DISCO

Data-driven and Dynamic Space and Assets for Physical Internet-led Urban Logistics and Planning

D5.2. Twinning Living Lab Implementation

BUAS, ZLC, VIU

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INLECOM INNOVATION ASTIKI MI KERDOSKOPIKI ETAIREIA	EL	INLE
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ACS TACHIDROMIKES IPIRESIES MONOPROSOPI ANONYM	EL	ACS
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Document history

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1.0	06/3/2026	Twinning LL's	Populating Draft Deliverable
1.2	26/3/2026	ZLC	Formatting and Review
1.3.	9/04/2026	LSP	Review
1.4.	14/04/2026	BUAS	Restructuring
1.5.	29/04/2026	BUAS	Finalisation

List of acronyms

AI	Artificial Intelligence
B2B	Business to Business
B2C	Business to Consumer
C2C	Consumer to Consumer
CCAM	Connected, Cooperative and Automated Mobility
DISCO	Data driven, Integrated, Syncromodal, Collaborative and Optimised urban freight meta model
DISCOBAY	DISCO module for multimodal logistics hubs
DISCOCURB	DISCO module for curbside management
DISCOPLAN	DISCO module for logistics planning
DISCOPROXI	DISCO module for proximity delivery hubs
DISCO X	General reference to the suite of DISCO modules or individual innovations
DT	Digital Twin
EC	European Commission
EDI	Electronic Data Interchange
EDPI	E-commerce Demand Potential Index
EIT	European Institute of Innovation and Technology
EUR	Euro
GPS	Global Positioning System
ICT	Information and Communication Technology
IoT	Internet of Things
IT	Information Technology
KER	Key Exploitable Result

KPI	Key Performance Indicator
LEAD	Low Emission Adaptive Last Mile Logistics Project
LEFV	Light Electric Freight Vehicle
L/U	Loading and Unloading Zones or Activities
MIXMOVE	Supply Chain Digital Twin Platform
MMS	Meta Model Suite
MVP	Minimum Viable Product
PCP	Pre Commercial Procurement
PI	Physical Internet
R&D	Research and Development
R&D&I	Research, Development and Innovation
SCH	Smart Consolidation Hub
SDP	Service Delivery Platform
SENATOR	Smart Network Operator Platform for Urban Logistics
SMEs	Small and Medium sized Enterprises
SPRO	Smart Parking Operations
SULP	Sustainable Urban Logistics Plan
SUMP	Sustainable Urban Mobility Plan
TRL	Technology Readiness Level
TMS	Transport Management System
UFDS	Urban Freight Data Space
WP	Work Package

1. Table of Contents

Executive Summary

D5.2 documents the second and final demonstration phase of Work Package 5 (Twinning Living Labs) within the DISCO Horizon Europe project (Grant Agreement No. 101103954). Covering project months 18 to 42, this deliverable reports on the **deployment, validation, and evaluation of data driven urban logistics** innovations across four European cities: Padua, Zaragoza, Barcelona, and Valencia. The demonstrations translate lessons from the four Starring Living Labs into local practice, evidencing the adaptability, scalability, and policy relevance of the DISCO innovation suite across diverse urban governance contexts. The four Twinning Living Labs produced the following headline results:

Padua (Italy) DISCOCURB + DISCOPROXI

Deployed a bookable curbside loading zone system integrated with mobile electric lockers (dynamic DISCOPROXI pods) and connected to the Urban Freight Data Space via DISCOLLECTION. Over a three-month pilot, 328 packages were delivered across three city stalls. The Greedy zone selection algorithm achieved an 84.4 percent delivery success rate confirming the viability of demand responsive curb management in constrained historic city centres.

Zaragoza (Spain) DISCOCURB + DISCOPROXI

Co designed a municipal microhub with last mile operator CityLogin, delivering over 7,000 packages from a repurposed food market. The team expanded the original scope to include a DISCOCURB measure, enabled by inter project knowledge transfer from the SENATOR project and developed a replicable demand driven microhub and parcel locker siting index (EDPI), advancing from analytical concept to operational tool.

Barcelona (Spain) DISCOCURB + DISCOLLECTION

Deployed AI powered computer vision across three Loading and Unloading (DUM) zones to monitor vehicle compliance, detect unregistered operations, and validate occupancy data against the city's existing SPRO self declaration system. The solution advanced from TRL 3 to TRL 7, producing the first objective, validated baseline of DUM zone activity for the monitored areas and directly informing Barcelona's forthcoming Sustainable Urban Logistics Plan.

Valencia (Spain) DISCOBAY + DISCOESTATE + DISCOPROXI

Following the devastating October 2024 DANA floods, the Valencia Living Lab pivoted its demonstration to provide emergency humanitarian logistics coordination. Deploying the UrbanPort model from a repurposed fruit warehouse in Alcàsser, the team delivered aid to 154,699 residents across eleven municipalities. The Alcàsser Hub outperformed all comparable facilities active during the crisis by over 40 percent in service capacity, operating at €2.18 per package, competitive with established commercial benchmarks under normalised conditions.

Across all four demonstrations, the evidence consistently indicates that early stakeholder trust building, shared ownership of objectives, and adaptive capacity, determined whether innovations succeeded under real world conditions. The Agile methodology deployed across WP5 functioned best not as a governance system but as a values framework, enabling teams to pivot, learn, and maintain momentum even under crisis conditions.

Results show that cross-pilot learning is not linear, but multi directional, peer to peer learning must be prioritised in demonstration settings. In addition to this, several cross-cutting lessons pertaining to policy, stakeholder governance and data sharing highlight the importance of paying attention to the softer elements of data driven urban freight innovation, and not solely technology and will.

The Technology Readiness Levels achieved across the demonstrations from TRL 5 to TRL 7 confirm that the DISCO innovation suite has moved well beyond laboratory validation into operational demonstration. The solutions are scalable, transferable, and policy ready.

1. Introduction

Urban freight is one of Europe's most persistent and under addressed challenges. Freight vehicles account for roughly 15 25% of vehicle kilometres in cities, yet freight vehicles account for around 20 40% of emissions[1], 40% of energy consumption, and 50% of particulate matter generated by urban transport. Last mile delivery alone accounts for approximately 20 to 30 percent of total logistics costs while consuming 20 40%[2] of premium urban space that cities are increasingly reclaiming for people, not parcels. The scale of the problem is not static: e commerce volumes are projected to increase by 18.39% CAGR by 2025 30[3], and the proportion of Europeans living in urban areas is expected to grow from 70 to 84 percent by 2050. Without structural innovation, the urban logistics systems serving these growing populations will become increasingly incompatible with climate neutrality commitments, public space governance, and quality of life.

1.1. DISCO Project

This is where the DISCO project intervenes. DISCO **(Data driven, Integrated, Syncromodal, Collaborative and Optimised urban freight meta model)** deploys a suite of data driven innovations across a network of European Living Labs, demonstrating that freight can be cleaner, smarter, and better integrated into city life. The goals of the DISCO project include demonstrating the scalability and transferability of data driven, integrated, and collaborative logistics solutions across different urban contexts, supporting sustainable and low emission freight transport, and providing evidence-based insights for policymakers and stakeholders.

The Twinning Living Labs have over 2 years modelled, deployed, demonstrated, and hosted an evaluation of data driven urban logistics solutions in four Twinning Living Labs, evidencing their adaptability and replicability. D5.2 covers this second demonstration phase, documenting

[1]Ruiz, Salvador, 2024, *Mail and parcel deliveries in cities go green,* https://projects.research and innovation.ec.europa.eu/en/horizon magazine/mail and parcel deliveries cities go green accessed 06/03/2026

[2]WorldBank, 2023, *Decarbonizing urban transport for development:* https://www.worldbank.org/en/topic/transport/publication/decarbonizing urban transport fordevelopment accessed 06/03/2026

[3] Bonafide Research, 2025, Ecommerce Market Outlook, 2030, https://www.researchandmarkets.com/reports/6103375/ecommerce market outlook#:~:text=According%20to%20the%20research%20report,%25%20CAGR%20by%202025%2D30 accessed 06/03/2026

implementations in Padua, Zaragoza, Barcelona, and Valencia, where lessons from the four Starring Living Labs are transferred into practice. This deliverable documents these efforts as well as the potential of the innovations to upscale and transfer across other European cities.

The objectives of work package 5 are:

- Objective i: Expand the demonstration replication power of DISCO solutions beyond Starring Living Labs
- Objective ii: Ensure successful set up and implementation of Twinning Living Lab activities within the project duration
- Objective iii: Ensure efficient learning from Starring to Twinning Living Labs
- Objective iv: Facilitate the connection of Twinning Living Labs with other work packages and ensure integration into overall project activities
- Objective v: Facilitate transferability of knowledge from Twinning Living Lab solutions to Follower cities and regions

While section 1.3 of this document delves into objectives i, iii, iv and v on a high level, this deliverable details extensively the contribution towards objective ii. Among the Twinning demonstrations the **Padua Living Lab** showcases the integration of modular electric pods, dynamic locker systems (DISCOPROXI), and bookable curbside loading zones (DISCOCURB), all feeding real time operational data into the Urban Freight Data Space via DISCOLLECTION. In **Zaragoza**, readers will find, among others, a microhub model co designed between the city council and last mile operator CityLogin, demonstrating how underutilised municipal spaces can anchor sustainable last mile networks, in addition to this, a real cross project development occurs within the DISCOCURB umbrella, taking a model from a project that the living labs had previously participated in and building the concept further. The **Barcelona Living Lab** introduces AI powered computer vision for monitoring loading and unloading zone compliance as part of DISCOCURB and DISCOLLECTION, a significant methodological step beyond manual app-based reporting. Finally, the **Valencia Living Lab** presents perhaps the most unexpected case study: the DISCO framework applied in real crisis conditions following the devastating October 2024 DANA floods.

1.2. Agile Methodology

The Agile methodology was introduced into the DISCO Twinning Living Labs (LLs) as a structured approach to managing the complexity of multi stakeholder urban logistics demonstrations as per deliverable 5.1. The intention being to provide teams with clear roles, regular feedback cycles, and a shared rhythm of planning and reflection. What emerged in practice was more nuanced and more instructive. The Twinning LLs each engaged with the Agile framework differently, adapting its ceremonies to suit their local realities rather than applying it uniformly. This was not a departure from the spirit of Agile; it was an expression of it. Agile, at its core, is a philosophy of continuous improvement and responsive action and while the structured ceremonies did not fit, the mindset behind them did.

The living labs faced various realities of operating at the intersection of public governance and private innovation. Large scale projects in complex cross institutional environments routinely encounters coordination and alignment challenges that purely procedural responses cannot resolve. The most significant outcomes from the Twinning LLs were not produced by adherence to the framework but by teams who had internalised its values: adapt, learn, and keep moving.

- Valencia's response to Storm DANA is the clearest illustration. When the flooding crisis struck, the Valencia LL redirected its demonstration activities toward emergency humanitarian logistics coordination, drawing on the local relationships and adaptive capacity it had built throughout the project. The LL did not pause; it pivoted. The innovation continued, serving an urgent community need while preserving the project's momentum and stakeholder relationships.
- Building on the foundation of the SENATOR project and informed by exchanges with the Starring LLs, Zaragoza expanded its original demonstration scope to incorporate a DISCOCURB measure. This was not part of the original plan; it was the result of iterative learning, inter project knowledge transfer, and a team that felt empowered to act on what it was discovering. Over and above this, the Zaragoza living lab went further to develop a parcel locker and microhub location index that when fed with data, outputs key areas where the proximity solutions would have the most demand.
- Padua's as well was faced with a regulatory constraint on public space, the team reoriented toward a curbside management trial using existing loading and unloading bays. The objectives of the DISCO X measure remained intact; the pathway to achieving them changed.

Where stakeholder trust was established early; through sustained engagement, shared ownership of objectives, and transparent communication, teams were better positioned to navigate obstacles and make confident adaptive decisions. In multi stakeholder, publicly funded urban innovation projects, Agile works best not as a governance system but as a values framework. The ceremonies are tools, not rules, Zaragoza, and Padua each demonstrated that project continuity under difficult conditions is less a function of plan adherence and more a function of adaptive capacity, relational investment, and local ownership. These are qualities that Agile, at its best, cultivates. Future urban logistics programmes would do well to invest as much in coaching, stakeholder engagement, and change management as they do in technical planning, because in complex multi actor environments, it is the human infrastructure that determines whether innovation scales.

1.3. Interaction with other Work Packages

The Twinning Living Lab demonstrations The Twinning Living Labs (WP5), are embedded in a dense web of cross work package dependencies that span DISCO's development and demonstration activities. These interactions are captured below:

Table 1 Work package interactions

WP 2: Meta Model Suite

The Meta Model Suite and DISCO X enabling tools, define the framework within which Twinning LL measures are implemented. WP5 feeds back into WP2 by providing real world evidence of replicability and TRL advancement, ultimately contributing to the Adaptive Blueprint (D2.6) and the SULP Topic Guide update (D2.7). This feedback has been contributed to these deliverables through the Twinning Lessons Learnt (Found in chapter 3) as well as the Physical Internet readiness questionnaires which have been fed into WP 2. These contributions to WP2 enable the third version of the meta model suite to be developed and earlier versions validated.

WP 3: Urban Freight Data Space

The Urban Freight Data Space (UFDS), developed in WP3, provides the data infrastructure that enables Twinning LLs to collect, share, and process logistics data across sites. WP5 partners are required to establish local data management registers and checklist systems aligned with the UFDS architecture. WP3 has also availed connectors to the UFDS for each of the living labs to access the data space. Data from Twinning LL demonstrations has been fed into the UFDS, contributing to the federated data catalogue and onboarding toolkit (D3.3). Within this deliverable the datasets availed by the living labs can be found under sections 2.1.5, 2.2.5, 2.3.5, further information on the data use cases related to the demonstrations can be found in the WP 3 deliverable D3.4, DISCO Data Space Open Software Repository Ver. 2 and Implementation Guide.

WP 4: Starring Living Labs

WP 4 has delivered the Starring demonstration results, from which WP5 directly learns. T5.1 explicitly establishes twinning pairings between Starring and Twinning LLs based on shared DISCO X innovations and contextual affinities. The Replication Plans developed within WP5 are built upon the outputs of WP4, including city specific Factsheets, KPI frameworks, and the Agile Model Implementation Roadmap (D4.1). WP4's evaluation results (D4.3) serve as the reference baseline against which Twinning LLs measure their own TRL advancement. WP4 is formally tasked with creating links to WP5 as one of its own objectives.

WP6: Market Business and Exploitation

WP5 demonstration outputs feed into WP6 by providing empirical evidence for business and operating model development. The market replicability demonstrated across the Spanish cluster (Zaragoza, Barcelona, Valencia) and Padua informs the exploitation plans developed in WP6, around value propositions for new market participants (D6.3). This is done by identifying key exploitable results from the Twinning lab, which are initiatives or tools with a TRL of 7 to 9 which can yield replicable results. This is touched on in Chapter 3 but deepened in the WP 6 deliverables exploring exploitation pathways.

WP 7: Dissemination Policy and Knowledge Transfer

The Twinning LL results documented in Chapter 2 provide the replication evidence required for the Replication Booklet (D7.3) and the Knowledge Hub. Secondly T7.5, the Policy Package task, which draws on Twinning LL insights to develop mission oriented policy pathways for sustainable urban freight and land use planning. WP7 in turn provides the dissemination and communication infrastructure through which WP5 results reach Follower cities (T7.2), enabling knowledge transfer beyond the project consortium. The Twinning labs have engaged in various webinars, workshops and podcasts as well as contributed to social media dissemination activities in order to boost the dissemination of results and garner interest in replication activities. The policy insights related to the Twinning living labs can be found in chapter 2 as well as chapter 3 of this deliverable.

1.4. Reading Guide

Chapter 2 forms the core of this document, organised by city. Each subsection follows a consistent structure covering city context, internal and external objectives, DISCO innovations deployed, implementation details, results including TRL evolution, transferability and lessons learnt, and a forward looking 'Beyond DISCO' perspective that outlines the next steps of the living labs.

Chapter 3 delves into the cross-cutting elements that characterise the learnings of the living labs per DISCO X and new insights. The chapter also reflects on the interaction between the Starring and the Twinning living labs by cataloguing the lessons learnt and synthesizing results.

The deliverable then concludes with a reflection on the objectives and closing remarks.

It is to be noted that quantitative results will not be discussed in depth within this deliverable as the Twinning Living Labs evaluation handbook, which constitutes deliverable D5.3 will deliver a full cross site evaluation which includes full key performance indicator computation, reflection on the cities SULP and SUMP positioning as well as a discussion on the impact of the demonstrations on achieving the sustainable development goals (SDG's). This upcoming deliverable is expected to be published publicly in July 2026.

2. Twinning Living Labs Measure Implementation

This chapter details the demonstrations at the 4 Twinning living lab locations, Padua, Barcelona, Zaragoza and Valencia, each section delves into the efforts that were taken by the living labs. The Living Lab demonstrations are split among various DISCO innovations. This chapter details the living lab contexts, objectives, data sets as well as how the demonstrations unfolded including the results and details pertaining to the transferability of knowledge and upscaling of urban freight innovations.

Table 2 Twinning living Lab DISCO X

BARCELONA LIVING LAB	ZARAGOZA LIVING LAB	VALENCIA LIVING LAB	PADUA LIVING LAB
•DISCOCURB •DISCOLLECTION	•DISCOPROXI •DISCOCURB* •DISCOLLECTION	•DISCOESTATE •DISCOBAY •DISCOPROXI	•DISCOPROXI •DISCOCURB* •DISCOLLECTION

The work package 5 key achievement indicators state that the living labs must deploy 9 innovations, the table 2 evidences that the Twinning living labs have overshot this target by deploying 11, with 2 extra DISCO X's deployed by Zaragoza and Padua. The 5 DISCO X models, also known as DISCO innovations, being demonstrated by the living labs are:

DISCOCURB Mixed use and dynamic streets space management smart and flexible use of curb side (e.g., of loading or on street parking zones with advanced data analytics or Digital Twin).

DISCOPROXI Proximity logistics urban corners or lockers for nearby deliveries and omnichannel shipments, to optimise multiple collection and delivery solutions at localised, mixed used lands and micro hubs with low emission vehicles (e.g., cargo bike, LEFV): a place of withdrawal and return close to home.

DISCOESTATE Multi purpose and temporary use of building space. Retrofitting building space for multi tenant and temporary use to enhance the reliability of B2B / B2C deliveries.

DISCOBAY Multimodal bays as mutualised and multimodal (e.g., rail/waterborne) distribution centres for green last mile pooling delivery to improve carbon footprint.

DISCOLLECTION Smart data collection Smart data collection methods for advanced access control and real time routing to simulate optimised and prioritised real time vehicle routing, incentivised and dynamic access permission and smart network management.

2.1. Padua

2.1.1. Background and rationale of the intervention

Padua is a medium sized Italian city with a population of approximately **207,000 inhabitants,** situated in the Veneto Region of Northern Italy. The demographic structure is characterized by an ageing population, with around **27% of residents aged 65 or older**, reflecting broader national trends. At the same time, Padua hosts a significant **student population**, due to the presence of one of Europe's oldest and largest universities, which contributes to a high share of young adults and temporary residents. Foreign residents account for roughly **15–16% of the population**, with the largest communities originating from Eastern Europe and Asia. Overall, Padua combines features of an ageing urban population with the dynamism of a university city, influencing mobility patterns, service demand, and urban logistics needs.

Figure 1 Padua Medieval City Centre

2.1.2. Objectives

The internal objectives of the Padua Living Lab focus on:

- Validation of Next's modular electric pods (DISCOPROXI) as a flexible, zero emission alternative to conventional delivery vans.
- The implementation of on demand curbside booking (DISCOCURB) to provide the data driven infrastructure needed to manage limited public space effectively which is a core challenge for integrated urban logistics.
- Introduce on demand loading unloading zones to support both the dynamic lockers operation while sharing curbside space with traditional logistics operators

Beyond technical testing, the city expects these measures to significantly improve transportation efficiency by reducing "search traffic" for loading zones and mitigating double parking issues.

