D2.3: Bologna Demonstrator

This project has received funding from the European Union's Horizon Europe research and innovation programme under grant agreement No. 101069782

Project & Document Information

Grant Agreement No	101069782	**Acronym**	URBANE
Project Full Title	UPSCALING INNOVATIVE GREEN URBAN LOGISTICS SOLUTIONS THROUGH MULTI-ACTOR COLLABORATION AND PI-INSPIRED LAST MILE DELIVERIES		
Call	HORIZON-CL5-2021-D6-01		
Topic	HORIZON-CL5-2021-D6-01-08	**Type of action**	IA
Coordinator	INLECOM INNOVATION		
Start Date	01/09/2022	**Duration**	42 months
Deliverable	D2.3	**Work Package**	WP 2
Document Type	R	**Dissemination Level**	PU
Lead beneficiary	ITL		
Responsible author	Alice Benini (ITL)		
Contractual due date	31/08/2024	**Actual submission date**	30/08/2024

Disclaimer and Acknowledgements

Co-funded by the European Union

This project has received funding from the European Union's Horizon Europe research and innovation programme under Grant Agreement No 101069782

Authoring, Revision & QA Information

Deliverable Contributors	
Contributor	Organisation (Acronym)
Alice Benini	ITL
Giuseppe Luppino	ITL
Luigi Russi	COBO
Silvia Bartoloni	COBO
Marco Torretta	GEL
Simona Melai	TYP
Gerardo Pisciotta	TYP
Andrea Franceschelli	Due Torri
Rafael Rosales	NORCE
Siri Veland	NORCE
Rod Franklin	KLU
Aristea Zafeiropoulou	KNT
Maria Kampa	INLECOM
Ade Fajemisin	SKEMA
Kostas Zavitsas	VLTN
Zisis Maleas	CERTH
Dimos Touloumidis	CERTH

Deliverable Contributors				
Version	Date	%	Changes	Author
0.1	27.07.2023	5%	Wrote the ToC	Alice Benini (ITL)
0.2	31.10.2023	30%	Added content to chapter 3, 4 and 5	Alice Benini and Francesco Nanni Costa (ITL)
0.3	30.11.2023	35%	Added content to chapter 6, 7 and 8	Alice Benini (ITL)
0.4	20.12.2023	40%	Review and received contributions	Giuseppe Luppino (ITL), Simona Melai (TYP), Marco Torretta (GEL), Silvia

			from Bologna LL partners	Bartoloni(COBO), Luigi Russi (COBO)
0.42	23.01.2024	42%	Review and comments by project coordinator	Maria Kampa (INLE)
0.5	29.02.2024	50%	Addressed comments, inclusion of additional content and interim version of the deliverable	Alice Benini (ITL)
0.6	31.05.2024	70%	Updated content to chapters 6, 8 and 10	Alice Benini (ITL)
0.7	22.07.2024	75%	Added content to chapter 10	Alice Benini (ITL), Luigi Russi (COBO)
0.8	05.08.2024	85%	Added content by WP3 partners to chapter 8 and by Bologna LL partners	Aristea Zafeiropoulou (KNT), Rod Franklin(KLU), Ade Fajemisin(SKEMA), Alice Benini(ITL), Marco Torretta(GEL), Luigi Russi(COBO), Gerardo Pisciotta (TYP)
0.9	09.08.2024	90%	Updated report and finalized draft version of the document	Alice Benini (ITL)
1.00	30/08/2024	100%	Final Version Ready for submission	Alice Benini (ITL)

Quality Control (includes pear & quality reviewing)			
Date	Version	Name (Organisation)	Role & Scope
30/07/2023	0.10	Efstathios Zavvos (VLTN)	QM ToC Approval
12/08/2024	0.91	Rod Franklin (KLU)	Peer review
14/08/2024	0.92	Yasanur Kayikci (VLTN)	Quality Check

14/08/2024	0.93	Maria Kampa (INLE)	Project Manager Check

Executive summary

The URBANE project aims to contribute to the EU's goal of creating safe and sustainable last-mile transport operations. By developing replicable and scalable innovative last-mile delivery solutions, based on a novel service collaboration model inspired by the Internet (the Physical Internet), URBANE will support the transition to a more efficient and environmentally friendly logistics sector. To facilitate the achievement of this goal the project deploys, monitors, and tests these innovative services in four Lighthouse Living Labs (Helsinki, Bologna, Valladolid, and Thessaloniki).

This document outlines the set up and operation of Bologna LL that consists in the realization of the Nearby Delivery Area (NDA), a measure included in the Sustainable Urban Mobility Plan (SUMP) and in the Sustainable Urban Logistics Plan (SULP) of the Municipality and Metropolitan City of Bologna, combined with a collaborative approach between logistics operators and with the utilisation of zero emission vehicles. By fostering this collaboration, the Bologna LL aims to create a dedicated area for logistics activities in close proximity to delivery destinations within Bologna city center Limited Traffic Zone (LTZ). Specifically, the NDA functions as a microhub where freight is transferred from conventional vans to light electric delivery vehicles.

The first part of the report provides an overview of the living lab, including its background, context, and objectives aligned with the Physical Internet concept. It also identifies key stakeholders and analyzes relevant policies and regulations. The second part focuses on the implementation phase, detailing real-world actions, the underlying physical and digital infrastructure, and models and tools developed by URBANE partners according to Bologna LL needs and specificities. The final chapter summarizes the identified KPIs for comparison with other living labs, along with lessons learned and recommendations for future adoption and scaling. The final KPIs measurements, sustainability triangulation and the transferability potential of Bologna LL are reported in *D2.1 Validation Report*.

The Bologna Living Lab introduces a novel approach by fostering collaboration between potential competitors in parcel delivery, sharing a common micro-hub. This business model aligns with the principles of the Physical Internet. The primary goal of the Living Lab is to develop a self-sustaining business model that can operate without ongoing external project funding. Work Package 5 (WP5) will concentrate on refining this model over the coming months to ensure its long-term sustainability and financial viability for all stakeholders involved.

Despite the various problems and challenges encountered during the implementation of the Living Lab, significant results and valuable lessons learned have been achieved (see *Chapter 10. Lessons learnt and results*). These can be utilized both for the development of the business model for the city of Bologna and for the replication of the solution and models developed in other cities with similar challenges.

Table of Contents

List of figures

List of tables

Glossary of Terms and Acronyms

ACRONYM/TERM	MEANING
A1, A13, A14	Autostrada (Italian Motorway) 1, 13, 14
A.K.A.	Also Known As
API	Application Programming Interface
B2B	Business to Business
B2C	Business to Consumer
BPMN	Business Process Model and Notation
BRT	Bartolini (courier)
BTW	By The Way
CBA	Cost Benefit Analysis
CDM	Collaborative Delivery Model
CO2	Carbon Dioxide
DT	Digital Twin
EC	European Commission
E.G.	Exempli Gratia
EV	Electric Vehicle
FaaS	Freight as a Service
FQP	Freight Quality Partnership
FUA	Functional Urban Area
GA	Grant Agreement
HZ	Herz
ICE	Internal Combustion Engine
I.E.	Id Est
IEE	Intelligent Energy Europe Programme
JWT	JSON Web Token
KPI	Key Performance Indicator
KM	Kilometre

kWh	Kilowatt Hour
L/U	Loading/Unloading
LEZ	Low Emission Zone
LL	Living Lab
LM	Last Miler
LSP	Logistics Service Provider
LTZ	Limited Traffic Zone
LTZ-T	Limited Traffic Zone – T area
LTZ-U	Limited Traffic Zone – University Area
MIMS	Ministero delle Infrastrutture e della Mobilità Sostenibili (Ministry of Infrastructure and Sustainable Mobility (MIMS))
MX	Month x
NDA	Nearby Delivery Area
NFC	Near Field Communication
NPV	Net Present Value
Open ENLoCC	Open European Network of Logistics Competence Centers
PAIR2030	Piano Aria Integrato Regionale (Regional Integrated Air Quality Plan) 2030
PI	Physical Internet
PoD	Proof of Delivery
PRIT2025	Piano Regionale Integrato dei Trasporti (Regional Integrated Transport Plan) 2025
PuDo	Pick-up Drop-off point
QR code	Quick response code
SDG	Sustainable Development Goals
SIM	Subscriber Identity Module
SULP	Sustainable Urban Logistics Plan
SUMP	Sustainable Urban Mobility Plan
TMS	Traffic Management System
UI	User Interface

1. Introduction

The purpose of this document is to provide a detailed analysis of the Bologna Lighthouse Living Lab (LL) as part of Work Package 2 (WP2) within the URBANE project. The report aims to outline the requirements for the setup and operation of the Bologna Living Lab, which involves the implementation of Nearby Delivery Areas (NDAs) — a measure listed in Bologna's Sustainable Urban Mobility Plan (SUMP) and Sustainable Urban Logistics Plan (SULP) — combined with a collaborative approach among logistics operators and the use of zero-emission vehicles. Additionally, the report describes the collaborative efforts with local authorities and business stakeholders, highlighting the constraints and measures for the transition to Physical Internet (PI)-enabled last mile deliveries.

It will encompass detailed requirements for defining NDA locations, digitalization needs, and infrastructure configuration. Additionally, it will cover fleet specifics, user stories involving all stakeholders, the Living Lab Digital Twin models, and optimization algorithms. The document also includes a comprehensive implementation plan, measurements taken during real-life operations, identified Key Performance Indicators (KPIs) with the baselines and lessons learned to support replication and scaling up. The final KPIs measurements, sustainability triangulation and the transferability potential of Bologna LL interventions will be reported in D2.1 Validation Report.

1.1 WP2 Tasks and Outcomes

1.2 URBANE Outputs Mapping to GA Commitments

TABLE 1 DELIVERABLE ADHERENCE TO GRANT AGREEMENT DELIVERABLE AND WORK DESCRIPTION

URBANE GA ITEM	URBANE GA ITEM DESCRIPTION	DOCUMENT CHAPTER(S)	JUSTIFICATION
DELIVERABLE			
D2.3 Bologna Demonstrator	*Demonstrator and report on user acceptance/lessons learned. D2.3 will describe the requirements for the setup and operation of Nearby Delivery Areas (NDAs) in collaboration with local authorities and business stakeholders, including the constraints and measures for the transition to PI-enabled last mile deliveries. It will include detailed requirements for the NDA's location definition, digitalisation requirements and configuration of infrastructure, fleet details, user stories involving all*	Chapters 3-10	This report consolidates the outcomes of the work carried out in Task 2.3 Bologna Living Lab implementation. The demonstrator consists in the implementation of Nearby Delivery Areas (NDAs), a key component of Bologna's SUMP and SULP, through collaboration among logistics operators and the use of zero-emission vehicles. The report also details collaborative efforts with local authorities and businesses, identifying challenges and strategies for transitioning to PI-enabled last-mile deliveries. Sections 4.1 and 7.2 provides in-depth specifications for NDA

	stakeholders, the LL DT models and optimization algorithms, a detailed implementation plan, measurements during operation in real life settings and lessons learned to facilitate replication and scale up.		locations, digitalization needs, and infrastructure setup. Additionally, the report covers fleet characteristics (Section 8.1), user experiences for all stakeholders (Chapter 5 and Section 8.3), Living Lab Digital Twin models, and optimization algorithms (Section 8.3). A comprehensive implementation plan (Section 7.1), operational data (Section 7.2), key performance indicators (Section 9.1), and lessons learned and results (Section 10) have been included to facilitate replication and expansion.
TASK			
Task 2.3 Bologna Living Lab Implementation	*The LL will implement the Nearby Delivery Areas (NDAs) concept in line with the SULP of the Metropolitan City of Bologna. LL stakeholders will co-design the operative model to optimise the functioning of sustainable and low impact micro-logistics hubs to be used for innovative delivery methods in urban areas. First activity is the requirements analysis, user stories development and implementation plan. Secondly, the DTs development and the implementation in real life settings.*	Chapters 3-10	Chapter 3 starts with the description of the Nearby Delivery Areas (NDAs) concept, challenges and context in accordance with the Bologna Metropolitan City's SULP by also illustrating the operational model to optimize sustainable and low-impact micro-logistics hubs for innovative urban delivery methods. Chapter 4 presents the LL implemented use case in line with the Physical Internet concept. Chapters 5 and 6 map the involved stakeholders and the relevant policies and analysis at different levels. Chapters 7 and 8 illustrate the implementation plan, the infrastructure and models/tools developed in URBANE included in the Digital Twin platform and the Impact Assessment Radar. Finally, chapters 9 and 10 present the identify KPIs reporting the baseline measurements and lessons learnt and results after real-world implementation.

1.3 Deliverable Overview and Report Structure

The deliverable is structured as follows:

- Chapter 2 focuses on data collection and analysis for the Bologna demonstrator.
- Chapter 3 is devoted to analyzing the Living Lab set up, including context, local plans and key initiatives and vision and challenges of the Living Lab.

- Chapter 4 presents the specific use case implemented in the LL in line with the PI concept.
- Chapter 5 takes a closer look at stakeholders and their role.
- Chapter 6 focuses on the most relevant policies and regulations structured according to the competent authority.
- Chapter 7 analyzes the implementation activities of the pilot, including the timeline and LL trial set up and preparation.
- Chapter 8 presents the physical and digital infrastructure of the Living Lab and the models and tools developed within URBANE according to Bologna LL needs and specificities.
- Chapter 9 is on the evaluation/impact assessment including the identified KPIs for the Bologna LL use case. The final values and analysis have been reported in the D2.1 Validation report.
- Chapter 10 concludes with lessons learnt and results both at the process and finalization stage level.

2. Data collection and analysis

Data collection is the process of gathering information for research or analysis. In URBANE WP2, the purposes are to: I) perform a mapping of stakeholders in the different LLs, generating an overview of their perspectives on the LL innovations, ii) assess the effectiveness and the sustainability impact of the URBANE LL innovations, iii) identify the potential or actual barriers and enablers to uptake, and iv) assess the transferability potential of the last mile solutions. For these purposes, different methods of data collection were used in URBANE, depending on the resources available to each LL. They included desk research, qualitative governance analysis, interest mapping through interviews, and survey-based public perception feedback data. These data were collected in each LL scoping document – demonstrator (*D2.2, D2.3, D2.4, D2.5*) and then assessed and validated. The results are reported in *D2.1 Validation Report*.

The adopted methods in this document are the following:

- **Stakeholder mapping:** the process of identifying and categorizing individuals or organizations impacted by or interested in a project. This involves creating an overview that lists relevant entities and groups them accordingly.
- **Desk research:** collecting information from existing sources such as the LL's own databases, books, articles, reports, and online resources, including SULPs. As most of these documents were in the LL's native language, each Living Lab contributed to this process by providing English translations of their findings.
- **Qualitative governance analysis:** examination of how decisions are made, and power is distributed within an organization or community.
- **Survey-based public perception feedback data:** gathering information about people's perceptions, attitudes, and opinions on a specific topic. While some LLs have incorporated regular surveys into their operations, others chose to conduct surveys specifically for the URBANE project.

- **T3.2 Structured Datasheets** (xls format): template and guidelines for selection and calculation of KPIs, accompanied by general guidelines on the use of sheets and by descriptions, units of measurement, target group, and calculation methodology for each KPI.
- **BPMN diagram of the AS-IS and TO-BE situation:** description of the process as it occurs before the implementation of the solution and during pilot execution.

Data collection was performed under the coordination of ITL with the assistance of NORCE and FIT Consulting (WP3 leader), who developed the methods and followed and guided the LLs in their implementation. The same methodology will be transferred to the Wave 2 LLs.

3. Living Lab setup

3.1 Context – Local plans – Key initiatives

3.1.1 Location/City

The Living Lab was implemented in the historical centre of the municipality of Bologna, with an area of about 4 km^2 (Figure 1). The coordinates of the most important square (*Piazza Maggiore)* are 44.493889°, 11.342778°.

Bologna is the regional capital of the Emilia-Romagna region, located in the centre-north of Italy. The city is one of the main nodes of national and international transportation networks. Indeed, it has direct access to the main motorways (A1 Milan-Naples, A14 Bologna-Bari, A13 Bologna-Padua) and to the regional and national rail networks (including the high-speed rail network). The Bologna International Airport (*Marconi*) and the railroad terminal (Bologna Freight Village, that is located in the territory of Bologna Metropolitan City) are classified as Core Nodes of three European Transport Corridors (Baltic Adriatic, Scandinavian Mediterranean, Mediterranean).

The municipality of Bologna has 387,842 inhabitants[1], of which 53,737 reside in the historical centre, namely the oldest part of the city that is included in the ring road system. Almost all the road traffic in the historical centre is regulated by limited traffic areas.

