-to-day functioning, procedures or workflows that the FEDORA solution must support or improve.

Examples:

- Coordination procedures between operators
- Incident response processes
- Monitoring routines

**Organisational**: Requirements that involve collaboration, internal coordination between entities, roles, responsibilities or institutional alignment.

Examples:

- Clarification of responsibilities between city departments
- Coordination mechanisms across logistics stakeholders

**Regulatory / Legal:** Requirements related to compliance with legal frameworks, operational authorisations, data protection constraints, transport regulations, or administrative procedures.

Examples:

- Legal constraints related to UAV operations
- Data-sharing agreements required between stakeholders
- Rules governing access to low-emission zones

**Data Management:** Requirements concerning datasets, data access, formats, updates, quality, interoperability or constraints for using/sharing the data needed by the pilot.

Examples:

- Need for real-time vehicle location data
- Requirement for harmonised formats for port/rail logistics data
- Access rights needed for traffic incident datasets

**Business / Financial:** Requirements related to economic feasibility, operational costs, incentive mechanisms, or financial sustainability of the solution.

Examples:

- Need for a viable incentive model for behavioural change
- Cost-efficiency expectations for data acquisition

**Other:** For needs that do not fit into any of the above categories.

- How pilots should choose the category:

Each requirement must be assigned to only one category. Pilots should always choose the category that best reflects the main nature of the requirement.

Examples:

- "Access to historical passenger flows in GTFS format" à Data Management
- "Coordination between police, UAV operator and municipality" à Organisational
- "Need to comply with LEZ access rules when implementing incentives" à Regulatory / Legal

How templates are used during Workshop 1

Templates 1 and 2 serve as dynamic tools during preparation, execution and follow-up of Workshop 1.

**Template 1 – Stakeholder Mapping**

-Before the workshop: Pilots complete all fields based on current knowledge.

-During the workshop: Pilots update:

- Participation confirmation,
- Additional stakeholders identified by the group,
- Updated roles or expected contributions.

**Template 2 – Requirements & Needs**

-During Workshop 1, pilots complete: description, category, stakeholder source, dependencies and governance inputs.
-After the workshop, pilots complete: MoSCoW priority, feasibility, and any missing clarifications.

## WORKSHOP 1 – STRUCTURE AND EXECUTION

### Objective of the WORKSHOP 1

"Workshop 1" is the core co-creation event of WP2, where each pilot gathers the information needed to build its official requirement set. The workshop has a common structure, but each pilot adapts it to its context.

Main objectives (consolidated and non-repetitive):

- Collect requirements from stakeholders
- Identify challenges, barriers and operational pain points
- Understand the real needs and expectations of the local ecosystem
- Identify data availability, gaps, and constraints
- Generate inputs for the internal WP2 alignment session (“Workshop 1.1”)

*(Note: Technology partners will use these requirement outputs later.)*

- o Workshops are expected to be interactive and based on group discussions, not presentations.
- o During “Workshop 1”, participants must focus on defining WHAT is needed, meaning:
    - Current problems and pain points
    - Functional needs
    - Required data
    - Constraints and conditions
    - Operational or governance objectives

Common agenda for all the pilots

All pilots must follow a minimum common structure, ensuring comparability, while still allowing **local adaptation**:

1. Welcome & purpose

- Short introduction to FEDORA
- Objectives of Workshop 1
- Explanation of how the results will be used in WP2 and later in WP6

2. Pilot context

- Brief description of the pilot and its relevance for FEDORA
- Local ecosystem: actors, infrastructure, modes
- Current challenges or operational constraints (baseline situation)

3. Co-creation session: the three wheels

-This is the structured methodology that all pilots must use.

- The workshops will be guided by a core common questionnaire (Block A), complemented by pilot-specific questions (Block B), which will be addressed within the same sessions of each wheel.

- Common questions (for all pilots)

These questions cover operational problems, data needs, collaboration challenges, barriers to data sharing, and future expectations.

- Pilot-Specific questions

-Each pilot will incorporate an additional 3–5 targeted questions adapted to its nature: logistics real environment, urban multimodal transport, UAV-road integration, or simulation-oriented pilots.

-The aim is to combine:

- Homogeneity (same logic across all pilots)
- Comparability (results can be analysed together)

- Local flexibility (each pilot adapts examples and terminology)

-The requirements collection process will follow a harmonised structure across all pilots, ensuring comparability while allowing adaptation to specific local needs.

Suggested agenda:

- Pilot-specific questions are discussed within each wheel, not as a separate session.
- **Pilots may adapt** the format depending on time, stakeholders and logistics. The following structure serves as **an example**:

**10:00 – 10:10 Welcome & introduction**

- FEDORA overview (few slides)
- Objectives of the workshop
- Expected outputs

**10:10 – 10:20 Pilot context & local constraints**

- Short presentation of pilot area, actors, mobility/logistics context.
- How the pilot connects with FEDORA innovations and WP2 goals.

**10:20 – 10:50 WHEEL 1: Current Problems (Breakout Groups)**

  - Format: 2-3 small groups (to ensure that all voices are heard, to have more concrete examples and to avoid dominant stakeholders that monopolise discussions)
- Each group discusses the *same* guiding questions.
- Facilitators collect:
  - Pain points
  - Missing data
  - Operational inefficiencies
  - Coordination barriers

-Discussion covers both common questions and pilot-specific challenges related to the local context.

**10:50 – 11:00 Plenary wrap-up & cross-discussion**

- Each group presents 2–3 key insights.
- Short cross-discussion to compare findings across stakeholders:
  - "Which issues appear in multiple groups?"
  - "Which problems are unique to specific actors?"

**11:10 – 11:25 WHEEL 2: Tools & Functionalities**

- Participants identify:
  - desired functionalities
  - Operational needs.
  - Required dataset.
  - Automation or integration opportunities.
- Output: preliminary functional + non-functional requirements.

-Discussion includes pilot-specific operational and technological needs.

**11:25 – 12:45 WHEEL 3: Data exchange & requirements**

- Structured exercise based on:
    - Data availability
    - Data format & standards
    - Access & sharing constraints
    - Trust and confidentiality
    - Regulatory barriers

**11:45 – 12:15 Consolidation & Agreement**

- Quick clustering of insights across the three wheels.
- Identify contradictions, open questions, missing stakeholders

**12:15–12:30 Networking**

<u>The "Three Wheels" approach</u>

-Each "wheel" contains common questions to all pilots.

-Also, there are specific questions depending on the pilot type.

- <u>WHEEL 1 - Current situation, vision and pain points</u>

**Purpose:** Understand the starting point and the desired end state.

**Examples**: Operational bottlenecks, user pain points, desired improvements, ideal scenarios.

- <u>WHEEL 2 – Needed tools & technologican capacities</u>

**Purpose**: Translate challenges into functional needs.

**Examples**: Decision-support tools, routing optimisation, real-time data integration, simulation capabilities.

- <u>WHEEL 3 - Data exchange and requirements</u>

**Purpose**: Identify data availability, quality issues, access limitations and barriers.

**Examples**: standards, confidentiality, sharing obstacles, legal constraints.



<u>Results produced during "Workshop 1"</u>

-By the end of the "Workshop 1", each pilot should obtain:

- A structured list of validated challenges.
- A prioritised list of needs and potential functionalities.
- A clear view of data availability and gaps.
- An updated: stakeholder table and requirement assumptions.

- **Note**: Stakeholder list will be updated during the session, but the formal summary is part of the deliverables (see Section 6.1).

## <u>OUTPUTS-DELIVERABLES REQUIRED FROM EACH PILOT AFTER "WORKSHOP 1"</u>

To ensure consistency across all pilots and enable WP2 to consolidate a coherent first version of the FEDORA requirements, **each pilot must submit a set of structured outputs after "Workshop 1"**. These outputs will serve as the foundation for the internal alignment session ("Workshop 1.1") and the subsequent refinement cycles.

- Each pilot is expected to begin working on these outputs/deliverables immediately after completing "Workshop 1".
- A **deadline** will be defined by MLC to guarantee that WP2 can perform cross-pilot analysis in due time: **15th February (2026)**.

Stakeholder engagement summary

A short report including:

- List of participating stakeholders.
- Key inputs provided.
- Missing stakeholders and plan to involve them.

Requirements Table - Version 1

This is the core output of "Workshop 1".

- Pilots must produce the first structured version of their requirements based on all evidence gathered.
- MLC will gather all the requirements in a standardised template to ensure alignment and provide the information clear to the technical partners.

Requirements must include:

- Operational and technical needs. Needs related to:
- Operations
- Planning
- Decision-making
- Coordination
- User interaction
- Real-time functionalities
- Automation

- Performance and quality expectations: Elements such as:
- Performance
- Usability
- Availability
- Interoperability
- Security
- Scalability

- Data requirements. Specifying:
- Data needed
- Data available
- Data formats

- Frequency
- Quality requirements
- Actors responsible for generating or consuming it.

o Barriers:

- Technical, operational, organisational, or regulatory obstacles identified during the workshop.

*Note: these labels describe the nature of the requirement, not classification categories. Pilots must classify each requirement using only the categories in Template.

Minimum quality criteria for template completion

To ensure consistency and comparability across pilots, each requirement included in Template 2 must meet the following minimum quality criteria. These criteria do not introduce additional fields or classifications; they simply clarify the expected level of completeness and precision when using the existing template:

1. **Clear and concise description:** Each requirement must be described, capturing the essence of the need without ambiguity.
2. **Correct selection of category:** The requirement must be assigned to the most appropriate category available in Template 2. Pilots should select only the category that best reflects the primary nature of the requirement.
2. **Stakeholder or origin identified:** Each requirement must clearly indicate whether it comes from a stakeholder intervention, an internal pilot need, prior meetings or institutional constraints.
3. **Impact on the pilot:** The requirement must specify the main effect or value it brings to the pilot (e.g., improved coordination, better data availability, compliance with rules, enhanced operational efficiency).
4. **Dependencies documented (if relevant):** When a requirement depends on another dataset, actor, process or technological enabler, this dependency should be noted.
5. **Feasibility indication:** Pilots should provide an initial feasibility estimation (high / medium / low) based on their knowledge of local context, data availability and organisational capacity.
6. **Alignment with pilot objectives:** Each requirement should link to at least one local pilot objective or challenge (e.g., improved multimodal coordination, enhanced safety, reduced congestion, faster logistics flows).
7. **MoSCoW justification:** The assigned priority (Must, Should, Could, Won't) must be justified with a brief rationale explaining why this level of priority is appropriate. (see section 6.6)

Example of a complete requirement entry:

- Requirement ID: VIE-004
- Description: "Integrate cyclist flow data from sensors into traffic-light optimisation."
- Category: Data Management
- Stakeholder source: Vienna traffic authority
- Impact: improves multimodal coordination and safety
- Dependency: API access to bicycle counter system
- Feasibility: Medium
- MoSCoW: MUST (critical for multimodal optimisation)

Prioritised list

-Each pilot must prioritise their Top 5-10 most critical requirements, selecting those that are:

- Feasible.
- Highly impactful.
- Essential for pilot execution.
- Relevant for WP3/WP5 development.

– The purpose is to enable WP2/WP3/WP5 to focus on what truly matters for the first implementation cycle.

Risk & Mitigation

| Risk | Description | Mitigation |
|---|---|---|
| **Missing key stakeholders** | Some essential actors do not attend the workshop. | Reinforce invitations; hold bilateral meetings if needed. |
| **Incomplete or unavailable data** | Required data is missing or difficult to access. | Identify alternative sources; discuss access early. |
| **Conflicts between stakeholders** | Different actors express conflicting interests or needs. | Facilitate discussion; document conflicts; resolve in Workshop 1.1. |
| **Contradictory requirements** | Stakeholders propose incompatible requirements. | Record contradictions clearly; address them during alignment. |
| **Unrealistic expectations** | Requests exceed FEDORA's scope or timeline. | Remind participants to focus on needs, not implementation. |
| **Regulatory or legal constraints** | Laws or regulations limit certain requirements. | Document constraints; explore alternative solutions. |



Prioritisation method (MoSCoW)

To ensure a consistent and comparable prioritisation across all six pilots, each site shall classify its identified requirements using the **MoSCoW method**. This approach helps distinguish what is essential for the pilot from what is desirable, optional or out of scope for the current phase.

MoSCoW stands for:

- **M: MUST have**
  Critical requirements without which the pilot cannot operate or cannot meet its core objectives.
  *Examples: essential datasets, mandatory platform integrations, key functionalities required by several stakeholders.*
- **S: SHOULD have**
  Important requirements that add significant value. The pilot can still run without them at the beginning, but they are highly recommended.
- **C: COULD have**
  Non-essential enhancements. Useful features that can improve usability or efficiency but are not required for the pilot's execution.
- **W: WON'T have (for now)**
  Requirements currently out of scope due to technical, regulatory, resource or timing constraints. These may be revisited later in the project.

**Implementation timeline:**

- Pilots will add a MoSCoW classification after “Workshop 1” in the template and in the report.
- The final prioritisation will be agreed during “Workshop 1.1” (internal WP2 alignment), with input from technical partners.

## Requirements traceability in FEDORA

-After “Workshop 1”, **each pilot will produce its updated Requirements & Needs table (Templates) with an annex report-document with the different explanations**.

-This structure does not require pilots to fill additional fields, but clarifies how MLC will work with the delivered templates.