External Objectives:

The demonstration strategy is designed to improve urban liveability for residents and in general for all pedestrians using the public space or to avoid unsuccessfully driving looking for a free parking spot, by transitioning toward quieter, low emission freight solutions by:

- Assessing the reliability of dynamic lockers and modular electric pods, evaluating daily operational processes.
- Identifying technical, organizational, and infrastructural constraints affecting last mile deliveries.
- Enriching the Urban Freight Data Space with real world operational data from the two solutions, the pilot
- Validate the KPI evaluation methodology
- Inform algorithmic improvements in dynamic locker bookings and support future planning and decision making at the European level.

Targeted Policy/Strategic Goals

The Padua Living Lab experimentation is directly embedded in the **Padua Sustainable Urban Mobility Plan (SUMP)**, which prioritizes the decarbonization of last mile logistics and the protection of the historic city center, basing such actions on the existing urban logistics system named Cityporto. The DISCO project activities explicitly support and enlarge the municipal strategy to reduce the volume of conventional freight vehicles in restricted zones. From a strategic perspective, the experimentation advances **local data driven urban governance** by providing the City of Padua with the digital tools and real time monitoring necessary to transition from fixed to flexible curbside management. This alignment ensures that the pilot is not merely a technical trial but a policy instrument designed to optimize public space usage and strengthen cooperation between the municipality and private logistics providers

2.1.3. Living Lab Partners and Roles in Project

- **VIU**: Venice International University is responsible for the coordination of Padua LL. VIU supported the other partners by providing expert insights, definition of objectives, supporting the scheduling of activities, and revising the outcomes. Besides, VIU supported the implementation of AGILE methodology within the LL assuring the alignment of the Padua LL with the overall goals of DISCO WP5 and DISCO overall objectives.
- **Padua Municipality**: The Municipality of Padua is responsible for the local implementation of the Living Lab. This includes the identification and management of public spaces for loading and unloading activities, coordination with local stakeholders, and alignment of the pilot with municipal regulations and urban mobility policies. Besides the municipality is responsible for the implementation of the bookable loading/unloading zones and related physical and digital infrastructure.
- **NEXT**: NEXT is a technology and hardware supplier which designs and produces modular electric vehicles. NEXT is responsible for the physical implementation of the mobile locker concept, for

the development of digital tools required to support the deployment of the mobile lockers and for running them to perform deliveries, while collecting the essential data to validate the technical/economic feasibility.

2.1.4. DISCO Innovations:

- **DISCOCURB**: **On demand Loading/Unloading zones** (physical/digital). The loading/unloading zones booking system is a digital tool that enables the temporary reservation and shared use of designated curbside spaces for freight operations. In the Padua Living Lab, the system allows authorized logistics operators to book specific loading/unloading stalls in advance for defined time slots, ensuring regulated access to public space in compliance with local traffic regulations. Each zone is equipped with digital signage displaying real time booking information and authorized vehicle details, supporting on street enforcement and transparency
- **DISCOPROXI**: **Dynamic Lockers for last mile deliveries** (physical/digital) To develop an urban logistics network based on urban spaces, strategically allocated to hub and dynamic lockers, i.e. a mobile locker filled at the hub and then deployed toward a destination optimised to reduce the average distance from the receivers of goods.
- **DISCOLLECTION**: **Connection to Urban Freight Data Space** (digital) To collect real time data and expose them through the Urban Freight Data Space (UFDS) as decision making tools of freight demand/space allocation to urban transport capacity in the last mile.

2.1.5. Utilized Datasets:

- **Historic Delivery Demand (Baseline):** This dataset comprises historical records from the Cityporto database (2016), specifically focusing on GLS express parcels delivered via van within Padua's LTZ (Limited Traffic Zone). It includes delivery coordinates and timestamps, which were processed using clustering algorithms to simulate synthetic demand for the 37 project volunteers.
- **Dynamic Locker Telemetry & IoT Data:** Data is generated by the locker's internal hardware, consisting of an ESP32 based relay control board and 12V/24V electronic solenoid locks connected via a 4G modem. The dataset records every entry event, including PIN validation logs, API query timestamps from the cloud backend, and the real time status (open/closed) of the 15 individual locker slots .
- **Operational Logistics & Vehicle Performance (Deliveries Dataset):** This dataset combines automated data from the Next Modular Electric Pod's interface and manual logs. It includes:
  - Energy Metrics: Battery State of Charge (Initial/Ending %), and total kWh consumed,
  - Mobility Data: GPS tracked kilometers travelled per trip,
  - Success Metrics: Number of packages delivered vs. unfulfilled per stall,
  - Environmental Impact: Calculated CO_2 equivalent (CO_2e) emissions based on energy consumption.

- **Curbside Management Data (DISCOCURB):** Collected through the CodaQ web/mobile booking platform and synchronized with Variable Message Signs (VMS) at the stalls. The dataset includes structured records for each reservation: Unique Identifier (UUID), geospatial coordinates in GeoJSON format, specific time slots (Start/End), and authorized vehicle license plates.

- The Living Lab also aims to generate detailed qualitative and quantitative data, improve coordination between digital tools and physical infrastructure, and support learning through continuous observation and experimentation at the local level. Ultimately, the main data collected through the dynamic lockers and on demand loading and unloading zones are made available through the UFDS.

2.1.6. Demonstration Description

DISCOCURB

Within the Padua Living Lab, DISCOCURB was implemented to optimize the shared use of urban curbside space through a digital booking system for some strategic loading and unloading zones, in line with the objectives defined in the DISCO replication plan. The solution was deployed under real operating conditions and integrated into the existing urban traffic and regulatory framework, enabling the testing of data driven curb management for urban freight operations.

The infrastructure

The DISCOCURB infrastructure consisted of three on demand loading/unloading stalls located in strategic areas, in Via Sarpi, Via Rezzonico and finally Via Oberdan, which are already used by logistics private operators of the city centre Figure.5, selected to support the deployment of dynamic lockers and last mile delivery activities.

The stalls were not exclusively reserved for the project but operated as shared public spaces, accessible to authorised users through a municipal digital booking platform, in compliance with the Italian Road Code, which does not allow permanent exclusive allocation of public curb space. Two stalls (where technically possible) were also equipped with programmable digital signage, displaying real time information on booking status, authorised vehicle identification, and time windows, thereby supporting both operational coordination and on street enforcement.

Figure 2 DISCOCURB Variable Message Signage

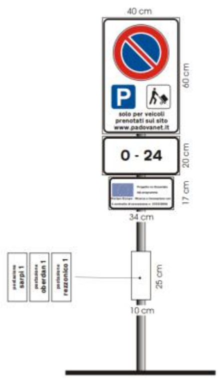


Figure 3 Signage without programmable signage displaying

Figure 4 Signage with programmable signage displaying

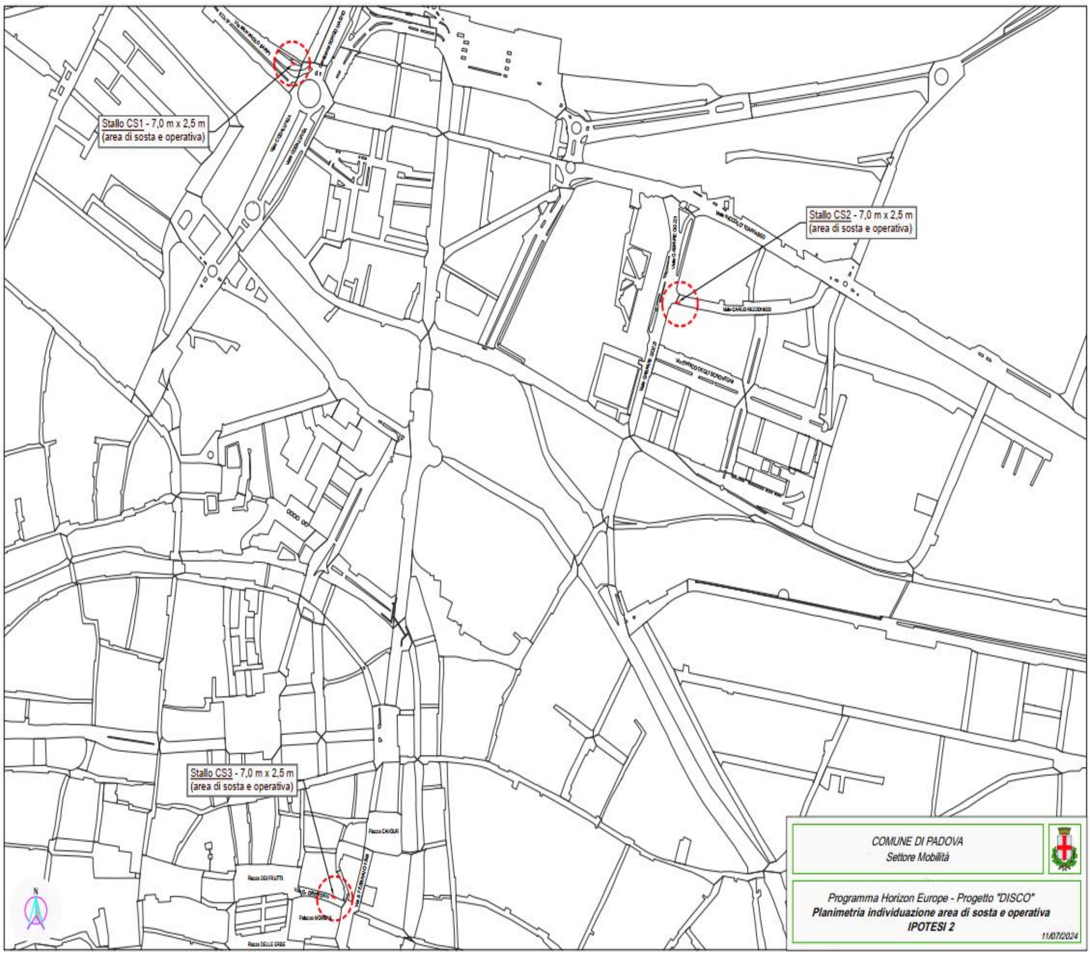


Figure 5map of the living lab sites

The booking platform

The booking system was managed through a web based interface developed by a private company CodaQ S.r.l. awarded the contract during the DISCO tenure. It is accessible via desktop and mobile devices (https://webapp.codaq.it/wpark/). The graphical user interface (GUI) was designed to be simple and intuitive, allowing users to view available stalls, select a location, choose a time slot, and confirm the reservation. Once the booking was completed, the system generated a digital authorisation associated with the vehicle, which was then reflected on the physical display installed at the stall. This real time synchronisation between the digital platform and the physical infrastructure ensured transparency and supported correct use of the reserved space.

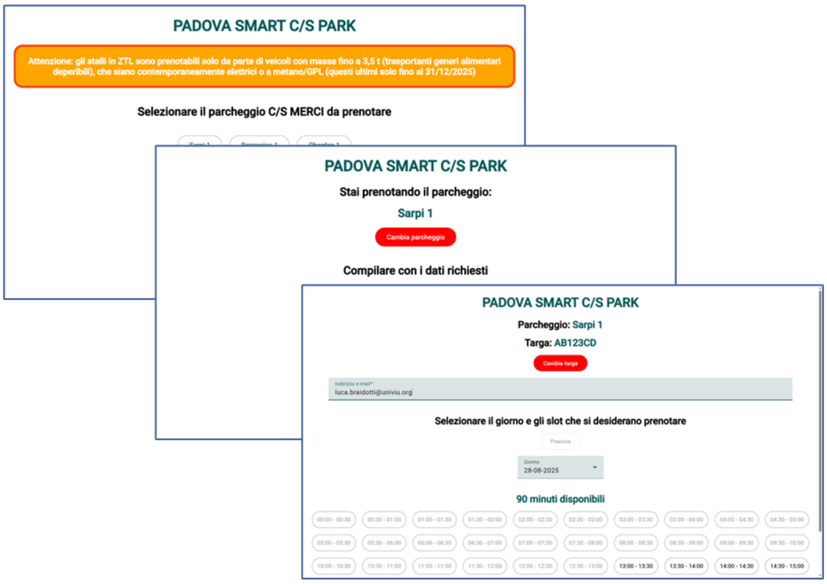


Figure 6 CODAQ Booking app interface

From an operational perspective, the workflow for booking and using the loading/unloading zones followed a structured sequence. Before entering the city centre, the operator selected and booked an available stall for a predefined time window through the platform. Upon arrival, the authorised vehicle accessed the stall, where the digital signage confirmed (if present) the active booking. The stall was then used for the deployment or servicing of dynamic lockers, after which the vehicle vacated the space at the end of the reserved slot, restoring availability for other users. This workflow enabled on demand, time limited, and shared use of curbside space, reducing conflicts and supporting more efficient last mile operations.

The DISCOCURB implementation in Padua demonstrates how digital tools and physical infrastructure can be effectively combined to manage curbside space in dense urban environments. By integrating booking functionalities, real time communication, and shared use principles, the solution supports flexible urban logistics operations while aligning with local regulations and broader DISCO objectives related to connected, collaborative, and data driven urban freight systems. The results of this deployment together with the deployment of DISCOPROXI and DISCOLLECTION will be jointly discussed in section 2.1.7.

DISCOPROXI

To test the functionality of the DISCOCURB features in conjunction with proximity logistics, Padua Living Lab deployed dynamic lockers under the DISCOPROXI umbrella, this section delves into the demonstration of these lockers. One of the Next pods had a parcel locker installed into it and this vehicle was positioned daily in one of the three stalls made available by the Municipality of Padua for the Disco Project. The stalls were the 3 loading/unloading zones shown in the figures 5 located in Via Sarpi, Via Rezzonico and finally Via Oberdan.

Every day the stall was selected following the zone selection policies outlined in the "Definition of Zone Selection Policies to be tested" paragraph and booked using the booking platform developed by CodaQ s.r.l.

Definition of Zone Selection Policies to be tested
4 zone selection policies were tested each day, with inputs being the synthetic demand and outputs the stall that will be served. The selected policies are:

- *Random policy*: randomly select the stall of the day; this basic policy serves as a baseline to evaluate the more articulated ones.
- *Cyclic policy*: implements a deterministic rotation through the three different locations.
- *Greedy policy*: optimises for user satisfaction by prioritising locations with the highest aggregate request count. This metric is calculated from the cumulative sum of all historical and current daily requests, ensuring the model is not limited to short term demand.
- *Waiting policy*: This strategy extends the greedy approach by incorporating a waiting factor that increases the priority of locations that have not been selected recently.

The first two policies were tested during the early deployment, then a review of the results, in line with the AGILE implementation scheme, will drive the testing/adoption of the other ones or the repetition of already tested ones.

Figure 7 Next pod with internal locker

Dynamic Locker design and physical implementation
The locker has been designed with the following key requirements in mind:

- At least 10 slots with the possibility of future expansion
- Codes and slot assignment must change daily
- Working codes must be consistent with email communication

Development of IT systems to run dynamic lockers
System Architecture and Equipment Requirements: The deployment of the dynamic locker system relies on a combination of custom hardware and cloud based software. The physical system is integrated into **Next modular electric pods** and consists of a mobile locker with **15 electronic solenoid locks** (12V/24V). The core control unit is an **ESP32 based relay board** equipped with a **WiFi connection** and supported by a **4G Modem** for continuous field connectivity. To ensure operational stability within the vehicle, the system includes a dedicated power supply unit with backup power.

<u>Data Collection and Processing Roles:</u>

NEXT is primarily responsible for the physical implementation and the collection of essential data to validate technical and economic feasibility. Data is gathered through three functional layers:

- Telemetry Layer: Records battery consumption (initial vs. ending %) and distance travelled (GPS tracked km).
- Operational Layer: Tracks throughput metrics, specifically successful vs. unfulfilled deliveries.
- Socio Economic Layer: Monitors labor costs and unit economics, such as cost per delivery.

The processing of this data is managed through a Google Apps Script API which connects the mailing system, the central database, and the IoT devices. Logic for stall selection and volunteer matching is automated via JavaScript coding within the cloud based Google Sheets environment. Unlocking events and PIN validations are logged in real time to maintain a precise audit trail of locker usage.
Synthetic Demand and Historical Baseline: The delivery demand was formulated based on historical data from the **Cityporto database** (Sept–Dec 2016). This included deliveries performed by Cityporto vans for GLS express parcels within Padua's Limited Traffic Zone (ZTL). Data was analysed using clustering algorithms to define demand distribution around the three designated loading/unloading zones: **Via Fra Paolo Sarpi 1 (Stall A)**, **Via Oberdan 2 (Stall B)**, and **Via Rezzonico 2 (Stall C).**

Functionally, the system works as follows:
The backend selects the best zone for the deliveries of the day according to the governing policy to respond to delivery demand.

1. The mailing system generates a number of email notifications for the customers of the day, a series of tuples (code, slot number) and updates a cloud database with these. Then, our employee fills the slots according to this database.
2. The vehicle is driven to the selected stall and awaits the customers
3. When a customer inserts the code provided in the external keypad:
    a. The system acquires the code and, via API call, queries our database.
    b. Our cloud backend confronts the received code with the generated table of the day.
    c. If the code *is not present,* it communicates to the customer and **access is denied**.
    d. If the code *is present,* then: the front door and the reserved slot are **unlocked**.
    e. *Optionally,* the user can enter a second code with the internal keypad and get another package.
    f. The vehicle door closes automatically after 30 seconds. If the retrieval of the package takes more, and the door closes behind the user, a *"panic button"* to unlock the door is located near the exit.

The unlocking events are logged in a spreadsheet.

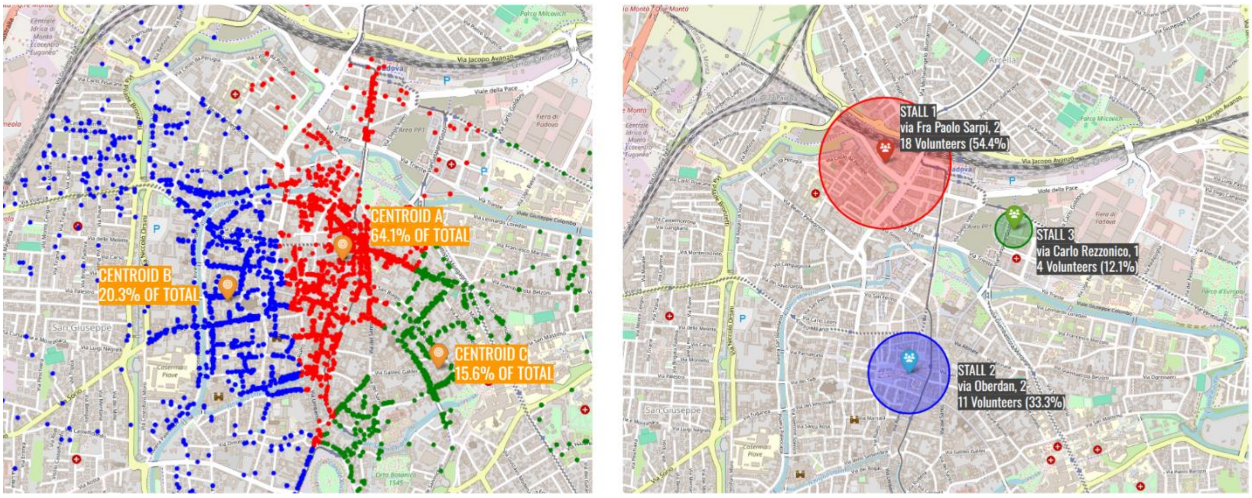


Figure 8 loading/unloading activities' density

Volunteer Grouping and Scenario Scaling

To create a synthetic demand normalized for the **37 available volunteers**, we matched historical clusters to stalls based on the preferred location of each volunteer group:

- Sarpi volunteers: 20
- Oberdan Volunteers: 12
- Rezzonico Volunteers: 5

From the full dataset, 14 days were selected to test each of the four delivery policies over two week intervals.