In the municipality of Bologna there are 6,866 active commercial businesses. Almost 40% of the total amount of these businesses (2,656) are in the historical centre and 2,312 are included in the Limited Traffic Zone (LTZ).

[1] http://inumeridibolognametropolitana.it/dati-statistici/superficie-e-densita-di-popolazione-al-31-dicembre

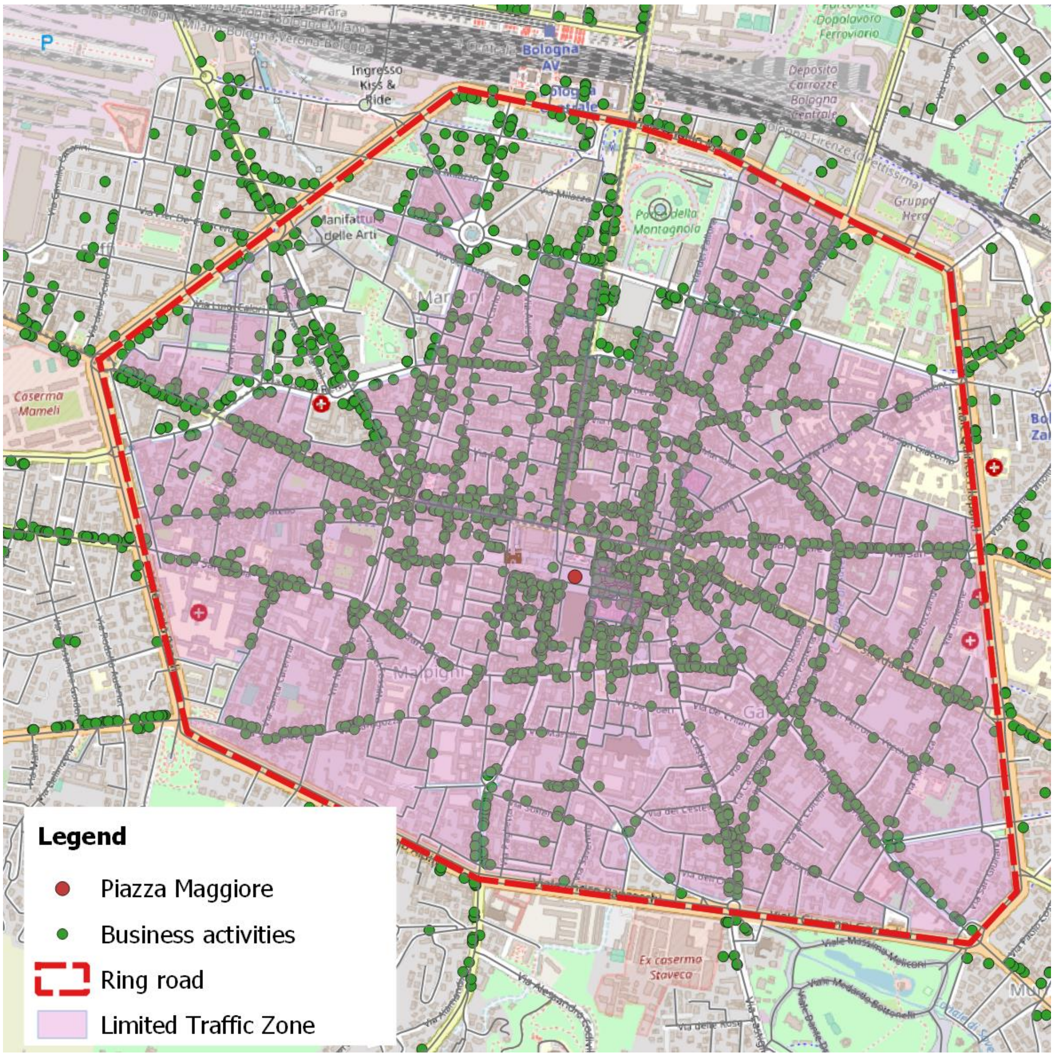

FIGURE 1 URBANE LL

The access to the LTZ is monitored by 22 main gates. Each gate monitors the vehicles accessing the restricted traffic zone, checking their inclusion in a “whitelist”. Those vehicles that do not have a permit to access the LTZ receive an administrative fine.

Each gate is also able to count the vehicles that enter the LTZ, classifying them into several categories. Figure 2 below shows the vehicles entering the LTZ through GATE 2.

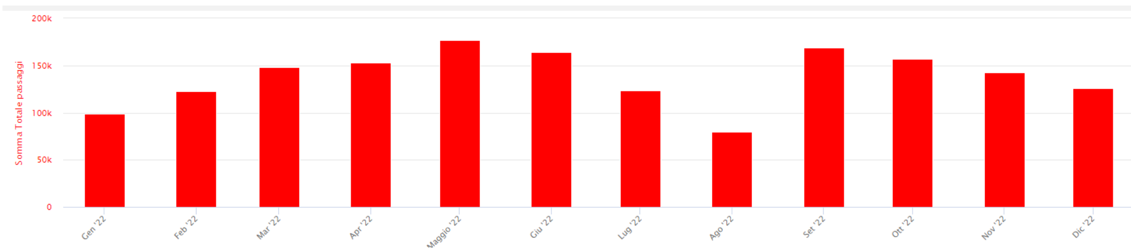

FIGURE 2 NUMBER OF VEHICLES ACCESSING THE LTZ THROUGH THE GATE 2 (YEAR 2022 – MONTHLY COUNT)

3.1.2 Context

The Municipality of Bologna, in cooperation with the Metropolitan City of Bologna, approved the SUMP and the SULP in late 2019 with a double layer approach: city level and metropolitan level - Functional Urban Area (FUA) level. The Metropolitan City of Bologna is the largest administrative division in the Emilia-Romagna region of Italy. It was created in 2015 and encompasses the same area as the former Province of Bologna. As the regional capital, it holds a unique position within Italy as the only large territorial entity that also serves as the capital of a region. The city shares borders with several other provinces in the region and extends into Tuscany[2]. The results of Bologna LL will be strongly interested to the first of the two mentioned planning levels.

The SULP is based on four main pillars (reduction of CO2 emissions, road congestion reduction, rationalization and concentration of logistics areas, logistics sprawl reduction) and on the implementation of the measures listed below (items in bold are primarily related to the city level approach):

1. **Logistics system at zero emissions**
2. increase of rail share for freight
3. Integration of logistics with industrial areas
4. **Integration and harmonization of city logistics rules in all the cities of the metropolitan area**
5. **Implementation of the Nearby Delivery Area (NDA)**
6. **Night deliveries**
7. Infrastructural works for promoting intermodal transport
8. **use of intermodal (passenger) nodes to maximize the impact of freight deliveries (e.g. with lockers in bus station)**

Moreover, Bologna has been chosen by the European Commission as one of the 100 climate-neutral and smart cities committed to reducing its emissions by 55% by 2030 (Cities Mission)[3].

3.1.3 BPMN Diagram of the AS-IS situation

The following figure provides a clear picture of the AS-IS scenario in which the process is the following: a buyer makes a purchase. The shipper (who can be a manufacturer or a retailer) processes and dispatches the orders. The deliveries focused on in this pilot are those destined for the historical center of Bologna.

Bologna LL AS-IS process (Figure 3) starts at this stage, with the couriers TYP and Due Torri departing from their warehouses (Due Torri has its own warehouses in the Bologna Freight Village, where they consolidate the loads, while TYP picks up directly from the shipper's warehouses, relying on a neighbourhood warehouse).

Both couriers have their own Traffic Management System (TMS) for planning and optimization of routes.

At this point, the couriers' vehicles enter the city directly and deliver the parcel to the end customer. Both TYP and Due Torri manage Business to Business (B2B) and Business to Consumers deliveries.

---

[2] https://www.cittametropolitana.bo.it/portale/

[3] More information are available in https://research-and-innovation.ec.europa.eu/funding/funding-opportunities/funding-programmes-and-open-calls/horizon-europe/eu-missions-horizon-europe/climate-neutral-and-smart-cities_en

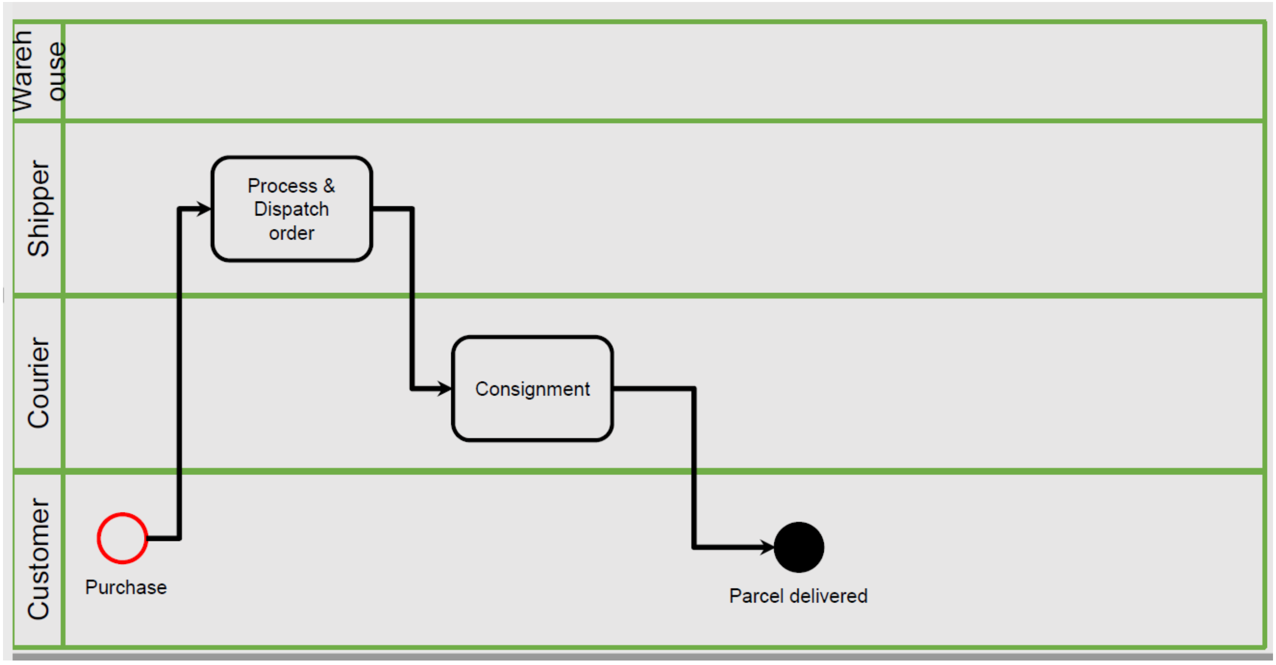

FIGURE 3 BPMN DIAGRAM OF THE AS-IS SITUATION

3.1.4 Governance and Business models

In terms of city logistics business models, the retailers nowadays are usually following omnichannel logistics techniques for providing the customer multiple delivery options and thus a more cohesive shopping experience. The retailers, and especially those from large chain stores, usually offer to the customer the option to either pick up or return the product from multiple points (parcels, in-store, at home, at work etc.). The role of the logistics operators is to deliver the product to the right location, unharmed and as fast as possible.

As shown in the map below (Figure 4), in Bologna City center, within the ring road, there are several Amazon and BRT (also known as Bartolini, is a courier service in Italy) lockers where people can pick up or return their online purchases for both Business to Business (B2B) and Business to Consumer (B2C).

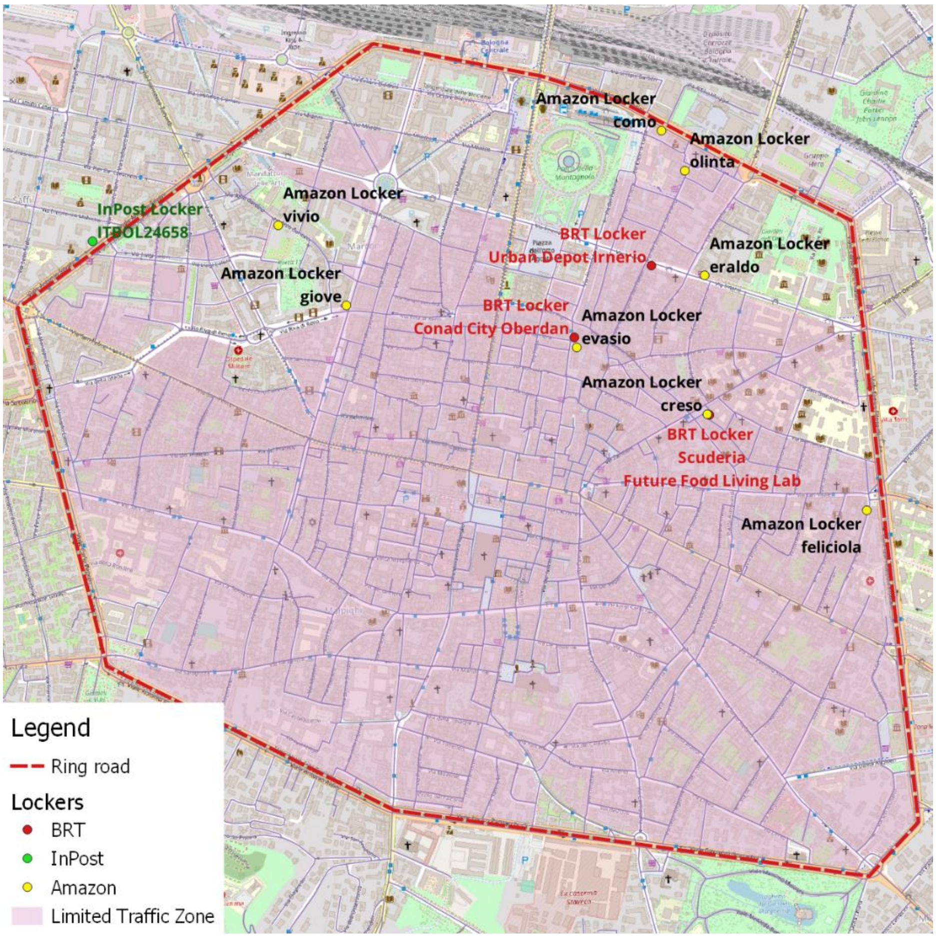

FIGURE 4 IDENTIFIED LOCATION OF THE EXISTING LOCKERS

In Bologna there are several types of LTZs, some of them with more restrictions than others. In particular, the T-zone is the very central area that takes its name from the shape of the roads, i.e. via Indipendenza, via Rizzoli and via Ugo Bassi (LTZ-T), while the U area is the University of Bologna (LTZ-U). The access of freight vehicles into the LTZ of Bologna for loading and unloading purposes in designated bays is regulated by the municipality. Loading and unloading is free of charge for the first 30 min, after this period the cost is 5€/30 min.

3.2 Vision and challenge to be addressed in URBANE

3.2.1 LL Objectives

The Bologna Living Lab aims to realize a measure listed in the SUMP, namely the **implementation of the NDA**, **combined with a collaborative approach between logistics operators and with the utilisation of zero emission vehicles**. The NDA is an area dedicated to logistics activities very close to the delivery area, and in the Bologna LL case, it is a micro consolidation centre for the transshipment of freight from conventional vans to light-Electric Delivery Vehicles or cargo bikes. The Bologna LL freight distribution scheme is showed in Figure 5.

The final objective of this use case is to define a guideline on how to implement sustainable, low-impact and innovative micro-logistics hubs to be used for innovative delivery methods in urban areas. The guidelines would have a great impact in terms of replicability in other contexts, thanks to the modular approach taken which allows service providers to implement multiple services or only a few of them. The Use Case tested has the ambition to promote Freight as a Service (FaaS) and the Physical Internet[4] approach in urban freight distribution, thanks to the use of vehicles with modular units able to make transshipment flexible, fast and sustainable.