**Link to pilot objectives**

During consolidation, each requirement is associated internally with the pilot’s objectives as defined in the Grant Agreement. (This allows WP6 to understand the context and purpose behind each need).

**Link to technical areas**

Using the existing “Category” field in Template 2 (Technical, Operational, Data Management, etc.), each requirement is automatically mapped to the corresponding technical area of WP6.

**Link to priority**

The MoSCoW prioritisation is used to guide the order in which requirements are considered during technical integration.

**Consolidation across pilots**

MLC merges all pilots’ requirements to:

- identify common needs,
- detect contradictions or overlaps,
- highlight pilot-specific needs,
- support WP6 in planning implementation.

  - Purpose of the traceability: This process ensures:
- a coherent structure across the six pilots,
- a natural transition to WP6,
- transparency in how requirements are interpreted and used,
- improved interoperability between pilot contributions.

## NEXT STEPS: INTERNAL ALIGNMENT WORKSHOP (Workshop 1.1 – WP2)

- “Workshop 1.1” is an internal session with pilots and technical partners, without external stakeholders.
- Its objective is to consolidate the outputs of “Workshop 1” and prepare the FEDORA cross-pilot requirements baseline.

**The goals of “Workshop 1.1” are:**

- **Identify common requirements across pilots**

-Find overlaps, shared challenges, repeated needs:

- multimodal coordination
- data-sharing issues
- interoperability needs
- recurring functionalities

- **Identify pilot-specific requirements**
  -Highlight what is unique to logistics, urban mobility, UAV and simulation pilots.

- **Unify the structure for WP6 (Demonstrations)**
  -Prepare consistent requirements structure that WP6 will later use to design demos and validation indicators.

- **Prepare the refinement plan for 2026**
  - what needs further validation
  - what requires additional bilateral meetings
  - what will be re-checked
  - how the next iterations of requirements will be handled

WORKPLAN FOR PILOTS; INMEDIATE ACTIONS

To ensure that all pilots are fully prepared for "Workshop 1" in February 2026, the following workplan defines the tasks that must be completed by each pilot site. The plan includes clear responsibilities, deadlines, and required outputs.

Overview calendar (December–MARCH)

| Deadline | Activity | Responsible | Output |
|---|---|---|---|
| **18/12/2025** | Confirm pilot typology | Pilot leaders | Confirmation to MLC |
| **31/12/2025** | Stakeholder List (Template 1) | Pilot leaders | Template 1 completed |
| **31/12/2025** | Initial Requirements v1 (Template 2) | Pilot leaders | Template 2 completed |
| **12/01/2026** | Workshop 1 agenda + invitations | Pilot leaders | Agenda + stakeholder invitations |
| **13/02/2026** | Execution of "Workshop 1" | Pilot leaders | Raw notes + attendance list |
| **17/02/2026** | Deliver "Workshop 1" outputs | Pilot leaders | Requirements v1 + summary + prioritisation |
| **31/03/2026** | Internal alignment workshop ("Workshop 1.1") | MLC + pilots | Consolidated cross-pilot requirements |

Complete Stakeholder List (Template 1)

Pilots must fill in Template 1 including:

- Stakeholders already contacted.
- Stakeholders still pending.
- Stakeholder type and role.
- Involvement status ("confirmed / in process / not yet").
  - Clarification**:** this list will be updated after "Workshop 1".

Complete Initial Requirements Assumptions (Template 2)

Pilots must complete the preliminary requirements in Template 2 using:

- previous project experience
- operational knowledge
- early bilateral meetings
- known data gaps or constraints.
  - **Note:** this is not final; it will be refined using the workshop discussion.

Preparation of “Workshop 1”

Pilots must prepare: Agenda, Stakeholder invitations, local context slides and execute plan for the 3 Wheels.

Deliver required outputs after “Workshop 1”

Pilots must deliver:

- Stakeholder Engagement Summary.
- Requirements Table v1.
- “Workshop 1” outcomes report

Participate in internal alignment workshop (“Workshop 1.1”)

Pilots must prepare a short 10-minute presentation including:

- Main outcomes.
- Main requirements and the MoSCoW prioritization.
- Data availability constraints.
- Contribution expected for WP6.

Tools and templates provided

-The following documents will be provided in the shared folder:

- Template 1 – Stakeholder List
- Template 2 – Requirements Table
- Template 4 – Workshop Agenda
- Workshop questions (Block A + Block B)
- Workshop outcomes report.

Monitoring and support

- To ensure consistency across all pilots and smooth transition into WP3/WP6, MLC will provide continuous monitoring and methodological support throughout the preparation, execution and consolidation of “Workshop 1”.
- Each pilot leader will be responsible of the execution of its pilot.

**MLC will:**

- Review all pilot submissions.
- Provide structured feedback.
- Ensure coherence across pilots.
- Guide prioritisation, including the MoSCoW method.
- Ensure connection of WP2 results with WP6 needs.

# Typical requirement patterns by Pilot type

The six FEDORA pilots operate in different contexts. This annex provides guidance on the types of requirements typically associated with each pilot category.

**Logistics / Industrial pilots (Basque Country, Budapest)**

- interoperability between transport modes,
- optimisation of multimodal flows,
- ETA prediction and event detection,
- integration of IoT and sensor networks,
- real-time visualisation of operations.

**Urban mobility pilots (Vienna, Reggio Emilia)**

- multimodal traffic management,
- integration of cycling and pedestrians,
- demand management and behavioural incentives,
- low-emission zones and access regulation,
- user experience and mobile app features.

**UAV / Hybrid mobility pilot (Nicosia)**

- coordination between aerial and ground systems,
- use of drones as mobile sensors,
- procedures for incident detection using aerial data,
- roles and responsibilities for drone operations,
- data integration between multiple modes.

**Simulation-based pilot (Copenhagen)**

- demand modelling and scenario simulation,
- representation of multimodal networks,
- dynamic pricing and policy evaluation,
- validation of transport KPIs under alternative futures,
- requirements related to data granularity and performance.

This annex helps pilots identify missing requirement types and align their inputs with the nature of their pilot.

# Common questions (BLOCK A)

- These questions apply to all pilots, regardless of typology.
- Each wheel has an extended explanation to make the methodology crystal clear for partners and to justify why we use this structure.
- Some questions may appear conceptually related across wheels. This is because the same topic is explored from different perspectives to ensure completeness and consistency.

## WHEEL 1 - CURRENT SITUATION, VISION & PAIN POINTS

- This wheel focuses on understanding how the system works today and identifying real-world operational frictions.

- We need this because FEDORA must start from existing problems, not assumptions.
- Capturing pain points ensures that the requirements collected during WP2 represent genuine needs expressed by stakeholders and not theoretical ideas from partners.

Allows us to identify:

- Current operational inefficiencies
- Missing data
- Digitalisation gaps
- Coordination barriers between actors
- Structural or regulatory limitations

**Questions**

- What are the main inefficiencies or problems in your current operations/mobility processes?
- Which processes are still manual or poorly digitalised?
- What information or data gaps affect your daily operations or decision-making today?
- Which actors are present in the chain, and which ones are missing or insufficiently involved?
- What barriers do you face when coordinating with other stakeholders?
- What practical limitations do you experience today when using data (format, frequency, quality, delays) in your operations?
- Where do you observe the biggest inefficiencies or delays in your everyday operations?
- What is your current level of digitalisation (traceability, system interoperability, monitoring…)?
- Which technological, organisational, or regulatory factors currently block improvements?
- If you had to prioritise the top 3 problems, which ones would they be?

## WHEEL 2 - NEEDED TOOLS & TECHNOLOGICAL CAPACITIES

- Once the pain points are clear, Wheel 2 helps transform those problems into concrete functional and technical requirements.

It is essential for WP2 because FEDORA must define:

- What tools are needed.
- What data is necessary.
- What technical capabilities must be enabled.
- What integrations or automations will generate value.
- This wheel ensures that the requirements are actionable and can be transferred directly to the technical partners (WP3, WP4, WP5) and to future planning under WP6.

**Questions**

- Which technical functionalities or tools (simulation, dynamic planning, real-time monitoring, dashboards…) would be most useful for your operations?
- What data would be necessary (type, format, frequency, standardisation) to improve planning or decision-making?
- Which of the identified manual or poorly digitalised processes should be prioritised for automation or integration?
- What characteristics should a solution or platform have to be truly useful for you (usability, APIs, interoperability, standard formats…)?

- What future capabilities would be relevant (prediction, optimisation, multimodal integration, early-warning alerts…)?
- Which KPIs would help you evaluate whether improvements are effective?
- What type of support would you need to adopt new technologies (technical, regulatory, training…)?
- What data or functionalities would improve cooperation with other actors?
- What kind of agreements or frameworks would facilitate technical integration?
- If you could select only one priority functionality, which one would it be?

WHEEL 3 – DATA EXCHANGE AND REQUIREMENTS

- This wheel focuses on data-related constraints and requirements, ensuring that any proposed solution is realistic, compliant and acceptable for all actors involved.
- Wheel 3 is essential to:
- identify barriers to data sharing and interoperability,
- understand legal, institutional and trust-related constraints,
- clarify minimum requirements for acceptable solutions,
- anticipate implementation needs for WP6.

**Questions**

- How should mobility/logistics ideally work in your environment within 3–5 years?
- Which improvements would have the greatest impact for you?
- What data exists today, which data is missing, and what prevents its availability or sharing?
- What data formats do you currently use (proprietary, Excel, APIs, standards like GTFS/NeTEx/AIS…)?
- What legal, technical or trust-related barriers limit data sharing today?
- What guarantees or agreements would you require to feel comfortable sharing information?
- What role should a platform like FEDORA play in facilitating cooperation and data exchange?
- What future capabilities or system-level improvements would you like to see enabled in the long term?
- How should collaboration between actors evolve in the future?
- What minimum requirements should any solution meet to be acceptable for your organisation?



# Pilot specific questions (BLOCK B)

- These questions are not common across all pilots.
- They are adapted to the type of pilot, ensuring that each workshop captures the operational, regulatory and technological realities of each site.
- This block helps to:
- Extract deep, domain-specific requirements.
- Avoid irrelevant discussions (e.g., incentives in a port, UAV regulation in a cycling city).
- Provide precise inputs for the technical partners later in WP2–WP5.
- Ensure that requirements are fully aligned with the pilot typology and ecosystem.
- Each pilot should use Block A + Block B together during “Workshop 1”.

REAL LOGISTICS / INDUSTRIAL PILOTS

- **BASQUE COUNTRY**

- **BUDAPEST**

These pilots involve:

- multimodal freight flows (maritime, road, rail, terminal operations),
- multiple private actors with heterogeneous systems,
- time-sensitive planning processes,
- significant data gaps and interoperability barriers.

The aim is to capture requirements related to:

- real-time optimisation,
- data quality and availability,
- coordination across operators and nodes,
- early detection of disruptive events.

**Specific questions (logistics pilots)**

- What problems currently occur during intermodal transfers (port–road, road–rail, airport–road, etc.)?
- What real-time data would you need to re-plan routes or anticipate delays, congestion or disruptions?
- What barriers prevent integration of information coming from different nodes, terminals or operators?
- Which optimisation or decision-support capabilities would be essential for your daily operations?
- Which operational processes would you like to automate or fully digitalise (slot allocation, documentation, customs, early warnings…)?
- Which disruptive events are most critical for your operations (weather, incidents, port delays, strikes, vessel delays…)?
- Which additional stakeholders are essential to ensure a smooth multimodal chain?



REAL URBAN MOBILITY PILOTS

- **VIENNA**
- **REGGIO EMILIA**

Urban pilots involve:

- a mix of pedestrians, bicycles, public transport, cars, micro-mobility,
- public authorities and transport operators,
- interest in sustainability and "social optimum" approaches,
- incentives and behaviour-change mechanisms.

The focus is on:

- traffic management,
- multimodal integration,
- user incentives,
- incident handling,
- alignment with existing mobility policies.

**Specific questions (urban mobility pilots)**

- What are the main challenges today in traffic management or in the allocation of urban space?
- What data is required to integrate pedestrians, bikes, buses, cars and other modes into a balanced mobility system?
- What incentives could influence user behaviour effectively?
- How should the city react to incidents or congestion in an optimal way?
- How should this information be integrated into existing mobility plans or urban policies?
- What barriers exist today between different mobility operators (public transport, bike sharing, taxis, etc.)?
- Which modes should be prioritised depending on the social objective (safety, equity, efficiency)?

UAV PILOT

- **NICOSIA**

This pilot introduces:

- UAVs as a new mobility mode,
- strong regulatory constraints,
- air–ground interaction,
- data from aerial sensors,
- opportunities for new services (deliveries, inspection, emergency response).

The focus is on:

- regulatory barriers,
- multimodal integration,
- safety and acceptance,
- operational feasibility.

**Specific questions (UAV pilots)**

- What opportunities and risks do you see in introducing UAVs into the mobility system?
- What information would you need to coordinate drone flights with ground traffic?
- What regulatory limitations currently hinder UAV operation?
- What data should UAVs capture, and how should this data be integrated with existing systems?
- Which urban services would benefit most from UAVs (delivery, inspections, emergency…)?
- Where should vertiports ideally be located to maximise efficiency and minimise impact?
- What technical, regulatory or operational conditions would make UAV services viable?

PURE SIMULATION / FORESIGHT PILOT

- **COPENHAGUEN**

This pilot does not operate in real conditions but through:

- large-scale multimodal simulation,
- agent-based behavioural models,
- long-term scenarios,

- MaaS, pricing and policy analysis.