Stall Selection

Based on the daily demand, each day the policy was then applied to select the stall that will be served for the day, along with the correct number of packages and the correspondent volunteers.

STALL DEMAND		
A	B	C
11	4	2
9	5	1
10	4	4
9	5	1
12	2	2
9	4	3
9	5	1
8	5	2
9	4	2
12	3	1

Figure 9 Stall Demand across sites

Data and Email Sending Automation: All the data for the stall selection and volunteers association were managed in a Google Sheet on our Google Drive. This allowed us to automate the algorithmic procedures using AppScript, the cloud based scripting platform developed by Google, which lets us automate tasks across Google Sheets via JavaScript coding.

As the daily match between loading/unloading zones, packages and volunteers was generated, two emails were automatically sent to the recipients (using AppScript), along with a randomly generated code (see figure) that would be needed to open the vehicle's door and assigned locker. A notice mail was sent one day before (Friday if the pick up date was set on Monday), and a pick up email was sent on the day of the designated package collection. The email structure was clear and concise, recalling the design of common delivery system notices.

Ciao Greta Russi,

Grazie per aver partecipato al progetto **DISCO!**

Puoi ritirare il pacco nella giornata di **oggi 09/10/2025 dalle ore 11:30 alle ore 13:00**, presso:

[Parcheggio Sarpi 1 (Stall A)]

Il tuo codice PIN è:

0978D

Inserisci il PIN nel tastierino accanto alla porta laterale per aprire il locker. A questo link trovi un video con le istruzioni complete su come utilizzare il locker

Per qualsiasi problema o domanda, non esitare a contattarci.

Grazie,
Il team DISCO e Next

Figure 10 Email sent upon stall booking

Start of early deployment: The early deployment phase of the innovative dynamic locker service started on September 1st 2026. This three month pilot program assessed the service's performance by collecting data required to determine the following Key Performance Indicators (KPIs):

- Total Distance Travelled: The total kilometres covered by the service vehicle.
- Daily Operational Cost: The sum of energy consumption and human resource costs per day.
- CO2 Emissions: Calculated as the CO2 equivalent (CO2e) based on kilowatt hours (kWh) consumed, given the fully electric nature of the vehicles.
- Cost per Kilometre (€/km): The ratio of the total operational cost to the total distance travelled.

Figure 12 Pod in Rezzonico stall

Figure 11 Delivery final phase Captured on Open Day

Assessment Methodology and Success Parameters: The service operated daily, with the vehicle positioned at one of the three designated loading/unloading zones to deliver packages to volunteers. To evaluate the effectiveness of the different delivery strategies, we established a **comparative baseline** using the **Random** and **Cyclic** policies.

The success of each policy is measured through the **Delivery Success Rate**, determined by analyzing the final count of successfully delivered versus undelivered packages. This analysis is performed upon the completion of the delivery route or the expiration of the designated service time, whichever occurs first. These parameters allow for a direct comparison between the baseline (unoptimized) scenarios and the advanced **Greedy** and **Waiting** algorithms.

DISCOLLECTION

DISCOLLECTION relates to the data collected during the DISCOPROXI and DISCOCURB demonstrations in Padua, the data is categorized and described below, including the interaction with the urban freight data space.

Data collected from dynamic lockers

- The data collected provides a high resolution window into the performance of the mobile locker across the Sarpi, Oberdan, and Rezzonico stalls. The data is categorized into three primary functional layers: **Telemetry & Environmental Layer**: Monitoring of battery state (Initial, Ending, and Δ %), energy consumption (kWh), distance travelled, and CO_2 equivalent emissions.
- **Operational & Logistical Layer**: Throughput metrics (Packages delivered vs. Undelivered), curbside interaction performance, and efficiency KPIs like deliveries per km.

- **Socio Economic Layer**: Tracking the number of drivers/volunteers and detailed financial mapping (cost per package/km).

Meta data Collection Methodology

The metadata is collected through a **hybrid approach**:

- **Automated**: Battery and energy consumption data are taken directly from the **vehicle interface**.**Manual**: Kilometers travelled, delivery success/failure counts, number of drivers, and operational costs are manually calculated and inserted into a **daily Google Sheet** by NEXT operators.

Data Collection Responsibility and Input

The responsibility for data collection and input is divided between the technology providers and the municipal platform managers. NEXT, as the vehicle and locker provider, is responsible for collecting all operational data related to the dynamic lockers. Data entry is performed by NEXT's staff and drivers, who manage the daily operations. For the curbside management component (DISCOCURB), data is automatically generated and managed through the booking platform developed by CodaQ S.r.l.

Data Collected through the Booking Platform

The DISCOCURB platform collects structured operational data generated through reservation APIs. Each reservation record is stored in the backend to support real time operations and include:
UUID: Unique identifier of the reservation.
Geometry: Geographic location (Point coordinates).
Description: Identifier for the specific parking slot or loading zone.
Temporal Data: Date, Start Time, and End Time of the reservation.

Data Collection and Formats

Initially, APIs were developed to manage the reservation of parking and loading/unloading areas. Following this first release, two additional API endpoints were introduced to allow access to aggregated data for statistical and analytical purposes. Upon request, the data returned by these endpoints can be formatted in **GeoJSON** to ensure compatibility with map based applications. Data can be returned either as an array of GeoJSON Feature objects or as a single Feature Collection.

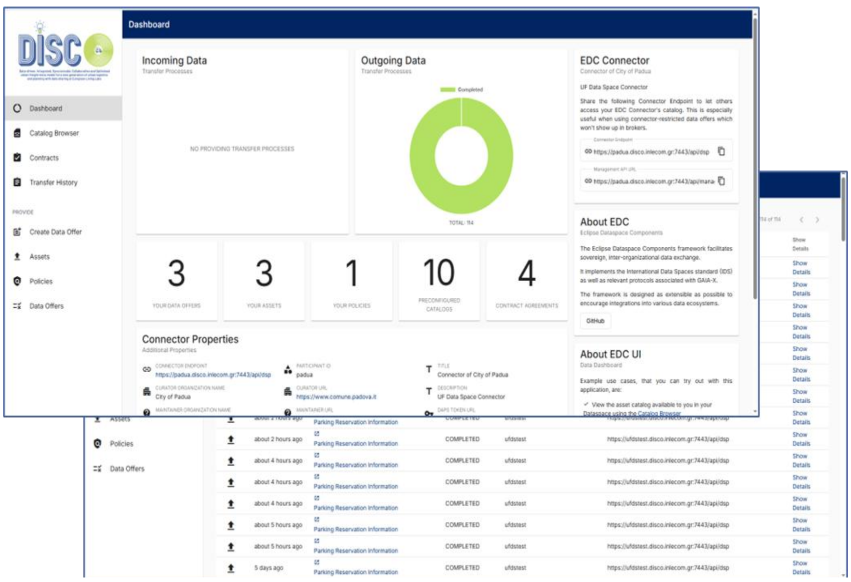


Figure 13 Urban Freight Data Space Interface for Padua

Data Sharing through the Urban Freight Dataspace A subset of the booking data is shared through the **Urban Freight Dataspace (UFDS)** to support interoperability and aggregated analysis. Shared data include geographic locations, UUIDs, and time slots.The shared dataset focuses on spatial and temporal information and does not include personal or sensitive user data, ensuring compliance with privacy requirements.

APIs Used by the Dataspace Connector

The Dataspace Connector interacts with the booking platform through RESTful APIs . Following the release of the GeoJSON enabled APIs, **INLECOM** successfully integrated these endpoints into their systems for spatial visualization.

2.1.7. Results

The DISCOPROXI pilot demonstrated a clear **Technology Readiness Level (TRL) evolution** by successfully integrating modular electric pods, dynamic lockers, and on demand loading/unloading stalls under real urban conditions. Operational validation confirmed that the system can be **scaled to multiple city zones**, with pods and lockers functioning reliably in combination with the booking platform, supporting adaptive last mile logistics and environmental efficiency.

The analysis of quantitative and qualitative data confirms several key operational insights. **Stall accessibility** remains a critical factor, as blocked or unavailable stalls reduce delivery success rates and increase operational costs. **Algorithmic assignment (Greedy)** effectively prioritises immediate benefits, but can lead to uneven locker usage and longer travel distances for some deliveries. **Technical interruptions**, such as locker failures, PIN duplication, or service cancellations, affect both cost efficiency and environmental performance. The integration of **observational data** from the pilot allowed correlating anomalies in occupancy, success rate, and delivery times, demonstrating the need to consider human and infrastructural factors alongside algorithmic optimisation.

Delivery Success Rate of the Policy Evaluation

Table 3 Positioning Policy Success Ratings

Policy Evaluation	Random	Cyclic	Greedy	Waiting
SUCCESS RATE	66,70%	68,17%	84,44%	77,19%

In conclusion, the pilot confirmed that the TRL of the system has advanced through real world validation and upscaling tests. Mean occupancy of loading/unloading zones indicates sufficient coverage but highlights areas for optimisation, particularly underused zones such as Rezzonico. Data collected through the booking platform provide actionable insights for stall allocation, operational planning, and future scaling to other cities, supporting a data driven approach for efficient, reliable, and sustainable urban logistics operations.

During the three months early operations Next delivered 328 packages across three different stalls: Sarpi, Oberdan and Rezzonico.
As shown in the graph below such deliveries were divided as it follows: 209 Sarpi, 82 Oberdan and 37 Rezzonico.
The unfulfilled packages were 126 respectively: 59 Sarpi, 39 Oberdan, 28 Rezzonico.

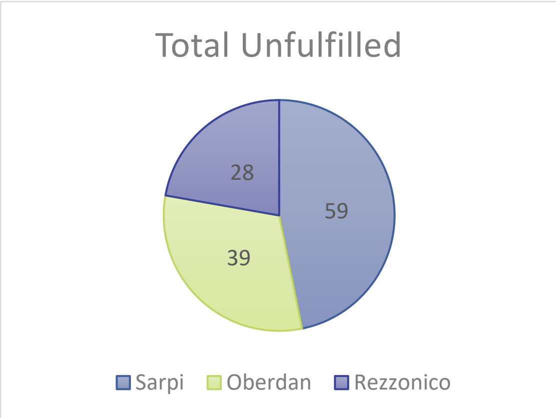


Figure 14 Unfulfilled deliveries per stall

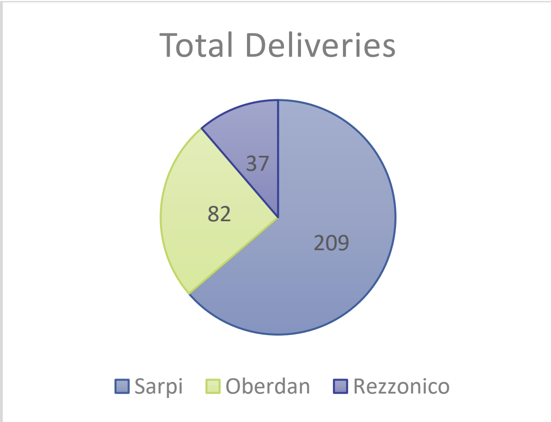


Figure 15 Total deliveries per stall

Such statistics highlight a success rate per stall of 78%, 68% and 57%, making Sarpi the most successful stall.

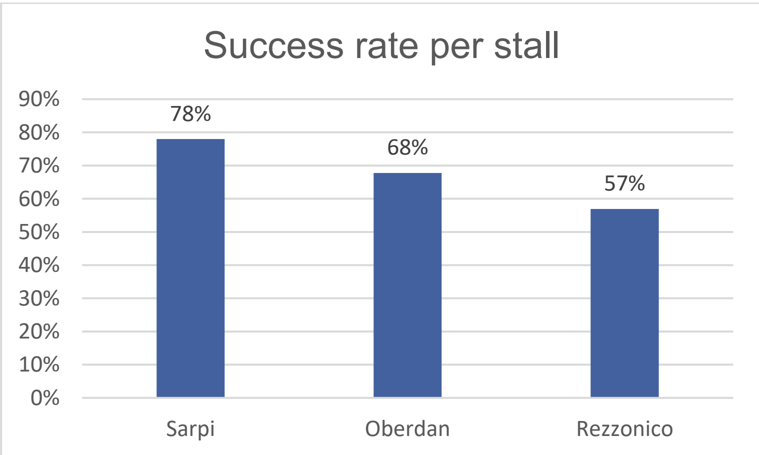


Figure 16 Success Rate of deliveries

The total kilometers driven were 607,2 with a total TONs of CO_2 equivalent emission of 0,092. Being our vehicles fully electric they do not directly emit CO_2, but the parameter has been calculated multiplying the amount of kWh consumed per 0,257 as indicated by ISPRA and divided by 1000 to convert it in TONs.

An interesting geographical discrepancy exists between our two busiest stalls:

- Sarpi: 268,8 km traveled over 32 trips.

- Oberdan: 252 km traveled over only 15 trips.

Despite Sarpi handling more than double the trips of Oberdan, the total mileage differed by only 16,8 km. This efficiency is due to Sarpi's proximity to the central hub, which is roughly half the distance of the route to Oberdan.

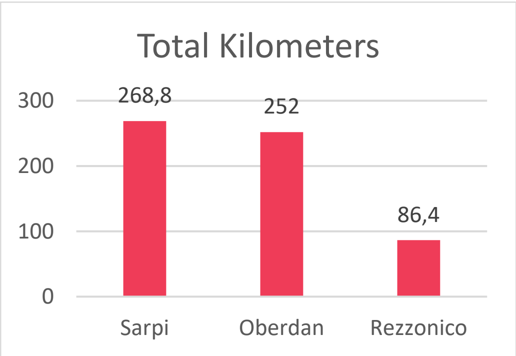


Figure 17 Vehicle kilometers

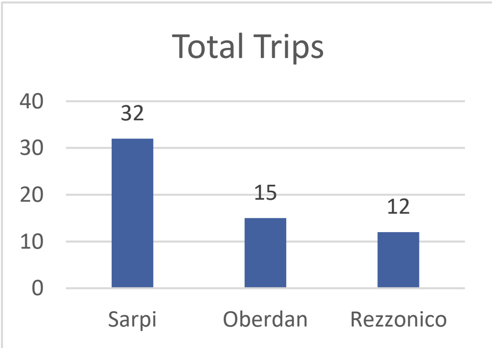


Figure 18 Vehicle trips

Because Next is offering a pioneer service, we lacked historical data for benchmarking. Consequently, we utilized Random (64,41% success) and Cyclic (68,17% success) policies to establish a baseline. As expected, these returned the lowest success rates.

- Greedy Policy (84.4% success): This was the most efficient strategy. It prioritized Sarpi to maximize volume but completely bypassed Rezzonico due to its lower demand. For this reason it has been tested less than the other policies.
- Waiting Policy (77,19% success): Although it yielded a slightly lower success rate than the Greedy policy, it offered a "fairer" distribution by ensuring stalls with less demand were still serviced. We have extended the testing period for this policy to better evaluate its long term viability.

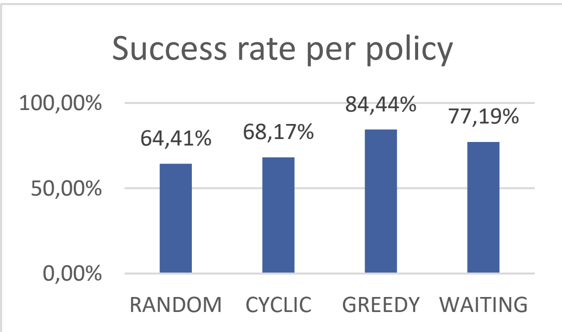


Figure 19 Policy success rates

Table 4 Policy Success Rates

Trips x stall x policy	RANDOM	CYCLIC	GREEDY	WAITING
Sarpi	6	5	8	13
Oberdan	4	5	2	4
Rezzonico	5	5	0	2

Currently, the cost per delivery stands at €14.94. While this figure is high, it is a expected byproduct of our early stage safety protocols and limited initial capacity.

Current Cost Breakdown

- Driver/Operator Labor: 95%
- Trip & Energy Costs: 5%

The primary driver of this cost is our conservative safety approach: we currently opted to keep an operator in or near the POD at all times. Additionally, for these pilot operations, we capped daily deliveries at just 9 units per day. Moving toward full operational maturity, a radical shift in unit economics is expected through two primary levers: Automation and Capacity Expansion.

1. Optimized Labor Utilization: in a fully operational environment, continuous human monitoring will no longer be required. Operators will only be accounted for during actual driving/intervention time. By reducing the driver cost attribution by a conservative 70%, we align our labour expenses with industry standards for autonomous and semi autonomous logistics.
2. Radical Capacity Increase: our current prototypes are underutilized by design. The next generation of Next PODs will feature:

    - Enhanced Hardware: better designed lockers with higher density.
    - Increased Volume: a single POD can carry 50+ medium packages.
    - Modular Coupling**:** by attaching 2 or 3 PODs together, we increase total vehicle capacity by **16–17x** compared to our current operations.
    - By combining labor efficiencies with our modular capacity scaling, we project a dramatic reduction in delivery costs.
    - **Projected Cost per Delivery: €0.50** (it accounts for additional costs not considered during the early operations such as depreciation or insurance cost, these costs must be further investigated in following steps of the implementation)

- This transition from €14.94 to €0.50 transforms the service from a technical pilot into a **highly competitive, high margin logistics solution** capable of disrupting the last mile delivery market.

Draft Plan for Automation & Capacity Expansion

To achieve the projected unit economics within current and evolving EU regulatory frameworks, the proposed automation roadmap shifts the focus away from unmanned public road driving. Instead, the strategy targets **capacity utilization (via physical coupling)** and the **automation of the parcel handover process**. This transition is structured as a progressive, three phase development plan:

- **Phase 1, physically Coupled Convoy (Driver to Volume Ratio)**: the initial scaling step involves a single human driver operating a "Lead POD," which is physically coupled to 2 or 3 "Follower PODs" (the lockers). This configuration immediately divides the driver's labor cost across multiple vehicles. Because the PODs are physically linked, they operate legally as a single articulated vehicle, effectively increasing the total carrying capacity per driver by 16–17x.
- **Phase 2, automated Decoupling & Stationary Service (The Mobile Locker):** upon reaching a designated urban drop zone, the Follower PODs are designed to automatically detach and park. From this moment, these detached units operate as fully automated stationary lockers. The human driver continues the route with the Lead POD for door to door deliveries. This process effectively removes the human operator from the parcel handover phase for the bulk of the cargo.
- **Phase 3, yard Automation & Remote Supervision:** while public roads will continue to require a human driver, the physical coupling and decoupling processes within private logistics depots (or designated municipal geofenced areas) are planned to be fully automated. Concurrently, a centralized Remote Supervision Hub will monitor the health and security of the deployed, stationary lockers across the city.

Basic Requirements for Automation

To successfully execute this roadmap, the foundational requirements fall into three main areas:

1. **Technology:** reliable physical coupling mechanisms for the vehicles and secure IoT infrastructure to allow independent user access to the lockers.
2. **Infrastructure:** a centralized remote supervision backend that seamlessly integrates with the logistics operators' existing routing software.
3. **Regulation:** ongoing compliance with European multi module vehicle regulations and municipal framework agreements for temporary curb side locker placement.

Average occupancy across three main zones highlighted:

- Sarpi: high utilization
- Oberdan: medium utilization

- Rezzonico: low utilization, pinpointing opportunities for operational improvements and next stage TRL testing.