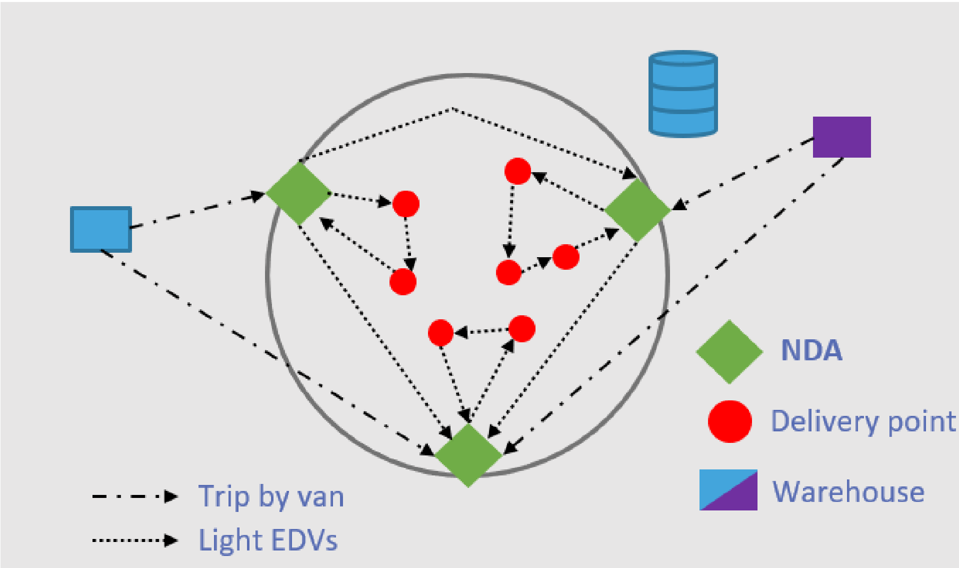

FIGURE 5 URBANE BOLOGNA LL DISTRIBUTION SCHEME WITH MICRO CONSOLIDATION

Preliminary analyses carried out in the planning of the LL and in the first months of the URBANE project have highlighted the optimal locations and the type of micro-hubs to be realised.

Each micro-hub is automated and unattended, and it is managed and monitored remotely (in our case, a locker). A detailed description is provided in Section 4 of this report.

3.2.2 Specific vision, ambition, and the LL Problem/Challenge to be addressed by URBANE

The main challenges of the Bologna LL are:

- Develop and set up a business model for an innovative delivery method in urban areas
- Promote collaboration between logistics operators that can be current or potential competitors in the logistics sector

[4] A more in-depth exploration and application of the Physical Internet concept is available in D1.1 URBANE framework for optimised green last mile operations.

- Reduction of the distance travelled by traditional delivery vehicles and consequently reduction of the negative externalities produced by them (road congestion, noise, CO_2 and pollutant emissions, etc..), increase of road safety and improvement of urban space quality
- Introduce Physical Internet delivery methods and assess the future potential application of crowdshipping
- Support for the development of a Digital Twin (DT) of the logistics micro-hubs network will be provided. The DT will be fed with real time data and used for planning and implementing measures.

3.2.3 BPMN diagram of the TO-BE Situation

In the TO BE process (Figure 6), three key elements/actors are introduced: the NDA, the last-mile delivery operator, and the intermediator and technology provider represented by GEL Proximity.

The NDAs are strategically positioned at three access points of Bologna's historic center. Each NDA comprises an automated and unmanned micro-hub that is remotely managed and monitored.

After the shipper processes and dispatches orders to TYP and DueTorri, the two transport operators select parcels suitable for storage in the NDA microhub based on factors like dimensions and weight. Unsuitable parcels continue to be delivered as per the existing AS IS situation.

If the parcels are deemed suitable, information about them is transmitted to the intermediator GEL Proximity. GEL Proximity optimizes the last mile by assigning parcels to the most convenient NDA, considering factors such as proximity to the recipient and box availability. A unique code is generated, permitting only authorized couriers to access the designated boxes for parcel drop-off/pick-up.

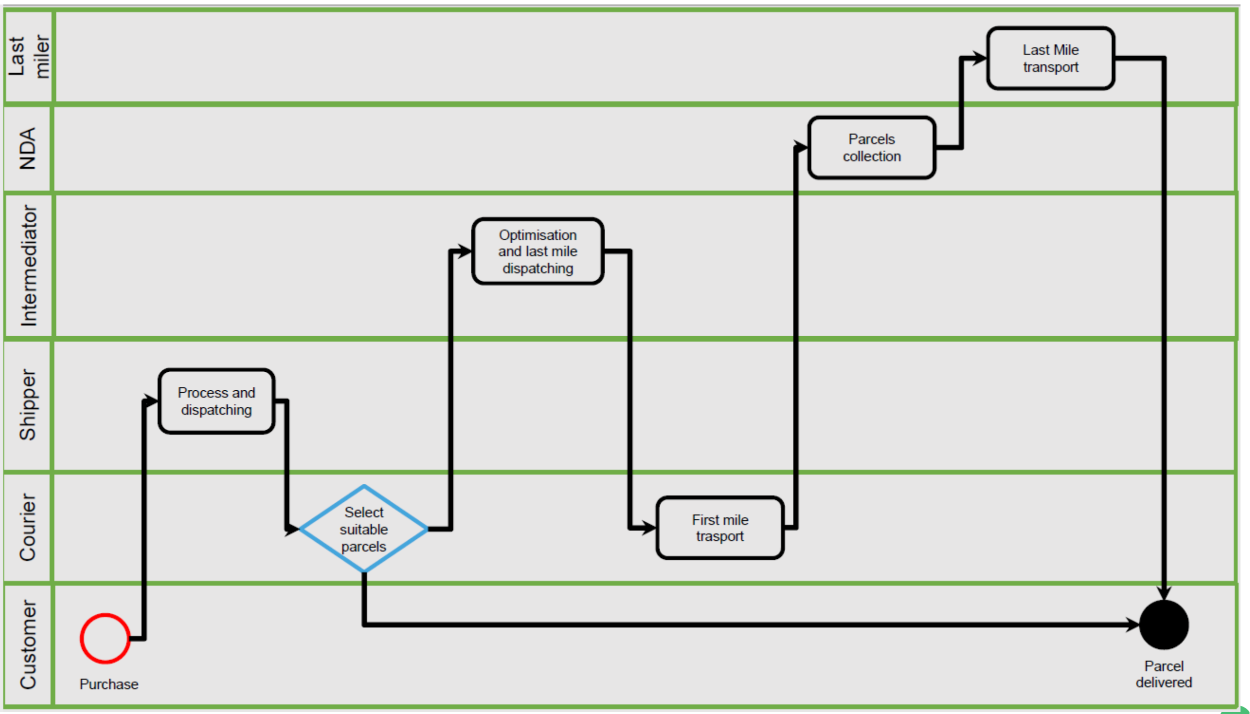

FIGURE 6 BPMN DIAGRAM TO BE SITUATION

4. Use cases

4.1 Use case 1: Micro-hubs networks and light EDVS – PI last mile deliveries

The participants involved in the Living Lab are:

- Municipality of Bologna
- ITL Foundation
- Due Torri
- TYP
- GEL Proximity
- Last miler (subcontracted)
- Micro-hub provider (subcontracted)

The delivery service offered by the Living Lab of Bologna is dedicated to private consumers (B2C) located in the historical centre of the city.

As mentioned before, each micro-hub is automated, unattended and installed in a specific identified NDA (Figure 7) according to 3 main criteria: accessibility, safety and equidistancy from the city center. The main characteristics of the micro-hub and the pilot activities are the following:

- Each micro-hub can receive up to 45 parcels (one per box)
- In full operation, the micro-hubs can handle approximately 135 parcels per day in the city centre of Bologna with zero emission vehicles
- The driver of traditional vans (operated by Due Torri and TYP) delivers goods parcels into designated boxes
- The last-mile operator then retrieves these parcels from the boxes and distributes them to the end customer located in the historical center of Bologna
- The system is monitored and managed through a complex operational process overseen by GEL Proximity. The primary steps include:
    - Collecting delivery requests from TYP and Due Torri
    - Checking the availability of microhub boxes and assigning parcels to the available boxes based on the final destination of the delivery
    - Facilitating communication between conventional vans, last-mile drivers, and micro-hubs to:
        - Specify the boxes for parcel placement or pickup
        - Manage potential issues, such as a blocked micro-hub Additionally, the system communicates with the end customer of the shipment to provide updates on the shipment status (e.g., parcel placement in the micro-hub, parcel retrieval by last-mile drivers, etc.).

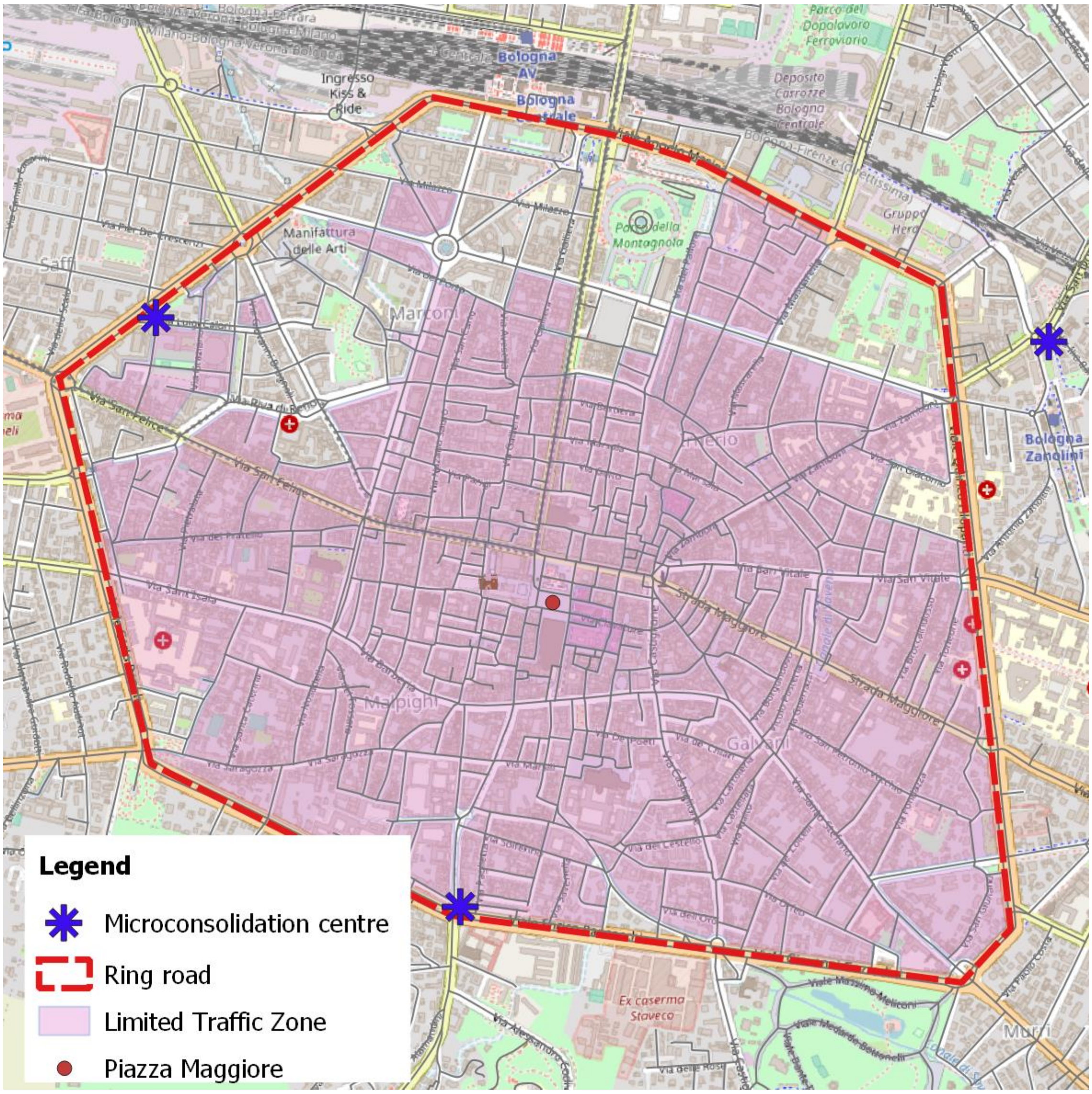

FIGURE 7 IDENTIFIED LOCATION FOR MICRO-CONSOLIDATION CENTERS

4.1.1 Interventions done in the scope of URBANE

The innovation provided by the Bologna Living Lab is that two potential competitors collaborate in the distribution of the parcels and use the same micro-hubs. This part of the business model also represents a concrete step towards the PI concept. A core objective of the Living Lab is to develop a self-sustaining business model capable of operating independently of external project funding. Over the coming months, WP5 will focus on refining this model to ensure its long-term viability from environmental and economic point of view.

To further enhance the business model's effectiveness, Bologna Living Lab partners recognize the value of integrating external data sources. By leveraging Floating Car Data and information from the Sirio electronic surveillance system, they can gain valuable insights into traffic patterns and urban mobility. Floating Car Data (FCD) is a method for determining traffic conditions on a road network. It involves collecting data from moving vehicles, in contrast to traditional methods that rely on fixed sensors. Sirio is a system used to control access to the LTZ in the historical center of Bologna. These data will be instrumental in optimizing delivery routes, reducing congestion, and minimizing environmental impact. Incorporating these data sets will also enrich the Cost-Benefit Analysis and other components of the Digital Twin platform, enabling more accurate performance evaluation and informed decision-making. This activity will be potentially included under WP5 together with the definition of Bologna LL business model (as requested by ITL within the budget adjustment proposal presented to the project coordinator).

To fully achieve the PI vision, the Bologna Living Lab seeks to expand its collaborative network to encompass multiple transport operators and last-mile delivery providers. This expansion will create a more dynamic and resilient logistics system, enabling greater flexibility, increased service levels, and reduced environmental impact. By demonstrating the benefits of such collaboration, the Living Lab aims to inspire broader industry adoption of the PI concept.

5. Stakeholders and their role

TABLE 2 LL STAKEHOLDERS AND ROLES

Stakeholder	Role	Internal (blank)/External (X)	Objective
Companies (B2B)	They are involved in most deliveries, and they primarily come through current customers of Bologna LL partners	X	Test the pilot action as they are customers of the 2 transport operators involved in the project as partners
Civil society groups concerned about environmental impact	They learn about the innovation through the information included on URBANE micro-hubs (URBANE logo and QR code linked to URBANE website and social media) and dissemination activities, such as the European Mobility Week event	X	Support the dissemination of the innovation to the civil society

	organized by CoBO targeted to citizens		
Residents	They learn about the innovation through the information included on URBANE micro-hubs (URBANE logo and QR code linked to URBANE website and social media) and dissemination activities, such as the European Mobility Week event organized by CoBO targeted to citizens	X	Support the dissemination of the innovation to the civil society
Emilia-Romagna Regional Government	Facilitator and promoter of the innovation	X	Support the transition towards climate neutral last mile logistics through the testing of innovative last mile delivery services
Municipality of Bologna (COBO: Comune di Bologna)	Public authority and institutional role in the Bologna LL providing access to operating zone/area. It is responsible for SUMP and SULP . It is the LL facilitator and the owner of the microhubs.		Support the transition towards climate neutral last mile logistics through the testing of innovative last mile delivery services
Metropolitan City of Bologna	It is responsible for SUMP and SULP together with the Municipality of Bologna.	X	Support the transition towards climate neutral last mile logistics through the testing of innovative last mile delivery services
TYP	Transport operator in the LL (First mile)		Implement the pilot action and it is interested in further development beyond the project
Due Torri	Transport operator in the LL (First mile)		Implement the pilot action and it is interested in further

			development beyond the project
Transport operators' competitors	Involved in the second phase of the pilot through specific meetings in order to inform them about the innovative solution and explore its potential for long-term adoption to enhance collaborative logistics beyond the pilot	X	They could be interested in adopting the solution
Salerno Trasporti	It is the subcontracted courier/transport operator for Bologna LL (Last mile)	X	Implement the pilot action and it is interested in further development beyond the project
Last mile couriers competitors	Involved in the second phase of the pilot through specific meetings in order to inform them about the innovative solution and explore its potential for long-term adoption to enhance collaborative logistics beyond the pilot	X	They could be interested in adopting the solution
GEL Proximity	Technology LL partner that builds the technology connection with the transport operators and the software of the micro-hubs		Implement the pilot action and it is interested in further development beyond the project
WIB - RICOH	Micro-hubs supplier	X	Implement the pilot action and it is interested in further development beyond the project
Open ENLoCC	Open network of regional logistics competence centres in the field of logistics, run	X	Involve its members and improve logistics knowledge by learning from URBANE project and disseminating its results through the open

	by public authorities or similar bodies		network. Raise awareness among members
Transport operators (shippers and carriers) associations (e.g. ABSEA – Associazione Bolognese Spedizionieri e Autotrasportatori, AICAI - Associazione Italiana dei Corrieri Aerei Internazionali)	They associate, assist and represent road haulage companies, couriers, shippers, logistics operators and waste disposal, storage and transport companies.	X	Communicate the project results to their associates
Institute for Transport and Logistics (ITL)	Bologna LL leader. It offers technical skills and competences on logistics and mobility to transport operators, public bodies, and companies in Region Emilia-Romagna, to exploit the opportunities from European Union and to facilitate growth in transport and logistics in Emilia-Romagna		Coordinate the development of the pilot action, transfer the acquired knowledge and its integration with URBANE digital models and algorithms to Wave 2 LLs and ensure its implementation at local level beyond the project. Coordinate the Freight Quality Partnership to support the city.