The focus is on:

- data granularity,
- model calibration/validation,
- future mobility behaviours,
- regional planning and policy evaluation.

## Specific questions (simulation pilots)

- What user behaviours would you like to simulate (mode choice, departure time, reaction to pricing…)?
- Which future demand scenarios are most relevant for your region?
- What interventions do you want to evaluate (dynamic pricing, restrictions, MaaS, incentives)?
- What barriers exist in accessing the data needed to calibrate or validate the models?
- What emerging mobility modes should be included (autonomous shared vehicles, electrification, etc.)?
- What KPIs are essential to evaluate future mobility policies.

# ANNEX IV: WORKSHOP 1 OUTCOMES REPORTS

This annex contains the Workshop 1 Outcomes Reports from each of the six FEDORA pilot sites, as produced by the respective pilot leaders following their co-creation sessions. It consolidates the qualitative and quantitative results of the first Co-Creation Workshop. It serves as the bridge between the initial assumptions (pre-workshop) and the validated requirements that will be used by WP2–WP6.

It also provides the initial input for WP6 (Pilot implementation), supporting pilot orchestration, alignment across pilots and preparation of demonstration activities under Task 6.1.

Instructions for Pilot Leaders:

- This report is a mandatory output of Workshop 1.
- Do not start from zero: reuse and update the information already collected in:
    - Template 1: Stakeholder List.
    - Template 2: Initial Requirements Table.
- Format:
    - This document provides the narrative summary.
    - The detailed and structured list of requirements must be provided in the updated Excel Template 2 (Requirements Table v1), attached to this report.
    - This document and the updated Excel templates will be used as the main input for WP2 consolidation and WP6 pilot planning.

# PILOT 1: VIENNA

**Executive Summary & Pilot Context**

The Vienna Co-Creation Workshop brought together key city, operator, research, and mobility stakeholders to discuss the current challenges of traffic light control and multimodal traffic management. Participants jointly identified major inefficiencies, missing data, and institutional bottlenecks, and outlined first functional, non-functional, and data-related requirements for the FEDORA pilot. The session established a shared understanding of the pilot's goals and the groundwork for developing the Social Optimum Model and future data-exchange processes.

- **Pilot Site:** Vienna
- **Date & Location:** Verkehrsverbund Ost-Region, Europaplatz 3/3, 1150 Wien
- **Confirmed Pilot Typology:** Urban Mobility
- **Main Objective:** Optimisation of urban mobility services in Vienna to integrate pedestrians, cyclists, public transport and private vehicles into a single, socially balanced traffic management system. The pilot project aims to move from motorised traffic-oriented management to multimodal optimisation that balances efficiency, fairness and sustainability.

**Stakeholder Engagement Summary**

The workshop was attended by a well-balanced mix of city administration (Stadt Wien - MA33), public transport (Wiener Linien), research institutions (AIT), and mobility agencies (Mobilitätsagentur Wien), as well as ITS Vienna

Region as pilot lead. No major gaps in the stakeholder list were identified during the session; no missing stakeholders were identified.

- **Participation overview:**
  - **Which key stakeholder groups attended? (e.g., city authorities, operators, logistics nodes)**
    - City authorities: City of Vienna, Public Lighting Department (MA 33 – Wien Leuchtet)
    - Mobility agency: Mobilitätsagentur Wien
    - Public Transport Operator: Wiener Linien
    - ITS Service Provider: ITS Vienna Region
    - Research Partner: Austrian Institute of Technology (AIT)
  - **Who was invited but did not attend?**

    N/A, representatives from every invited group attended
- **Missing actors & mitigation:**
  - **Are there critical stakeholders missing? (list them)**

    n/a
  - **What is the plan to involve them before Workshop 1.1? (e.g., bilateral meetings, calls)**

    n/a
- **Dynamics:** *Briefly describe the atmosphere.*
  - **Were there conflicting views between stakeholders?**

    Only on minor issues
  - **Was there a consensus on the main problems?**

    Yes.
- **Institutional aspects:**
  - **Were public authorities present or represented?**

    Yes, a representative from the City of Vienna, Public Lighting Department (MA 33 – Wien Leuchtet) attended.
  - **Are there decision-making bodies that should be involved in later stages?**

    As the changes made to the traffic control system are only temporary, there is no need for a formal approval by the police or traffic authority (MA46).

**Workshop Findings: The "Three Wheels”**

The workshop highlighted several overarching themes regarding Vienna’s traffic light control system. Participants pointed to **inefficiencies in current signal operations** due to **suboptimal green-time allocation**. A need for **real-time monitoring** was discussed. The necessary data on pedestrians, cyclists and behavioural patterns are partly open access for static data, but for a successful pilot (near) real-time data is needed. Possible KPIs to measure the pilot’s success were discussed and included waiting times, travel times, unnecessary green phases, number of braking manoeuvres along others. Lastly relevant actors with decision making power where listed and most notably include local government, traffic authorities (MA46), the police and partners part of the FEDORA consortium.

Wheel 1: Current Situation & Pain Points

Stakeholders identified inefficiencies in Vienna's current traffic light control system, mainly stemming from **inefficient green-time allocation**, lack of **real-time monitoring**, and **insufficient or missing data**—particularly for pedestrians and cyclists. Traffic flow issues such as **congestion**, **accident-related delays**, and insufficient digitalisation were also highlighted.

- **Operational bottlenecks: What are the main inefficiencies identified by the users?**

  Inefficiencies in traffic light control and traffic light operation

  - Inefficient green time distribution results in unnecessary waiting times
    - Waiting times for pedestrians and cyclists are not currently considered
  - There is no ongoing monitoring
    - There is no automated evaluation of traffic light cycles.
    - Control systems are only evaluated in the initial phase.
    - There is no ongoing monitoring of traffic light configurations.
    - Gradual changes can be overlooked.
  - Possible misconfiguration
  - Temporary hardware failure

  Inefficiencies in traffic flow

  - Traffic jams
  - Delays due to accidents or other disruptions, insufficient digitalisation of traffic event massages

- **Manual processes: Which processes are currently non-digitalized or disconnected?**

  There is no monitoring.

  Delays due to accidents or other disruptions are not detected automatically.

  Automatic adaption of traffic signal plans is not implemented or insufficient.

- **Key "Pain Points": What keeps stakeholders from operating efficiently today?**

  Inefficiencies in approval processes

  - In some cases, there are obstacles to the implementation of processes/improvements due to politics, lack of money, etc.
    - Conflicts between priorities
    - City aims to concentrate motorised individual transport on main roads and thus prioritizes car traffic on these sections

  Lack of knowledge/data about demand.

  - Statistical data is available in some cases.

- **Specific issues regarding traffic management or incentives.**

  Inefficiencies in green time distribution result in unnecessary waiting times for all modes of traffic. Currently waiting times for pedestrians and cyclists are not considered, when configuring the signal plans.

Wheel 2: Tools & Technological Capabilitiesd

A need for an **adaptive social optimum contro**l for traffic light cycles was identified. Several possible KPIs have been identified, such as waiting times, travel times, 'pointless' green times, among others. **Continuous monitoring** was discussed and should help to ensure the solution to stay effective with minimal intervention needed.

- **Desired functionalities: What specific tools did stakeholders ask for? (e.g., "Real-time dashboard," "Prediction tool," "Booking app").**

  The main functionality of the pilot should be to adapt traffic signal plans to reach a social optimum.

  The Social Optimum Model component itself should communicate to other system parts using APIs (OpenAPI).

- **Automation needs: Where do they expect FEDORA to automate decisions?**

  The social optimum control should automate decisions on the configuration of the traffic light cycles in an adaptive way.

- **KPIs: Did stakeholders mention how they will measure success?**

  Possible KPIs:

  - Unnecessary or excessively long green phases (for all modes)
    - Green phases for which there is no (sufficient) demand in the respective mode
  - Travel times for individual modes
  - Waiting times for individual road users
  - Minimum/maximum travel times
  - Number of braking manoeuvres
  - Monetary costs
    - Is the order of magnitude relevant?
    - Estimates of monetary costs usually depend on other KPIs
  - Congestion times, congestion length
  - Number of people crossing at red light
  - Complaints to MA33

  Calculating weights of transport modes

  - Weighting according to the polluter pays principle
    - Emission estimates usually depend on other KPIs
  - Traffic lights are only necessary for motorised individual transport (pedestrians can organise themselves -> see Stephansplatz)
  - Transport policy decision on which modes should have priority
  - The model or objective function should not be too complex
  - Not all KPIs/loss functions need to be included in the objective function

- **Expected role of FEDORA: Which decisions or processes do stakeholders expect FEDORA to support or improve?**

  Expected functionality:

  - Monitoring
  - social optimum control

- interfaces to traffic light components

Wheel 3: Data Exchange & Governance

Gaps in the available data have been identified in relation to pedestrian, cycling and behavioural data. Static data is mostly open government data, while real-time data access is often limited, due to performance issues, IP or licence rights as well as security concerns.

Several actors with power to influence decisions have been identified. Most notably local government, traffic authorities (MA46), the police and FEDORA partners such as ITS Vienna Region (VOR) and the city of Vienna (MA33).

- **Data availability gaps: What data is needed but currently missing or hard to access?**

  Pedestrian data
    - should, where possible, be generated using AI from traffic cameras
    - possibly collect additional data empirically
    - People crossing at a red light? -> could be an indication of inefficiency

  Cycling data
    - can be generated
    - there are only a few counting stations, including Praterstern
    - Monthly time series are freely available on the internet

  Behavioural data
    - Individual (walking) speed, time pressure
    - Destination

- **Block 3A - Data exchange conditions:**
    - **What are the conditions for sharing data? *(e.g., anonymity, specific agreements)***

      The conditions vary for different data sources. In general, much of the static data (network graph, timetables, yearly traffic counts) is open government data.

      Access to real-time data (real-time traffic counts, FCD) and some sensitive static data (signal plans, passenger counts, ...) is usually restricted because of

      - Performance issues
      - Intellectual property rights
      - License rights
      - Security concerns

    - **Are there trust issues between private operators and public authorities?**

      Not discussed during the workshop.

- **Block 3B - Multilevel governance:**
    - **Who are the key actors with decision-making power?**

      Key actors are

      - Local government (city and district level) - representation, regulation and funding
      - The traffic authority (MA46) - approval of permanent traffic measures
      - The police – in charge of traffic control and traffic management using the traffic control system provided by the city, approval of signal plans

- Public lights department (MA33) – installation and operation of traffic signals and traffic control system, planning of signal plans
- ITS Vienna Region – data provider

○ **Are there regulatory or institutional barriers identified during the session?**

Approval by the traffic authority and police is only needed for permanent traffic measures such as lasting changes to signal plans; the FEDORA pilot would need only temporary and restricted changes (shortening and lengthening of some phases) that do not need approval.

○ **Which actors have formal decision power?**

Local Government, Traffic Authority, Police

○ **Which actors influence decisions informally**

Public transport operators, district level politics, lobbying groups, citizens

**Requirements CONSOLIDATION AND PRIORITISATION.** MoSCoW prioritisation



| **Priority Rank** | **Requirement ID** | **Short Description** | **Why is it critical?** |
|---|---|---|---|
| 1 | *VIE-001* | Real-time optimized signal phase plans including the preferences of pedestrians and bicyclists | Core functionality of Vienna pilot |
| 2 | *VIE-002* | Integration into traffic light control system | Core functionality of Vienna pilot, without this no changes can be made to the signal phase plans |
| 3 | *VIE-003* | Continuous monitoring of signal plan impacts (traffic situation, waiting times, ...) | This is needed for evaluation and input for re-calibration of social models |
| 4 | *VIE-004* | Real-time detection of pedestrians and bicyclists | This is essential input data for the real-time optimization |
| 5 | *VIE-005* | Real-time traffic situation data | This is essential input data for the real-time optimization |
| 6 | *VIE-006* | Signal plans | This is essential input data for the real-time optimization |

## Risks & Mitigation

| Risk Identified | Impact on Pilot | Mitigation Strategy |
| --- | --- | --- |
| It could be difficult to get access to C-ITS data. | Less data for motorized vehicles | Talks with C-ITS infrastructure providers |

## Next Steps

- **Pending validations: What still needs to be checked with technical partners?**
  - Discussion on app – FRONT.
  - Access to C-ITS as data source – city of Vienna (MA33) and VOR (ITS-VR) will start talks with C-ITS provider.

# PILOT 2: BASQUE COUNTRY

## Executive Summary & Pilot Context

- **Pilot Site:** Basque Country, Spain.
- **Date & Location:** 24 February 2026, Autoridad Portuaria de Pasaia facilities, Pasaia, Gipuzkoa.
- **Confirmed Pilot Typology:** Logistics
- **Main Objective:** The Basque Country pilot focuses on improving the efficiency and coordination of multimodal freight operations at the Port of Pasaia and its surrounding logistics ecosystem. The workshop aimed to identify the main operational bottlenecks and information gaps affecting port operators, road and rail transport companies, customs agents and port authorities, and to gather the functional requirements that will inform the definition of the pilot use case. A key cross-cutting theme throughout the session was the governance of data sharing: the conditions, roles and trust mechanisms needed for information to flow between actors that today operate in silos. Based on the workshop outputs, a potential use case has been identified centred on the anticipation of maritime operational events and their propagation to the road transport chain, leveraging real-time port data to reduce uncertainty and improve coordination between the maritime and terrestrial legs of the logistics chain.