DISCOCURB

The DISCOCURB booking platform further contributed to TRL advancement by validating the software and data driven management of urban curbside spaces:

- **Data collection and analytics:** Real time and historical booking data allowed measuring stall efficiency, providing evidence based criteria for allocation, time slot management, and potential expansion.
- **Operational validation:** The platform proved reliable in managing dynamic reservations, supporting TRL progression from a software prototype (TRL 4–5) to a validated operational system (TRL 6–7).
- **Integration with SULP and local policy relevance:** By feeding data into the **Shared Urban Logistics Platform**, DISCOCURB connected technological implementation with governance. The analysis supported the integration of **SULP guidelines** and the adoption of a **new municipal ordinance** for flexible curbside management, optimizing low emission urban logistics and shared public space usage.

DISCOLLECTION

The DISCOLLECTION component focused on interoperability and integration with the **Urban Freight Data Space**, enabling TRL progression in the data and digital infrastructure domain:

- **API implementation and data exchange:** Proper management of datasets, including GeoJSON compatible formats for mapping applications, demonstrated operational readiness for data driven logistics (TRL 6–7).
- **Stakeholder engagement:** Although engaging external stakeholders proved challenging, connection of available datasets via CodaQ demonstrated practical interoperability, supporting TRL advancement toward system validation in a real operational environment.
- **Operational insights:** Analysis confirmed correlations between stall availability, delivery success, and route efficiency, reinforcing lessons learned from DISCOPROXI and DISCOCURB.

2.1.8. Lessons Learnt: Transferability and Replication

DISCOCURB

The Padua Living Lab pilot provided important insights into the operational, technical, and organisational challenges of implementing dynamic urban logistics solutions. The following issues were observed, along with the lessons learnt for future deployment and scaling:

variable message signage (VMS) procurement presented delays caused by cross departmental municipal contracting were overcome by establishing a direct contract with a specialist software provider.

The five ongoing challenges share a common thread of coordination failure at different levels:

- Physical infrastructure is constrained by the absence of available kerbside space in the historic centre; the project is currently scoping conversions of existing areas into loading/unloading bays.
- Governance and stakeholder alignment remains a bottleneck, with slow decision making hampering the definition of operational procedures for new loading zones.
- Enforcement gaps undermine the booking system on two fronts: illegal occupation by third parties, and scheduling conflicts between private operators and municipal maintenance crews who held overlapping valid permits without visibility of each other's bookings. Both point to the need for cross departmental communication protocols and stronger enforcement presence.
- Operational resilience is currently low. If a reserved stall is unavailable, the entire delivery route fails. The proposed mitigation is clustered stall redundancy, creating fallback options within the same vicinity.

The overarching lesson is that technology deployment (VMS, booking systems) is insufficient without corresponding institutional coordination, enforcement capacity, and physical infrastructure to back it up.

DISCOPROXI

- **Inefficiency of standard professional lockers** *Resolved*
  Off the shelf "professional" lockers are ill suited for installation on pods. They present three primary issues:
  - Cost: The dynamic lockers carry high acquisition and operational expenses.
  - Generic lockers are designed to withstand outdoor elements (weather and vandalism), protections that are unnecessary for a locker mounted inside a pod.
  - Their standard dimensions do not allow for optimal utilization of the limited space on board the pod.

It is better to adopt a **custom designed storage solution** built with bespoke components. This approach ensures the hardware fits the specific internal geometry of the pod, maximizing space efficiency while eliminating costs associated with unnecessary outdoor rated features.

DISCOLLECTION

The implementation of DISCOLLECTION, with specific reference to the CodaQ tender and the connection to the Urban Freight Dataspace, highlighted several technical and organisational challenges. These issues provided valuable lessons for improving tender specifications, API design, and interoperability with federated data spaces.

- **Alignment of Tender Specifications with Dataspace Requirements**
  During the CodaQ tender, the initial specifications mainly addressed operational booking functionalities. The experience showed that interoperability and data sharing requirements for connection to the Urban Freight Dataspace should be explicitly included from the tender definition phase.
- **Availability of Data for Statistical Purposes**
  The first release of the CodaQ APIs focused on managing reservations, while access to aggregated and historical data was limited. This highlighted the need to plan from the outset for statistical data access to support dataspace integration and monitoring activities.
- **Adoption of Standardised Data Formats**
  The request to provide booking data in GeoJSON format demonstrated the importance of adopting standardised spatial data formats. GeoJSON outputs enabled direct compatibility with map based systems and facilitated integration with the Urban Freight Dataspace.
- **Iterative API Development**
  The connection to the Urban Freight Dataspace required iterative refinements of the CodaQ APIs after the initial release. This confirmed that flexibility and incremental development are essential when local platforms are connected to federated data spaces.
- **Coordination with Dataspace Integrators**
  Collaboration with INLECOM during the API update process highlighted the value of early and continuous coordination with dataspace integrators to ensure that exposed endpoints meet dataspace technical requirements.

2.1.9. Beyond DISCO

Building on the results and insights obtained during the Padua Living Lab experimentation, the next steps for DISCOCURB focus on further enhancing operational efficiency, usability, and integration with the broader DISCO urban logistics ecosystem. Planned actions include:

System Scalability and Expansion

- Extend the deployment of on demand loading/unloading stalls to additional strategic areas of the city centre, increasing the coverage and flexibility of the urban logistics network.

User Experience and Platform Improvements

- Refine the web and mobile GUI to improve intuitiveness, reduce PIN related issues, and enhance booking visibility.
- Introduce advanced notifications for stall availability and booking reminders to optimise vehicle arrival and reduce conflicts.

Data Driven Optimisation

* Leverage the data collected through the booking platform and the Urban Freight Dataspace to inform predictive algorithms for stall assignment, time slot allocation, and traffic aware delivery planning.
* Analyse patterns of stall usage and vehicle arrivals to improve the efficiency and equitable utilisation of urban infrastructure.

Operational Reliability and Maintenance

* Implement preventive maintenance schedules and remote monitoring for digital signage and communication systems to minimise service interruptions.

Develop contingency protocols for temporary stall blockages, ensuring uninterrupted last mile delivery even under unforeseen circumstances.

Building on the promising results gathered during this initial operational phase, the next steps for DISCOPROXI will focus on transitioning from these successful early deployments to a robust, scalable commercial model. A primary objective is to refine our financial projections by conducting a more granular analysis of the Total Cost of Ownership (TCO). The intention is to move beyond the specific conditions of this first stage by factoring in realistic urban costs such as commercial parking permits and industrial energy tariffs to ensure the model is stress tested for market entry.
In addition to financial modeling, we plan to deepen our engagement with logistics operators to uncover any remaining hidden operational frictions and further refine the integration between our modular PODs and existing hub and spoke networks. This dialogue will be crucial for validating our capacity scaling theories. We aim to demonstrate how moving from the small scale delivery counts of our early operations to a full 150 package modular convoy can fundamentally disrupt current unit economics.

A key hypothesis for the upcoming phases involves the validation of our delivery policies against a significantly more substantial volume of data. While the current data has allowed us to establish a reliable baseline, testing our "Greedy" and "Waiting" algorithms with larger datasets would allow us to observe how these strategies behave under extreme demand fluctuations and high density scenarios. This would be a vital step in confirming whether the "Waiting" policy's fairer distribution remains the most effective approach when the service scales to full frequency urban activity.
Finally, we will focus on the regulatory requirements for "itinerant locker" status within urban centers. Ensuring that the flexibility of our mobile pods is matched by a clear legal framework is a priority for the next stage of development, as it will allow us to move from established baseline data toward a finalized, TRL 9 ready deployment strategy that prioritizes both high volume efficiency and inclusive urban service.

What needs to be in place to ensure continuity of innovation

The next phase of DISCOCURB requires a combination of technical, operational, and organisational prerequisites to ensure the smooth scaling and optimisation of on demand loading/unloading zones. Key requirements include:

1. **Infrastructure Readiness**
    * Availability of additional loading/unloading stalls in strategically selected city areas.

- Fully operational variable message signs and digital signage systems to inform drivers of real time stall availability.
- Reliable connectivity between stalls, pods, and the booking platform to guarantee seamless communication and monitoring.

2. **System and Platform Preparedness**
    - Upgraded web and mobile booking interfaces for improved usability and timely notifications.
    - Integrated backend systems capable of collecting, processing, and sharing booking and occupancy data with the Urban Freight Dataspace.
    - Algorithmic improvements to optimise stall assignment and ensure equitable distribution of deliveries across zones.
3. **Operational Coordination**
    - Staff training for drivers and operators to handle the dynamic deployment of pods and lockers.
    - Defined procedures for managing conflicts, technical failures, or unauthorised stall occupancy.
    - Alignment with municipal regulations and local authorities to secure permissions and manage public space use.
4. **Stakeholder Engagement**
    - Coordination with municipal authorities, freight operators, and other relevant stakeholders to support operational decisions.
    - Communication of operational guidelines and responsibilities to all parties involved in the pilot.
5. **Data and Analytics**
    - Collection and preliminary analysis of existing occupancy, booking, and delivery data to inform decisions on stall placement and scheduling.
    - Mechanisms for monitoring performance indicators (KPI) to measure success and identify areas for improvement during upscaling.

Meeting these requirements will ensure that DISCOCURB can be effectively scaled, delivering **efficient, reliable, and data driven last mile logistics** while maintaining alignment with urban policies and operational constraints.

Scaling the system requires securing logistics partnerships to generate the high volume data needed to stress test operational policies. Regulatory clarity is also needed, with municipal authorities required to define the legal framework for temporary ground occupation and parking permits for itinerant lockers before convoy deployment. Concurrently, finalisation of modular coupling protocols and locker designs will complete the hardware development needed to progress from TRL 8 to full market entry.

Concluding Policy Impacts.

Operational data from the DISCOCURB booking system will inform evidence based curbside space decisions within the next SULP phase, assessing whether existing loading/unloading stalls are optimally located, sufficient, and appropriately distributed. Booking, occupancy, and operational data will guide stall placement, time slot allocation, and potential system expansion, alongside technical constraints and policy considerations to ensure operational feasibility and regulatory alignment.

The Municipality of Padua is also engaging the national ministry to advocate for road code amendments enabling more flexible use of urban space, which would broaden the curbside management options available to the city. Together, these efforts aim to establish a scalable framework connecting Padua's operational lessons to national and European last mile delivery strategies.

2.2. Zaragoza

2.2.1. Background and rationale of the intervention

Figure 20 Zaragoza landscape

Zaragoza is the capital of the Aragon region. It has an urban population of 701,299 inhabitants, making it the fourth largest city in Spain. Located in the northeast of Spain, Zaragoza occupies a privileged geostrategic position in the Western European communications network. Thanks to its equidistant location—approximately 300 km from Madrid, Barcelona, Valencia, and Bilbao—and its advanced transport infrastructure, it has established itself as a key hub for trade and the distribution of goods.

A key element of this position is the Zaragoza Logistics Platform (PLAZA), one of the largest logistics centers in Europe, which combines road, rail and air transport, facilitating efficient connectivity at a national and international level. Furthermore, Zaragoza boasts a major cargo airport, key rail interconnections, and a dense network of highways, reinforcing its competitiveness as a global logistics hub.

2.2.2. Objectives

Internal Objectives:

The Zaragoza pilot is mainly based on the implementation, testing and validation of a last mile delivery microhub operated with clean vehicles (DISCOPROXI), together with the gathering, treatment and analysis of the relevant data for impact assessment and for future enhancement opportunities (DISCOLLECTION). On a later stage, the DISCOCURB solution was added to the Living Lab.

To achieve this, the Zaragoza Living Lab established a series of internal objectives:

- **Microhub design and evaluation:** implement and test a microhub near a municipal market to assess operational viability, business model, and replicability as a blueprint for a future citywide microhub network.
- **Data integration for logistics improvement** : consolidate dispersed urban freight data into a unified data space to drive continuous improvement in last mile operations, optimise service quality, and provide evidence based tools for public decision makers.
- **Stakeholder consolidation and collaboration**: build public and private stakeholder support around data driven, emission reducing initiatives and deepen cooperation with smart logistics operator CityLogin to accelerate sustainable last mile deployment.

External Objectives:

The external objectives focus on the broader impact of the Zaragoza pilot within the DISCO project and its contribution to the urban logistics ecosystem. The objectives include:

- **Proof of concept in real urban conditions**: Demonstrate the feasibility, efficiency, and environmental impact of clean vehicle microhub delivery systems, generating practical evidence for other cities and stakeholders.
- **Knowledge sharing across DISCO**: Promote exchange of insights, methodologies, and best practices from the Zaragoza pilot, including dissemination of data driven evidence, operational guidelines, and lessons learned for application in other Living Labs.
- **Policy and regulatory support**: Provide concrete data, analysis, and recommendations to inform decisions on low emission zones, urban mobility planning, and sustainable delivery strategies, aligned with local and European goals.
- **Stakeholder and community engagement: S**trengthen involvement of local businesses, logistics operators, and citizens; demonstrate tangible improvements in efficiency and environmental performance to encourage adoption of similar initiatives elsewhere and advance DISCO's broader city logistics objectives.

Targeted Policy/Strategic Goals

The Zaragoza Living Lab operates within a broader strategic and regulatory framework that guides the city's transition towards sustainable mobility, decarbonization, and climate neutrality. In particular, the pilot activities implemented under the DISCO project contribute to several key local and European policy objectives:

1. The living lab supports Zaragoza's Sustainable Urban Mobility Plan by optimising loading/unloading zones, reducing unnecessary vehicle circulation, and improving coexistence of freight operations with other sustainable mobility modes.

2. The lab also advances sustainable urban logistics planning through microhub consolidation, optimised delivery routes, and zero emission vehicles; generates reliable data for evidence based policymaking in support of the city's Logistics Plan (SUMP revised 2019, new plan expected 2027).

3. Facilitate the city's Low Emission Zone rollout by enabling zero emission last mile delivery, reducing vehicle kilometres travelled, and providing data to inform future LEZ regulations and logistics access policies.

4. Contribute to Zaragoza's EU Mission commitment to climate neutrality by deploying microhubs, promoting zero emission vehicles, and developing data driven logistics management tools that directly reduce urban freight emissions.

5. Support policy innovation and evidence based governance by integrating digital tools, AI, and real time data collection to support adaptive urban logistics policymaking, helping local authorities refine regulations and planning processes in line with local and European climate objectives.

The knowledge generated through the Living Lab will help local authorities refine mobility and logistics policies, improve planning processes, and support the design of future regulatory frameworks aligned with both local priorities and European climate objectives.

2.2.3. Living Lab Partners and Roles in Project

- **Fundación Zaragoza Ciudad del Conocimiento (FZCC):** The FZCC was the leader of the Living Lab until its dissolution and subsequent withdrawal from the DISCO project at the end of 2025. Its mission was to manage data governance and promote social innovation, as well as stakeholder engagement through mediation and mentoring in urban innovation.
- **Ayuntamiento de Zaragoza:** It is the institutional body that provides infrastructure, data, and facilities. It is responsible for decision making and acts as a regulatory body. It promotes the participation of the various stakeholders involved. It facilitates public private partnerships on infrastructure, regulations, and other matters. It provides information on the city's needs.
- **CityLogin**: Logistics service provider and last mile delivery operator with a fleet of electric and ultra low emission vehicles. They provide real activity data to feed predictive models to choose the best locations and business models, and test the use of solutions and facilities.
- **ALIA (Aragón Logistic Cluster):** An association representing global logistics. It facilitates collaboration and innovation in logistics, mobility, and transport in Aragón. It contributes with logistics performance data and insights from associated members, and facilitates data sharing among logistics operators

- **Zaragoza Logistics Center (ZLC):** A research center in charge of creating and validating DISCOCURB's model in Zaragoza.

2.2.4. DISCO Innovations:

- **DISCOPROXI**: To establish a collaboration between last mile operator (Citylogin) and the City Council to identify a currently under used urban space and install/test a logistics micro hub at the San Vicente de Paúl market to support last mile operations and reduce vehicle congestion in the city center. The facility will be operated by CityLogin (LSP) and will host part of its low emissions fleet. It leverages shared urban spaces and collaboration between stakeholders to facilitate greener and more efficient last mile logistics.
- **DISCOLLECTION**: To implement data driven logistics services to support local initiatives and sustainable freight transport implanting digital innovations with intensive use of freight data. Specifically, to develop a predictive model about local demand and last mile deliveries so that the local LSP (Citylogin) can optimize its resources and its deliveries' QoS, acting as a demonstrator upon which to attract more LSPs to collaborative, data driven modes of operation.
- **DISCOCURB**: To validate a Loading and Unloading Zones (LUZ) model for Zaragoza. Specifically, gathering combined B2B and B2C freight transport demand using accessible macro spatial models, and subsequently confront this demand against existing physical infrastructure, specifically Loading/Unloading Zones (LUZs), using stochastic queuing theory.

2.2.5. Utilised Datasets

- CityLogin freight operational data covering electric and ultra low emissions vehicle routes, delivery operations, and logistics service metrics
- SENATOR project data: Control tower dataset
- **Volveremos platform data:** Behavioural and commercial data from the Volveremos Groupon model digital platform
- UFDS – 4 datasets accessible in the Zaragoza dataset

2.2.6. Demonstration Description

DISCOPROXI

DISCOPROXI in Zaragoza establishes a public private microhub model in an underutilised municipal location, transitioning last mile delivery from traditional van based operations to a microhub model using pedestrian infrastructure and low emission vehicles. The pilot aimed to establish a public private framework for repurposing underutilised municipal space for sustainable logistics, improving delivery quality while reducing city centre vehicle traffic and emissions. The pilot also targeted job creation in urban logistics and sought to demonstrate a scalable, replicable model for other European cities.

Location and Context

Figure 21 Mercado St Vicente de Paul Photograph from https://www.senatorproject.eu/

- Situated in a 15 m² space within the San Vicente de Paúl municipal market, inside the Zaragoza Low Emission Zone
- Originally allocated to the Living Lab through the SENATOR project, where a locker based logistics facility already operates
- The site is located near the Historic City Centre, an area with high pedestrianisation, access restrictions, and strong last mile demand
- Serves as a consolidation point for deliveries originating from PLAZA, Zaragoza's main logistics platform, 15 km from the city centre

Operations

In the pilot, two high capacity assisted carts, each with a capacity of 750 litres, were used, allowing for the delivery of 60 parcels per day in two rounds. The average parcel size is 0.20 m3 and weighs 1 kg. The goods were mainly textiles purchased through e commerce. It enabled the delivery of 60 parcels in 6 hours of pure delivery activity (productivity of 10 parcels per hour) in the B2C model.

Figure 22 Loading packages into CityLogin cart

Goods arrive by high capacity van each morning and are sorted for distribution by electric vehicles, cargo bikes, and assisted delivery carts. Daily schedule:

Figure 23 Zero Emission Vehicle Types used by CityLogin

1. 10:00–11:00 Loading at PLAZA
2. 11:30 Arrival at microhub
3. 11:30–12:30 Sorting and departure
4. 12:30–20:30 Deliveries and collections
5. 20:30–21:30 Returns and end of day processing

Supporting Technology

Operations are supported by CityLogin's Transport Management System (TMS), which optimises on foot delivery routing and manages the use of large capacity assisted delivery carts. These carts operate on pavements and pedestrian areas, removing the need for road access during final delivery.