6. Governance Analysis

The governance analysis is the process of studying how decisions are made and how power is distributed. Below it is reported an overview of policies and regulations that influence the roll-out of the Bologna LL innovation.

Regulatory context at city level:

The **Municipality** and the **Metropolitan City of Bologna** are the main responsible entities for the regulatory and policy contexts of the LL area, as presented below:

- **LTZ (Limited Traffic Zone):**
    - The access to a larger part of city centre is regulated by a **LTZ**, monitored **by 22 cameras during certain time-windows (7am - 8pm or, in some specific areas, 24h)**

  - Access **is allowed for certain categories of vehicles** (including freight vehicles) and **it is granted after a payment of an administrative tax for specific time windows**
  - The SULP has introduced **prohibition of access to the most polluting vehicles' categories**
  - **Authorised freight vehicles** can use **loading and unloading bays** in the LTZ for free for the **first 30 mins**. After that, they must pay a fare (5€/30mins)
- **Parking regulation (from January 2020):**
  - for residents of the historic centre, parking for the second vehicle of the family nucleus is no longer free: it is possible to ask for the reduced rate of 120 euros per year. For the first vehicle and from the third onwards, the provisions in force remain unchanged
  - for residents in peripheral areas subject to the parking plan (semi-central area and semi-peripheral area): parking starting from the third vehicle in the household is no longer free. It is possible to purchase a parking pass at the rate of 120 euros per year. For the first two vehicles, the provisions in force remain unchanged.

The governance will update the regulatory context based on the LL results to push innovation. NDAs are already envisioned in Bologna's SULP; the local government will facilitate the roll out of LL innovation making more locations available once the business model is proven to be economically sustainable.

<u>Regional government policies and regulations:</u>

Piano Aria Integrato Regionale (PAIR2030): PAIR2030 has the aim of reducing pollutant emissions. Its remit covers transport, biomass combustion, agriculture, and industry, both on a large (Po Valley Basin and national) and local scale. Moreover, it prevents acute pollution episodes by reducing local peaks.

Piano Regionale Integrato dei Trasporti (PRIT2025): represents the main transport regional planning instrument. It provides the guidelines and directives of the regional policies related to the transport sector and the main actions and interventions for the achievement of regional objectives. The Plan, approved by the Regional Assembly on the 23rd December 2021, includes the same provisions stated in the version that was adopted in the 2019.

Piano Regionale "Mi muovo Elettrico": Mi Muovo elettrico is the regional plan for the development of electric mobility that was created to implement an integrated, region-wide approach to ensure the interoperability of the charging network and to reduce the impact of the transport sector on air pollution and greenhouse gas emissions.

Harmonization of city logistics measures at the regional level (& durability of projects outputs) has been a commitment of the Emilia-Romagna Region since 2003. The region actively supports cities in the development of more sustainable measures that are also standardized across the region. Notably, this includes:

- the implementation of harmonized time windows for EURO4 freight vehicles in 2014, achieved through the C-Liege project (funded by IEE).
- In a more recent development, an agreement has been reached with the major cities in the region to create a regional web portal. This portal allows transport operators to request permits for LTZ from all cities in a single location. The process follows the same rules, administrative requirements, and features harmonized data collection. This initiative is a result of the NOVELOG project under Horizon2020.

National plans and strategies:

New General Transport and Logistics Plan (2022): published by the Ministry of Infrastructure and Sustainable Mobility (MIMS), is a comprehensive strategy designed to guide the development of Italy's transportation and logistics sector. This plan outlines the government's vision and priorities for the coming years with the aim of creating a more efficient, sustainable, and resilient transportation system.

Key objectives of this plan typically include:

- Promoting sustainable mobility: Encouraging the use of environmentally friendly transportation modes such as rail, public transport, and cycling
- Improving infrastructure: Investing in the modernization and expansion of transportation infrastructure, including roads, railways, ports, and airports
- Digitalization: Leveraging digital technologies to enhance the efficiency and connectivity of the transportation system
- Logistics optimization: Streamlining logistics operations to reduce costs and improve delivery times.
- Integration of different modes of transport: Promoting the seamless integration of various transportation modes to create more efficient and flexible supply chains.

EU-level policies and regulations:

As early as 2011, the European Commission in its **Transport White Paper** set the goal of a 'carbon-free urban freight distribution', i.e., zero direct carbon dioxide (CO_2) emissions by 2030.

In 2020, the European Court of Justice ruled against Italy for exceeding the daily PM10 limit in the eastern and western plains of Emilia-Romagna between 2008 and 2014.

To address these issues, the Emilia-Romagna region has updated its air quality planning with a horizon to 2030. The previous plan, PAIR2020, had a horizon to 2020. It was extended until the approval of the new plan and was integrated with additional measures.

Being part of the **100 climate-neutral European cities by 2030 mission**, Bologna is committed to facilitate a green and digital transition also in the area of urban mobility and transport. Following the ELTIS guidelines (and the national regulation), a dedicated SULP was developed in collaboration with private stakeholders in the framework of the SUMP. The application of clear urban freight planning and frameworks at the local, national and European level is expected to allow logistics stakeholders to exploit the necessary economies of scale to remove the risk factor from investments and thus accelerate the transition towards sustainable urban logistics. At the European Level, the proposed **revision of TEN-T (Trans-European Transport Network) Regulation** is followed with great attention from the cities, especially the part related to the **definition of the Urban Nodes**, which will influence city logistics planning, as well as the ambitious target of phasing out ICE (Internal Combustion Engine) vehicle sales by 2035.

7. URBANE LL implementation

7.1 Timeline

Table 3 below outlines the key activities of Bologna LL. Starting in September 2022, simultaneously with the URBANE project, these activities involved stakeholder engagement, interaction with other work packages, the surveying of public areas based on SULP criteria for NDA characteristics and the tender procedure. Following an intensive testing phase preparation and stakeholder involvement phase, pilot activities were conducted from February 2024 to August 2024.

Pilot activities will extend beyond the planned timeline, enabled by last-mile co-financing from the EU MOVE 21 project and the continued commitment of Bologna LL partners to developing and refining a business model.

TABLE 3 BOLOGNA LL TIMELINE

Activities / Month	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
	S22	O22	N22	D22	J23	F23	M23	A23	M23	J23	J23	A23	S23	O23	N23	D23	J24	F24	M24	A24	M24	J24	J24	A24
Survey of public areas																								
Definition of NDAs characteristics																								
Identification and tender procedure for the microhub and the last miler selection																								
Testing phase preparation																								
LL testing phase																		★						
Drafting D2.3 (Bologna Demonstrator)																								
Stakeholder involvement & FQP																								
WPs activities																								

LEGENDA:

★: Start of the pilot activities

7.2 LL trial set up and preparation

The LL trial set up and preparation is characterized by the following activities:

- **Survey of public areas and definition of NDAs characteristics:** the implementation of the NDA is a measure defined in the Sustainable Urban Logistic Plan (SULP). The identified NDAs are located in correspondence of 3 old city gates on 'viali di circonvallazione' of Bologna, the avenues that form a ring road around what were once the 13th-century walls: Porta Lame, Porta S. Donato and Porta S. Mamolo. These areas were selected according to 3 criteria established in the SULP of the city of Bologna: accessibility, safety and equidistancy from the city center. In the three identified areas Bologna LL partners decided to install three automated and unattended micro-hubs with a capacity of about 40 boxes each exclusively designated for B2B use (in Bologna LL use case private users are not allowed to directly retrieve parcels from the micro-hub). The delivery process involves two transport operators dropping off packages, and a green last-mile operator subsequently collecting these packages from the micro-hubs. The last-mile operator then delivers the parcels to end users situated in the historic center of Bologna.
- **Identification and tender procedure for the micro-hub and the last miler:**

  Last miler: after a deep investigation carried out by all Bologna LL partners, the identified last mile operator is Salerno Trasporti, a transport and logistics company with more than 20 years of experience very focused on environmental and social sustainability. In the pilot they use innovative vehicles with zero impact, suitable for transiting pedestrian areas and urban areas with limited traffic. The extraordinary peculiarity of impact vehicles with zero emissions of polluting gases allows them to transit in restricted traffic zones, effectively realizing the idea of sustainable mobility of zero-impact green logistics.

  Micro-hub: an exploratory survey was carried out, requesting technical data sheets and economic estimates for the supply and installation of the micro-hub from 3 different suppliers. According to the analysis of the technical-functional characteristics of the offered products the selected supplier is RICOH/ WIB (a partnership of 2 digital services companies). The selection was based on the best price/quality ratio, as the selected companies were providing a well structured hardware and software solution with an affordable budget.

  The hardware part is managed by RICOH which, in addition to already being present in the Italian market, offers maintenance services with high standards and atypical functions useful for the purpose of the project. A variant powered by solar panels will also be available in the near future.

  The software part (managed by WIB) can be customized to specific needs and the final cost is compatible with the project budget. The strong partnership between the two companies ensures that the installation, management and maintenance of the hardware and software components is efficient.
- **Testing phase preparation:**

- Preparation of the preliminary technical documentation (from June to September 2023)
- Release of 1st deliverable: definitive technical documentation (complete with all services not yet available to date) by 10th October 2023
- Release of 2nd deliverable: API for creating orders and modifying statuses for carriers and last miler by 27th October 2023
- Release of 3rd deliverable: API for planning and communicating orders (this release also includes the service through which GEL communicates to the carrier which orders are "accepted", in which the automated micro-hub and related unlock code) by 14th November 2023
- Telematic testing activities (one-to-one) were carried out between GEL and the individual carriers and between GEL and RICOH/WIBB with a physical test in Ivrea (Piemonte – Italy) by the end of November/beginning of December 2023
- The micro-hubs were transported and installed in Bologna city centre, in the 3 identified NDAs, and the micro-hub wrap was installed in January 2024
- End-to-end telematic tests involving all LL actors took place on 25th and 30th January 2024
- The first physical test with all LL actors took place on Friday 2nd February 2024. However, the test reported some anomalies, so it was decided to realize another physical in the *production environment* (the digital environment used only in a process that generates real shipping and return orders) the week after on Thursday 8th February. The second physical test was successful, and the pilot went live on Monday 12th February 2024.

- **Pilot starting date (go live):** 12th February 2024.

FIGURE 8 MICRO-HUBS INSTALLATION

FIGURE 9 MICRO-HUB INSTALLED IN VIA CALORI, 1

FIGURE 10 SCOOBIC LIGHT - ELECTRIC VEHICLE USED BY THE LAST MILER

8. Infrastructure

8.1 Existing physical infrastructure

This section outlines the physical infrastructure deployed within the Bologna Living Lab. Specifically, it comprises three automated, unattended microhubs, whose specific characteristics are detailed below.

Micro-hub infrastructure

Each micro-hub is composed by 3 modules: 1 Master + 2 Slave (Table 4 and Figure 11). The Master module is the brain of the operations, containing the Control Unit managing and coordinating the entire system and it has also 13 cells. The Control Unit includes a user interface comprised of a touchscreen monitor, a QR/barcode scanner and a NFC reader (badge reader). The Slave module is the subordinate unit controlled by the Master module and contains 16 cells.

TABLE 4 MICRO-HUB INFRASTRUCTURE CHARACTERISTICS

MASTER MODULE	SLAVE MODULE
Dimensions: mm (960L x 500W x 2,025.5H) Canopy overhang: 130 mm	Dimensions: mm (960L x 500W x 2,025.5H) Canopy overhang: 130 mm
Control Unit + 13 cell	**16 cells**
3 L: mm (365L x 480P x 334H)	4 L: mm (365L x 480P x 334H)
7 M: mm (365L x 480P x 216H)	8 M: mm (365L x 480P x 216H)
3 S: mm (365L x 480P x 98H)	4 S: mm (365L x 480P x 98H)

Material: Powder-coated sheet metal – RAL Rosso Bologna 3011

Structure: ▪ Modular ▪ Adjustable feet

User Interfaces: ▪ 15” touchscreen monitor ▪ QR/barcode scanner ▪ NFC reader (badge reader)

Note: The installed NFC badge reader is an ACR122U model. If incompatible with the customer's badge, additional devices and software integration will be quoted separately following technical analysis.

Languages: Italian and English

Data Connection: Ethernet cable with RJ-45 connector

Power Supply: 110V – 230V, 50Hz – 60 Hz

Control Module Power: 160W

Storage Module: Negligible

Control Module Consumption: 3.8 KWh/24h

Storage Module Consumption: Negligible

Doors: ▪ Electric anti-intrusion lock ▪ Manual emergency release

Sensors: ▪ Anti-intrusion ▪ Machine status

Weight per module: 160 kg

Master module **Slave module**

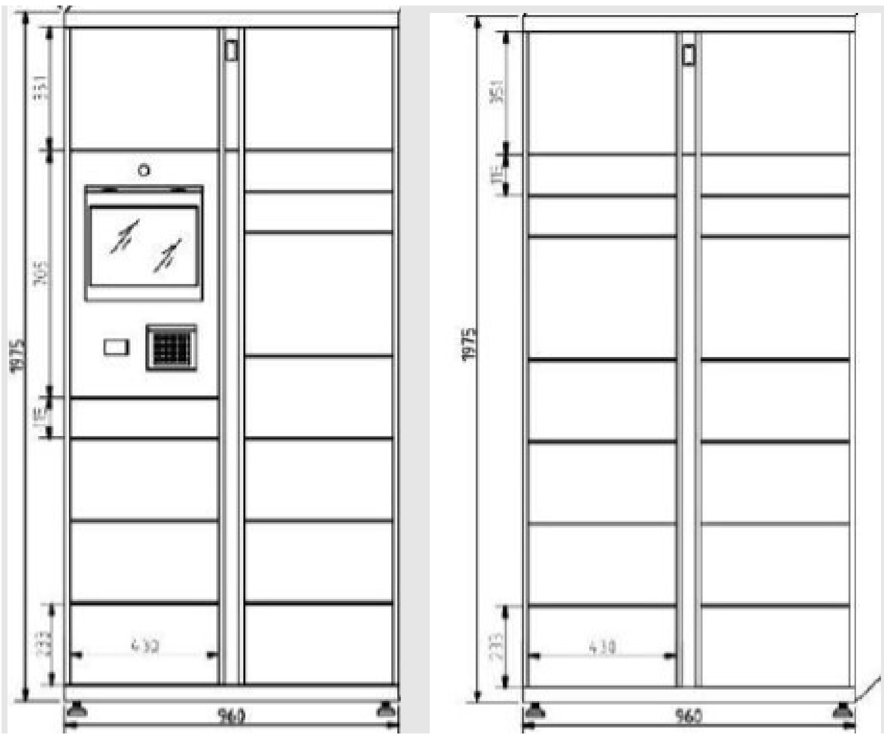

FIGURE 11 MICRO-HUB MODULES OUTLINE

Micro-hub wrap

Bologna LL partners designed also the micro-hub wrap (Figure 12), featuring a logo, slogan, and a QR code linking to a dedicated URBANE project section on the Bologna Municipality website. This attracts attention and provides information to interested parties about the solution.

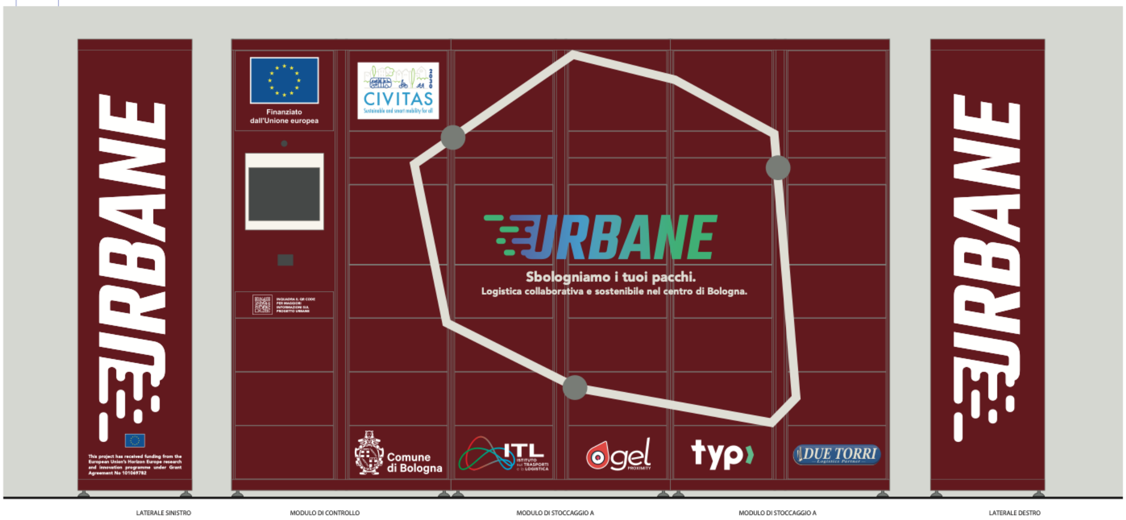

FIGURE 12 MICRO-HUB WRAP

In Table 5, all measures and infrastructures related to Bologna LL solution, regarding consolidation & infrastructure, delivery, fleet technology, governance and new technologies, are reported.