## Stakeholder Engagement Summary

- **Participation overview:**
  - Which key stakeholder groups attended?

    The workshop brought together a diverse and representative group of actors from the Port of Pasaia logistics ecosystem. The following stakeholder groups were present: port authority (Autoridad Portuaria de Pasaia), stevedoring and port operators (Toro y Betolaza, Artaza, Algeposa), maritime and logistics operators (Bergé Marítima), rail freight operators (Railsider), inland logistics platforms (Zaisa), customs agents (Colegio Oficial de Agentes de Aduanas), and Adur Software Productions. MLC attended as pilot leader and co-organiser.

- Who was invited but did not attend?

  Operators: Transportes Vicuña and Echemar. Also GUITRANS as sectorial institution.

- **Missing actors & mitigation:**
  - **Are there critical stakeholders missing?**

    Several actor categories were not represented in this first session:

    - rail infrastructure operators (Renfe/Adif) — rail-port coordination was identified as a pain point, but no rail representative was present.
    - technology providers — no ICT or platform providers were present beyond the session facilitator, although a potential data provider had been identified through separate engagement.
    - and freight clients: some pain points raised point to the need to involve freight clients directly in later stages.
  - **What is the plan to involve them before Workshop 1.1?**

    MLC will conduct bilateral meetings. Priority contacts are rail operators and the potential data provider identified for the maritime data feed, to confirm the terms of collaboration. Customs authorities will be engaged at a later stage given the regulatory nature of their involvement.

- **Dynamics:**

  The session had an open and constructive atmosphere. Participants engaged actively and were open about the operational problems they face daily. The format (two parallel working groups, each facilitated separately), allowed for in-depth discussion and ensured that different types of actors had space to express their perspectives.

  There were no major conflicting views between stakeholders. There was a strong and spontaneous consensus around the core problems: lack of real-time visibility, disconnected systems, and the absence of a shared data governance model. The main tension that emerged was not between stakeholders but around the data sharing question; participants acknowledged the value of sharing information but expressed legitimate concerns about trust, competitive sensitivity and cybersecurity.

- **Institutional aspects:**
  - **Were public authorities present or represented?**

    The Autoridad Portuaria de Pasaia (APP) was present and actively participated throughout the session. As a public authority and the central actor in the port ecosystem, the APP was consistently identified by other participants as the most legitimate body to lead the data governance framework. Its involvement at this early stage is a positive signal for the pilot's institutional grounding.
  - **Are there decision-making bodies that should be involved in later stages?**

    No regional or national transport authorities were present in this first session. Given the regulatory dimensions identified (customs inspection centralisation, rail infrastructure coordination), the involvement of higher-level institutional actors should be explored for subsequent stages.

**Workshop Findings: The "Three Wheels"**

Wheel 1: Current Situation & Pain Points

- **Operational bottlenecks: What are the main inefficiencies identified by the users?**

  The discussions revealed a port ecosystem where the lack of real-time information sharing between actors creates cascading inefficiencies across the entire logistics chain. The most critical bottleneck identified is the absence of a shared operational picture: each actor (port authority, stevedores, road transport operators, rail operators and customs agents) manages their own data independently, with no common platform or agreed protocols for exchange.

  Truck access and waiting times emerged as one of the most immediate and costly problems. Vehicles arrive at the port without prior coordination, generating significant congestion at the access points, particularly at the main ramp in Lezo. Operators reported that on some days, planned trips could not be completed due to access delays, representing a direct and measurable economic loss for transport companies. The geographical constraints of the port area (mountainous terrain and high land prices) make physical expansion of waiting areas unfeasible in the short term, making intelligent access management even more critical.

  Port nautical services are coordinated by phone, with no digital visibility of their availability or location. This makes it difficult to plan vessel entry and exit operations with anticipation, and creates unnecessary delays when services are occupied or unavailable. During the session, the port authority itself acknowledged that, sometimes, locating its own tugboats required resorting to external tools.

  Rail-port coordination is also limited. Rail operators receive last-minute notifications by email regarding wagon availability and scheduling, with no prior planning or digital integration with port operations. The possibility of co-loading wagons between operators, which would increase rail efficiency significantly, exists in theory but cannot be realised in practice due to the absence of shared data and mutual trust. Participants also noted that the information gap is bidirectional: rail operators are equally unaware of port incidents and works that affect their planning.

- **Manual processes: Which processes are currently non-digitalized or disconnected?**

  A significant share of the operational and administrative processes remains manual or paper based. These include:

  - cargo documentation (packing lists, delivery notes and customs summaries, which in many cases are still handwritten or handled in disconnected systems);
  - vehicle access control (Civil Guard collecting delivery notes on paper at access points);
  - vessel arrival notifications (manually uploaded by consignees to Puertos del Estado);
  - customs clearance procedures (requiring physical displacement to Bilbao or Irún for inspections that cannot be performed at Pasaia);
  - and berth occupancy tracking (currently estimated visually, with no digital record of how long cargo remains in the port).

- **Key "Pain Points": What keeps stakeholders from operating efficiently today?**

The following pain points were consistently raised across both working groups as the most operationally damaging:

- No advance knowledge of vessel arrival times for operators who need to plan resources accordingly.
- No real-time visibility of port nautical service availability, forcing coordination by phone and causing delays.
- Truck congestion at port access with no slot system or waiting zone assignment, resulting in significant vehicle downtime.
- No digital traceability of cargo from port exit to final delivery; berth occupancy estimated visually with no reliable data.
- Disconnection between APP systems, stevedores and customs, creating administrative delays that affect all actors in the chain.
- Lack of coordination with rail operators, preventing efficient multimodal planning.
- Tidal constraints generating operational uncertainty that cascades across all actors in the chain with no anticipation mechanism.

- **Specific issues regarding interoperability or event detection.**

The session highlighted a structural interoperability gap: the systems that do exist at the port are not connected to each other and were not designed to exchange data. As a result, even when data exists within one actor's system, it is invisible to others who need it. Event detection is currently either manual or simply absent.



## Wheel 2: Tools & Technological Capabilities

- **Desired functionalities: What specific tools did stakeholders ask for?**

Participants were specific about the tools they would find most valuable. The following functionalities were most frequently demanded:

- Truck slot management system: A tool allowing transport operators to book time slots for port access in advance, reducing congestion and enabling better resource planning on both sides.
- Real-time operational dashboard: A shared platform providing visibility of vessel ETAs, berth status, port service availability (tugboats, mooring, pilots) and cargo location, accessible to all relevant actors.
- Cargo tracking platform: End-to-end visibility of container and cargo status from vessel unloading through port exit to final delivery.
- Digital documentation chain: Integration of packing lists, delivery notes and customs summaries into a single digital flow connecting clients, stevedores, APP and customs agents.

- **Automation needs: Where do they expect FEDORA to automate decisions?**

Participants expressed that repetitive and time-sensitive coordination tasks should be automated. The most cited were:

- automatic notification of vessel ETA updates to all relevant operators.
- automatic assignment of truck waiting zones based on real-time occupancy.
- automatic alerts when port services become available or when a scheduled operation is at risk of delay.

- and automatic propagation of delay estimates to downstream actors (transport operators, stevedores) when a disruption is detected.

There was also interest in the system being able to generate operational suggestions in real time; for example, recommending that a transport operator bring forward or delay a trip based on current port conditions.

- **KPIs: Did stakeholders mention how they will measure success?**

  Stakeholders did not explicitly define KPIs during the session. However, the problems described point clearly to measurable outcomes that could serve as performance indicators for the pilot:

  - Reduction in truck waiting time at port access
  - Increase in the number of completed daily transport trips per operator
  - Reduction in vessel turnaround time
  - Reduction in manual coordination interactions (phone calls replaced by digital notifications)
  - Improvement in advance notice time for vessel arrivals

- **Expected role of FEDORA: Which decisions or processes do stakeholders expect FEDORA to support or improve?**

  To act as an integration that connects existing data sources with the actors who need that information to coordinate their operations. A potential scenario has been identified around the anticipation of maritime operational events and their propagation to the road transport chain, which will be assessed for technical feasibility and alignment with the FEDORA technical partners.

## Wheel 3: Data Exchange & Governance

- **Data availability gaps: What data is needed but currently missing or hard to access?**

  The session identified several categories of data that are needed for efficient port operations but are currently unavailable or inaccessible to the actors who need them. These include: real-time vessel position and ETA within the port area; real-time availability and location of nautical services (tugboats, mooring crews, pilots); truck arrival forecasts and real-time queue status at port access; cargo stay time within the port (entry is tracked but exit traceability is incomplete); rail wagon availability and scheduling from rail operators; and berth occupancy in real time (currently estimated visually with no digital record).

- **Block 3A - Data exchange conditions:**

  The session produced a detailed discussion about the conditions under which actors would be willing to share data: clear governance rules defining who can access data, for what purpose and under what legal framework; cybersecurity guarantees demonstrating robust security standards before actors commit to connecting their systems; mutual benefit ensuring that data sharing generates visible value for the actor providing the data, not only for others; and confidentiality.

- **Block 3B - Multilevel governance:**

  Formal decision-making power: The Autoridad Portuaria de Pasaia holds the highest level of formal authority within the port perimeter and was consistently identified as the actor best placed to lead a shared data governance framework. Customs and border control authorities hold formal power over the administrative and regulatory dimension, particularly regarding customs inspection procedures. Rail infrastructure managers hold formal authority over rail scheduling and network access.

- Informal influence: The stevedoring companies exercise significant influence over port operations due to their central role in cargo handling and their strong labour organisation. Large logistics operators also carry informal weight given the volume of operations they represent.
- Regulatory and institutional barriers: Two significant barriers were identified:
  - the centralisation of customs physical inspections in facilities outside the port perimeter, which prevents Pasaia from processing certain categories of merchandise autonomously and creates a competitive disadvantage for the port.
  - the absence of a formal data sharing agreement framework between port actors, which means that even technically feasible integrations cannot be implemented without first establishing a legal and organisational basis for cooperation.

## CONSOLIDATION AND PRIORITISATION

### MoSCoW prioritisation



| Priority Rank | Requirement ID | Short Description | Why is it critical? |
|---|---|---|---|
| 1 | BCO-001 | Real-time visibility of vessel arrival times accessible to all port operators | Without this, the use case has no input. All downstream coordination — nautical services, stevedores, transport operators — depends on knowing when the vessel will arrive. |
| 2 | BCO-002 | Real-time availability and status of port nautical services (tugboats, mooring, pilots) | Without this, the anticipation chain breaks at the first operational step. Knowing the ETA is useless if nautical services cannot be coordinated in advance. |
| 3 | BCO-010 | Data governance framework defining conditions and roles for data sharing among port actors | Without this, no actor will commit to sharing data regardless of technical capability. It is the organisational prerequisite for everything else. |
| 4 | BCO-016 | Real-time maritime operational data feed covering vessel ETAs, ATA/ATD events, nautical services status, intra-port movements and incident registry | Without this, there is no data source to power the use case. |

### Risks & Mitigation

| Risk Identified | Impact on Pilot | Mitigation Strategy |
| --- | --- | --- |
| Use case not yet fully validated | Medium: pilot scope may need adjustment | Check with technical partners to validate alignment between identified needs and available FEDORA tools |
| Data sharing agreement with potential maritime data provider still under exploration | Medium: primary data source for the use case pending confirmation | Continue bilateral engagement; formal agreement not required at this stage given the exploratory nature of the pilot |
| Absence of a data governance framework among port actors | Medium: data exchange between actors requires a minimum organisational basis | Not a blocker at current TRL |
| Stakeholders absent from Workshop 1 | Low: multimodal dimension of use case allows other actor engagement in later stages | Conduct bilateral meetings if needed |

**Next Steps**

- **Pending validations: What still needs to be checked with technical partners?**
    - Validate the potential use case identified for the Basque Country pilot with technical partners to assess alignment with the FEDORA toolbox.
    - Confirm terms of collaboration with the potential maritime data provider identified through separate engagement.



# PILOT 3: NICOSIA

## Executive Summary & Pilot Context

The workshop was held over two separate days, both in person and online, in order to accommodate the availability of all stakeholders. It brought together representatives from public authorities, service providers, and the main road network operator of Cyprus, the Public Works Department (PWD). During the sessions, the FEDORA project was presented, followed by a high-level overview of the Nicosia pilot. The discussions generated several constructive ideas, including valuable suggestions regarding data availability, integration, and potential enhancements to support the pilot's implementation.

- **Pilot Site:** Greater area of Nicosia, Cyprus
- **Date & Location:** 02 & 09 February 2026, Nicosia

- **Confirmed Pilot Typology:** Hybrid-UAV
- **Main Objective:** The objective of the pilot is to integrate urban air transport (UAVs) into the existing multimodal mobility system through a dual-use deployment combining "Urban Park & Fly" operations and aerial traffic monitoring. The pilot will evaluate mode interaction between vertiports and ground transport networks, while assessing the role of UAVs as real-time urban traffic sensors enhancing network perception and incident management. By enabling multi-route optimisation across air and ground modes, the system will support dynamic routing, congestion avoidance, and improved multimodal coordination. Performance will be assessed through measurable KPIs. The pilot aims to demonstrate how Urban Air Mobility can enhance resilience, operational efficiency, and travel-time reliability within a future-ready multimodal transport ecosystem.