Figure 24 Rehabilitated previously underutilised space and e cart used by delivery personnel

Timeframe and Activity Data

- Operations launched 7 October 2024, coinciding with the peak e commerce season
- 120 parcels were delivered on the first day using two assisted delivery carts
- Pilot concluded 30 January 2025
- The logistics operator has shared an anonymised two week activity dataset from the most operationally mature period, representing peak turnover

Job Creation

- Two full time positions created (36 hours per week, Monday to Friday), dedicated to on foot delivery using the assisted carts
- Roles do not require a driving licence, lowering barriers to entry and improving accessibility for vulnerable jobseekers
- Positions are designed to generate local employment, with preference for workers able to commute on foot

Results of DISCOPROXI:

•Operational volumes are on an average of 95 packages per day.
•Deliveries by assisted carts are reduced to Monday through Friday only at mid of December due to lack of volume in weekends.
•On weekends, deliveries are made by ONE electric tricycle due to the low volume of orders (around 50 deliveries) mixed with peripheral areas.
•A total of 7,058 B2C packages were distributed during the Pilot period.

Reducing operations to Monday through Friday and providing service on weekends with electric tricycles from the point of origin reduces the impact of labor costs. A few points can also be made regarding the pilot results:

- Labor costs now account for 70% of the business, equipment costs have been reduced to 18%, and activity support costs to 12% (the delivery cost breakdown has been redefined).
- The **total cost per delivery increases by 6.3%** without currently having any costs for the premises.
- Punctuality in deliveries slightly ahead compared with business as usual, improving reliability in time slots by 25%.

In addition to this, the worker's sentiments were:

- They view their daily work very positively, as their stress levels are reduced when searching for parking and in relation to traffic jam.
- They report feeling closer to the neighbourhood residents.

- On the negative side, rain and wind have caused a minor ankle injury due to a slip, which has led to analysis of footwear adapted to the routine of delivery on foot pushing an assisted trolley, as well as breathable warm/rain protection clothing for longer activity time outdoors.

DISCOCURB

Zaragoza has 779 Loading and Unloading Zones (LUZ) across the city, but their availability does not always match actual demand. Freight transport planning has traditionally been secondary to passenger mobility, resulting in inefficiencies and traditional micro agent based simulation models for loading and unloading zone allocation, while highly accurate, are computationally heavy, require massive amounts of disaggregate data, and are notoriously difficult for municipal planners to implement and maintain. Zaragoza has thus developed a replicable LUZ location methodology based on queuing theory and Poisson distribution, integrating georeferenced open data, commercial licenses, and fieldwork to model.

This section outlines the practical, questionnaire based methodological framework developed for DISCOCURB. The objective is to gather combined B2B and B2C freight transport demand using accessible macro spatial models and subsequently confront this demand against existing physical infrastructure, specifically Loading/Unloading Zones (LUZs), using stochastic queuing theory. DISCOCURB approach is highly dependent on structured questionnaires distributed to three key stakeholders: consumers, retailers, and delivery operators/drivers.

Spatial and Mathematical Modeling Framework
To translate research into practice for Zaragoza, virtual multi agent network routing was avoided, instead utilizing a two step modeling approach:

- **Spatial Regression with Demographic Proxies:** DISCOCURB calculates a combined B2B/B2C demand index at the zonal level (e.g., zip codes or grid cells) using standard multiple linear regression 2, 3. This allows to estimate total last mile deliveries based on spatial variables like retail sector employment and residential population density, mapping the results using Geographic Information Systems (GIS).
- **Stochastic Queuing Models for LUZs:** To evaluate if the existing LUZs can handle the estimated spatial demand, each LUZ is treated as an isolated service system. For basic capacity approximations, the **M/G/c/∞/FIFO model** is utilized, which simulates waiting times based on random arrivals and general delivery durations 4, 5. For highly congested areas where physical queuing on the street is impossible, the **M/M/C/C Markov model** is applied, to calculate the probability of the LUZ being completely full, resulting in rejected vehicles and illegal parking.

Data Collection Strategy

The foundation of the spatial and queuing models relies entirely on primary data gathered through targeted questionnaires.

- *Consumer Questionnaires (B2C Demand)*

To construct the B2C segment of the spatial demand model, questionnaires are deployed to households to capture online shopping behaviour and delivery preferences.

- **Dependent Variables:** The foundational question across all B2C models asks consumers about their frequency of online shopping and parcel orders. DISCOCURB also captures preferred delivery locations (e.g., home, workplace, parcel locker, or physical shop) depending on the type of goods purchased.
- **Independent Variables (Demographics):** The surveys gather core socio economic descriptors, with Age and Income being the most universally applied variables to predict online shopping behavior. DISCOCURB collects data on Gender, Education, and Household Size (number of children).
- **Spatial Proxies:** DISCOCURB requests the consumer's zip code and residence type (e.g., single family home vs. large apartment building). In the spatial model, this data is scaled using population density and urbanization levels to allocate B2C parcel demand across the city.

- *Retailer Questionnaires (B2B Demand)*

To gather Freight Trip Generation (FTG) for the commercial sector, DISCOCURB deploys surveys to local businesses and retailers.

- **Establishment Size and Economics:** Every reliable study relies on measuring the establishment's size to predict delivery frequency. Therefore, the questionnaire captures the number of employees, the floor area in square meters, and the specific economic sector or industry category (e.g., grocery, clothing, food service).
- **Deterministic Operational Inputs:** To size the loading zones mathematically, DISCOCURB asks retailers explicit operational questions: How often do you receive deliveries (daily/weekly amounts)? What are your preferred delivery time windows? What types of vehicle classes (e.g., light vans vs. heavy trucks) usually drop off your goods?

- *Delivery Operator and Driver Questionnaires (Supply and Queuing Parameters)*

To feed the mathematical queuing models without relying on external ambient city traffic data, DISCOCURB gathers operational and behavioural parameters directly from the delivery companies and their drivers.

- **Infrastructure Capacity (c):** Because only the linear length of the LUZs is known, DISCOCURB asks operators for the dimensions of their vehicles and the extra clearance space required for rear or lateral unloading manoeuvres. This allows to divide the linear curb space into a discrete number of parallel "servers" or bays (c).

- **Arrival Rates (λ) and Service Times (μ):** DISCOCURB asks operators for the distribution of their delivery times (e.g., what percentage of deliveries take less than 5 minutes vs. 15 to 29 minutes). This variance serves as a General service time distribution (G). DISCOCURB also requests the number of vehicles arriving during peak hours.
- **Driver Behavioural Thresholds (Reneging):** To model system failures, DISCOCURB surveys drivers on their psychological limits: *"What is the maximum waiting time you accept before giving up?"*, and *"What alternative actions do you take if the LUZ is occupied?"* (e.g., double parking, cruising, rescheduling).

Model Integration and System Evaluation
Once the questionnaire data is collected, DISCOCURB combines the B2B and B2C demand to evaluate the urban infrastructure.

- **Time Varying Demand:** The total surveyed deliveries are transferred into a time varying arrival rate, $\lambda(t)$. Because B2B deliveries often peak in the morning and B2C fluctuates differently, DISCOCURB distributes the combined demand across the hours of the day to feed a Non Homogeneous Poisson Process.
- **Combined Service Rates:** DISCOCURB factors the distinct operational realities into the service time distribution, $G(t)$. For instance, B2C parcel deliveries require shorter dwell times, whereas B2B bulk deliveries require significantly longer durations.
- **Evaluating Traffic Intensity (ρ):** DISCOCURB calculates the traffic intensity for the specific zone using the formula $\rho(t)=\lambda(t)/[\mu(t)\times c]$. If this calculation results in $\rho(t)>1$, it proves mathematically that the combined B2B+B2C demand exceeds the physical capacity of the LUZs at that specific time.

Scalabilty
The methodology outlined for DISCOCURB implementation in the city of Zaragoza provides a, data driven tool for local authorities. By relying on structured questionnaires rather than complex micro simulations, municipalities can easily gather the necessary parameters to evaluate their street space. Crucially, by integrating driver behavioural thresholds into the queuing models, DISCOCURB demonstrates that unbounded queues ($\rho>1$) do not merely cause delays; they directly translate into negative urban externalities, such as cruising for parking, double parking, and illegal sidewalk occupation. This framework can empower policymakers to mathematically prioritize where loading zones, micro hubs, or new enforcement policies should be spatially deployed.

Results DISCOCURB
Due to the DISCOCURB demonstration still being active at the time of publishing, the full results will be published in the Twinning Living Lab Evaluation Handbook deliverable D5.3. expected to be published in July 2026.

DISCOLLECTION

Within the Zaragoza Living Lab, DISCOLLECTION focuses on the data driven identification and validation of proximity based microhub locations for urban parcel collection. The demonstration combines:

- Geospatial modelling of parcel demand.
- Evidence based prioritisation of candidate locations.
- Validation of the existing DISCO microhub in San Vicente de Paúl.
- Identification of scalable expansion areas.
- Definition of technical, spatial and infrastructural requirements.

Rather than testing a purely conceptual model, the activity was developed in a real urban context, using operationally relevant datasets and the existing pilot microhub as a validation reference point. The exercise therefore constitutes a structured planning demonstration that directly informs deployment decisions and reduces uncertainty for scaling.

Unlike conventional last mile pilots focused exclusively on operational KPIs, Zaragoza contributes a methodological demonstration layer, enabling demand driven infrastructure deployment aligned with real spatial conditions.

Data Driven Demand Modeling (EDPI Framework)

The Zaragoza pilot implemented a composite E-commerce Demand Potential Index (EDPI) integrating:

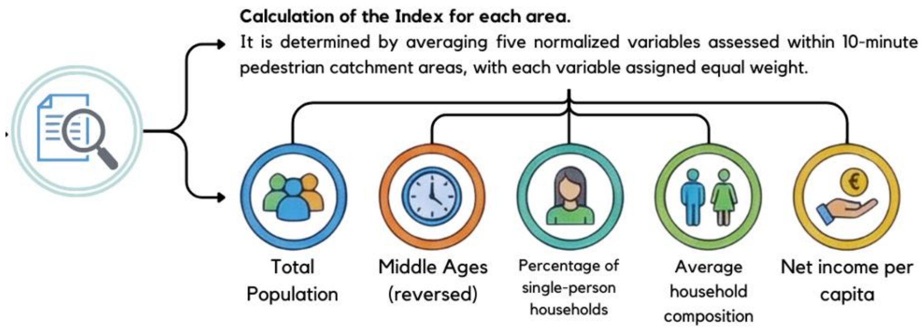


Figure 25 EDP Index input data

All variables were normalised using min–max scaling and equally weighted to ensure transparency and methodological neutrality. The objective was not to estimate absolute parcel volumes, but to establish a relative demand ranking across neighborhoods under consistent spatial criteria.

Catchments were defined using 10 minute walking isochrones, ensuring that potential microhub service areas reflect realistic pedestrian accessibility rather than administrative boundaries.

Spatial Distribution of Demand Drivers

Prior to aggregating variables into the EDPI, Zaragoza conducted a spatial exploration of individual demand drivers to identify structural clustering patterns.

Key findings include:

- Strong population concentration in consolidated central districts.
- High prevalence of single person households in the urban core.
- Purchasing power gradients reinforcing central cluster suitability.
- Clear spatial differentiation between dense mixed use districts and lower density peripheral areas.

This variable level analysis ensured transparency in index construction and supported evidence based interpretation of cluster formation.

Identification of High Demand Clusters

Neighbourhoods were classified into:

- Very High Demand
- High Demand
- Moderate Demand
- Low Demand

Which revealed a continuous high demand cluster across the areas: Centro, Universidad, Casco Histórico, Parts of Delicias and San José. These clusters combine:

- High pedestrian accessibility
- Demand density
- Mixed use urban fabric
- Strong residential commercial overlap

The clustering confirms that e commerce demand in Zaragoza is spatially concentrated rather than uniformly distributed, reinforcing the logic of proximity based parcel collection.

Table 5 Consolidated neighbourhood level indicators (Each row represents a functional urban catchment defined by a 10 minute walking isochrone; some big districts were subdivided)

Area_ID	District	Total Population	Average Age	Total Homes	% unipersonal homes	Average Home Size	Net income per person	Net income per home	Pedestrians/day	Population entrance	Population exit	Commercial Spaces	Offices	% touristic residences	EDPI
ZAR_01_1_ACTUR	ACTUR	27832	45,75	10827	21,7	2,6	15759,48	40754,86	140	19541	16139	4090	635	0,3	24,8
ZAR_01_2_PARQUE_GOYA	ACTUR – PARQUE GOYA	8863	37,14	3038	23,64	2,73	13984,13	38234,28	402	3198	3436	4562	998	0,45	25,3
ZAR_02_CASABLANCA	CASABLANCA	11951	46,19	3950	26,12	2,56	21978,76	56917,79	2423	5031	3818	2894	555	0,35	38,9
ZAR_03_1_CASCO_HISTOR	CASCO HISTORICO	30333	45,39	13251	36,51	2,27	16144,53	36563,11	8325	18310	18777	10416	2593	1,51	53,8
ZAR_03_2_GANCHO	GANCHO	28187	46,15	12621	36,9	2,25	15055,11	33997,91	2819	13683	17297	16854	3060	1,63	50,4
ZAR_04_CENTRO	CENTRO	38855	47,69	16806	39,19	2,2	19912,69	44152,96	7385	13365	12743	12124	2723	1,49	67,0
ZAR_05_DELICIAS	DELICIAS	63186	46,28	26746	33,79	2,35	13507,72	31801,08	6317	41953	47389	9332	1022	0,36	52,3
ZAR_06_1_MONTECANAL	DISTRITO SUR	9204	35,46	3687	23,46	2,71	17542,85	48833,48	6	3960	3876	2894	555	0,24	36,9
ZAR_06_2_ROSALES_DEL_	DISTRITO SUR	6611	36,57	2027	21,57	2,78	15461,34	43116,02	6042	2082	2411	3678	680	0,18	25,0
ZAR_07_RABAL	RABAL	28384	43,57	10634	26,83	2,53	14657,72	37231,63	2148	18641	20609	4090	635	0,59	33,6
ZAR_08_LA_ALMOZARA	LA ALMOZARA	26606	47,95	11811	29,23	2,36	15289,46	36443,2	6176	18642	18343	13531	1769	0,48	35,8
ZAR_09_LAS_FUENTES	LAS FUENTES	52873	47	22629	33,46	2,29	13697,56	31346,19	3900	33786	34512	11555	2710	0,56	49,7
ZAR_10_MIRALBUENO	MIRALBUENO	10097	38,15	3078	21,56	2,74	16241,29	45179,3	1080	3750	4790	7222	592	0,64	26,9
ZAR_11_1_VALDEFIERRO	VALDEFIERRO	10051	42,02	3376	21,12	2,7	16500,79	44882,5	6176	4211	3992	3678	680	0,2	22,2
ZAR_11_2_OLIVER	OLIVER	18867	41,92	7236	23,87	2,63	15121,44	40295,43	5236	7998	8191	7222	592	0,44	27,5
ZAR_12_SAN_JOSE	SAN JOSE	50507	47,7	22543	32,94	2,31	15474,24	35707,2	4296	21114	24962	6227	1501	0,37	50,6
ZAR_13_SANTA_ISABEL	SANTA ISABEL	11842	41,45	4145	19,72	2,75	14638,28	40483,54	2819	3541	4596	472	363	0,22	16,2
ZAR_14_TORRERO_LA_P	TORRERO LA PAZ	34075	45,54	14727	31,68	2,35	13364,71	31480,9	543	14857	15083	7321	1234	0,21	40,7
ZAR_15_UNIVERSIDAD	UNIVERSIDAD	44723	47,77	19293	37,86	2,23	18786,69	42362,63	6848	22140	19826	14599	2472	0,38	63,9

Candidate Microhub Locations

Based on EDPI results and spatial continuity analysis, three primary nodes were identified.

1. Centro (Primary Anchor Node)

Centro emerges as the strongest candidate due to:

- 38,855 residents (10 min catchment)
- 39.2% single person households
- Net income per person: €19,913
- 7,385 daily pedestrians
- Strong commercial density

Centro combines residential demand with activity driven flows, positioning it as a scalable anchor node within a potential multi hub network.

Figure 26 Primary candidate: CENTRO

2. Universidad (High Stability Node)

Universidad shows:

- 44,723 residents
- 37.86% single person households
- Net income per person: €18,786
- 6,848 daily pedestrians

Compared to Centro, Universidad presents greater spatial flexibility, strong residential stability and balanced activity flows;This makes it suitable for sustained, medium scale microhub operations.

Figure 27 Secondary candidate: UNIVERSIDAD

3. San Vicente de Paúl (Current DISCO Microhub Location)

The existing pilot microhub location was assessed against EDPI results.

- 30,333 residents
- 36.51% single person households
- 8,325 daily pedestrians
- Moderate but stable purchasing power

The analysis confirms strong alignment between pilot location and high demand cluster. However, spatial constraints linked to historic urban fabric limit large scale expansion potential. San Vicente de Paúl is therefore best interpreted as a high intensity demonstration node which is operationally suitable at small to medium scale. It is complementary to additional nodes in Centro and Universidad.

Figure 28 Current DISCO Microhub at San Vicente de Paúl

Data Technology, Real Estate and Infraestructure Requirements

In accordance with the template requirement, the Zaragoza implementation explicitly identifies enabling conditions for deployment and scaling.

Data Requirements

Mandatory datasets:

- Fine grained socio demographic data.
- Income proxies.
- Household composition.
- Pedestrian network.
- Isochrone modeling capability.

Recommended:

- Mobility flow indicators
- Commercial density data
- Tourism pressure metrics

Future scaling requires operational datasets such as parcel volumes, locker utilisation rates and energy consumption metrics.

Technology Requirements

- GIS capable analytical platform.
- Isochrone modelling.
- Composite index computation.
- Structured data storage.
- API compatibility with Urban Freight Data Space.

Operational phase requires locker monitoring and basic digital integration systems.

Real Estate Requirements

- Ground floor adaptable units (30–80 m² recommended)
- Mixed use urban context
- Zoning compatibility
- Manageable heritage constraints

Centro and Universidad offer greater scalability potential, while Casco Histórico presents spatial limitations.

Infrastructure Requirements

- Strong pedestrian accessibility
- Basic grid connection
- Optional EV charging capability
- Compatibility with Low Emission Zones policies

Overall the demonstration successfully developed and applied a demand driven microhub planning methodology, validating the existing operational location while identifying two additional high potential expansion nodes. The process defined the data, spatial, and infrastructural requirements for scaling and produced a structured analytical framework transferable to other urban contexts.

Results DISCOLLECTION

The DISCOLLECTION demonstration in Zaragoza successfully validated a data driven urban freight planning framework within a real operational environment, advancing from TRL 2 at project inception to TRL 5 at the end of the demonstration period.

Initially defined at conceptual level, the solution has now been validated in a relevant urban context through:

- Institutional validation (formalized public private agreements).
- Operational validation (real deliveries generating structured data).
- Analytical validation (application of modelling techniques to real datasets).
- Ecosystem validation (stakeholder engagement and co creation).

Operational and Data Validation

A major milestone was the formalisation of the agreement between the City of Zaragoza and CityLogin, enabling the transfer and conditioning of municipal premises for microhub operations.

Between November 2024 and October 2025, the Living Lab moved from infrastructure preparation to active logistics operations. In October 2025, operations formally started, surpassing 1,000 deliveries during the initial operational phase. This provided a sufficiently robust operational dataset to validate the analytical framework under real urban conditions.

For DISCOLLECTION, the key advancement lies in the structured aggregation and analytical use of:

- Operator delivery data.
- Municipal open datasets.
- Contextual traffic and environmental indicators.
- KPI monitoring aligned with the DISCO framework which will be delved into further in deliverable 5.3. Evaluation Handbook for Twinning Living Labs expected in July 2026.

The demonstration confirmed that freight data streams can be consolidated into an actionable analytical layer supporting:

- Validation of microhub siting decisions.
- Monitoring of operational efficiency.
- Assessment of zero emission vehicle integration.
- Strategic planning for network expansion.

Importantly, this validation occurred within a functioning urban microhub operating in Zaragoza's Low Emission Zone, ensuring relevance to real regulatory and operational constraints.