TABLE 5 INFRASTRUCTURE

Consolidation & Network Infrastructure	Description
City infrastructure	Number of PuDo in the demo area – Agnostic: 17; Number of PuDo in the demo area - Courier specific: 265 (data from currently integrated networks on GEL Proximity); Number of loading/unloading spots in the demo site: 430; Number of electronically controlled loading/unloading spots in the demo site: 323
Vehicle Fleet	First mile vehicles_Transport operators TYP and Due Torri: Light Commercial Vehicle, max. allow mass kg 3.500, diesel, EURO 6, fuel consumption per km: 8km/L.; Last mile vehicle_Salerno Trasporti operator: Scoobic light (Scoobic Light - Scoobic – Figure 10 above), an electric tricycle with a carrying capacity of a van.
Land-use planning & City infrastructure	
General planning tools	LTZ (Limited Traffic Zone); development of SUMP (Sustainable Urban Mobility Plan) and SULP (Sustainable Urban Logistics Plan); cities in Emilia-Romagna are moving to comply with Directive 2008/50/EC, which was transposed into Italian law with Legislative Decree 155/2010; implementation of Piano Aria Integrato Regionale (PAIR2030) to reduce pollutant emissions; implementation of Piano Regionale Integrato dei Trasporti (PRIT2025) providing guidelines and directives of the regional policies related to the transport sector
Delivery Schemes & smart logistics solutions	
Parcel Lockers	Several parcel lockers in all parts of the city, in active use by logistics operators and customers; home deliveries.
Vehicle Technologies	
Electric Vehicles	Last miler vehicle details: Scoobic light (Scoobic Light - Scoobic – Figure 10 above), an electric tricycle with a carrying capacity of a van and the following characteristics: - License: Scooter;

	- Speed: 45km/h - Range: 80-100 km - Dimensions: 1850x980x2920 mm - Carrying capacity: 250kg - Cargo volume: 1400 L

8.1.1 Additional equipment/infrastructure needed for URBANE

The required additional equipment/infrastructure for the implementation of the activities are **internet connection, road markings and the security cameras**.

- **Internet connection**: power and internet lines are available in all locations. Internet switch has been installed by the service provider Lepida (relevant for cameras only). Mobile SIM cards for the microhubs connectivity initially provided 20 GB of data with automatic monthly renewal. However, higher-than-anticipated data consumption during the pilot's initial phase prompted the Municipality of Bologna to increase the plan to 100 GB per locker, automatically renewed four times per month, for a total of 400 GB monthly.
- **Road markings:** preparation of the road markings started in November together with the municipal ordinance.
- **Security cameras**: they have been purchased and installed to protect the micro-hubs from vandalism and monitor the operations.

8.2 Existing digital infrastructure

To manage the delivery flow to the micro-hubs it is necessary for all the partners involved in the LL (Transport Operators and Last Miler) to carry out a technological integration on their systems with GEL Proximity, which acts as orchestrator/integrator of all the information that must be shared for the correct management of the process.

The micro-hub platform supplier RICOH/WIB is in charge of preparing its own systems to allow the exchange of data between the micro-hub hardware and GEL Proximity to guarantee the correct execution of the flow: the integration with the micro-hub supplier is carried out by GEL Proximity.

The methods of integration take place via REST API with JWT authentication.

During the different stages of integration of GEL Proximity, it is likely that the system returns or requires specific information and data, such as identification codes relating to withdrawal points, networks, services, and much more. The different types of data that must be known for a correct technical integration are the following reported in Table 6:

TABLE 6 DATA FOR THE TECHNICAL INTEGRATION WITH GEL PROXIMITY PLATFORM

RecipientType

Recipient	Code
Transport operator	CARRIER

Last miler	LASTMILER
Pickup Point	POINT

ActionType

Action	Code
To be delivered to the destination address	DELIVERY_TO_ADDRESS
To be returned to the origin warehouse	RETURN_TO_WAREHOUSE
Unable to schedule shipment to a decoupling point due to unavailable slots	CANNOT_SCHEDULE

ErrorCode

Action	Code
The recipient was not present at the time of delivery	RECIPIENT_MISSING
The address provided was incorrect or incomplete	ADDRESS_WRONG
The recipient refused to accept the delivery	RECIPIENT_REFUSED
The indicated destination is not recognized or does not exist at the specified house number	DESTINATION_UNKNOWN
The parcel is damaged or in a compromised condition	PARCEL_DAMAGED
The specified goods were not present	PARCEL_MISSING
Unable to deliver for general reasons	DELIVERY_UNAVAILABLE
Unable to deliver due to force majeure	DELIVERY_IMPOSSIBLE

ShipmentStatusCode

Code	Value	Description
	New	The order was imported to Gel Proximity and it is possible to manage it
ST_0003	In transit	Parcel delivered
ST_0004	Available at the Point	The parcel is ready to be collected at the pick-up point
ST_0005	Delivery cancelled	The delivery has been cancelled
ST_0006	Error	The delivery is in error

ST_0007	Collected by customer	The parcel has been delivered to the final customer
ST_0008	Parcel delivered	The parcel has been delivered to the pick-up point
ST_0009	Collected from the Point	The parcel has been collected from the pick-up point
ST_0010	In delivery process	The parcel is in the delivery process to the recipient address
ST_0011	Returned to the Point	The parcel has been delivered back to the pick-up point due to the impossibility of delivery
ST_0012	Back in stock	The parcel has been returned to the transport operator warehouse

8.2.1 Existing ICT Solutions and Operational information systems

GEL Proximity is a service that allows service providers to make deliveries and returns to Pick-up Points. Likewise, it allows the Networks and possibly also the eCommerce businesses themselves to make their Pick-up Points available and manage the operational flows that a Network of Pick-up Points needs.

The GEL Proximity platform allows integration via dedicated libraries and APIs that can be used by any IT system without limitations. The purpose of GEL Proximity is to make integration with different Pick-up Point Networks simple and unified, internally managing all the complexities of standardizing heterogeneous data and exposing unique and scalable integration methods.

Automations:
The GEL Proximity platform is designed to manage a high number of transaction volumes efficiently. For this reason, request management is often managed in an asynchronous and massive manner. The main asynchronous operating logics that must be understood to carry out correct integration are illustrated below.

Importing shipments or returns:
The GEL Proximity system records all requests for confirmation of new shipping or return orders that are made by each Merchant. In this phase the orders, defined as temporary orders, are not visible on the platform and must first be processed: every minute an automated process identifies the shipping and return orders to be imported, and once verified makes them available on the platform. This operation is called importing an order.

Environments
To allow the verification of integration on different systems, GEL Proximity offers two different types of environments: Test and Production.

Testing environment
The Test environment is the environment to be used during integration with GEL Proximity or during any testing activity. All requests made in the Test environment don't generate any definitive orders nor are communicated to the relevant Networks.

To use the Test environment, it is necessary to add the URL in front of each endpoint or where required:

https://qa-platform.gelproximity.com/

Production Environment
The Production environment is the environment to be used only in a process that generates real shipping and return orders.
To use the Production environment, it is necessary to add the URL in front of each endpoint or where required:

https://platform.gelproximity.com/

All calls that will be made in the *Production environment* will generate real shipping and return orders. This environment must be used only in the production version of the Merchant system.

8.2.2 Available datasets related to LL scope

The available datasets collected in the Data Request template are the following:
ID 1_Delivery demand data: available in GEL, transport operators and last mile operator IT platforms
ID 2_Supply/service-related data: each transport provider has its own dataset that can share
ID 4_Supply/service-related data -- charging stations available: open access data so they can be directly downloaded from the Open Data platform of Bologna Municipality (https://opendata.comune.bologna.it/explore/dataset/colonnine-elettriche/information/?disjunctive.area_statistica)
ID 6_Urban environment geospatial and network data 1: open access data so they can be directly downloaded from the Open Data platform of Bologna Municipality (https://opendata.comune.bologna.it/explore/dataset/rifter_arcstra_li/information/)
ID 7_Urban environment geospatial and network data 2: open access data so they can be directly downloaded from the Open Data platform of Bologna Municipality (http://dru.iperbole.bologna.it/cartografia; http://sitmappe.comune.bologna.it/pugviewer/#!/app/map/default)
ID 8_City related data: open access data so they can be directly downloaded from the Open Data platform of Bologna Municipality (http://inumeridibolognametropolitana.it/basi-territoriali-del-comune-di-bologna; http://inumeridibolognametropolitana.it/dati-statistici/popolazione/; https://opendata.comune.bologna.it/explore/dataset/bologna-daily-mobility/information/)
ID 9_Blockchain: these data are directly communicated by carriers and last milers and they are available in GEL, transport operators and last mile operator IT platforms
ID 11_Transport documents: available in GEL, transport operators and last mile operator IT platform
ID 12_EPCIS data: these data are directly communicated by carriers and last milers and they are available in GEL, transport operators and last mile operator IT platform

ID 13_Demand data (socio-demographic characteristics): open access data so they can be directly downloaded from the Open Data platform of Bologna Municipality (https://opendata.comune.bologna.it/explore/dataset/redditi-per-area-statistica/information/)
ID 24_City-related data: open access data so they can be directly downloaded from the Open Data platform of Bologna Municipality (https://opendata.comune.bologna.it/explore/dataset/parcheggi/information/?disjunctive.tipologia&disjunctive.tariffa)

8.3 Models & tools developed/used/extended in URBANE

8.3.1 Decision Support Digital models

SKEMA Collaborative Delivery Model (CDM)

To address the two Bologna LL challenges listed below, SKEMA developed the Collaborative Delivery Model. These challenges are to:

- Promote the collaboration between logistics operators, that can be current or potential competitor in the logistics sector;
- Reduction of the distance travelled by the traditional vehicles and consequently reduction of the negative externalities produced by them (road congestion, noise, CO2 and pollutant emissions, etc..), increase of roads safety and improvement of urban space quality.

The CDM uses an innovative modeling approach that captures the tradeoffs between city-level stakeholders (e.g. minimize emissions and number of delivery vehicles) and service providers (e.g. maximize profit, client satisfaction). The model is designed to assign packages from first milers to the most suitable micro-hubs, and then assign packages from the micro-hubs to the most suitable last milers (and optimize the pickup & delivery operations of the last milers). An example of an assignment of packages to last milers such that the operational areas of the last milers do not overlap is shown in the Figure 17 below.

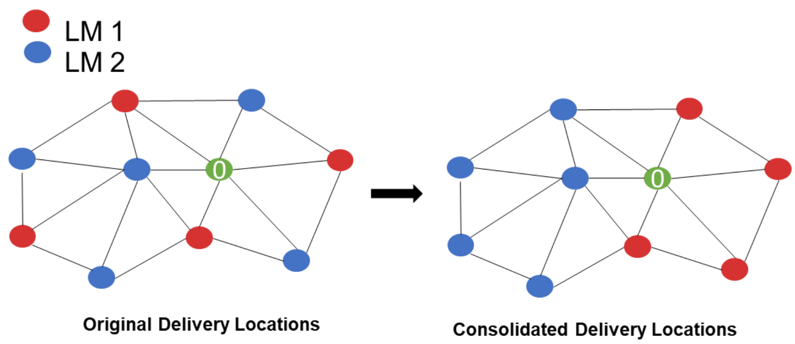

FIGURE 13 EXAMPLE OF CONSOLIDATED DISTRIBUTION OF PARCELS AMONG LAST MILERS

The CDM uses a bilevel optimization (a.k.a. leader-follower) approach to optimize last-mile deliveries in each city. The leader represents the city, whose goal is to minimize the total amount of emissions and the number of last mile vehicles in the city's low-emission zones (LEZs) and low-traffic zones (LTZs). There are two types of followers: first mile followers, whose goals are to find the minimum routing cost required to deliver packages to micro-hubs, and last mile followers, who wish to pick up packages from micro-hubs and deliver them to customers within specific time windows. While a follower might wish to use as many vehicles as possible to ensure packages do not arrive later than expected, the leader wants to ensure that only a minimal number of vehicles are present in the city's LEZ/LTZ. In the CDM, the leader minimizes emissions by first assigning packages from first milers to micro-hubs, and then from micro-hubs to last milers in such a way the total amount of emissions and the total number of delivery vehicles used are minimized. The minimization of the number of delivery vehicles means that noise and congestion are also correspondingly reduced in the LEZ/LTZ.

This model supports the logic of GEL to optimize parcel allocation in the micro-hub and routing looking to the scale up, to check if, by adding more automated micro-hubs, increase volumes of freight and increase operators, this optimization would lead to make convenient the process that currently needs to be subsidized. The CDM system architecture is illustrated in Figure 18 below.

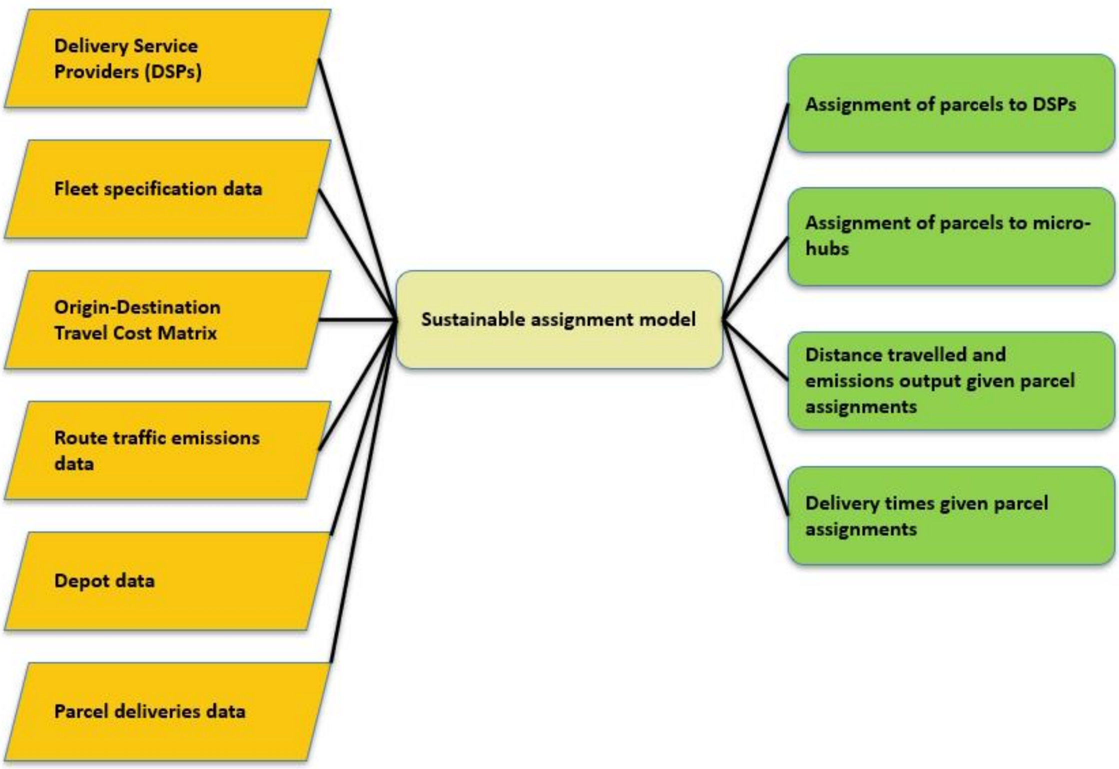

FIGURE 14 SYSTEM ARCHITECTURE OF THE CDM

Recommendations

The SKEMA Collaborative Delivery Model, integrated into the URBANE Digital Twin platform, presents a mutually beneficial solution for both first and last-mile operators by streamlining delivery operations, lowering costs, and enhancing sustainability. Specifically, it empowers operators to boost efficiency, minimize delivery failures, reduce CO2 emissions, and alleviate traffic congestion. The model's effectiveness and efficiency will amplify as the number of automated micro-hubs, freight volumes, and participating operators increase. Moreover, this model provides essential inputs to the Cost-Benefit Analysis model outlined below to determine the financial break-even point for the solution.