## Stakeholder Engagement Summary

During the 2-day workshop, representatives from key public authorities and relevant bodies, including Municipalities, Governmental Bodies and the Police, participated alongside the main road network operator (PWD) and mobility service providers (NEXTbike and Bolt). The discussion provided valuable insights regarding the feasibility and operational aspects of the proposed pilot, as well as the identification of potential data gaps and integration needs. Importantly, no critical stakeholders were identified as missing from the consultation process.

- **Participation overview:**
  - Which key stakeholder groups attended? *(e.g., city authorities, operators, logistics nodes)*

    City Authorities:

    - Nicosia Municipality
    - Egkomi Municipality
    - Aglantzia Municipality
    - Strovolos Municipality

    Road Authority:

    - Public Works Department

    Public Authority

    - Department of Civil Aviation
    - Department of Land and Surveys

    Service Provider

    - BOLT
    - NEXTbike
  - Who was invited but did not attend?

    N/A
- **Missing actors & mitigation:**
  - Are there critical stakeholders missing? *(list them)*

    It was discussed how the Public Transport Operator could be involved as a stakeholder in the pilot.

- <u>What is the plan to involve them before Workshop 1.1?</u> *(e.g., bilateral meetings, calls)*

  Call.

- **Dynamics:** *Briefly describe the atmosphere.*
  - <u>Were there conflicting views between stakeholders?</u>

    No conflicting views were identified among the stakeholders. Nevertheless, concerns were raised regarding data availability and accuracy. Specifically, certain datasets provided by the Department of Lands and Surveys appear to be outdated and will require updated information and further validation. Furthermore, stakeholders highlighted potential constraints related to GDPR compliance when collecting and processing data through UAV-based monitoring systems, necessitating appropriate data protection safeguards and anonymisation mechanisms.

  - <u>Was there a consensus on the main problems?</u>

    The innovative component of the pilot and how it could be implemented.

- **Institutional aspects:**
  - <u>Were public authorities present or represented?</u>

    Yes, there was a representative from each public authority.

  - <u>Are there decision-making bodies that should be involved in later stages?</u>

    Ministry of Transport, Communications and Works could be involved in later stage of the pilot to provide insights and potential scalability of the solution.



## Workshop Findings: The "Three Wheels”

### Wheel 1: Current Situation & Pain Points

- **<u>Operational bottlenecks: What are the main inefficiencies identified by the users?</u>**

  Stakeholders highlighted several operational inefficiencies affecting mobility management in the greater Nicosia area:

  - Limited real-time visibility of traffic conditions across the full urban network.
  - Fragmented data sources between the Public Works Department, municipalities, police, and private mobility operators.
  - Delayed incident detection and response due to reliance on ground-based monitoring and manual reporting.
  - Limited integration between road traffic management systems and emerging mobility services (shared bikes, scooters, ride-hailing).
  - Absence of structured interaction between potential vertiport locations and existing multimodal hubs.

- **<u>Manual processes: Which processes are currently non-digitalized or disconnected?</u>**

  The following processes remain partially manual or disconnected:

  - Incident reporting from police to traffic management centres.

- Authorisation procedures for UAV missions (case-by-case approval).
- Passenger count collection in certain transport modes.
- Updating of cadastral and land-use datasets.
- Coordination between municipalities for infrastructure planning.
- Data exchange often occurs through static reports rather than automated interfaces.

- **Key "Pain Points": What keeps stakeholders from operating efficiently today?**

  Stakeholders identified the following constraints:

  - Limited predictive capability for congestion evolution.
  - Lack of integrated multimodal optimisation tools.
  - Incomplete or outdated infrastructure datasets.
  - Institutional fragmentation in decision-making.
  - Uncertainty around UAV regulatory compliance.
  - GDPR-related concerns when introducing aerial monitoring.
  - The absence of a unified multimodal optimisation layer was repeatedly mentioned as a structural gap.

- **Specific issues regarding traffic management or incentives.**

  Below, issues related to traffic management or incentives are listed:

  - No dynamic rerouting based on real-time multimodal optimisation.
  - Limited incentives to shift from private car usage to multimodal combinations.
  - Lack of integrated park-and-ride intelligence.
  - No aerial-based traffic sensing to complement fixed cameras.
  - The pilot was seen as an opportunity to introduce dynamic, data-driven multimodal coordination.

## Wheel 2: Tools & Technological Capabilities

- **Desired functionalities: What specific tools did stakeholders ask for? (e.g., "Real-time dashboard," "Prediction tool," "Booking app").**

  Stakeholders expressed interest in the following tools:

  - Real-time multimodal traffic dashboard.
  - UAV-assisted congestion detection module.
  - Predictive congestion forecasting tool.
  - Dynamic routing optimisation engine (air + ground).
  - Simulation environment to test vertiport placement.
  - KPI monitoring dashboard.
  - Secure data-sharing interface between authorities and private operators.

- **Automation needs: Where do they expect FEDORA to automate decisions?**

  Stakeholders expect FEDORA to automate:

  - Route optimisation across ground modes.
  - Congestion detection using UAV sensing.
  - Incident impact estimation.
  - Simulation-based evaluation of hub configurations.
  - Decision-support recommendations for traffic managers.

- Automation should support and not replace, human decision-making.

- **KPIs: Did stakeholders mention how they will measure success?**

  The following performance indicators were considered relevant:

  - End-to-end travel time.
  - Travel time variability.
  - Waiting time at hubs.
  - UAV mission success rate.
  - Traffic speed improvements.
  - Bottleneck duration reduction.
  - User satisfaction and perceived safety.
  - $CO_2$ emission variation (estimated)

- **Expected role of FEDORA: Which decisions or processes do stakeholders expect FEDORA to support or improve?**

  Stakeholders expect FEDORA to:

  - Provide an integrated optimisation layer.
  - Improve situational awareness through aerial sensing.
  - Enable simulation-backed infrastructure decisions.
  - Support multimodal coordination.
  - Enhance resilience during congestion or incidents.
  - Provide evidence for policy-level scalability discussions.

  FEDORA is seen as a decision-support and optimisation framework rather than a standalone operational system.

## Wheel 3: Data Exchange & Governance

**Data availability gaps: What data is needed but currently missing or hard to access?**

The following data gaps were identified:

- Updated high-resolution road infrastructure datasets.
- Real-time passenger occupancy levels.
- Standardised incident reporting feeds.
- Historical congestion datasets with sufficient granularity.
- Real-time shared mobility availability data.
- Airspace geofencing maps in interoperable format.

- **Block 3A - Data exchange conditions:**

  - **What are the conditions for sharing data? (e.g., anonymity, specific agreements)**

    Conditions for data sharing include:

    - GDPR-compliant anonymisation mechanisms.
    - Data processing agreements between entities.
    - Role-based access control.
    - Clear data retention policies.

        - Secure API-based data exchange.
        - Private operators indicated willingness to share aggregated or anonymised data but expressed sensitivity regarding commercially sensitive datasets.

    - **Are there trust issues between private operators and public authorities?**

      No major trust conflicts were identified. However:

        - Private operators require clear governance frameworks.
        - Public authorities require legal compliance assurance.
        - UAV data collection raises privacy perception concerns.
        - Trust is conditional upon transparency and formal agreements.

- **Block 3B - Multilevel governance:**
    - Who are the key actors with decision-making power?

      Key decision-making actors:

        - Public Works Department (main road network authority)
        - Department of Civil Aviation (UAS authorisation)
        - Municipalities (local infrastructure decisions)
        - Ministry of Transport (strategic scaling)
        - Police (strategic scaling)

    - Are there regulatory or institutional barriers identified during the session?

        - UAV geofencing restrictions.
        - Airspace classification constraints.
        - GDPR compliance for aerial sensing.
        - Multi-level administrative approvals.

    - Which actors have formal decision power?

        - Department of Civil Aviation (flight approval)
        - Public Works Department (road operations)
        - Municipalities (hub location permits)
        - Ministry (strategic deployment)

    - Which actors influence decisions informally

        - Police (incident management input)
        - Private operators (data provision leverage)
        - University of Cyprus (technical validation)

**Requirements. CONSOLIDATION AND PRIORITISATION.** MoSCoW prioritisation

| Priority Rank | Requirement ID | Short Description | Why is it critical? |
|---|---|---|---|
| 1 | *Nic-001* | *Real-time traffic data.* | *Core datasets for the optimization* |
| 2 | *Nic-002* | Historical traffic data | *Core datasets for the optimization* |
| 3 | *Nic-003* | Mission authorisation | This aspect is critical for mission operations. Prior authorisation from the Unmanned Aircraft Systems (UAS) Department of Civil Aviation will be necessary, given that Nicosia falls within several geo-fencing zones imposed due to military restrictions and the island's political status. |
| 4 | *Nic-004* | Transport infrastructure datasets | *Core datasets for the optimization* |
| 5 | *Nic-005* | Passenger Counts | *Core dataset for the optimization* |

**Risks & Mitigation**

| Risk Identified | Impact on Pilot | Mitigation Strategy |
|---|---|---|
| *Legal obligations regarding GDPR regulation on data gathering* | *High - Operations cannot start* | Set up anonymization procedure for data gathered from drones (e.g. car registration plates) |
| UAS Geographical Restriction Zones imposed due to military reasons and the island's political status. | *High - Operations cannot start* | *Start discussion with Unmanned Aircraft Systems Department of Civil Aviation immediately.* |
| Delays in UAV authorisation | High | Early pre-application consultation |
| Limited participant recruitment | Medium | University-led recruitment campaign |
| Inconsistent data formats | Medium | Define API standards early |

| Risk Identified | Impact on Pilot | Mitigation Strategy |
|---|---|---|
| Weather constraints affecting UAV tests | Medium | Flexible scheduling & simulation fallback |
| Public perception concerns | Medium | Communication & transparency strategy |

## Next Steps

- **Pending validations:** What still needs to be checked with technical partners?
  - Confirm availability of updated infrastructure datasets.
  - Validate UAV geofencing constraints.
  - Define API feasibility for real-time integration.
  - Confirm passenger count data granularity.
  - Validate SUMO simulation model calibration with real data.

- **Support needed:** Do you need specific help from MLC, ERTICO, or technical partners?
  - Legal support for GDPR framework.
  - Technical support for API harmonisation.
  - Guidance from WP2 on data model standardisation.



# PILOT 4: COPENHAGEN

## Executive Summary & Pilot Context

- **Pilot Site:** Greater Copenhagen, Denmark
- **Date & Location:** 30/01, 02/02/2026
- **Confirmed Pilot Typology:** Simulation.
- **Main Objective:** The pilot aims to leverage a large-scale activity-based simulation of the Greater Copenhagen area to evaluate and forecast the impacts of demand-management strategies such as congestion pricing and tradable credits. By leveraging on an open-source agent-based simulation, SimMobility, applied to the pilot local context, the pilot seeks to inform national and regional authorities about how different demand management schemes can reduce congestion, emissions and inequality while supporting budget planning for public transport operations.

## Stakeholder Engagement Summary

- **Participation overview:**
  - **Which key stakeholder groups attended?**

- The national road directorate's (Vejdirektoratet) modelling team responsible for the Danish Transport Model (GMM).
- The mobility development unit from the Capital Region of Denmark (Region Hovedstaden), which oversees regional public transport planning and budgeting.
- Researchers from the Technical University of Denmark (DTU) who operate the SimMobility platform and coordinate the Horizon-Europe project.

  - **Who was invited but did not attend?**
    - Public transport operator Movia (bus) and Metroselskabet (metro), whose data and operational insights are critical for multimodal modelling.
    - Representatives from the City of Copenhagen (Kobenhavn Kommune).
    - Sund & Bælt is responsible for society's largest transport construction investments and improves connections in Denmark nationally and internationally. The company is a key stakeholder in the development of the on-going road pricing pilot in Denmark.

- **Missing actors & mitigation:**
  - **Are there critical stakeholders missing? (list them)**

    See above.
  - **What is the plan to involve them before Workshop 1.1? (e.g., bilateral meetings, calls)**
- **Dynamics:** *Briefly describe the atmosphere.*

  The discussions were collaborative and open; participants exchanged information about their current use of modelling tools and policy priorities.
  - **Were there conflicting views between stakeholders?**

    There were no major conflicts; however, the modelling team focused on technical challenges (calibration, runtime), while regional planners emphasised forecasting and budgeting needs.
  - **Was there a consensus on the main problems?**

    Consensus emerged around the need to reduce model runtime costs, improve data sharing and develop intuitive tools for scenario configuration and visualisation.
- **Institutional aspects:**
  - **Were public authorities present or represented?**

    Public authorities were well represented through the national road authority and the regional government; these bodies are key decision-makers for transport policies.
  - **Are there decision-making bodies that should be involved in later stages?**

    No municipal representatives were present; involving city authorities (e.g.: CPH Commune) and the Ministry of Transport will be important for Pilot outcomes discussions considering the scenarios of analysis being considered. Public transport operators (service provision) and private mobility providers (MaaS integration) may also be relevant to bring at a later stage.

## Workshop Findings: The "Three Wheels"

## Wheel 1: Current Situation & Pain Points

**Operational bottlenecks: What are the main inefficiencies identified by the users?**

- Existing simulation models could benefit from calibration methods against current traffic counts and public transport flows; calibration algorithms exist but have not been applied to Denmark in a systematic way.
- Running the full activity-based model is costly and time-consuming; cloud-based runs require dedicated funding and can take about four days per simulation.
- Freight flow data are lacking; while passenger data are readily shared, freight information is commercially sensitive and difficult to obtain.
- Stakeholders desire the ability to model specific sub-regions in detail while keeping the rest of the network aggregated to reduce computational demand, but current architecture does not support this.