What the Demonstration Proved

The Zaragoza Living Lab demonstrated that a mid sized European city can operationalise a freight data hub integrating public and private datasets without requiring fully automated real time infrastructure.

Specifically, the demonstration proved that:

- Freight data can support evidence based microhub location validation.
- Structured KPI monitoring enhances transparency and decision making.
- Public private data collaboration is institutionally viable.
- Data driven planning reduces uncertainty in scaling sustainable last mile models.

By supporting proximity based deliveries and zero emission vehicle operations, the data framework contributes structurally by enabling proximity based consolidation and zero emission vehicle integration within a Low Emission Zone context.

Stakeholder and Ecosystem Validation

The Open Day Zaragoza (May 7, 2025) constituted a key ecosystem validation milestone. With more than 150 participants; including public authorities, logistics operators, startups and research centres, the event showcased DISCO solutions and strengthened collaborative dynamics.

The open day included the presentation of the urban freight data hub concept, co creation workshops generating over 20 collaborative project ideas, the launch of structured interviews and surveys targeting producers, carriers and commercial actors as well as the reinforcement of interregional partnerships.

The event generated strong interest in replicating the Zaragoza microhub and data driven planning model in other European cities. Media coverage further positioned Zaragoza as an emerging reference in intelligent and sustainable urban logistics.

This stakeholder validation reinforces the practical feasibility and social acceptance of the DISCOLLECTION framework.

TRL Evolution

At the beginning of the project, DISCOLLECTION in Zaragoza was at TRL 2, with the analytical concept defined but not validated in operational conditions. Through:

- Formal governance arrangements.
- Integration of operator and municipal datasets.
- Real microhub operations generating delivery data.
- Structured KPI monitoring and review.
- Stakeholder validation through public demonstration.

The solution reached **TRL 5,** validated in a relevant urban environment. In line with the Horizon Europe TRL framework, the validation includes real users, real infrastructure, real logistics activity, and structured data analysis within operational urban constraints.

While large scale automation and cross city integration would correspond to higher TRL levels, the Zaragoza demonstration provides a robust operational validation of the core analytical and governance model.

Strategic and European Added Value

Beyond local operational success, DISCOLLECTION generated structural outcomes with European relevance:

- Established a replicable framework for freight data collaboration.
- Demonstrated feasibility in a mid sized Southern European city context.
- Strengthened alignment with climate neutral urban strategies and SULP development.
- Provided a scalable analytical blueprint for proximity based, zero emission logistics systems.

The Zaragoza living lab site validation using the EDPI index increases confidence in transferring the model to other European cities facing similar regulatory, spatial and data fragmentation challenges.

2.2.7. Lessons Learnt: Transferability and Replication

DISCOPROXI

The implementation of DISCOPROXI in Zaragoza revealed several technical, organisational, laboral and economic insights relevant for replication in other cities.

- **Location selection:** Choosing the best location(s) is key to implementing the solution. It has a greater impact in areas with more pedestrian traffic and high demand for B2B or B2C deliveries (Also echoed by DISCOLLECTION results). Having locations close to these areas or, if they are within them, ensuring they are accessible to large capacity vehicles is key to multiplying their impact in terms of scalability with few square metres available.
- **Assignment of liability agreements for activity:** The agreements between the leasing party (the municipality), the hub operator and the LSP must clearly define the activity, roles, responsibilities and insurances as well as the risks associated with the processes carried out. For the demonstration, under no circumstances were e commerce parcels stored at the

microhub due to liability concerns. Only the delivery vehicles are parked at the microhub, simplifying municipal permits relating to space security and insurance.

- **Rental fee:** The use case does not establish a cost for use during the pilot, so it must be calculated and added to the operating cost structure of the last mile logistics operation.
- **Employment accessibility:** The model lowers the barriers to entry into last mile delivery work by allowing access to a larger and more vulnerable population by eliminating the need for driving licences and simplifying delivery operations.

DISCOCURB

Based on the model developed, the following recommendations could be followed to transfer/replicate DISCOCURB:

- To expand the study area to include new urban and peri urban zones,
- Integrating new dynamic variables such as real time data sources.
- Develop a zone classification system based on saturation and intervention priority to support future dynamic management policies (pricing, shared use, time slot regulation, etc.).
- Simulation of What if scenarios, such as spatial redistribution, regulatory changes, and integration of nearby micro hubs.
- Design of a technical and replicable module for other DISCO cities (methodological guide, parametric model, and GIS template)

DISCOLLECTION

The implementation of DISCOLLECTION in Zaragoza, linked to the operational launch of the microhub and the structured aggregation of freight data, revealed several technical, organisational and economic insights relevant for replication in other cities.

- **Governance before Technology:** The most critical enabler was the formal agreement between Zaragoza City Council and the logistics operator. Data integration proved to be less a technological challenge and more a matter of governance, trust and clearly defined roles. Without formalised public private collaboration, freight data valorisation cannot scale.
- **Operational Data is Essential for Analytical Validation:** The start of microhub operations (October 2025) and the completion of more than 1,000 deliveries provided a real dataset for validation. The analysis showed no increase in total delivery time compared to the conventional model, but a shift in cost structure: labour intensity increased while vehicle related costs decreased, resulting in a net cost increase of approximately 9.5% under current conditions. These results highlight the importance of regulatory alignment and scale effects in improving long term economic performance.
- **Structured Data Integration Can Precede Full Automation:** Semi structured integration of operator data, municipal open data and contextual indicators was sufficient to validate the analytical framework in a relevant environment. Full automation and API based interoperability remain future scaling steps rather than prerequisites for initial deployment.

- **Cost Transparency Supports Policy Alignment:** The data driven assessment demonstrated that proximity based, low emission models may shift cost structures rather than automatically reduce them. Transparent measurement enables municipalities to align incentives, regulatory tools (e.g., Low Emission Zones), and logistics strategies with climate objectives.

Advice for Parties Looking to Implement and Upscale Measures

Based on the Zaragoza validation, the following conditions are critical for successful replication:

- **Start with Institutional Alignment**: Define data sharing agreements, KPIs and responsibilities before investing in advanced digital platforms. Early governance clarity reduces implementation risk.
- **Adopt a Phased Digital Maturity Model**: Cities can begin with structured data aggregation and periodic KPI analysis before moving toward automated, real time integration and connection to federated data spaces.
- **Combine Operational Testing with Data Analytics**: Analytical frameworks gain credibility only when validated through real logistics activity. Microhub or last mile demonstrations should generate operational data to feed the analytical layer.
- **Integrate Economic Assessment from the Outset**: Replication must include cost modelling and labour impact analysis. Data driven transparency allows policymakers to evaluate support mechanisms and scaling pathways realistically.

Zaragoza therefore provides not only a tested analytical framework, but also a governance and economic reference model for cities transitioning toward data driven urban freight systems.

2.2.8. Beyond DISCO

The pilot demonstrated that microhub based delivery can operate effectively in highly pedestrianised areas without compromising service quality, though with a marginal increase in average delivery cost. Replicability is strongest in areas transitioning toward full pedestrianisation with restricted motor vehicle access.

Key continuity factors include:

- The Citylogin continues to operate from the Zaragoza microhub using electric tricycles, having expanded to a larger facility with dedicated electric charging infrastructure covering the full service area
- The multi operator hub model, hosted in an underutilised municipal market with existing heavy vehicle access, offers a transferable template for new and adapting urban spaces.

The EDPI index is also a tool that can be applied to other Spanish cities through the collaboration between ALIA, Pickageo and Zaragoza Logistics Center. The correct selection of spaces is vital for scaling, therefore creating or adapting them is essential. Recipients or sellers must accept that the model is slightly more expensive in terms of labour, but the impact on work quality, environmental quality and infrastructure use leads to greater common good. Awareness campaigns targeting end users and involving retailers are crucial for the implementation of the tested model.

Policy Impacts.

The Zaragoza Living Lab demonstration contributes to urban logistics policy development by providing real evidence on how microhub based last mile distribution can be integrated into existing urban environments while supporting environmental and operational objectives. The pilot shows that underused municipal spaces, such as traditional food markets, can be repurposed as logistics nodes, enabling a more efficient use of urban infrastructure and supporting sustainable urban planning decisions.

The results of the pilot provide practical insights for local authorities regarding the design and implementation of **Sustainable Urban Logistics Plans (SULPs)** and their alignment with **Sustainable Urban Mobility Plans (SUMPs)**. By generating operational data on delivery patterns, vehicle typologies, and microhub performance, the demonstration supports **evidence based policymaking** for the management of urban freight flows and curb space allocation.

The Living Lab also highlights the policy relevance of **data driven logistics governance**, showing how shared data spaces and digital tools can support better monitoring, forecasting, and management of urban freight activities. This contributes to the development of integrated policies that combine logistics planning, land use planning, and digital infrastructure.

Furthermore, the pilot provides guidance for policy measures related to:

- the integration of **microhub networks** in dense and pedestrianised city centres,
- the promotion of **zero emission last mile delivery solutions** using light electric vehicles,
- the **dynamic management of loading and unloading areas**, and
- the creation of **public private collaboration frameworks** between municipalities, logistics operators, retailers, and technology providers.

Finally, the Zaragoza demonstration contributes to the **replicability of sustainable urban logistics solutions across European cities**, offering a transferable methodological approach that can inform future EU and local policies aimed at reducing congestion, emissions, and land use conflicts associated with urban freight.

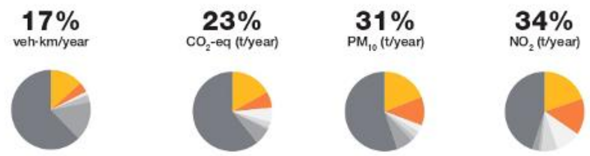
2.3. Barcelona

2.3.1. Background and rationale of the intervention

Barcelona, situated on the northeastern coast of Spain, stands as the capital and largest city of the region of Catalonia. It is the second most populous municipality of Spain, with approximately 1.68 million inhabitants within its city limits. The broader urban area of Barcelona hosts over 4.8 million inhabitants, establishing it as the European Union's fifth largest urban area, following Paris, the Ruhr area, Madrid, and Milan. The city proper covers an area of roughly 101.4 square kilometers and features a high population density exceeding 16,600 inhabitants per square kilometer. This population density is not uniform; central districts such as Eixample are among the most densely populated urban areas in Europe, with over 35,000 inhabitants per square kilometer.

Barcelona's high residential density is mirrored by its intense commercial concentration. The city center; particularly the Eixample and Ciutat Vella districts, features a massive density of retail, business, and HoReCa (Hotel/Restaurant/Café) establishments. This dense commercial fabric acts as a major gravitational pull for urban freight, driving an intense daily demand for B2B and last mile delivery services to keep these establishments stocked.

While Barcelona boasts a robust public transportation and active mobility network, urban freight distribution presents significant environmental and traffic challenges. According to municipal mobility data, commercial vans (Light Duty Vehicles) and lorries (Medium & Heavy Duty Vehicles) account for roughly 17.5% of the total vehicle kilometers traveled per year in the city. However, these freight vehicles disproportionately contribute to local emissions. They are responsible for 23.5% of the city's transport related CO_2 equivalent emissions. More critically for local air quality and public health, freight vehicles produce 30.7% of the PM_{10} particulate matter and 34.5% of the NO_2 emissions generated by traffic.



Category	veh·km/year (thousands)	veh·km/year (%)	CO_2-eq (t/year)	CO_2-eq (%)	PM_{10} (t/year)	PM_{10} (%)	NO_2 (t/year)	NO_2 (%)
Vans (LDV)	592,678	13.3%	163,347	17.0%	38.7	19.1%	551.0	19.8%
Lorries (MDV & HDV)	185,551	4.2%	62,388	6.5%	23.6	11.6%	410.4	14.7%
Buses	44,443	1.0%	55,844	5.8%	5.6	2.8%	281.5	10.1%
Coaches	20,815	0.5%	23,484	2.4%	5.5	2.7%	184.2	6.6%
Mopeds	127,231	2.9%	7,334	0.8%	3.8	1.9%	32.5	1.2%
Motorcycles	708,546	15.9%	65,430	6.8%	13.6	6.7%	73.6	2.6%
Cars	2,770,779	62.3%	584,173	60.7%	112.0	55.3%	1,249.8	44.9%
Total	**4,450,043**	**100.0%**	**961,999**	**100.0%**	**202.71**	**100.0 %**	**2,783.07**	**100.0%**

Figure 29 Traffic intensity and impacts breakdown for Barcelona

To manage this massive logistics demand, Barcelona has implemented an extensive network of designated Loading and Unloading (L&U / DUM) curbside spaces. There are approximately 2,610 designated L&U areas across the city, encompassing a total of 9,988 individual parking spaces. The vast majority of these (8,486 spaces) are actively managed by the municipal company B:SM within regulated zones, while 1,502 spaces remain outside the B:SM L&U area. The standard operational timetables for these spaces are highly regulated, with the most common window being Monday to Friday, 8:00 AM to 8:00 PM. Operational data indicates that L&U spaces experience immense turnover and peak utilization during morning working hours. In high demand areas like Eixample, occupancy rates consistently exceed 65% in the morning, with individual parking spaces registering over 150 delivery stops per year during peak hours (10:00 AM to 1:00 PM).

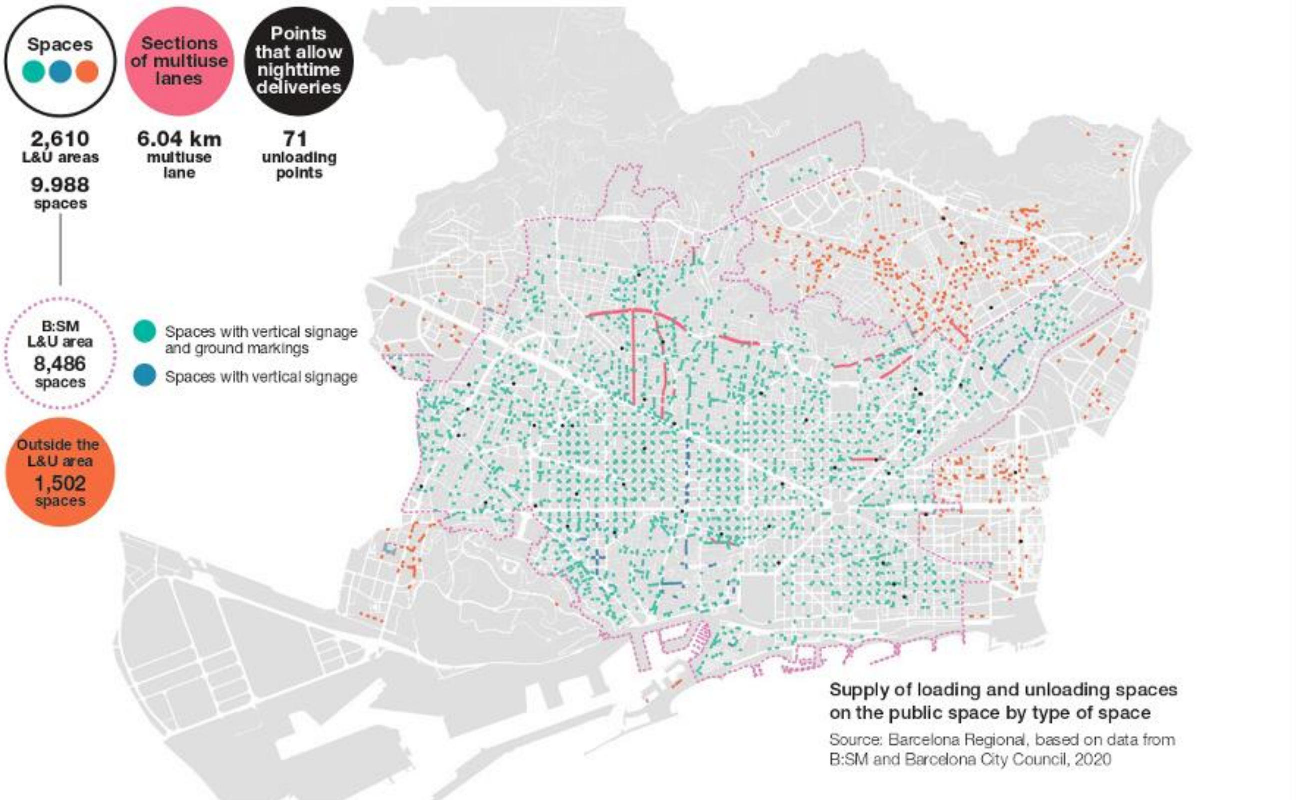


Figure 30 Supply of loading and unloading spaces in Barcelona

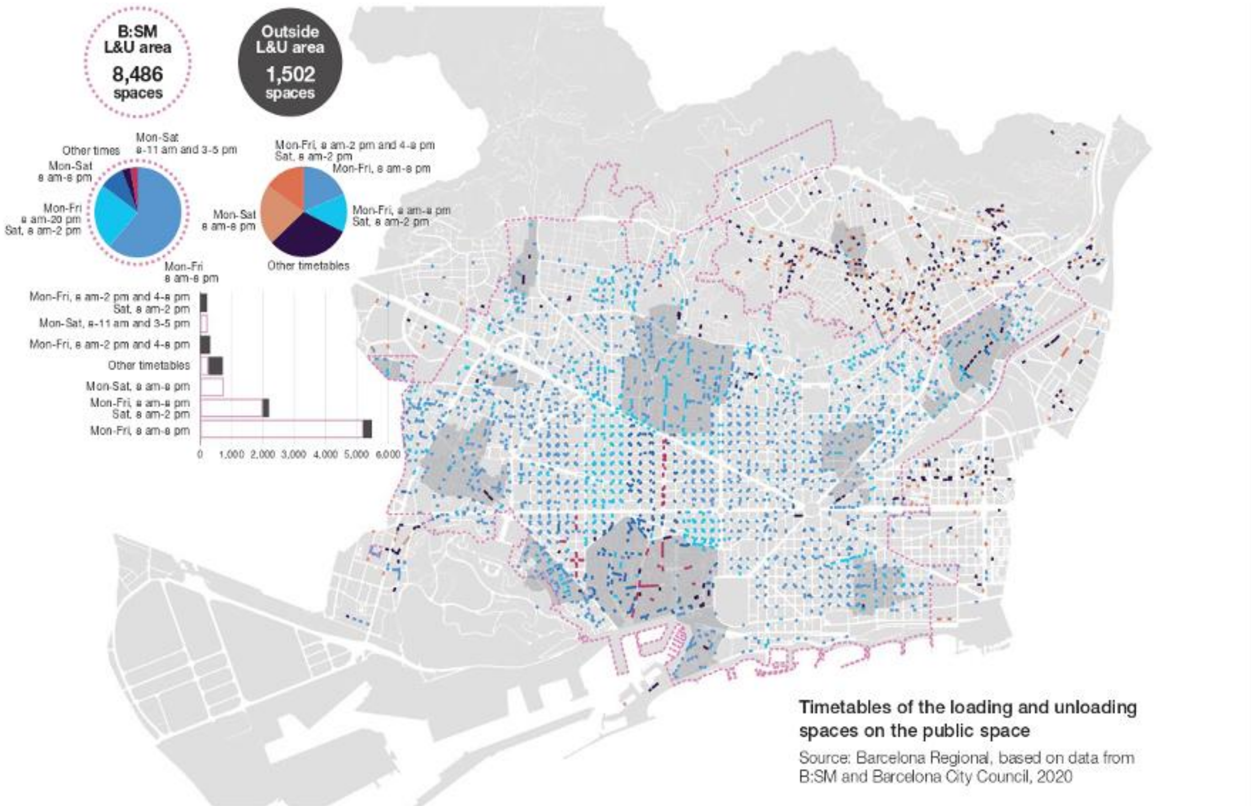


Figure 31 Timetables of loading and unloading spaces in Barcelona

2.3.2. Objectives

The Barcelona Living Lab aims to improve the management of urban logistics within the city through an innovative data driven approach, focusing on the management of DUM zones. With this goal, the internal objectives can be stated as:

- Developing and validating a robust deep learning system for vehicle detection, tracking, and license plate recognition in DUM zones, achieving an accuracy rate of at least 95% in varied conditions and scenarios (chamfered corners, and pedestrian priority parking slots).
- Deploying CCTV camera systems in 3 selected DUM zones across Barcelona, successfully collecting and transmitting data while complying with privacy and data protection standards.
- Analyzing the correlation between SPRO app data and actual DUM zone usage, and areas for improvement in the current parking management system and supporting the implementation of Barcelona's SUMP and SULP.
- Applying data analysis to extract DUM zone usage patterns, including vehicle types, duration of stays, and peak usage times, to contribute to the urban logistics planning in Barcelona.