Cost Benefit Analysis (CBA)

The CBA model is a component of the URBANE Digital Twin (DT) platform and has been developed to connect to other tools and models in the platform. This tool is designed to evaluate both cost structures and overall performance of urban last-mile and middle-mile delivery operations. It further allows for impact analysis of infrastructure investments and various operational models. The initial Cost Benefit Analysis tool assesses the impact of infrastructural investments alongside operational adjustments, specifically focusing on the utilization of parcel lockers and green last-mile delivery solutions. The Cost Benefit Analysis tool receives several inputs from the Collaborative Delivery Model (CDM), including vehicle type, number of vehicles, and number of deliveries. These inputs are then combined with the CDM's output, which is the total distance traveled per operator.

The CBA calculations are divided into two categories. The first category analyzes daily costs, primarily focusing on staff and vehicle fuel. The second category extrapolates these daily costs to generate monthly and yearly cost-benefit projections.

<u>Category A Calculations: Daily Cost Estimation</u>

The daily cost is estimated based on fuel and staff cost components. For the calculation of fuel/ energy cost, the total distance driven by the vehicles of each operator and their fuel type are considered. For the estimation of staff costs, the following assumptions are made:

- Each vehicle in the fleet is staffed by at least one person
- One person can deliver up to 120 parcels per day

Considering the total number of vehicles in the fleet and the total number of deliveries, the minimum staff and are estimated respectively. The largest of the two values is then chosen and multiplied by a daily work rate that is provided by the user through the UI. Currently the staff cost of user input is per delivery (rather than per day).

<u>Category B Calculations: Monthly and Long Term Projections</u>

The user is asked to provide an initial investment cost associated to the operational set-up that is examined in the analysis. The user optionally may provide a planning horizon and an annual discount rate, that by default are set to five years and 3% respectively. An NPV calculation takes place in the CBA by considering discounted operational expenses (Figure 19).

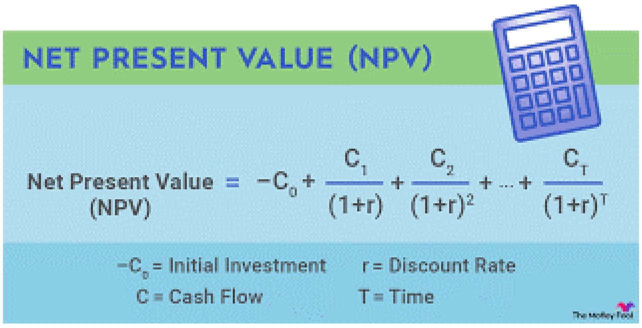

FIGURE 15 NPV

The investment's break-even point in time is estimated by the CBA tool. To complement this metric, the break-even point calculation will be extended to estimate the units/ day that require to be delivered for a profitable daily operation as well as the total number of units sold for counterbalancing the initial investment. This is estimated by dividing the total fixed costs associated with production by the revenue per individual delivery minus the variable costs per unit. In this case, fixed costs refer to those that do not change depending upon the number of units sold.

Figure 20 below illustrates an overall representation of the CBA inputs, calculations and processes.

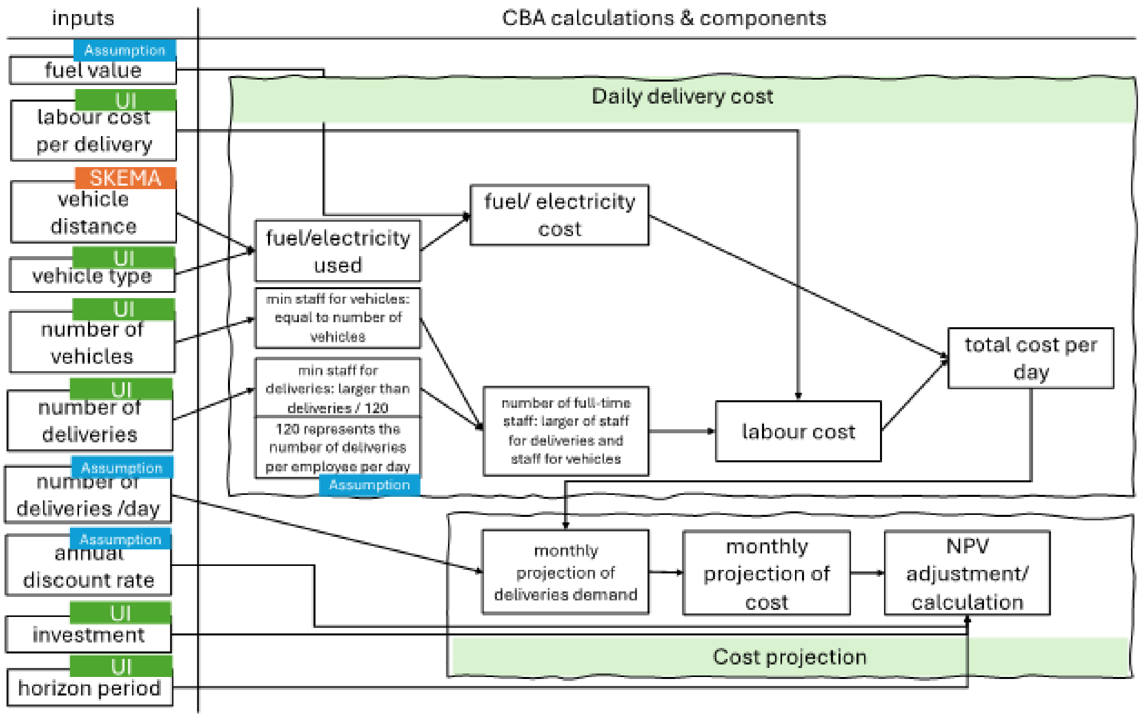

FIGURE 16 CBA CALCULATIONS AND COMPONENTS

Recommendations

The Cost Benefit Analysis (CBA) model, integrated into the URBANE Digital Twin platform, offers significant value to both transport operators and municipalities by providing a robust tool for evaluating the financial implications of various urban delivery strategies.

The benefits for transport operators are the following:

- Optimized operations: by analyzing daily, monthly, and yearly cost structures, operators can identify cost-saving measures, optimize resource allocation, and improve operational efficiency.
- Informed decision making: the model enables operators to compare the financial performance of different operational models (e.g., using different vehicle types, delivery routes, or technologies) and make data-driven decisions.

At the same time the tool can support municipalities as follows:

- Sustainable urban planning: the CBA model supports municipalities in developing sustainable urban planning strategies by evaluating the economic impacts of different transportation policies and infrastructure investments.
- Cost-Benefit Analysis of public investments: the model can be used to assess the financial viability of public investments in urban logistics infrastructure, such as micro-hubs or last-mile delivery facilities.

The model can improve its accuracy and responsiveness if integrated with real-time data from various sources (e.g., traffic sensors, weather data, delivery platforms).

8.3.2 DT Decision support capabilities, services and expected requirements to facilitate the vision

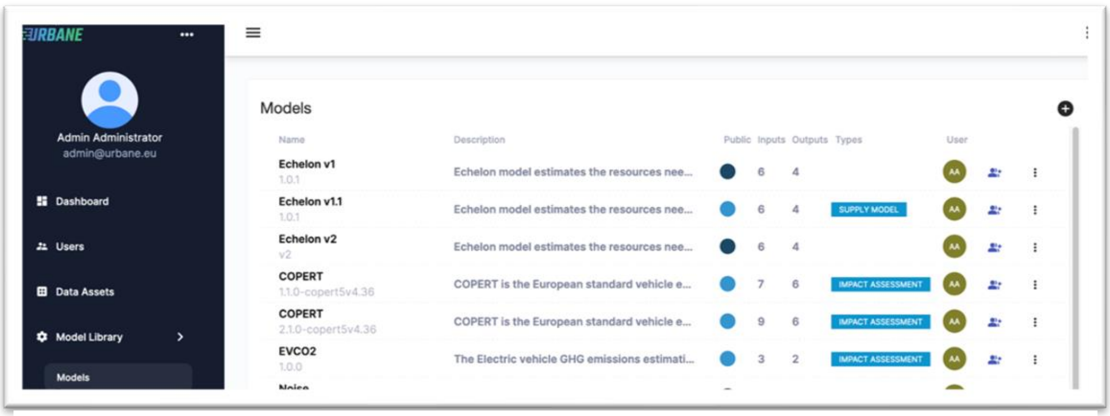

FIGURE 17 URBANE DIGITAL TWIN PLATFORM

The URBANE Digital Twin Platform (DT) simulates different delivery scenarios aspiring to answer different "what-if" questions. This allows users to test new strategies, such as adding new microhubs or changing delivery vehicles, and see how they impact efficiency, costs, and the environment before implementing them in the real world. The Digital Twin makes use of a series of models developed in the project and presented in section 8.3.1. that seek to explore the Living Lab's operational performance. All models have been integrated into the DT following a meticulous integration process and are available for exploration and testing through the Portal of the DT, as shown in Figure 17. Through the Portal users can use the models to define *scenarios* (i.e., a sequence of models) and test these scenarios using different inputs, which in turn allows them to explore different "what-if" questions.

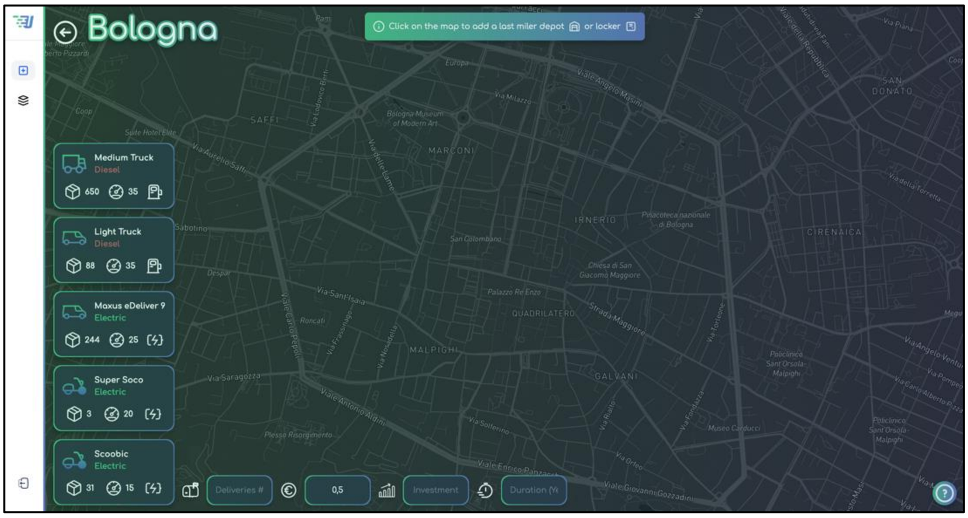

FIGURE 18 CITIQORE APPLICATION

The URBANE Digital Twin Platform was made available for access to project partners in 2023. The feedback received from users suggested that a more user-friendly version of the platform could help users navigate through the models in a more intuitive manner. Taking all this into consideration, a domain-specific application on top of the URBANE Digital Twin was designed and developed that would offer a user-friendly and intuitive experience to the LL users. The application, called CitIQore, focused initially on the models and use case of the Bologna LL, as shown in Figure 18. It is a web-based application, available to the LL partners via authentication.

As the users navigate through the application, they are called to choose from scenario-specific input fields, such as different vehicle types and number of deliveries to be made, but also add lockers and last miler depots directly on the map interface that is presented to them. In this manner, they choose the input parameters for the models that will be triggered in the background. Following that, the CitIQore application calls the DT models with the selected user inputs, using the DT as the backend. A sequence of models is called and executed in this scenario in the following order:

1. The Random Delivery Generation Model, which returns random delivery points on a map for a given number of deliveries.
2. The Collaborative Delivery Model, which orchestrates the deliveries between depots, lockers and last milers to achieve fewer emissions.
3. The EVCO2 and copert models, which are models developed and used in a previous Horizon project (i.e., LEAD project [5]). These calculate the emissions for electric and non-electric vehicles respectively.

[5] https://www.leadproject.eu/

4. The Cost Benefit Analysis (CBA) model addresses the economic aspects of a potential investment in the given scenario.

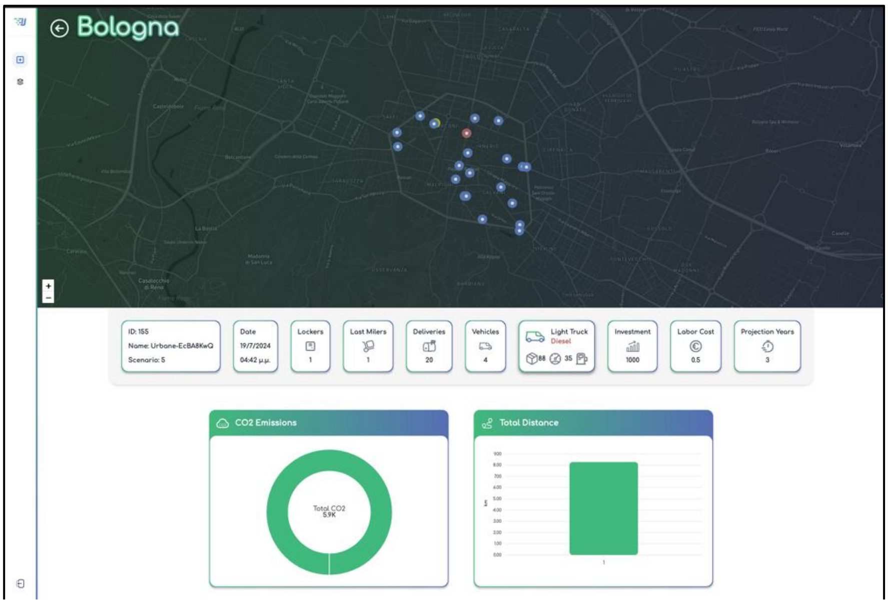

FIGURE 19 CITIQORE SCENARIO DASHBOARD

The outputs of the executed scenario are presented in a dedicated Dashboard, following the successful execution of the above-mentioned sequence of models. A screenshot of the Dashboard is presented in Figure 19. A Demo video was also prepared to project partners, which can be found using the following link.

The CitIQore application together with the URBANE Digital Twin are the central components of the WP3 Innovation &Transferability Platform. Therefore, reusability and transferability are key features of the developed solution. With that in mind, even though the presented solution was developed for the Bologna LL, it can be applied to any other location or city, by allowing the users to select different locations on the map (Figure 20). In this case, the sequence of models will be executed for the user-selected location.

FIGURE 20 CITIQORE APPLICATION. USER SELECTED POLYGON

Recommendations

The Digital Twin Platform was evaluated by two key Bologna stakeholders: the Municipality of Bologna and transport operators TYP and Due Torri, primary users of the platform.

The platform demonstrated significant potential for enhancing operational efficiency and decision-making capabilities for both actors.

In particular, the Municipality can effectively plan future green logistics actions by simulating various development scenarios, such as SULP updates, scaling up NDAs, engaging transport operators, and navigating new regulations. The platform ability to be tuned to local case studies provides a distinct advantage, allowing municipalities to make informed decisions based on highly relevant data. Furthermore, the built-in monitoring functionalities offer invaluable support to decision-makers.

To further optimize the platform's utility, incorporating real data from the pilot phase would significantly enhance its accuracy and reliability. Additionally, assessing the model's ability to predict the impact on congestion, specifically regarding van access to Low Traffic Zones (LTZ), and its implications on the utilization of loading and unloading zones would provide crucial insights for operational improvements.

For transport operators, this platform is invaluable in optimizing the number of delivery vehicles. By including key parameters such as depot location, predefined delivery locations, vehicle availability, type, and capacity, allowed delivery timeframes, and route/area constraints (including real-time traffic conditions), operators can gain critical insights into fleet optimization.

The platform's added value lies in its ability to store, classify, and analyze historical data to generate predictive models based on geographical factors and seasonal demand fluctuations. This enables data-driven decision-making and improved operational efficiency.

To further enhance the platform, it would be useful to include also user-defined delivery locations instead of relying on random generation. Additionally, the ability to generate customizable reports on various operational metrics would facilitate in-depth performance analysis and the identification of specific improvement areas.

8.3.3 Blockchain technology in LLs

The objective of the blockchain system is to guarantee non-repudiation throughout the shipment process when multiple parties are involved. The first step was to identify the events at which the package is transferred and tracking is required. For purposes of clarity, the list of events for this use case is presented in Table 7.