- **Manual processes: Which processes are currently non-digitalized or disconnected?**
  - Scenario configuration is not beginner-friendly; users must edit scripts and know how to adjust numerous parameters.
  - Data preparation and model calibration rely on manual scripting and ad-hoc procedures; there is no automated pipeline to ingest sensor counts and travel surveys.
  - Result interpretation often requires manually generating graphs; while the team has begun automating some plots, a comprehensive visualisation tool is lacking.
- **Key "Pain Points": What keeps stakeholders from operating efficiently today?**
  - The high cost of cloud computation and the long runtime for each model run discourage experimentation and rapid policy testing.
  - Limited access to freight and multimodal capacity data creates uncertainty in forecasts and prevents integrated analysis.
  - Lack of an intuitive interface for configuring scenarios and analysing outputs limits participation beyond the core modelling team.
  - Existing data sharing arrangements do not cover public transport occupancy or MaaS usage, making it difficult to validate modal shifts
- **(For Urban pilots): Specific issues regarding traffic management or incentives.**
  - Regional planners want to use simulation outputs to forecast bus-service requirements and budgets over the next one or two years.
  - Reducing private car traffic by around 10 % on congested corridors was cited as a goal that could influence public transport budgets.
  - There is interest in understanding how new mobility hubs, curb-space allocations and ride-hailing pick-up points interact with demand management policies.

## Wheel 2: Tools & Technological Capabilities

- **Desired functionalities: What specific tools did stakeholders ask for? (*e.g., "Real-time dashboard," "Prediction tool," "Booking app"*).**
  - A results-visualisation dashboard that automatically generates maps and charts of flows, mode shares and emissions.

- A user-friendly interface for configuring pricing, tradable credit and MaaS scenarios without editing scripts.
- The ability to extract insights by area to reduce complexity, runtime or cost.
- Integration of public transport, road and shared-mobility data into a single platform to support multimodal analysis.
- Forecasting tools that carefully consider all KPIs for public transport and multimodality (e.g.: estimate future bus-service hours, seat capacities and budget impacts).

- **Automation needs: Where do they expect FEDORA to automate decisions?**
  - Automated calibration of the model to traffic counts and public transport ridership, reducing manual tuning efforts.
  - Automated data ingestion pipelines to process sensor data, survey responses and public transport timetables.
  - Automated generation of standard reports and key performance indicators after each simulation run.
- **KPIs: Did stakeholders mention how they will measure success?**
  - Reduction in traffic congestion and travel time on targeted corridors.
  - Changes in mode share, particularly shifts from private car to public transport or shared mobility options.
  - Impacts on public transport demand by corridors, and level of service.
  - Impacts of pricing or tradable credit schemes, including how revenues or credits are distributed among space and across different segments of the population
  - Computational efficiency – cost and runtime per scenario as a measure of operational viability.
- **Expected role of FEDORA: Which decisions or processes do stakeholders expect FEDORA to support or improve?**
  - Showcase calibration and validation simulation platform capable of modelling congestion pricing, tradable credits and MaaS integration for the Greater Copenhagen area.
  - Supply decision-support dashboards that allow policy-makers to explore alternative scenarios, view KPIs and understand trade-offs in near real-time.
  - Support capacity planning by forecasting demand, usage of modes of transport for different road pricing strategies.



## Wheel 3: Data Exchange & Governance

- **Data availability gaps: What data is needed but currently missing or hard to access?**
  - Freight movement data are scarce; unlike passenger data, freight operators do not readily share information. CPH pilot within FEDORA will not cover this.
  - Detailed public transport ridership and seat-capacity data are not integrated with road congestion data in large scale simulations, limiting multimodal analysis.
  - Up-to-date occupancy data for shared mobility services (car-sharing, ride-hailing, bike-sharing) are missing, complicating MaaS modelling.
  - Accurate information on curb-space usage and planned mobility hubs is not yet available for modelling pick-up and drop-off dynamics.

- **Block 3A - Data exchange conditions:**
  - **What are the conditions for sharing data? (e.g., anonymity, specific agreements)**
    - Passenger travel data are generally shared openly, but freight data remain proprietary, creating an asymmetry in data availability.
    - Data sharing agreements must respect confidentiality and may require anonymisation or aggregation, particularly when using vehicle or passenger-level data.
  - **Are there trust issues between private operators and public authorities?**
    - Public authorities indicated a willingness to share traffic and public transport data, but integration depends on institutional mandates; the road authority's new master data system does not yet include bus or rail data.
    - Trust between agencies is relatively high in Denmark, but formal agreements are still necessary to define responsibilities and access rights.
- **Block 3B - Multilevel governance:**
  - **Who are the key actors with decision-making power?**
    - Key actors with formal decision power include the Ministry of Transport, the national road directorate, Banedenmark, the Capital Region of Denmark and municipal councils.
    - Public transport operators (Movia, DSB) and shared-mobility providers influence decisions through service provision and operational constraints.
  - **Are there regulatory or institutional barriers identified during the session?**

    Regulatory barriers include funding restrictions on running large-scale simulations, limitations of current IT contracts for tool development and data sharing mandates for freight operators.
  - **Which actors have formal decision power?**

    (see above)
  - **Which actors influence decisions informally**

    Informal influencers include research institutions and consultants who develop and operate the simulation model and provide technical advice.

## Requirement. CONSOLIDATION AND PRIORITISATION

### MoSCoW prioritisation

| Priority Rank | Requirement ID | Short Description | Why is it critical? |
|---|---|---|---|
| 1 | CPH-001 | Develop a fully calibrated and validated Greater Copenhagen simulation model with integrated modules for congestion pricing and tradable-credit schemes | The ability to develop a Greater Copenhagen simulation model with integrated congestion-pricing and tradable-credit modules is critical because, without a tailored and validated simulation engine that includes these policy levers, it is impossible to realistically quantify how such demand-management schemes will affect travel behaviour and congestion in the region. |
| 2 | CPH-002 | Integrate traffic counts, public transport ridership in an automatic validation procedure | Without accurate calibration to local traffic counts and ridership data, the model's outputs would not reflect real conditions and would therefore be unusable for policy decisions. |
| 3 | CPH-003 | Provide a user-friendly scenario configuration and results-visualisation tool to enable non-experts to design and assess policy scenarios | Non-expert stakeholders need an intuitive interface to design scenarios and interpret results; otherwise the simulation remains the domain of specialists. |
| 4 | CPH-004 | Showcase alternative computational architectures and resources to support regular model runs and experimentation, thereby lowering the barrier to innovation | High cloud-computing costs and long runtimes currently impede experimentation; without dedicated resources the model cannot be used for iterative policy analysis |
| 5 | CPH-005 | Establish a framework for MaaS integration in large-scale simulations | A clear framework is needed to understand how shared-mobility providers and its user behaviour can be included in current and future models. |

## Risks & Mitigation

| Risk Identified | Impact on Pilot | Mitigation Strategy |
|---|---|---|
| High computational cost and long runtimes | Running the simulation on local server can limit the impact of the pilot. | Explore HPC resources and heavy parallel architecture |
| Data gaps and lack of integration | Freight data and public transport ridership are either unavailable or not integrated | Rely on existing access from smart card data on public transport usage. No action on freight. |
| Limited stakeholder engagement | Key stakeholders such as municipal authorities, public transport operators and private mobility providers were absent from the initial workshop. | Arrange bilateral meetings, invite them to follow-up workshops and incorporate their feedback into our scenario generation process and results analysis. |
| User friendliness of tools | Scenario configuration and results analysis currently require expert knowledge | Develop intuitive interfaces, provide training and produce documentation to broaden the user base. |
| Institutional and contractual constraints | Existing academic development may limit competition for practice-ready tool development and may slow down innovation | Engage with local modelling teams multiple times during the FEDORA project to showcase development and usage as knowledge transfer. |

## Next Steps

- **Pending validations: What still needs to be checked with technical partners?**
  - Prepare a summary of the pricing and TCS scenarios and associated KPIs to guide scenario design

- <u>**Support needed: Do you need specific help from MLC, ERTICO, or technical partners?**</u>
    - Seek support (ERTICO) to identify technical solutions for result showcasing, visualisation.
    - Coordinate with ETH possible simulation scenarios on artificial currencies to include in the pilot's portfolio.

# PILOT 5: REGGIO EMILIA

## Executive Summary & Pilot Context

- **Pilot Site:** Reggio Emilia, Italy
- **Date & Location:** *15/1/2026 online*
- **Confirmed Pilot Typology:** *Urban Mobility*
- **Main Objective:** *The primary objectives of this workshop were to:*
    - Share and align on the pilot's aims and methodology: Present the FEDORA project and the Reggio Emilia tradable mobility credits scheme to key stakeholders, ensuring a common understanding of the pilot's objectives, expected outcomes, and implementation approach;
    - Identify and validate the most appropriate Telematics Service Provider (TSP) infrastructure: assess the technical feasibility, operational compatibility, and participant recruitment viability of different TSP solutions. The initial assumption of building upon the existing Move-In regional system was thoroughly examined based on direct stakeholder input;
    - Gather stakeholder requirements and constraints: Collect critical inputs from the local ecosystem regarding data availability, privacy requirements, governance frameworks, and operational barriers to inform the pilot's technical architecture and implementation strategy.

## Stakeholder Engagement Summary

- **Participation overview:**
    - <u>Which key stakeholder groups attended?</u> *(e.g., city authorities, operators, logistics nodes)*

      • Municipality of Reggio Emilia
      • Emilia-Romagna Region
      • TSP providers (OCTO Telematics, AIR)
      • Universities and research centre (Joint Research Centre ISPRA, DUT)

    - <u>Who was invited but did not attend?</u>

      None.
- **Missing actors & mitigation:**
    - <u>Are there critical stakeholders missing?</u> *(list them)*

No. Insurance companies were mentioned during the workshop as a potential stakeholder to support users engagement in the pilot, but after the discussion this option was not considered feasible and therefore they will not be involved, at least in this stage.

- What is the plan to involve them before Workshop 1.1? *(e.g., bilateral meetings, calls)*

  Not applicable.

- **Dynamics:** *Briefly describe the atmosphere.*
  - Were there conflicting views between stakeholders?

    The workshop was highly focused and technical, with constructive exchanges. There was strong alignment on the pilot's overall objectives, but concerns emerged regarding the initial technical approach:

    - Move-In integration feasibility: Initial assumption questioned due to:
      - Limited number of Move-In users in Reggio Emilia
      - Complex privacy framework already established for Move-In that may not accommodate additional data sharing
      - Potential mismatch between Move-In objectives (old polluting vehicles driving less) and FEDORA objectives (behaviour change across user spectrum)
      - Geographic coverage uncertainty (users registered in region but actual Reggio Emilia daily usage unknown)
    - Privacy and authorization: Debate on whether additional GDPR authorizations would be required for FEDORA data collection beyond existing Move-In consent
    - TSP data access: Different views on feasibility of direct user recruitment via existing black box owners vs. need to work through intermediaries (i.e. insurance companies)

  - Was there a consensus on the main problems?

    Main areas of consensus:
    • The pilot concept is valuable and innovative
    • Privacy and GDPR compliance are non-negotiable requirements
    • Data integration architecture must be clearly defined before implementation.

- **Institutional aspects:**
  - Were public authorities present or represented?

    Yes. Municipality of Reggio Emilia (pilot leader) and Emilia Romagna Region (Move-In system governance and regional air quality management)

  - Are there decision-making bodies that should be involved in later stages?

    Beyond the local and regional level, national authorities (i.e. Ministry of Infrastructure and Transport) could be involved in later stages of the pilot to assess scalability and broader applicability of the tradable mobility credits scheme.

## Workshop Findings: The "Three Wheels"

## Wheel 1: Current Situation & Pain Points

- **Operational bottlenecks:** What are the main inefficiencies identified by the users?

  1. Limited existing telematics infrastructure suitable for pilot

     - Move-In system has few active users in Reggio Emilia
     - Most existing black boxes are insurance-owned with restricted data access
     - No direct channel to contact potential participants who already have telematics devices

  2. Data governance complexity

     - Move-In already operates under a complex privacy framework
     - Individual trip-level data is not accessible in current Move-In architecture
     - Adding FEDORA-specific data requirements may require new privacy assessments
     - No established protocol for academic/research access to telematics data for behavioral experiments

  3. Uncertainty about participant recruitment pathways

     - Initial strategy relied on Move-In integration (now questioned)
     - Alternative pathways not yet developed
     - Timeline pressure to identify and onboard 300-500 participants

- **Manual processes:** Which processes are currently non-digitalized or disconnected?

  Currently in Reggio Emilia there is no structured process — manual or digital — for dynamically orienting individual driver behaviour toward more sustainable mobility choices. Current instruments (ZTL access restrictions, Low Emission Zones, static signage) are unidirectional and rigid: they communicate rules but do not interact with users, do not provide personalised feedback, and do not create adaptive economic incentives linked to actual behaviour.

  The gap identified during the workshop is therefore not one of digitalisation but of absence of tools capable of:

     - collecting information on individual mobility choices in real time
     - providing personalised feedback to users on the impact of their travel decisions
     - creating dynamic economic incentives that respond to actual behaviour patterns
     - enabling users to actively participate in demand management through a market-based mechanism

- **Key "Pain Points":** What keeps stakeholders from operating efficiently today?