- Developing and testing dynamic freight modeling techniques using the collected data, aiming to predict DUM zone occupancy and propose data driven recommendations for optimizing DUM zone use within operational hours.

External Objectives:

Within the context of DISCO, the Barcelona Living Lab directly contributes by deploying and validating advanced digital curb management frameworks (DISCOCURB and DISCOLLECTION) under real urban conditions. By utilizing computer vision and artificial intelligence to monitor loading/unloading (DUM) zones, the pilot overcomes the reliability limitations of manual app based reporting, providing precise, data driven insights into stall occupancy, operation durations, and vehicle typologies. Together, these tools demonstrate the scalability and transferability of digital curb monitoring, generating highly accurate datasets and quantitative KPIs that evaluate the environmental and operational impacts of urban freight. By translating this data into tailored policy recommendations such as dynamic time slots and predictive modelling, providing actionable insights for city planners and stakeholders. This supports the evidence based design of the next generation of Sustainable Urban Logistics Plans (SULPs), promoting efficient, compliant, and zero emission logistics practices in alignment with DISCO’s European wide objectives.

Targeted Policy/Strategic Goals

Dynamic curbside management piloted through DISCOCURB and DISCOLLECTION directly supports Barcelona's PMU 2025 2030 and Climate Plan by improving the efficiency of existing loading/unloading zones. Optimising occupancy and turnover reduces the time delivery vehicles spend searching for parking, cutting unnecessary kilometres travelled and potentially lowering CO_2, NO_x, and particulate emissions. Reduced freight related congestion, double parking, and noise further contributes to a safer and more livable urban environment.

These operational improvements directly support Barcelona's ambitious local and regional quantitative targets:

- **Modal Shift:** The PMU 2025 2030 sets a target to reduce the proportion of journeys made in private motor vehicles to just 15% over the next five years, while pushing sustainable transport modes to 85%. Managing the footprint of urban freight is essential to reclaiming public space for these sustainable modes.
- **Climate Neutrality:** Barcelona has committed to the EU Mission for Climate Neutral and Smart Cities, targeting climate neutrality by 2030. Because urban freight typically accounts for up to 20% of urban traffic and a disproportionate share of transport emissions, the digital transition of the DUM zones is a critical strategic lever.

By feeding accurate, AI generated data into the next generation of Sustainable Urban Logistics Plans (SULPs), Barcelona can effectively track and meet these aggressive emission reduction and mobility targets without compromising the economic vitality of its logistics sector.

2.3.3. Living Lab Partners and Roles in Project

- **UPC/Carnet**: The Universitat Politècnica de Catalunya (UPC) and the research center CARNET are responsible for the Barcelona Living Lab. Its roles are coordinating the pilot's partners, managing the sensor installation in the pilot zones, creating and testing the computer vision and AI algorithms to gather accurate information about the L/U operations, analyzing this information, and creating the final datasets.
- **Ajuntament de Barcelona**: As the local government, the Barcelona City Council is responsible for the definition of policies, the control of loading/unloading zones, and their administration. In the pilot, the Barcelona municipality has also secured permissions to install the cameras, defined the pilot areas, and the alignment of the pilot with municipal regulations and urban mobility policies.
- **Barcelona Serveis Municipals (B:SM)**: B:SM is a public company that operates commercial loading and unloading in the city of Barcelona. B:SM owns the SPRO app data, that collects the parking operations registered by commercial vehicles.
- **CityLogin**: CityLogin is a private logistics operator providing last mile deliveries. They specialize in sustainable logistics. They have a presence in several big cities in Spain. Its role in the project is the provision of commercial vehicle data for the data spaces and to provide insights about the needs of the private sector.

2.3.4. DISCO Innovations

- **DISCOCURB** involves installing cameras in loading/unloading (DUM) zones to monitor vehicle operations using computer vision and artificial intelligence. Using cameras looking at the parking zones, this system will automatically track parking activities, collecting data on the duration of stays, the frequency of operations at different times of the day, and the types of vehicles using the space. License plate recognition will help distinguish between commercial and non commercial vehicles, assess the environmental impact based on vehicle types (e.g., CO_2 emissions), and cross check SPRO records to evaluate their accuracy.
- **DISCOLLECTION** will leverage this data to generate policy recommendations for improving DUM regulations. Using advanced data analysis techniques, we will identify patterns and inefficiencies in the current system and propose tailored adjustments to enhance efficiency, compliance, and sustainability.

2.3.5. Utilized Datasets

- **SPRO dataset**: This dataset records all the parking operations at the load/unload zones that are analyzed in the pilot. This information comprises the times of arrival and departure, the license plate of the vehicles, and whether it is an authorized or unauthorized operation.

- **UPC dataset:** The UPC dataset is generated as an outcome of the pilot. Its contents are the corrected information about the loading/unloading operations, after fusing the SPRO dataset with the data gathered from the street sensors. The type of information is the same as in the SPRO dataset.
- **CityLogin dataset**: This dataset contains information about delivery routes in the Barcelona metropolitan area. It includes source and destination, date/time of the route, vehicle type, etc.

2.3.6. Living Lab Implementation outline

DISCOCURB

Deployment of the AI Based Curb Monitoring System: Within the Barcelona Living Lab, DISCOCURB was implemented through the installation of fixed CCTV camera systems in three selected Loading and Unloading (DUM) zones located in high demand central areas of the city. These zones were selected to represent different geometric and operational configurations (e.g., chamfered corners and pedestrian priority areas), ensuring that the system could be validated under diverse real world urban conditions.

Monitored un/loading areas:

Figure 32 Camera positioning per installation in pedestrianised street

Figure 33 Positioning of cameras in Valencia street overlooking chamfered spaces

The physical infrastructure consists of:

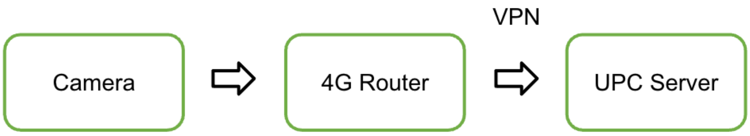


Figure 34 Flow chart of visual inputs

- High resolution IP cameras installed in elevated positions to ensure full visibility of the DUM spaces
- 4G router connected to the cameras and VPN for secure data transmission
- Centralized storage and processing infrastructure hosted on UPC servers

All video streams are transmitted directly to the UPC servers, where the full processing pipeline is executed.

Privacy by design principles were strictly applied. Video streams are processed automatically, and only structured metadata required for analysis are stored. Personal data handling follows GDPR and local data protection regulations. Raw video footage is retained only for the minimum time necessary for processing and validation.

Computer Vision Pipeline Architecture

All detection, tracking, and recognition tasks are executed centrally on UPC's server infrastructure. The AI pipeline consists of the following stages:

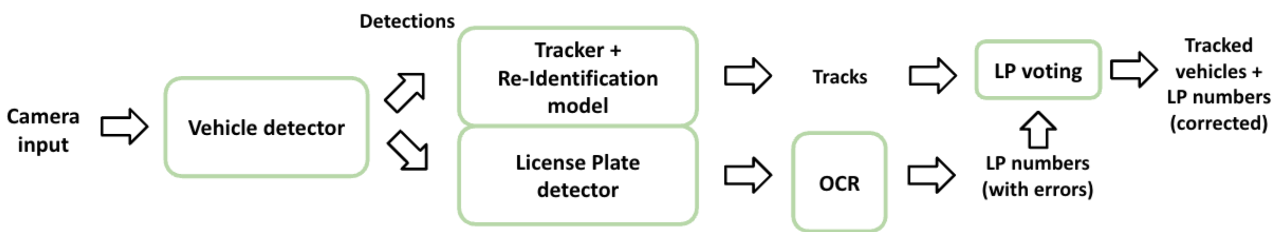


Figure 35 Flowchart of inputs to AI detection

1. **Vehicle Detection**
   Deep learning models identify vehicles entering and exiting the DUM zones from the video stream.
2. **Multi Object Tracking (MOT)**
   Each detected vehicle is assigned a unique tracking ID, enabling continuous monitoring throughout its presence in the parking space and even if the LP is not readable.

3. **License Plate Detection and Recognition (LPR/OCR)**
   A dedicated model detects the license plate region and applies Optical Character Recognition (OCR) to extract alphanumeric characters.
4. **License Plate Voting Mechanism**
   Because OCR outputs may contain frame level errors, multiple readings collected during the vehicle's stay are aggregated through a temporal voting mechanism. This process generates a corrected and highly reliable final plate number.

This centralized architecture produces structured parking events containing:

- Arrival timestamp
- Departure timestamp
- Duration of stay
- License plate identifier
- Zone identifier

The AI pipeline, covering vehicle detection, tracking, licence plate recognition, and temporal voting, operated autonomously to generate structured datasets of parking events including occupancy patterns, durations, and vehicle identifiers.

Workflow
The operational workflow in each monitored DUM zone is as follows:

1. A vehicle enters the monitored loading/unloading space.
2. The camera records the operation and streams the video to UPC servers.
3. The centralized AI pipeline performs detection, tracking, and license plate recognition.
4. When the vehicle exits, the system computes the total parking duration.
5. A structured parking event is generated and stored in the UPC dataset.
6. The event is cross checked with the SPRO dataset provided by B:SM to assess compliance and registration accuracy.

This workflow ensures continuous and objective monitoring of curb usage without relying exclusively on manual app based declarations.

DISCOLLECTION

Data Fusion and Dataset Generation

DISCOLLECTION in Barcelona focuses on transforming raw sensor outputs into validated, structured datasets suitable for policy evaluation and modelling.

Three datasets are integrated:

- **SPRO dataset (B:SM)**: App based records of DUM operations
- **UPC dataset**: DUM dataset derived from video processing with AI pipeline
- **CityLogin dataset**: Delivery route and operational data from a private logistics operator

The core innovation lies in the systematic comparison between SPRO declarations and AI detected parking events. This allows:

- Identification of unregistered operations
- Detection of overstays
- Measurement of compliance rates
- Quantification of discrepancies between declared and observed usage

The resulting corrected dataset represents a high resolution and validated record of DUM zone activity.

Data Structure
For each parking operation, the structured dataset includes:

- Unique operation ID
- DUM zone identifier
- Arrival time
- Departure time
- Compliance status
- Total duration
- Vehicle type classification
- License plate
- SPRO registration match indicator

This harmonized dataset enables temporal, spatial, and behavioral analysis of urban freight curb use.

2.3.7. Results

DISCOCURB

The DISCOCURB demonstration in Barcelona validated an AI based curb monitoring system under real urban operating conditions, moving from TRL 3 at project inception to TRL 7 by the close of the demonstration period. As a Twinning Living Lab within the Spanish Cluster, the Barcelona pilot was designed to enhance the replicability of DISCOCURB by validating the solution under a distinct urban freight governance context, specifically, the management of designated Loading and Unloading (DUM) zones in one of Europe's densest urban freight environments.

The progression was achieved through:

- Technical validation of the full end to end AI pipeline operating on camera feeds under real urban conditions

- Operational validation through continuous monitoring of three DUM zones across high demand central districts of Barcelona from December 2024 through February 2025
- Institutional validation through formal agreements with the Barcelona City Council enabling camera installation in the public right of way
- Ecosystem validation through structured engagement with municipal operators, private logistics actors, and sectoral stakeholders

Operational and Technical Validation

Images of the installation of the cameras:

Figure 36 Camera installation in municipal light fixtures and traffic lights

Deployment generated significant lessons for replication. Coordinating installation across public spaces was complicated by fragmented municipal concessions, with different districts managing street infrastructure through separate private contractors requiring independent negotiations. Combined with institutional procurement obligations, this resulted in costs and timelines exceeding initial estimates and a reduction in camera coverage relative to the original design.

While challenging, these constraints are typical of real world urban sensor deployment in European cities operating under similar regulatory and procurement frameworks. The documentation of these barriers, and the strategies developed to navigate them, is direct transferable knowledge for follower cities planning similar deployments.

What the Demonstration proved

The Barcelona Living Lab demonstrated that an automated, camera based DUM zone monitoring system can be deployed and operated in a dense European city under real institutional and regulatory constraints. Specifically, the demonstration proved that:

- Deep learning based vehicle tracking and license plate recognition operates with enough reliability in active urban freight zones under variable real world conditions
- Privacy by design principles are operationally viable at scale: structured metadata retention without raw video storage was successfully implemented in compliance with GDPR requirements
- Coordinating sensor deployment across fragmented municipal infrastructure concessions is institutionally feasible, though it requires dedicated project management capacity and realistic timeline planning
- A centralized university hosted processing architecture proved to be valid for multi month monitoring operations

DISCOLLECTION

The DISCOLLECTION component advanced from a conceptual data fusion framework to an operational analytical pipeline validated against real datasets. By crossing the AI detected parking events with SPRO app declarations provided by B:SM, the demonstration produced the first objective, validated baseline of DUM zone usage for the monitored areas. This cross referencing enabled:

- Identification of parking operations not registered in the SPRO system
- Detection of overstays beyond the standard 30 minute regulatory window
- Quantification of discrepancies between declared and observed loading and unloading activity
- Characterization of temporal and spatial occupancy patterns across the monitored zones

The resulting dataset represents a validated operational record of DUM zone activity that directly supports the evidence based design of Barcelona's forthcoming Sustainable Urban Logistics Plan (SULP), providing for the first time an objective empirical counterpart to the existing self declaration monitoring model.

Stakeholder and Ecosystem Validation

The Barcelona Open Day, held on 26 February 2026, constituted the central ecosystem validation milestone of the Living Lab. The event gathered more than 35 participants across four structured presentations, convening key institutional and private stakeholders from across the urban freight value chain. Attendees included representatives from the Barcelona City Council's DUM strategy responsible, B:SM's team responsible for the SPRO loading zone management platform, UPC researchers presenting the technical architecture of the DISCOCURB monitoring system and CItyLogin as private transport operators.

The event enabled the dissemination of the AI monitoring technology, direct exchange between technology developers and operational end users, and concrete policy dialogue on the transition from self declaration to objective monitoring. Institutional feedback confirmed strong interest in integrating camera generated data with the SPRO platform to identify registration gaps and improve compliance monitoring, directly validating one of the core assumptions of the DISCOLLECTION analytical framework.

TRL Evolution

At the beginning of the project, DISCOCURB and DISCOLLECTION in Barcelona were at TRL 3, with core algorithms developed and validated in laboratory and test conditions but not yet demonstrated in an operational urban environment.

Through:

- Physical deployment and operation of camera systems across three active DUM zones in central Barcelona
- Execution of the AI pipeline over a three month monitoring under real urban freight conditions
- Integration and systematic cross referencing of multi source operational datasets
- Stakeholder validation through the Barcelona Open Day (26 February 2026, 35+ participants across municipal, operational, and sectoral representatives)
- Documentation of real world deployment barriers and strategies directly informing replication by follower cities

The solution reached **TRL 7, system prototype demonstrated in an operational environment**.

In line with the Horizon Europe TRL framework, this level reflects a fully functional system prototype operating continuously under real urban conditions, with real logistics actors, live camera infrastructure, and validated multi source data integration.

Strategic and European Added Value

Beyond local operational validation, the Barcelona demonstration generated structural outcomes with direct European relevance:

- Established a replicable technical blueprint for camera based DUM zone monitoring applicable to any city with regulated curb freight infrastructure and existing sensor mounting points
- Produced the first validated, objective dataset of Loading and Unloading zone activity for the monitored areas, enabling evidence based policy design where only self declared data previously existed
- Generated transferable institutional knowledge on navigating fragmented municipal infrastructure governance and public procurement constraints, a common barrier to urban sensor deployment across EU cities
- Demonstrated practical alignment between AI generated freight data and the analytical requirements of Sustainable Urban Logistics Plans, directly supporting the DISCO objective of evidence based SULP development

- Reinforced the viability of public private data collaboration between a university, a municipal operator, and a private logistics provider within a real operational context
- Provided concrete empirical grounding for the transition from static, one size fits all DUM zone regulations toward the dynamic, data driven curb management model envisioned in Barcelona's Urban Mobility Plan 2025 2030

2.3.8. Lessons Learnt: Transferability and Replication

DISCOCURB

Because DISCOCURB relies on camera sensors and mature computer vision algorithms, its transferability is very high; it can be applied to almost any city with minimal adaptations. The detection and tracking algorithms are robust enough to generalize across different urban environments, providing tabular data that is straightforward to integrate into existing city dashboards.

However, regarding the hardware, sensor installation in public spaces faces significant hurdles: installation costs, maintenance requirements, and privacy concerns. Powering the systems is a particularly notable challenge, as it often requires expensive civil works. The camera system utilized in our DISCOCURB implementation offers several advantages over other types of sensors:

- **Cost Effective Hardware**: Cameras are relatively inexpensive to purchase and maintain.
- **Infrastructure Synergy:** They can be installed on existing urban elements (e.g., light poles, traffic lights) that frequently already have power lines.
- **Broad Coverage**: A single camera can monitor parking zones comprising several bays, significantly reducing the cost per parking space.
- **Frictionless User Experience**: Cameras do not require drivers to use specific hardware or software to register their presence. This simplifies the process for delivery personnel and allows for the automatic detection of unauthorized operations.
- **Rich Data Capture**: They can capture license plates to obtain vital data regarding vehicle typology, CO_2 emissions, and other relevant metrics.
- The primary disadvantages relate to scalability costs and privacy concerns.
- **Privacy:** Cameras inherently capture sensitive personal data, such as faces and the license plates of non commercial vehicles. Follower cities must proactively address these concerns through data masking, partial anonymization, and edge processing to ensure no sensitive raw data is transmitted or stored. Also, local regulations must be checked to see if the installation is allowed.
- **Cost**: Additionally, while the per unit cost is lower than some alternative sensors, the financial impact of deploying cameras across hundreds or thousands of parking zones must be carefully evaluated in upscaling plans. Moreover, profiting from existing infrastructure may be difficult, as other factors (presence of trees, etc.) may affect this. Thorough planning of the camera locations is crucial, as it may severely impact the performance of the computer vision algorithms.

DISCOLLECTION

Because DISCOLLECTION focuses on the analysis of the generated data, its transferability lies not in replicating Barcelona's specific policy recommendations, but in adopting its analytical methodology. Different cities possess unique logistics needs, regulatory environments, and urban layouts. However, in every case, data driven analysis will benefit follower cities if they adhere to a few key implementation principles:

- Establish a Baseline First: Before drafting new regulations, cities should use the analytical framework to establish a clear baseline of current curb usage, unauthorized parking rates, and average dwell times.
- Focus on Interoperability: Ensure that the data pipelines established by the camera systems can feed directly into the city's existing data lakes or Digital Twins via standard APIs. The value of DISCOLLECTION is maximized when curb data is cross referenced with other city metrics (e.g., traffic flow, air quality).
- Contextualize with Stakeholders; Raw data identifies patterns, but local context explains them. Follower cities should present the analyzed data to local stakeholders (logistics operators, local businesses, residents) to co-create policies that are both effective and publicly acceptable.