TABLE 7 EVENTS INCL. TSN CODES

• Order registered (84)	• Order delivered (21)
• Order arrived at warehouse (1E)	• Order not delivered (23)
• Order in compartment (64B)	• Order delivered to secondary location (82)
• Order retrieved from compartment (13)	

The second key objective of the system is to assess performance to guarantee that the service has been delivered in line with the previously agreed service level agreements. To achieve this, a range of rules can be selected by the user including missed events, damaged shipments, and delayed shipments. The living labs send the event data through an API to the platform where it is processed and stored on the blockchain. The information is then displayed in the URBANE blockchain dashboard (Figure 21).

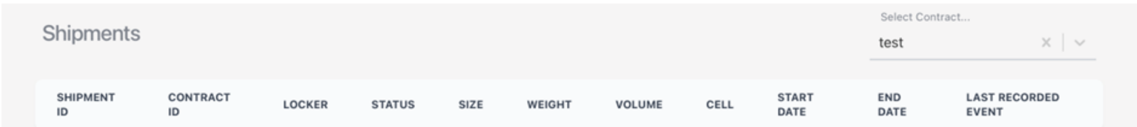

FIGURE 21 SHIPMENT OVERVIEW

The user may select the events to be monitored and the rules to be checked at this stage. Once the contract is in place and data from new events is sent to the platform via the API, these events will be visible in the Shipments Dashboard (Figure 22).

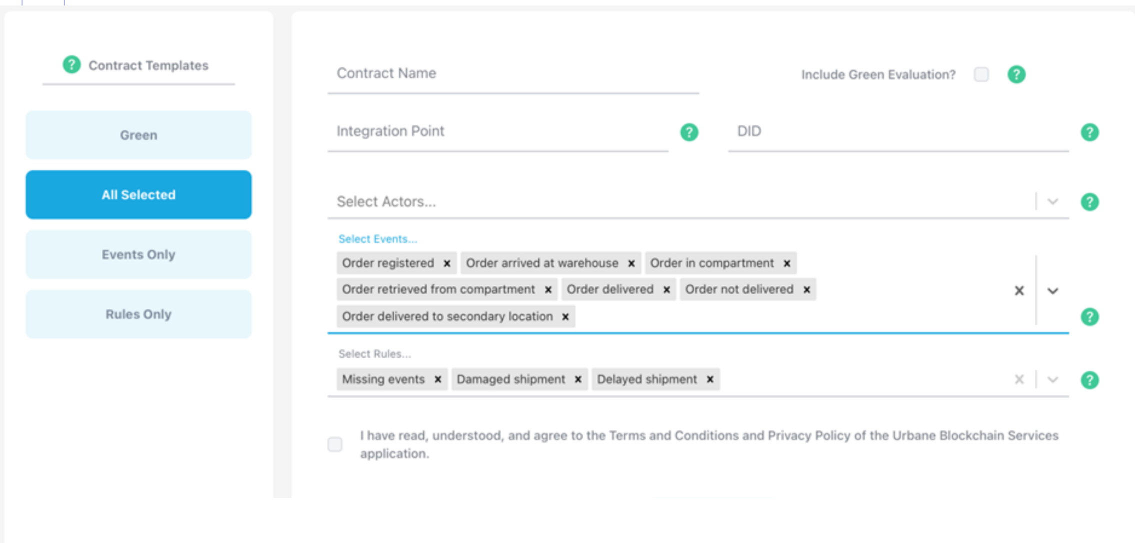

FIGURE 22 CONTRACT GENERATOR INTERFACE

To gain a more detailed overview of the events, one can select the Last Mile Events tab to view all events that have already been registered under a shipment. Additionally, alerts will appear when the rules have been executed with the corresponding result. Further information on the URBANE blockchain infrastructure is available in D3.1.and by the demonstration of the tool prepared using link.

GEL (intermediator) assigns a smart contract to every order at the cut-off time (the day before). The closing of the contract occurs at the delivery or at coming back to the warehouse (in case of missing recipient). The data to be shared in the distributed registry are the following:

- Shipment ID
- The step (delivered or not)
- Geographic location
- Signature
- Recipient name

This info will be replicated in the blockchain and will be visible to the entitled parties.

The smart contract serve mainly as Proof of Delivery (PoD): the procedure depends on shipper requirements, some ask for signature or PIN code, in other cases no proof is required; By the way signature, if available, is useful for complaints. PoD is therefore the main added value of the To BE situation for the blockchain. All actors have visibility and can access information during and after the shipment process to have steps certified (according to respective needs). The focus of the smart contracts is to improve visibility of the Supply Chain for operators and by this manner enhance their collaboration.

The longer-term impact will be to attract more operators and make their operations more efficient and at the same time to aggregate information about volumes and flows (link to PI concepts). Another impact would be to make available aggregated data to the Public Authority to assess the efficiency of their policies related to NDAs and the SULP actions. This information will be available in the URBANE blockchain platform. We envision the development of a business and governance model to ensure sustainability of these concepts.

Recommendations

The proposed blockchain system offers several potential advantages for a transport operator:

Enhanced visibility and transparency:

- Real-time tracking: the ability to monitor shipments in real-time provides valuable insights into package location and status, aiding in efficient route planning and resource allocation.
- Improved communication: clear visibility into the shipment process can facilitate better communication with operators, reducing inquiries and disputes.

Increased efficiency and productivity:

- Optimized operations: the system can help optimize delivery routes and vehicle utilization by providing accurate and up-to-date shipment information.
- Reduced administrative burden: automation of data collection and processing can streamline operations and free up staff for more value-added tasks.

Strengthened trust and reliability:

- Non-repudiation: the blockchain's immutable record provides a strong legal foundation for resolving disputes and ensuring accountability.

The system can be improved by expanding Smart Contract functionality through the integration of insurance contracts on the blockchain, streamlining claims processing and reducing administrative overhead. Additionally, implementing smart contracts that dynamically adjust shipping rates based on real-time factors such as fuel prices, traffic conditions, and demand can optimize operations.

8.3.4 Impact assessment radar

The initial phase of the Impact Assessment Radar, the Strategic Level (Figure 23), aims to evaluate the readiness of the city's ecosystem to implement innovative urban logistics solutions and identify potential weaknesses towards the implementation of micro-consolidation centers equipped with automated lockers. The Radar operates as a strategic tool helping the city gain a better view of their current capacity in terms of regulations, planning, infrastructure, data, logistics actors, citizens, etc. Specifically, it supported the Municipality of Bologna in gaining a comprehensive understanding of the interrelationships among existing city, regional, and national plans, initiatives, and regulations, as well as stakeholder involvement. Additionally, it facilitated a deeper analysis of available smart resources, infrastructures, key actors, accessible urban logistics networks, and associated safety, security, and quality standards. In particular, what emerged from the survey results was the lack of a dedicated team specifically assigned to sustainable urban logistics planning within the city.

FIGURE 23 IMPACT ASSESSMENT RADAR 1ST LEVEL - STRATEGIC

In the planning phase, the second level of the Impact Assessment Radar is instrumental, the Tactical Level (Figure 24). It can leverage data on current city demand and input from last-mile delivery providers to simulate various scenarios. These simulations (Figure 24 – Set up) could help a data driven decision making in real life interventions through estimating the optimal number of lockers needed to fully meet demand in the planning phase. The results (Figure 25 – Results) from the scenarios tested could guide the stakeholders on the decision of the number of lockers to be installed around the perimeter of the city centre. Additionally, the Tactical Level could support the evaluation of the assumptions made at the planning phase.

Set up:

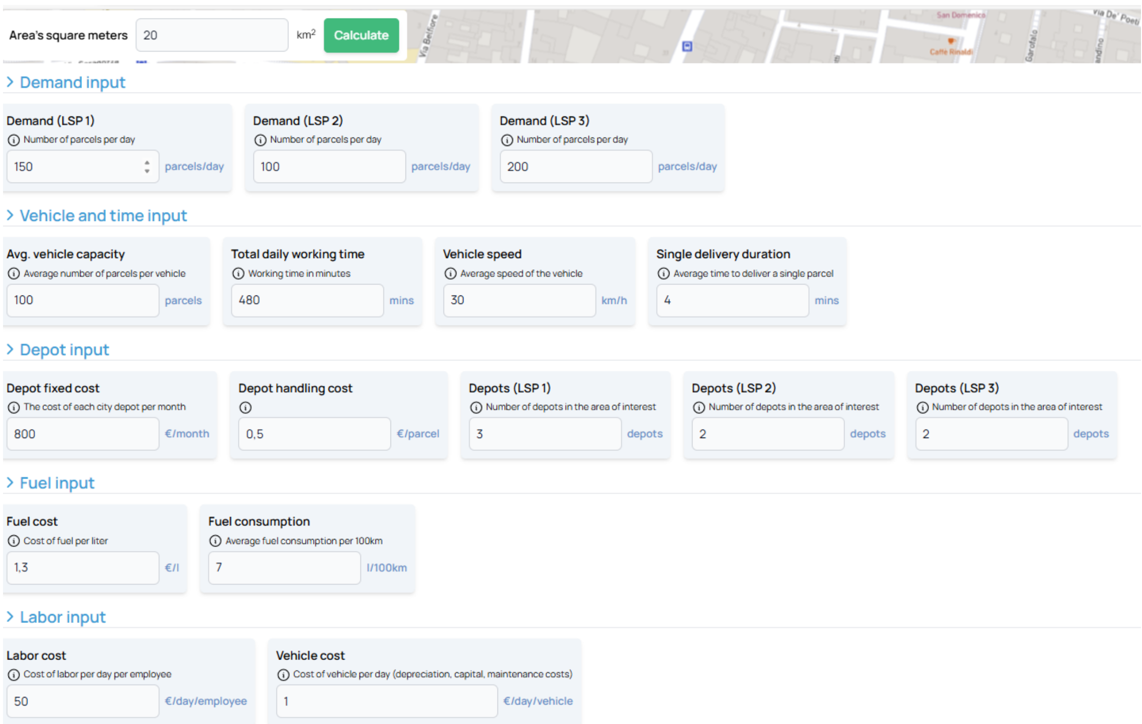

FIGURE 24 IMPACT ASSESSMENT RADAR 2ND LEVEL - SET UP

Results:

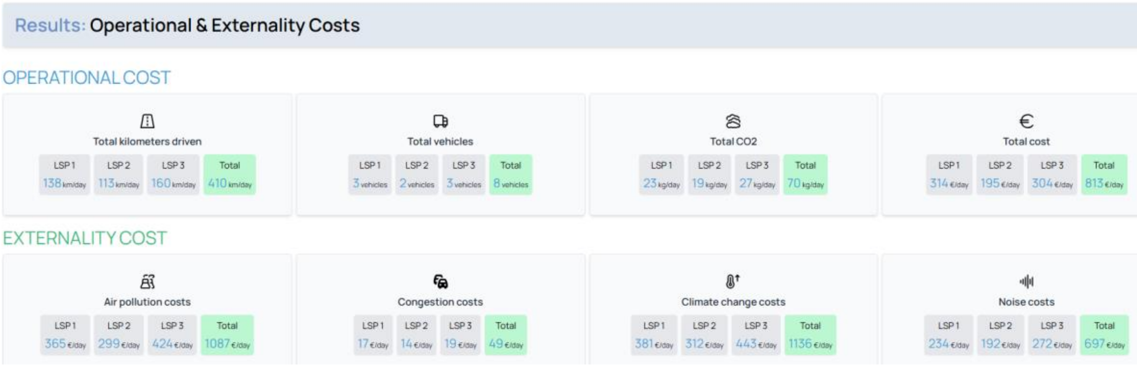

FIGURE 25 IMPACT ASSESSMENT RADAR 2ND LEVEL - RESULTS

The third level of the Impact Assessment Radar, the Operational Level, offer an overview of the KPIs to ensure continuous monitoring and optimization of operations. In the future the integration in real time with the data from the stakeholders and the digital twin outcomes will enable the dynamic calculation of KPIs based on real life data as well as simulation and optimization results. Regarding the Bologna LL KPIs, these were included manually in the system and they were are related to the efficiency of locker usage, the timeliness of deliveries, and the management of adverse events. These KPIs will further fit the development of the Impact Assessment Radar design and usage by the Wave 2 LLs.

Recommendations

The Impact Assessment Radar offers several advantages for the municipalities and for the transport operators.

For the municipalities:

- Strategic planning: the 1st level can support municipalities to conduct a thorough assessment of the city's ecosystem, identifying areas in need of improvement. It is essential for prioritizing innovations and ensuring that interventions effectively address the specific challenges of city's urban logistics landscape. The city can make informed decisions about implementing innovative logistics solutions, such as micro-consolidation centers and automated lockers.
- Optimized resource allocation: the Radar's ability within the 2nd level – Tactical level to simulate various scenarios (Step 1: Number of companies in the city logistics operations and Step 2: Area of interest and demand input) and estimate optimal locker numbers helps the city strategically allocate resources for urban logistics infrastructure to maximize accessibility and efficiency.
- Improved decision making: real-time and KPIs monitoring and optimization through the 3rd Level – Operational Level and integration with the Digital Twin platform provide valuable data for making informed decisions regarding urban logistics operations.

For the transport operators:

- Optimized operations: by leveraging data on city demand and infrastructure and simulating different scenarios within the 2nd level – Tactical level, carriers can optimize their delivery routes and vehicle utilization. Additionally, the 3rd level – Operational level will support LSPs to measure and monitor the impact of their operations.

- Increased efficiency: the integration of the Radar with the Digital Twin platform allows for KPIs and real-time adjustments to delivery operations, improving efficiency and reducing costs.

Considering the municipality and transport operator perspective, the tool can be improved by including additional data sources, such as traffic patterns, public transportation data and by aligning the radar with existing urban planning and sustainability policies to ensure logistics decisions support broader city goals.

9. Evaluation/Impact assessment

9.1 KPIs

These data come from the work carried out in Task 3.2 Impact Assessment Methodology and KPIs, where FIT Consulting provided all URBANE LLs with a holistic and comprehensive framework, KPIs, tools and methodologies to perform their impact assessment. In the table below the Bologna LL KPIs have been defined and the baselines have been collected. All KPIs are connected to Use case n.1: Micro-hubs networks and light EDVS – PI last mile deliveries. The final values collected after the pilot implementation are included in D2.1 Validation Report.