- Municipality perspective: The core challenge is strategic resource allocation across the road network. The Municipality needs to understand which corridors to invest in and how to shift users toward them but without a mechanism to interact with individual drivers, this remains largely guesswork.
- Research perspective: The pilot addresses a genuine knowledge gap: how do users respond to tradable credit mechanisms in real urban conditions? This has never been tested empirically at scale in Europe. The scientific value lies precisely in the novelty of the instrument.
- TSP perspective: While the concept is sound, the practical challenge is reaching a sufficient population of users. Existing telematics infrastructure is fragmented across insurance companies and TSPs, with no established channel for research-oriented engagement with users.

- *(For Urban pilots)*: Specific issues regarding traffic management or incentives.

- Absence of a ready participant base: There is no existing community of users enrolled in a comparable scheme that could be migrated or expanded. Participant recruitment must be designed and executed as a new process.
- Need to demonstrate value to users: For the mechanism to work, participants must perceive the credit scheme as meaningful and worth engaging with. Unlike a restriction (which is imposed), a trading scheme requires voluntary active participation, making user experience and communication critical success factors that do not arise in traditional traffic management.
- Measurement of behavioural change as a new operational requirement: Current traffic management does not routinely measure individual-level behavioural responses to policy interventions. The pilot introduces this as a core operational need, requiring data collection, analysis and feedback loops that are entirely new to the local ecosystem.
- Integration: Achieving pilot objectives requires coordinating actors who currently operate in separate institutional and regulatory domains with no established data sharing framework between them.

## Wheel 2: Tools & Technological Capabilities

- **Desired functionalities:** What specific tools did stakeholders ask for? (*e.g., "Real-time dashboard," "Prediction tool," "Booking app"*).

  need for a user-facing digital platform — app or web-based — that would allow participants to interact with the credit scheme in a transparent and accessible way. The key functional needs identified were:

  - A personal dashboard giving users visibility over their credit balance, recent activity, and current token price, so that they can make informed travel decisions
  - A token trading interface enabling users to buy and sell credits, with sufficient market information to support meaningful decisions
  - A charging scheme visualisation showing users how many tokens are required for different road types and time bands
  - A trip history and personal statistics view, allowing users to track their own behaviour over time and understand their impact relative to other participants

  Beyond the user interface, stakeholders identified the need for a backend system capable of:

  - Receiving trip data from the TSP and automatically applying the charging scheme to calculate token consumption
  - Managing credit balances, market transactions, and weekly allocations
  - Enforcing basic market rules to prevent speculation or manipulation
  - Allowing the Municipality, as regulator, to adjust the charging scheme in response to external events such as pollution alarms, and to intervene in the market as a last resort if needed

- **Automation needs:** Where do they expect FEDORA to automate decisions?

  - Automated trip processing
  - Automated credit lifecycle/marketplace management

- **KPIs:** Did stakeholders mention how they will measure success?

  Stakeholders did not define precise KPIs at this stage, but implicitly oriented the discussion around:

- Reaching a sufficient number of active participants to generate statistically meaningful evidence
- Demonstrating technical feasibility and robustness of the digital implementation at real-world scale
- Achieving a meaningful shift in travel behaviour (route, timing, or mode)

- **Expected role of FEDORA**: Which decisions or processes do stakeholders expect FEDORA to support or improve?

  Stakeholders expect FEDORA to support the local authority in implementing more effective and flexible traffic demand management policies, overcoming current instruments which operate through rigid, binary access rules. Furthermore, outcome of this system may orient infrastructure investments and mobility interventions across the road network.

## Wheel 3: Data Exchange & Governance

- **Data availability gaps:** What data is needed but currently missing or hard to access?

  TSP trip data, the core input to the charging mechanism. Key open questions include what exactly constitutes a trip in the TSP's system, in what format data is transmitted, at what frequency, and how individual users are identified in a privacy-preserving way. The discussion highlighted that the integration with Move-In was ultimately considered not viable, partly due to the complexity of its existing privacy framework: any deviation from the consent and data processing model already approved for Move-In would likely require a new engagement with the Privacy Authority, with uncertain timeline implications.

- **Block 3A - Data exchange conditions:**
  - What are the conditions for sharing data? *(e.g., anonymity, specific agreements)*

    Any data sharing must be grounded in explicit informed consent from participants, covering what is collected, how it is used, and their GDPR rights.

    Data minimisation was consistently emphasised: the system should collect only what is strictly necessary for the scheme to function
  - Are there trust issues between private operators and public authorities?

    Stakeholders expressed confidence that a privacy-by-design approach could address most concerns. However, the complexity of the privacy framework required for Move-In was cited as a cautionary reference: establishing a compliant data processing architecture takes time and should not be underestimated.

- **Block 3B - Multilevel governance:**
  - Who are the key actors with decision-making power?

    The discussion confirmed that the Municipality of Reggio Emilia holds central governance authority as lead authority, regulator, and primary data owner. However, effective implementation depends on a constellation of actors, abovementioned, whose roles and relationships need to be formalised.
  - Are there regulatory or institutional barriers identified during the session?
    - GDPR and privacy compliance

- TSP contractual constraints
- Absence of a formal data sharing framework

- Which actors have formal decision power?
  - Municipality of Reggio Emilia —formal authority over the scheme design, credit allocation rules, charging parameters, and market governance
  - Privacy Authority — formal regulatory authority over the data processing framework; its approval may be required before data collection can begin
- Which actors influence decisions informally
  - Research institutes involved in the pilot: while they hold no formal governance authority, their methodological recommendations carry significant weight in shaping the scheme design, the allocation strategy, and the research framework
  - TSPs as a technically expert actor with direct knowledge, their assessments of what is and is not feasible strongly condition the options available to the Municipality, even without formal decision power
  - Emilia-Romagna Region: formal governance authority over Move-In and regional policies
  - Ministry of Infrastructure and Transport: not involved in pilot phase, but relevant for scalability assessment and potential policy replication at national level

## Requirements CONSOLIDATION AND PRIORITISATION

### MoSCoW prioritisation

| Priority Rank | Requirement ID | Short Description | Why is it critical? |
|---|---|---|---|
| 1 | RE-001 | Establish a formal partnership framework with TSPsMove | without direct agreements with TSPs, there is no viable channel to recruit participants or access the telematics data required for the scheme to function |
| 2 | RE-002 | Establish a GDPR-compliant data processing architecture Data | Data collection cannot begin without a legally sound framework |
| 3 | RE-003 | Define and formalise the technical specifications for TSP data collection and transmission | The entire charging and tracking pipeline depend on agreed data specifications |

| Priority Rank | Requirement ID | Short Description | Why is it critical? |
|---|---|---|---|
| 4 | RE-004 | Recruit 500 participants to install black boxes who regularly travel within the Reggio Emilia road network | Sufficient participant numbers are the minimum threshold for the statistical validity of the experiment |
| 5 | RE-005 | Implement token trading marketplace with market rules engine | Core of the pilot concept. |
| 6 | RE-006 | Develop user-facing platform | only interface through which participants interact with the credit scheme; without it, the behavioural change mechanism cannot operate |
| 7 | RE-007 | Develop a backend system for receiving and processing TSP data and managing market transactions | The backend is the operational core of the scheme; without it, trips cannot be charged, balances cannot be managed, and trading cannot take place |



## Risks & Mitigation

| Risk Identified | Impact on Pilot | Mitigation Strategy |
|---|---|---|
| Move-In integration not viable, removing a potential source of baseline participants | Medium — already largely anticipated; accepted as a working assumption | Proceed with an independent recruitment and data collection strategy; treat Move-In as a reference model only, not as an operational dependency |
| GDPR compliance process requires formal Privacy Authority review, causing timeline delays | High — data collection cannot begin until the legal framework is approved | Engage a Data Protection Officer (DPO) from the outset; design the data architecture with strong data minimisation and privacy-by-design principles; prepare a full Data Protection Impact Assessment (DPIA) in advance |
| Participant recruitment falls short of the | High — undermines the statistical validity of the experiment and its demonstration value | Design an attractive and clearly communicated incentive package; develop a multi-channel recruitment strategy from the outset; consider |

| Risk Identified | Impact on Pilot | Mitigation Strategy |
|---|---|---|
| minimum viable threshold | | a hybrid approach combining existing black box users and direct recruits. |
| Low participant engagement with the trading platform, limiting behavioral response measurement | Medium — reduces the effectiveness of the experiment and the quality of evidence generated | Prioritise usability in platform design; maintain minimal interaction requirements; monitor engagement metrics during the soft-start phase and adjust communication strategy accordingly |

## Next Steps

- **Pending validations:** What still needs to be checked with technical partners?
    - TSP selection and technical specifications
    - Token allocation methodology
    - Charging scheme parameters

- **Support needed:** Do you need specific help from MLC, ERTICO, or technical partners?
    - DTU/JRC already providing support for pilot design.
    - Support needed from FRONTIERS or other relevant partners for software development.



# PILOT 6: BUDAPEST

## Executive Summary & Pilot Context

At the Budapest workshop, the representatives of vessel operators and their representation association, law enforcement, traffic safety and water authorities, Hungarian River Information Services (RIS) provider and public transport operating company thought together about the safety and multimodal development opportunities for Budapest's sightseeing, event and hop-on-hop-off shipping. The participants jointly identified the problematic areas of navigation, the development opportunities, the available and necessary data, and the bottlenecks of developments. They separately analyzed the city government's urban development plans affecting navigation. The participants gained insight into the work of FEDORA project and the goals and opportunities of Budapest pilot.

- **Pilot Site:** Budapest
- **Date & Location:** 12.03.2026, BME Meeting room, Stoczek Str. 6, 1111 Budapest
- **Confirmed Pilot Typology:** Logistics
- **Main Objective:** Reducing conflict situations in passenger vessel traffic of Budapest. Integration sightseeing, event and hop on-hop off passenger vessel traffic and land based traffic. Identifying

possible and required AIS data based developments for increasing IWT safety, integration of waterway passenger and land based traffic. Identifying required traffic management and simulation tasks related to IWT traffic of Budapest.

## Stakeholder Engagement Summary

The workshop was attended by key stakeholders in Budapest's passenger shipping sector from passenger ship operators, associations, relevant authorities and the river information system. Although the Budapest Municipality, Centre for Budapest Transport, some major ship operators and the ÉKM Shipping Department were absent from the workshop, their positions were known through the preparatory (bilateral) meetings or participation of Federation of Hungarian Passenger Vessel Operators and BME replaced them. Since Federation of Hungarian Passenger Vessel Operators (HUNPASS) knows the opinions of missing operators and they are in continuous negotiations with the municipality, who's needs and goals were represented by HUNPASS.

- **Participation overview:**
    - **Which key stakeholder groups attended? (e.g., city authorities, operators, logistics nodes)**
        - Public authorities: Budapest police, Ministry of Construction and Transport - Transportation Safety Bureau, Central Danube Valley Water Management Directorate.
        - Vessel operators: Armada Budapest Kft., Európa Rendezvényiroda Kft., Scenic & Emerland Luxury Cruises, Legenda Kft.
        - Public transport company: BKV Zrt.
        - River Information Services (RIS) provider: RSOE, NAVINFO (Hungarian RIS dispatch centre).
        - Advocacy associations: Hungarian Federation of Danube Ports (HFIP), Federation of Hungarian Passenger Vessel Operators (HUNPASS).
    - **Who was invited but did not attend?**
        - Public transport organizer: Centre for Budapest Transport (BKK).
        - Passenger vessel operators: Legenda Kft., MAHART Passnave.
        - Public authority: Ministry of Construction and Transport - Shipping Authority Department.

- **Missing actors & mitigation:**
    - **Are there critical stakeholders missing?**
        - Passenger vessel operator: MAHART Passnave
    - **What is the plan to involve them before Workshop 1.1?**
        - Calls and bilateral meetings.
- **Dynamics:**
    - **Were there conflicting views between stakeholders?**

      There were no conflicts. All of participants welcomed the project goals.
    - **Was there a consensus on the main problems?**

Yes.

- **Institutional aspects:**
    - **Were public authorities present or represented?**

      Yes: Budapest police, Ministry of Construction and Transport - Transportation Safety Bureau, Central Danube Valley Water Management Directorate

    - **Are there decision-making bodies that should be involved in later stages?**

      Ministry of Construction and Transport – Shipping Authority Department: There have already been discussions on the legal issues of handling and using AIS data, but further discussions are needed on the impacts of the project's developments on local shipping regulations.

## Workshop Findings: The "Three Wheels"

### Wheel 1: Current Situation & Pain Points

- **Operational bottlenecks: What are the main inefficiencies identified by the users?**

  Budapest Municipality's plan to change the Danube Bank Building Regulations (DÉSZ) from 2027

    - Drastic reduction of piers
    - Piers will be only stopovers, continuous mooring will be not allowed
    - No impact study on passenger ship traffic and waterborne tourism

  Navigation safety

    - No trust in AIS data in critical navigation situations
    - Lack of ECDIS availability and usage
    - Safety-critical situations due to non-compliance with (local) navigation rules
    - Safety-critical situations when departing from and arriving to the piers, due to heavy traffic and lack of knowledge about exact departure times of vessels.
    - Heavy traffic at some critical junctions creates safety-critical situations
    - Water level affects on routes, due to the available water depth. High level local knowledge required form skippers.