TABLE 8 KPIS

LL	Category	KPI description	Baseline KPIs (provided by the activities of task 3.2) (M12)	Comments
Bologna	**Infrastructure& Policy**	L55. Number of PuDo in the demo area - Agnostic and courier specific	17 and 265	Number of agnostic and courier specific PuDo (PickUp DropOff points that can be used by any LM operator) in the demo area; PuDo includes any kind of designated area for consumers to receive and leave parcels (e.g. parcel lockers, local shops, postal offices etc). Data come from currently integrated networks on GEL Proximity. TO BE benefits: increase of agnostic PuDos (improvement of goods distribution and traffic congestion)
		L16. Number of loading/unloading	430	Number of areas in the demo site (Municipality of Bologna datasource). TO BE benefits could stem from less usage of L/U zones, less access to LTZ.

		spot in the demo site		The Impact assessment radar developed in URBANE can be used for scale-up of the adoption of the solution by LSPs.
		L28. Accidents involving freight vehicles	253	Data for 2022 (latest full year available) from Metropolitan city of Bologna statistical data. TO BE benefits could stem from: less vehicles, smaller vehicle (less occupancy of the road and sidewalk), reduction of mixture of traffic (e.g. commercial and pedestrian)
		L29. People killed or seriously injured in collisions involving freight vehicles	killed: 1; injured: 45	Data for 2022 (latest full year available) from Metropolitan city of Bologna statistical data. TO BE benefits could stem from less vehicles, smaller vehicle (less occupancy), reduction of mixture of traffic (e.g. commercial and pedestrian)
		L25. Investment in infrastructures/facilities included in the TO BE situation	Infrastructures/facilities: € Vehicles: € Administrative costs: € Utilities: €	Microhubs purchase, cameras purchase and installation and last miler service
	Operations	L19. Quality of transport services (% of on time deliveries on total deliveries): number of deliveries taking place at the appointed time/ Total number of deliveries planned	TYP: 97%; DUE TORRI: 97%	TO BE benefits: vehicles and microhub monitoring through GEL parcel tracking system and cameras. The quality level is linked to the transit time according to the geographical zone of the delivery agreed with the client. The baseline is the media of the delivery respecting the agreed service levels. It can be facilitated through blockchain.
		L36. Safety of deliveries (no damages): Number of deliveries and pick ups made in the right form (i.e. not damaged)/total number of	TYP: 99,5%; DUE TORRI: 98%	TO BE benefits: vehicles and microhub monitoring through GEL parcel tracking system and cameras. It can be facilitated through blockchain.

		deliveries and pick ups		
		L37. Security of deliveries (no losses or thefts): Number of deliveries and pick ups made in the right quantity (no loss or theft)/total number of deliveries and pick ups	TYP: 99,7%; DUE TORRI: 98%	TO BE benefits: vehicles and microhub monitoring through GEL parcel tracking system and cameras. It can be facilitated through blockchain.
		L53. Degree of innovation of logistics companies (%)	TYP: 5-10 % DUE TORRI: 5-10 %	This should be monitored to highlight the fact that digital capabilities of LSPs is a driver; on the other hand, the last miler has usually a poor level of innovation
		L56. Information accessibility, e.g. Quality (e.g. real time, completeness of information) with which information on access limitations (e.g. LEZ rules, roadworks) and traffic are shared with LSPs. likert scale (1-4)	Construction site data: NO; exceptional events: NO; accessibility conditions due to weather conditions: NO	The Digital Twin can help LSPs to optimize the deliveries between depots, lockers and last milers to achieve fewer emissions and less costs. In addition, if the DT will contain also real time data on construction sites, exceptional events and accessibility due to weather conditions, could support LSPs in organizing their deliveries better.
		L62. Parking accessibility in existing consolidation/logistics hubs (microhubs, lockers, consolidation centers etc.) - Likert scale (1-4)		Since accessibility to NDA is one of the criteria to select the area, this should probably be assessed (of course, no baseline value, but for the TO BE situation)

		L65. Fuel cost (euros per litre) and electricity cost (euros per kWh): Costs incurred by LSP to power vehicles in operations included in the pilot. Calculated as average cost per litre of fuel used in the AS IS situation	TYP: 1.841 euro/l First semester 2023 DUE TORRI: 1.841 euro/l First semester 2023	TO BE benefits: the Digital Twin platform can support the calculation of CO2 emissions and fuel/electricity costs for electric and non-electric vehicles respectively according to different what-if scenarios.
	Delivery Costs - LSPs	Total delivery costs	TYP: 3 to 5 Euros; DUE TORRI: 12 Euros. It is compose by the following costs. Labor costs (TYP: 45%; DUE TORRI: 45%) Vehicle and fuel costs (TYP: 45%; DUE TORRI: 45%) Technology management costs (TYP: 2%; DUE TORRI: 2%); Insurance costs (TYP: 1%; DUE TORRI: 1%); Order management costs (TYP: 1%; DUE TORRI: 1%); Waste management costs (TYP: 1%; DUE TORRI: 1%); Marketing and promotion costs costs (TYP: 1%; DUE TORRI: 3%)	The Impact Assessment Radar and the Digital Twin Platform, receiving the input from the Collaborative Routing Model, can help to find the break-even point (i.e. which "factors" should we change to make this delivery model profitable?);
	Vehicles operations: Vehicle A: TYP and DUE TORRI: Light Commercial Vehicle; Max allowed mass: kg 3,500; Fuel: Diesel; Euro class: EURO 6;	Average number of km per trip per vehicle	Vehicle A: TYP: 80 km; DUE TORRI: 80 km. Vehicle B: DUE TORRI: 80 km.	TO BE: also the last miler will be included. This will be facilitated by SKEMA Collaborative routing model
		Average number of km per vehicle per day	Vehicle A: TYP: 80km; DUE TORRI: 160 km; Vehicle B: DUE TORRI: 160 km.	TO BE: also the last miler will be included. This will be facilitated by SKEMA Collaborative routing model
		Average distance of km travelled in demo area per day	Vehicle A: TYP: 50 km; DUE TORRI: 50km. Vehicle B: DUE TORRI: 50km.	TO BE: decrease of TYP and DueTorri deliveries. This will be facilitated by SKEMA Collaborative routing model

	Fuel consumption per Km: 8KM/L) Vehicles operations. **Vehicle B:** DUE TORRI: Light Commercial Vehicle; Max allowed mass: kg 3,500; Fuel: Diesel; Euro class: EURO 6; Fuel consumption per Km: 0,125 KM/L)	Time to complete a delivery route (minutes)	Vehicle A: TYP: 480 minutes; DUE TORRI: 480. Vehicle B: DUE TORRI: 480.	Maybe it could be relevant to include a KPI on the time from the warehouse to the final destination (Blockchain)
		Average time for loading/unloading (minutes)	Vehicle A: TYP: 20; DUE TORRI 40. Vehicle B: DUE TORRI: 40.	Loading/unloading at first depot (different from loading/unloading at each stop)
		Average vehicles load factor (% in weight or volume per Km)	Vehicle A: TYP: 80%; DUE TORRI: 90%. Vehicle B: DUE TORRI: 90%	TO BE: also the last miler will be included
		Average number of deliveries per trip	Vehicle A: TYP: 60 to 70; DUE TORRI: 20-30 (BIGGER SHIPMENTS THAN TYP). Vehicle B: DUE TORRI: 20-30	TO BE: Less deliveries per trip for Due Torri and TYP (only to 3 NDAs instead to the single recipients)
		Average number of failed deliveries per trip	TYP: 2	
		Number of vehicles	TYP: 8; DUE TORRI: 4	
	SDG Decent work	Personnel turnover	DUE TORRI: 12%; TYP: 0%; GEL: 0%	
		Average salary	DUE TORRI: 2,282.36; TYP 2,500	TO BE: could change with the numbers of deliveries (= number of drivers)
		Education level	PhD: DUE TORRI, TYP an GEL: 0%; Master's degree: DUE TORRI: 35%; TYP: 20%; GEL: 0%; Bachelor's degree: DUE TORRI: 37%; TYP: 20%; GEL: 80%; High School Diploma: DUE TORRI: 100%; TYP: 53%; GEL: 20%; Lower Educational level: DUE TORRI: 0%; TYP: 6,67%; GEL: 0%	TO BE: higher education level due to a higher level of technological innovation
		Gender diversity	DUE TORRI: 48%; TYP: 53,33%; GEL: 0%	
		Percentage of self-employed workers	DUE TORRI: 0%; TYP: 6,67%; GEL: 0%	

		Percentage of part-time workers	DUE TORRI: 2%; TYP: 0%; GEL: 0%	
		Precariousness rate	DUE TORRI: 15%; TYP: 0%; GEL: 0%	
		Flexibility of working hours	DUE TORRI: Yes; TYP: Yes; GEL: Yes	
		Percentage of remote work	DUE TORRI 27%; TYP 80% have the option to choose remote working; GEL: 40%	

10.Lessons Learnt and results

The pilot preparation activities started right after the project began in September 2022 and the pilot went live on February 2024, after a very intense test phase preparation closing with end-to-end telematic and physical tests involving all LL actors. Bologna LL stakeholders identified lessons learnt and results both at process and finalization stage level:

Stakeholders' collaboration, engagement and Physical Internet concept:

- At the beginning of the pilot activities, it is important to have frequent interactions/ calls (twice a week) and to start the testing activities with low volumes of parcels in order to consolidate the relationships between all LL stakeholders and optimize the logical and physical flow from the start. This enhanced the collaboration among all LL actors and in particular between the 2 logistics operators involved as partners (TYP and Due Torri) that are potential competitors in the logistics sector.
- One challenge encountered was attracting participation from transport operators beyond the initial project partners. To address this, the Bologna Living Lab partners initiated targeted outreach activities and developed specific questionnaires for transport companies. These activities were aimed to assess their interest in the microhub solution and similar innovative approaches to urban goods delivery. The difficulty in attracting broader participation stems primarily from the diverse operational characteristics and needs of different transport operators. For example, specific challenges were encountered with Due Torri (URBANE partner), who needs the return of paper shipping certificates and tag. Additionally, ITL and the Municipality of Bologna held specific meetings with larger couriers like UPS, GLS, and Poste Italiane to explore their potential involvement in the pilot activities and beyond the project to expand the solution. The goal was not only to foster collaboration among different transport operators but also to integrate other last-mile delivery operators directly contracted by each courier. This broader approach would optimize the delivery processes. While UPS declined due to security concerns on sharing operational information and logistics data, discussions with GLS and Poste Italiane remain ongoing, indicating their potential interest.

Thanks to the 2 points outlined above, Bologna LL pioneered Physical Internet delivery methods and initiated the development of a business model for innovative urban delivery services. This business model will be finalized in WP5 with the support of the models developed within WP3 aiming at diving into more details on inceptives for attracting transport operators and overcoming the expressed hesitations.

CO2 emissions:

- Transport operators’ CO2 emissions saving: TYP (one of the transport operators involved as partner in the project) saved about 3.298 CO2 Kgs a day (-52%) comparing their conventional door-to-door deliveries with the new deliveries with micro-hubs and Electric Delivery Vehicles Last Miler in the demo area. The calculation of these data has been included in the KPIs final values in *D2.1 Validation report.* The less kms driven consequently contributed to the increase of road safety and improvement of urban space quality.

Delivery quality and security:

- The quality of the deliveries increased as most of the parcels were delivered on the first attempt. This is a very good result as traditional deliveries usually have a lower first attempt delivery rate.
- Bologna Living Lab's collaborative logistics experiment showcased the viability of data sharing without compromising security or privacy. This was achieved through the implementation of information flow management systems by GEL Proximity and URBANE blockchain and smart contracts solution. The blockchain allowed to certify the occurrence of events relating to the logistics process, such as the Proof of Delivery. In this regard, blockchain can be used as an argument against the reluctancy of transport operators’ participation on collaborative delivery methods.

Urban Mobility and Logistics regulations in Bologna’s City Center:

- Bologna LL realized a measure included in the SULP: implementation of the NDA. The 3 micro-hubs are the first NDAs, established as part of the SULP and SUMP. They are strategically located near the historic center in the following areas: Porta San Mamolo, via Calori, and via Berlinguer.
- The experiment has highlighted the need to enhance the current Bologna city center LTZ monitoring system. Differentiating between commercial vehicle categories within the existing camera and permit system could improve its effectiveness. This data would provide valuable insights into the volume and type of commercial vehicles (e.g., delivery vans) and transport operators entering the LTZ. This would allow for a clearer understanding of delivery traffic within the LTZ, including the specific types of vehicles used. This information would be invaluable for the municipality in defining regulatory policies. By analyzing commercial vehicle data, the city could optimize microhub locations, the installation of designated loading and unloading areas and improve the regulatory policies in line with LSPs, local retailers and citizens’ needs.
- The launch of the pilot project coincided with the introduction of “Bologna 30km/h city” creating an interesting intersection between two initiatives aimed at improving urban mobility and logistics and consequently the city center livability. However, the simultaneous implementation of these two significant changes to urban mobility generated mixed results.

While some citizens and transport operators expressed concerns about increased travel times or difficulty accessing the city center, the project attracted the interest from other municipalities and stakeholders beyond Bologna and the Emilia-Romagna region. To promote the initiative's value, the Bologna Living Lab partners organized press events and actively participated in external events to share detailed information about the solution.

Shipment typology and pick up point:

- To simplify the microhub pilot, the activities were concentrated on single-item shipments, excluding multi-item orders. This streamlined the process but resulted in a lower package volume. This limitation arose because a significant portion of the customers of one of the participating carriers (Due Torri), primarily retailers in Bologna's city center, typically place multi-item orders. To ensure a well-rounded test of collaborative logistics with diverse operators, Bologna LL intentionally partnered with two distinct carriers. TYP, a newer and smaller operator, specialized in single-item deliveries and B2C services, while Due Torri, a larger carrier, handles predominantly multi-item shipments for local retailers and HoReCa business. The microhub has limitations related to capacity for the multi-item deliveries, having a limited number of available compartments and specific dimensions for the parcels it can hold.
- The microhub would give a greater benefit if it were also exploited also as a pickup point directly by the final recipient. This would provide: 24/7 access, accessible at any time of day, allowing recipients to pick up parcels when most convenient for them.

Technological integration and Digital Twin Platform:

- For all couriers, integrating with the GEL Proximity management platform, the software driving microhub operations, is mandatory. While this ensures a smooth, coordinated delivery process for all participants, it can also present challenges for courier companies. These challenges include additional costs associated with the integration process and the time investment required for implementation and staff training.
- URBANE DIgital Twin platform (incorporated with the models presented in chapter 8.3) demonstrated significant potential for enhancing operational efficiency and decision-making capabilities of both municipality and transport operators. In particular, the Municipality can effectively plan future green logistics actions by simulating various development scenarios, such as SULP updates, scaling up NDAs, engaging transport operators, and navigating new regulations. The platform ability to be tuned to local case studies provides a distinct advantage, allowing municipalities to make informed decisions based on highly relevant data. For transport operators, this platform is invaluable in optimizing the number of delivery vehicles. By including key parameters such as depot location, predefined delivery locations, vehicle availability, type, and capacity, allowed delivery timeframes, and route/area constraints (including real-time traffic conditions), operators can gain critical insights into fleet optimization.

Solution physical and technical installation and implementation:

- The selection and implementation of NDAs require careful assessment to ensure compatibility with surrounding infrastructure. This includes public transportation stops, parking lots, loading/unloading areas, bike lanes, and sidewalks. The goal is to minimize inconvenience and avoid creating mobility barriers. One challenge encountered during the preparation phase arose after the initial site inspection of the microhub provider's chosen areas. The soil at the S. Mamolo location was not level enough to fit the microhub structure. This resulted in delays for the Municipality as they had to install a concrete screed to create a flat surface. Additionally, the initial plan did not consider that the microhubs would be placed outdoors and not wall mounted. This unforeseen situation led to issues with exposed cables. These experiences highlight the importance of ongoing collaboration and close supervision throughout the project lifecycle. Regular communication with the microhub provider can help identify and address potential issues proactively, minimizing delays and ensuring a smooth implementation process.

- The installation of cameras on the lockers encountered several challenges. During the procurement phase, the integration of the camera feeds into the local police system was considered only in terms of network infrastructure, resulting in an installation that would not comply with surveillance regulations in terms of data use and processing. Therefore, a wider collaboration with local police on the technical specifications of the cameras from the early design stages might be beneficial to ensure their compliance with the police surveillance system in terms of purpose of data processing.
- Higher-than-expected data consumption from microhub SIM cards has been observed. Therefore, before starting operations, it is crucial to request the microhub provider to carefully evaluate the data consumption of each locker to obtain a more accurate estimate. This evaluation should be documented and incorporated into the final contract with the provider.
- The management of maintenance and technical assistance for microhubs presented significant challenges. Timely maintenance and technical assistance facilitate a positive user experience, making it easy for both couriers and recipients to interact with the system, and to maintain the accuracy and reliability of data collected by the microhubs. Finding a third-party operator to provide first-level support can present difficulties. Common issues can include equipment malfunctions, such as failed door mechanisms, requiring remote repairing or on-site intervention. In Bologna LL case, the ITL Foundation took direct responsibility for providing this support throughout the pilot. The most frequent malfunction involved drivers (carriers or last-mile delivery personnel) being unable to open a microhub locker door. In these cases, the initial response involved remotely forcing the door open (for package delivery or collection) from the microhub dashboard, accessible only to ITL Foundation and the Municipality of Bologna. If this didn’t resolve the issue, ITL then contacted the microhub provider's second-level assistance team (Ricoh – WIB). These findings highlight the importance of incorporating a third-party call center operator into the first-level assistance structure. This would speed up technical problems resolution ensuring the smooth operation of the system.

References

[1] Città Metropolitana di Bologna website: https://www.cittametropolitana.bo.it/portale/

[2] D1.1 URBANE framework for optimised green last mile operations

[3] D2.1 URBANE Validation Report

[4] D3.1 URBANE Collaboration Governance Ledger and Smart Contracts

[5] EU Mission: Climate-Neutral and Smart Cities: https://research-and-innovation.ec.europa.eu/funding/funding-opportunities/funding-programmes-and-open-calls/horizon-europe/eu-missions-horizon-europe/climate-neutral-and-smart-cities_en

[6] I Numeri di Bologna Metropolitana database: http://inumeridibolognametropolitana.it

[7] Lead Project: https://www.leadproject.eu/

[8] Move 21 Project: https://move21.eu/

Project Coordinator: **Ioanna Fergadiotou**
ioanna.fergadiotou@inlecomsystems.com

Project Manager: **Maria Kampa**
maria.kampa@inlecomsystems.com

Communication, Dissemination, and Upscaling Manager: **Alonso Davila Graf**
adavilagraf@polisnetwork.eu

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the granting authority. Neither the European Union nor the granting authority can be held responsible for them. Any communication or dissemination activity related to the action must use factually accurate information.

Funded by The European Union