  Increasing the quality of tourist services at connection to land

    - Delays in departure due to heavy traffic or late of passengers (mainly tourist groups)
    - The arrival time is determined either by the schedule or the advertised sailing time.
    - No centralized information about pier numbers and its locations
    - No, or individual (tour guide) solutions for tourists in smooth access between piers/vessels and tourist bus parking place or mobility points (public transport, micromobility)
    - No interface between sightseeing, event or hop on-hop off shipping and land-based route planning.

  Business

- Although every passenger vessel service provider has its own sales channel, ticket/voucher sales are mainly through international tourist agent online platforms

- **Manual processes: Which processes are currently non-digitalized or disconnected?**
    - Only experience based opinions of passenger vessel operators in consultations about change of Danube Bank Building Regulations (DÉSZ)
    - *Departure and arrival times are only expected based on schedules and asked by skippers via VHF radio*
    - *"Manual" and experiment based estimation in AIS data consolidation by skippers.*
    - *In multimodal route planning the tourists are use only land based transportation route planners and the official schedule of vessels (if available).*

- **Key "Pain Points": What keeps stakeholders from operating efficiently today?**
    - Planned change of Danube Bank Building Regulations (DÉSZ) is without any impact study on IWT.
    - There is no gathered and up to date information about passenger vessel departure times and locations (pier No.).
    - No thrust in AIS data since low frequency, accuracy, missing and false data.
    - Lot of of shipping emergencies can be traced back to non-compliance with navigation rules.
    - *Lack of support for tourists in easy access between piers and tourist bus parking place or mobility points. Sometimes this leads to delay in departure of vessels.*
    - High impact of international tourist agent online platforms (like TripAdvisor, GetYourGuide). About 30% loss in incomes because of these vouchers instead of direct sales.

- **Specific issues regarding interoperability or event detection.**
    - The Municipality's intention to change DÉSZ is a strong political will, but it is likely to worsen the profitability of sightseeing cruises, increase conflict situations in cruises and pollution (higher fuel consumption), and the logistical changes have not been worked out (e.g. where will the ships park, where will the remaining ports be compared to the bus parking lots).
    - Departure and arrival times are only expected based on schedules and asked by skippers via VHF radio. Boat masters have to pay special attention to planning their docking and departure manoeuvres, and conflict situations often arise. When departing, ships are often delayed due to traffic.

## Wheel 2: Tools & Technological Capabilities

- **Desired functionalities: What specific tools did stakeholders ask for? (e.g., "Real-time dashboard," "Prediction tool," "Booking app").**
    - IWT logistics impact study on change of Danube Bank Building Regulations (DÉSZ)
    - Gathered information source about up-to-date departure times of vessels. Some stakeholder asked a departure registration system.
    - Although the use of ECDIS is not mandatory, decision-makers would welcome ECDIS-based skipper/boatmaster assistant developments such as the indication of local landmarks, graphical display of local navigation rules, departure and arrival times and ship routes.
    - AIS data consolidation in accuracy, frequency, missing and false data.

- Route planner for passengers (tourists), which help in finding piers and support passengers in further land based route planning after shipping.
- Common website for direct sales, excluding international tourist agent online platforms.

- **Automation needs: Where do they expect FEDORA to automate decisions?**
    - Investigating with simulations the pier reorganization plans of Municipality
    - Up to date departure and arrival timetable (with pier numbers) based on schedules and AIS data. ECDIS plugin would be also welcomed beside a website.
    - ECDIS based skipper assistant developments (plugins) are welcomed.
    - Consolidated AIS data for ECDIS plugins, departure and arrival timetable, Budapest Go! integration and for trajectory visualization or ship collision avoidance.

- **KPIs: Did stakeholders mention how they will measure success?**

  Budapest Municipality's plan to change the Danube Bank Building Regulations (DÉSZ):
    - Travel times and distances
    - Expected fuel consumption and pollution ($CO_2$)
    - Congestion, areas with increased traffic on water and land
    - Change in transport prices

  Consolidated AIS data:
    - Reliability and integrity of PNT data

  Up-to-date departure and arrival timetable:
    - Reliability and integrity of pier numbers and times
    - Number of delays
    - Number of safety critical situations
    - Number of website visitors
    - Passenger (tourist) and tour operator satisfaction

  ECDIS based skipper assistant developments:
    - Frequency and time of use of ECDIS and plugins
    - Boatmaster feedback

  Route planner for passengers (tourists)
    - Number of uses
    - Number of website visitors
    - Number of delays
    - Passenger (tourist) and tour operator satisfaction

- **Expected role of FEDORA: Which decisions or processes do stakeholders expect FEDORA to support or improve?**
    - FEDORA could simulate the effect of Budapest Municipality's plan to change the Danube Bank Building Regulations (DÉSZ) on IWT and related land-based passenger transport.
    - FEDORA could provide a local dataspace with consolidated AIS data
    - FEDORA could develop and share (website, ECDIS plugin) the Up-to-date departure and arrival timetable based by collecting timetables, pier numbers and locations, consolidated AIS data. (Maybe a timetable management solution could be also introduced)
    - FEDORA could develop and share (website/app) a route planner for sightseeing vessel passengers (tourists) including waterborne and land-based transport.

## Wheel 3: Data Exchange & Governance

- **Data availability gaps: What data is needed but currently missing or hard to access?**
    - AIS data: Only anonymized data can be used for development and storage.
    - Consolidated AIS data: Scientific and technical development needed for increasing PNT (AIS) data frequency of vessels and creating missing data (physical and statistical model-based iteration, and prediction algorithm), filtering false data.
    - Access to micromobility data is different by operators.
    - The planned timetables for sightseeing and event vessels are available on vessel operators' websites, in html format. The final timetables (e.g. whether the boat will depart) are decided about 1 day in advance.
    - Arrival and departure times and pier numbers of cruise (hotel) vessels are not public, but well known by MAHART Passnave (passenger vessel operator and pier handler of cruise vessels).
- **Block 3A - Data exchange conditions:**

    **What are the conditions for sharing data?**

        - Ministry stated that according to rules the anonymized AIS data should be used and published.
        - Historical AIS data (e.g. for ship model development) have to be asked from National River Information Services provider (RSOE) on the basis of permission of Ministry of Construction and Transport.
        - Timetables of cruise (hotel) vessels have to be reached by an agreement with MAHART Passnave.
        - Accurate, up-to-date and more easily usable/accessible ship schedules require the cooperation of ship operators.
    - **Are there trust issues between private operators and public authorities?**
        - Trust between operators and authorities is strong. However, legal frameworks (e.g. AIS and RIS regulations) determine the management, sharing and use of traffic data, so permissions (e.g. historical AIS data) and agreements (e.g. cruise (hotel) vessel schedules) are required.
- **Block 3B - Multilevel governance:**
    - **Who are the key actors with decision-making power?**
        - Ministry of Construction and Transport - Shipping Authority Department: in IWT regulation
        - Budapest Municipality: As “owner” of Danube bank, through the Danube Bank Building Regulations (DÉSZ) has decision making power on IWT.
        - Centre for Budapest Transport (BKK) (Budapest Municipality owned company), as transport organizer of the city has decision making power on land based (public) transport.
        - RSOE and the RIS dispatch service it operates has no formal decision-making power but has big influence on IWT related decisions.
    - **Are there regulatory or institutional barriers identified during the session?**
        - Regulatory barriers in IWT are the AIS data rules, some rules on River Information Services (e.g. what data, who can/must share)

- Regulatory barriers in land-based transport are the Ministry or Municipality rules on data sharing.

- **<u>Which actors have formal decision power?</u>**
  - Ministry of Construction and Transport - Shipping Authority Department: in IWT regulation
  - Budapest Municipality: As "owner" of Danube bank, through the Danube Bank Building Regulations (DÉSZ) has decision making power on IWT.
  - Centre for Budapest Transport (BKK) (Budapest Municipality owned company), as transport organizer of the city has decision making power on land based (public) transport.

- **<u>Which actors influence decisions informally</u>**
  - RSOE and the RIS dispatch service it operates has no formal decision making power but has big influence on IWT related decisions.
  - Budapest Police
  - Ministry of Construction and Transport - Transportation Safety Bureau
  - Central Danube Valley Water Management Directorate.

## Requirements. CONSOLIDATION AND PRIORITISATION

### MoSCoW prioritisation

| Priority Rank | Requirement ID | Short Description | Why is it critical? |
|---|---|---|---|
| 1 | BUD-001 | Municipality plan to change Danube Bank Building Regulation, without impact analysis on IWT. | FEDORA have chance to support the process |
| 2 | BUD-002 | Consolidation of AIS data: frequency of position data, estimation of missing data, refinement or filtering of false data. | For smoother traffic management solutions cannot be performed without consolidation of AIS data |
| 3 | BUD-003 | Sharing real time ship departure and arrival data (time, pier No.) with skippers, tourists and event organizers | This has big impact on safer navigation and tourist satisfaction |
| 4 | BUD-004 | Support of sightseeing tour planning of individual tourists with involving sightseeing and ho on-hop off ships into (public transport and micromobility) route planner. | Increasing tourist satisfaction and ITW service quality. Working out possible solution for later development of Budapest Go! application |
| 5 | BUD-005 | Support of tourists in finding pier numbers, tourist bus parking places, closest public/micromobility connection points | Increasing tourist satisfaction and ITW service quality |



## Risks & Mitigation

| Risk Identified | Impact on Pilot | Mitigation Strategy |
|---|---|---|
| *Anonymized AIS data* | *Information lost during anonymization makes developments more difficult.* | *Agreement with Ministry to establish a local FEDORA data platform, what collect full AIS data, but consolidated data are shared in anonymized form.* |
| Cruise vessel schedules | Timetables of cruise (hotel) vessels are not public now. For up-to-date departure and arrival time estimation these data are required also. | Agreement with data handler (MAHART Passnave) |

| Risk Identified | Impact on Pilot | Mitigation Strategy |
|---|---|---|
| Sightseeing vessel schedules | Accurate, up-to-date and more easily usable/accessible ship schedules are required. | Involving and engaging ship operators in data sharing |

## Next Steps

- **Pending validations: What still needs to be checked with technical partners?**
    - Hosting of FEDORA local dataspace (RSOE or BME).
    - Origin of real time AIS data (RSOE or BME).
    - Conditions for availability of hotel ship schedules (bilateral discussion and agreement with MAHART Passnave).
- **Support needed: Do you need specific help from MLC, ERTICO, or technical partners?**
    - Identify FEDORA participation possibility in simulate the effect of Budapest Municipality's plan to change the Danube Bank Building Regulations (DÉSZ) on IWT and related land-based passenger transport.
    - Identify FEDORA participation in develop and share a route planner for sightseeing vessel passengers (tourists) including waterborne and land-based transport.
    - Identify FEDORA participation in develop and share the Up-to-date departure and arrival timetable.
    - Selecting appropriate Use Case scenarios for the project.

# ANNEX V: TECHNICAL COMPONENT SPECIFICATIONS TEMPLATE

*NOTES*:

Please fill in the following template considering the **operational** mode of the component, i.e. its expected final form when the component will be deployed and running normally.

We only want a **high-level overview** of the component here, so that other partners can gain an understanding of what your component does and what its inputs and outputs look like.

If some aspects have not been defined yet, then mention them as **TBD** or similar, so that we have an idea of how many aspects need attention.

Leave the document version major number as is, this will be used to keep track of the FEDORA Component Specifications Template iterations. Increment the minor version number (x) for consecutive updates of the component's specifications if needed.

| **Overview** | | | |
|---|---|---|---|
| Component name: | [Component name] – Tx.x | | |
| Created by: | Creator Name – Partner short code | Document version: | 0.3.x |

| **Purpose** |
|---|
| Short description of the component's purpose (2 lines) |
| **Description** |
| Detailed description of the component. Should include:<br>- Longer explanation of what the component will do<br>- Description of any sub-components that constitute the main component |

| **Interfaces** | |
|---|---|
| How this component will be implemented, and what interfaces it will provide to be accessed by other components. | |
| **Dependencies and assumptions** | |
| Input Data: | - List of all input data that this component will require (down to the sub-component level, where known). Include data formats where known |
| Output Data: | - List of outputs this component will provide. Include formats where known |
| Assumptions: | - List of any assumptions (i.e. not-yet verified aspects) that have been made when designing this component. Also acknowledge severity if assumption proves to not be accurate. |
| **Diagrams** | |
| Conceptual Component Diagrams that can help in component understanding (if available) | |

| Non-functional requirements | | |
|---|---|---|
| Operational Performance | Availability: | Describe the availability of the component during expected operation, i.e. Is the component expected to be always running and producing outputs? Is the service waiting to respond to incoming requests? Is it a software that needs to be launched externally each time? |
| | Frequency: | The frequency at which the component will operate, if the component is operating at fixed intervals then mention how often the component will execute. If the component operates only when requested then mention this explicitly here. |
| | Latency: | The maximum acceptable time for generating an output when requested. |
| Manageability and Maintainability | Monitoring: | How component operation should be monitored to check health. Examples include regular health check requests, logging of incoming requests/warnings/errors, outputs, etc. |
| | Extensibility: | To what degree is the component expected or able to be extended, both in the scope of FEDORA and afterwards. (e.g. “in future versions we expect to handle additional vehicle types”, “In the future the tool will also be able to parse geoJSON data format in addition to the currently accepted formats”) |
| Security | Authorization and Authentication: | Who can access the services provided by the component (e.g. only authorized users, open to public, levels of access authorization) |

| Additional Information | |
|---|---|
| Notes and Issues: | Any additional information |