Cities are advised to test new policies (such as dynamic pricing or reserved time slots) in localized pilot zones before scaling city wide, using the analytical framework to measure the impact of the policy change in real time. Iterative policy design that meets the needs of the local conditions trumps copy and paste approaches.

2.3.9. Beyond DISCO

Building on the results and insights obtained during the Barcelona Living Lab experimentation, the next steps for DISCOCURB and DISCOLLECTION focus on transitioning from localized pilot zones to a city wide digital curb management model, deeply integrated with Barcelona's broader mobility ecosystem. Necessary actions may include:

- **System Scalability and Expansion**
    - Extend the deployment of DISCOCURB camera sensors to a wider network of high demand DUM zones across different districts, capturing diverse urban logistics profiles (B2B, B2C, and HoReCa).
- **Integration and Platform Improvements**
    - Cross reference DISCOCURB's automated computer vision data directly with the city's existing SPRO mobile application in real time to identify registration discrepancies, improve data fidelity, and automatically flag unauthorized use.

- Study the real time implementation of the system. This could be used to develop a driver facing interface within or linked to SPRO to broadcast real time parking availability, reducing cruising time for delivery vehicles.

- **Data Driven Policy Optimisation (DISCOLLECTION)**
  - Use the comprehensive datasets generated by DISCOCURB to transition from descriptive analysis to predictive modeling, feeding into the city's Digital Twin infrastructure.
  - Implement and evaluate advanced, dynamic policy models—such as variable time limits based on vehicle typology or time of day, and hybrid free/paid extension systems—to replace the current static 30 minute rule.
- **Operational Reliability and Maintenance**
  - Implement proactive maintenance schedules for the camera hardware and edge computing nodes to ensure continuous, high fidelity data capture regardless of weather or lighting conditions.

The next phase of the Barcelona Living Lab requires a combination of technical, operational, and organizational prerequisites to ensure the smooth scaling of DISCOCURB and the effective application of DISCOLLECTION's policy recommendations. Key requirements include:

- **Infrastructure Readiness**
  - Availability of municipal infrastructure (such as light poles or traffic signals) with adequate power supply and positioning to support scaled camera deployments without requiring prohibitive civil works.
  - Reliable, high bandwidth network connectivity at the edge to guarantee the seamless transmission of processed tabular data to the city's central servers.
- **System and Platform Preparedness**
  - Upgraded backend APIs capable of seamlessly integrating DISCOCURB's real time occupancy data with the existing SPRO application database and the broader Urban Freight Dataspace.
  - Computationally and energy improved computer vision algorithms would reduce operational costs and make implementation easier.
- **Operational Coordination**
  - Alignment with municipal parking enforcement agencies (e.g., Guàrdia Urbana or designated parking wardens) to define how camera generated alerts of unauthorized occupancy will be handled operationally.
  - Defined operational procedures for maintaining hardware and handling technical failures in the public right of way.
- **Stakeholder Engagement**

- Coordination with municipal authorities, freight operators, and merchant associations to secure buy in for data driven policy changes (e.g., transitioning away from the universal 30 minute free period).
- Clear communication campaigns directed at citizens and drivers to explain the privacy protections in place and the benefits of the new monitoring system.

- **Data and Analytics**
    - Establishment of a continuous feedback loop where policy changes recommended by DISCOLLECTION are monitored in real time by DISCOCURB to measure success and identify necessary adjustments.
    - Mechanisms for tracking KPIs related to emissions reductions, cruising time, and DUM zone turnover rates.

To initiate these next steps, the primary requirement is the consolidation of the pilot's operational data into a formal feasibility study for city wide expansion. We need to secure long term municipal budget commitments based on a definitive Total Cost of Ownership (TCO) that proves the return on investment through increased logistical efficiency and reduced environmental impact.

A major operational prerequisite is establishing a robust data governance framework. The city must finalize the protocols for data masking, retention, and sharing, ensuring that the insights generated by DISCOLLECTION can be utilized by urban planners while strictly adhering to privacy regulations.

Finally, we require collaborative dialogue with local lawmakers to update the municipal traffic and parking ordinances. Establishing a clear legal framework that legally recognizes camera based occupancy detection and dynamic pricing/time limits is a mandatory requirement before Barcelona can fully realize the benefits of a digital, decarbonized curb management ecosystem.

Policy Impacts

The Barcelona Living Lab demonstration will directly inform future modifications to loading/unloading (L/U) zone policies and the design of the upcoming Sustainable Urban Logistics Plan (SULP). To transition toward a more dynamic curb management model, future policy updates must be fundamentally data driven.

The deployment of the DISCOCURB solution addresses this by capturing highly accurate, real world data on L/U operations, such as DUM zone occupancy rates, precise parking durations, and vehicle typologies. This intelligence will enable the development of advanced, tailored policies. Anticipated innovations include dynamic time slots mapped to specific delivery needs, digital reservation systems, hybrid pricing models (e.g., a free base period combined with paid extensions), and the physical adaptation of parking spaces to accommodate varying vehicle sizes. Furthermore, this system can facilitate real time curb management by broadcasting parking availability to drivers and automatically detecting unauthorized use, thereby streamlining both operations and enforcement.

2.4. Valencia

2.4.1. Background and rationale of the intervention

València is one of Spain's major urban centres, ranking as the country's third most populous city after Madrid and Barcelona, with 844,424 inhabitants as of 1 January 2025, according to the municipal register published by the València City Council. The city has a dense urban structure, with 6,170 inhabitants per km², and displays demographic patterns typical of large Mediterranean cities, combining an ageing population with a strong presence of young adults, students, and foreign residents.

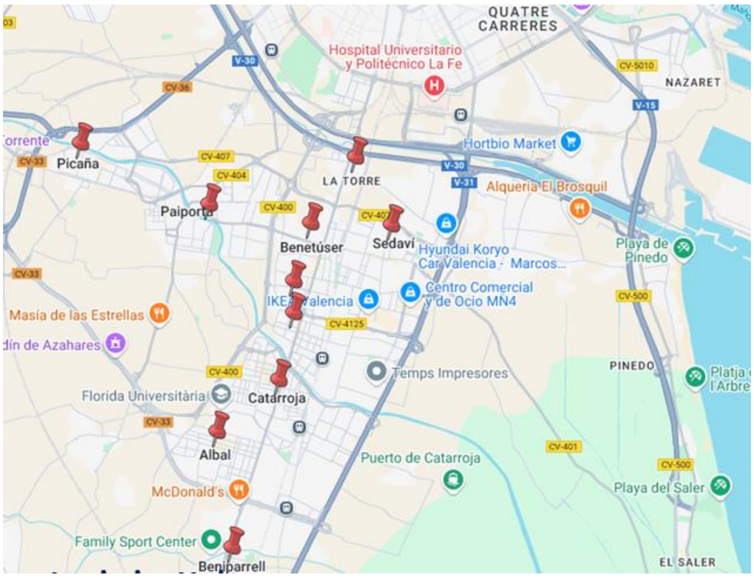


Figure 37 Municipalities served within the framework of the Valencia Living Lab.

The Valencia Living Lab was primarily developed in the neighbourhoods of La Torre, Forn d'Alcedo and Castellar but also extended to a wider set of surrounding municipalities. These included Picanya, Paiporta, Sedaví, Massanassa, Catarroja, Beniparrell, Benetússer, Alfafar and Albal, which were among the areas most affected by recent flood-related disruptions in the province.

City/Town	Population
La Torre (Valencia)	4878
Picanya	11,876
Paiporta	27,748
Alfafar	22,131
Sedaví	10,908
Lloc Nou	121
Benetusser	16,322
Massanassa	10,327
Catarroja	30,142
Albal	17,157
Beniparrell	2,089

Figure 38 City population affected by DANA floods

The municipalities served within the framework of the Valencia Living Lab accounted for a total combined population of 154,699 inhabitants. The breakdown by municipality is as follows:

It is important to highlight that these municipalities represent 5% of the GDP of the Valencian Community, with an economic impact of more than 6.500 million €.

The València Living Lab framework was pivoted in response to the devastating flash floods of 29th October 2024 in the province of Valencia, which caused 230 fatalities and severe infrastructure damage across multiple cities surrounding València city.

The disaster paralysed transport services and disrupted access to essential goods and utilities, leaving hundreds of thousands of residents across the affected municipalities without water, electricity or safe mobility options in the days immediately following the event, causing widespread chaos throughout the affected area.

In the immediate aftermath, rail services were suspended, bridges and key road arteries were destroyed, and emergency services struggled to regain control of the territory.

Road closures and transport disruptions persisted for days after the DANA, as thick mud, standing water and severely damaged infrastructure made mobility extremely difficult, significantly hampering response operations and access to basic supplies.

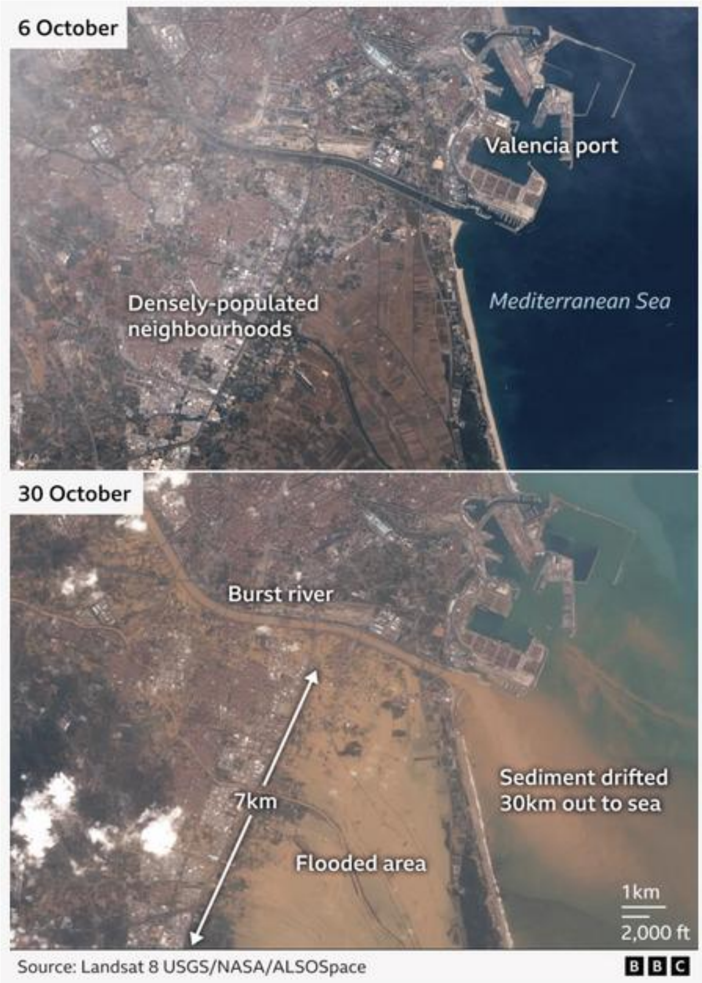


Figure 39 Satellite Images of Valencia Before and After the 29 October Floods (Source: BBC, based on Landsat 8 imagery (USGS/NASA) and ALOSpace).

2.4.2. Objectives

After the crisis caused by the severe rainfall associated with the DANA event in October 2024 and given that T box, the logistics partner in our LL, belongs to Torres Group and most of the staff from the group lived in the affected areas, the company immediately shifted its focus on the pilot as part of DISCO project. As a result, the pilot goal was reoriented toward providing a rapid and efficient logistics response to the emergency, demonstrating the adaptability and resilience of the “supply chain hub” concept under real crisis conditions.

External Objectives:

The Living Lab sought to test a scalable logistics model combining

- Rapid conversion of unused infrastructure (DISCOBAY)

- Digital coordination platform to match community requests for aid with the availability of supplies
- Low emission last mile deliveries using electric vehicles where and when possible. (DISCOPROXI)

Targeted Policy/Strategic Goals:

the demonstration was explicitly designed to advance the city's "Missions Valencia 2030" programme, which commits Valencia to becoming a zero emissions city and the first fully integrated Smart City in Spain. Beyond its local implementation, the Valencia model now presents a coherent, scalable framework with strong potential for replication across European contingency planning and international humanitarian operations

In this context, scaling and adapting the Valencia approach could substantially enhance Europe's capacity to anticipate and mitigate the compounded consequences of climate change. Doing so would help safeguard public health and economic stability, while strengthening the resilience of the most vulnerable communities.

2.4.3. Living Lab Partners and Roles in Project

- **FUNDACIÓN VALENCIAPORT:** innovation centre that collaborates with Valencia City Council in port city relations, as the development of joint initiatives to improve efficiency in urban freight logistics.
- **LAS NAVES** (València Capital Innovation): Valencia Innovation Capital is a platform of the Innovation Department of the Valencia City Council, created to promote a dynamic, diverse, and creative city. Its goal is to bring together all the agents of Valencia's innovation and technological entrepreneurship ecosystem to work together on the political and economic transformation towards a sustainable and technologically advanced future.
- **T BOX**: innovative start up offering advanced logistics services and implementing technology solutions for the Valencia Hub. It is focused on Efficient Supply Chain Management, with special attention and performance in the Last Mile.

2.4.4. DISCO Innovations

The VLC LL was built around three DISCO key components:

DISCOBAY Supply Chain hub concept tested at DISCOESTATE identified locations

DISCOESTATE infrastructure identification and reuse with real time data and community coordination.

DISCOPROXI Consolidating multi sector B2B and B2C last mile flows from supply chain hub urban space using a 100% electric fleet.

2.4.5. Utilized Datasets:

- Valencia Open Data Portal https://valencia.opendatasoft.com/pages/home/

- INE
  https://ine.es/dyngs/INEbase/es/operacion.htm?c=Estadistica_C&cid=1254736177095&menu=ultiDatos&idp=1254735572981

Regional / metropolitan mobility datasets

- Generalitat Valenciana open data portal – mobility tag (regional bus services, traffic and transport layers): https://dadesobertes.gva.es/es/dataset?tags=Movilidad
- GTFS datasets collection (multiple regional and interurban operators in the Valencia Region): https://dadesobertes.gva.es/dataset?res_format=GTFS

UV / UPV datasets and research data

- Inter-municipal Mobility in Valencia Province, 2022–2024 (daily origin–destination matrices between municipalities, built from MITMA data; includes specific subsets for the 2024 DANA disruption, very useful for resilience and emergency logistics modelling):
- UV record: https://produccioncientifica.uv.es/documentos/68c41a6008c3ca034ca75a10

2.4.6. Demonstration Description

T box developed a dedicated Emergency Action Plan drawing on its last mile logistics expertise and the immediate response it mounted for flood affected citizens. The emergency action plan came at an opportune time as the Valencia living lab was preparing to demonstrate DISCOESTATE, DISCOBAY and DISCOESTATE in Valencia city, with supply chain hub ideated in connection with the Valenciaport. What ensued was then the application of what was meant to be a pilot, to a real life situation where not only logistics was at the centre, but people's lives were on the line. T Box, a member of the Torres Group, sprung into action to create a response plan, which was shared with the army, local logistics service providers and companies such as Amazon, local councils, the Valencian Regional Government, and other organisations, leading to t box being appointed to manage the Alcàsser logistics and distribution hub.

The overwhelming volume of incoming donations created an immediate bottleneck threatening logistics across the province. Rather than managing supply first, t box prioritised generating demand, using analyses of population density, flood impact, and social media activity alongside direct coordination with local councils to build an initial registry of affected residents. This demand mapping became the foundation for designing a new supply chain that was simultaneously resilient, flexible, and temporary, negotiated with the Valencian government, local councils, and partners including Amazon, and built on underutilised infrastructure and fleet capacity freed up by the disaster itself.

Once sufficient demand had been established, t box deployed a web portal through which affected citizens could submit assistance requests. Using geolocation data from portal submissions, t box identified delivery points and optimised routing, extending logistics coverage across the affected area from a full supply chain perspective.

DISCOBAY

Hub infrastructure and storage optimization.

A vegetable and fruit warehouse in Alcàsser served as the primary logistics hub, strategically selected for its optimal geographic positioning and availability during the off season. This hub provided a ample space for the consolidation and storage of donated goods, following the UrbanPort Model and the DISCOBAY approach which explores the potential of underutilised bays to serve as hubs for collecting and dispatching goods.
The site offered ideal conditions for deploying the UrbanPort model: it was located close to the most affected area while remaining safely outside the flood-risk zone, as verified through Sentinel and Maxar satellite data.

Figure 40 Hub considerations

The location also provided three critical factors that enabled what became, almost unintentionally, an Integrated Emergency Transport and Logistics System. First, the local authorities fully supported the operation and granted the t box team complete operational freedom, recognising their expertise. Second, two unused infrastructures were made available and effectively repurposed. Third, a network of well connected secondary roads allowed delivery fleets to move freely between affected towns, avoiding congestion on main routes while leaving clear access for heavy equipment used by the army and other emergency teams.


Figure 41 Alcasser Distribution Centre

Incoming donations were systematized and classified by product category. And once classified, requested product batches were consolidated into optimized boxes and pallets to streamline delivery processes.

This supply chain demonstrated the highest performance among other ones active to tackle the crisis due to its location, structure and organisation. The Alcàsser Hub delivered around 400 daily services, substantially higher than the ones in Feria de Valencia (280), Alberic (160) or La Pobla de Farnals (149). In terms of daily aid packs, Alcàsser reached 1,600 units, outperforming the next best performing hub (Feria de Valencia, 1,120 packs) by more than 40%. Its superior capacity, combined with its strategic proximity to the most affected municipalities, resulted in faster, safer and more reliable deliveries across the affected municipalities.

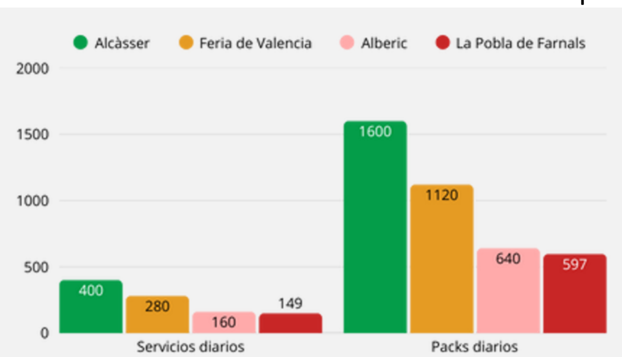


Figure 42 Logistics facilities comparison (Source: T box).

Added to this was the persistent bottleneck that remained in the area and its surroundings for months. However, this did not affect the operations of the Alcàsser Hub, as it had uninterrupted access to Zone 0 through a network of secondary roads. This strategic advantage not only ensured operational continuity but also highlighted the model's complementarity, facilitating the work of other humanitarian actors such as the army and emergency services using the main roads.

Figure 43 Alcàsser Hub connectivity with secondary roads (Source: T box).

At the Alcàsser Hub, all incoming goods and donations were first received, registered and and classified by product category, leveraging t box's technological infrastructure and operational expertise and following its Material Requirements Plan. After classification, requested product batches were consolidated into optimised boxes and pallets to streamline the onward logistics process.

DISCOESTATE

Inventory management and classification systems

To optimize distribution and reduce inefficiencies, t box developed a web portal for affected communities to request specific supplies. This approach, inspired by the DISCOESTATE model, allowed families to directly communicate their needs, enabling a more effective allocation of resources through geolocation.

T box could establish the different delivery points and proceed with the most efficient routing, completing and expanding logistics coverage from a supply chain approach clearly focused on the affected population.

Figure x. Web portal for requesting aid and delivery locations (Source: t box).

Figure 44 Platform used for the collection of humanitarian supply needs of families

Using vans, t box ensured that aid reached impacted families promptly. In addition to food and hygiene products, the platform facilitated requests for essential household items such as mattresses, bedding, domestic appliances, and furniture critical for rebuilding homes in the aftermath of the disaster. The entire delivery process was supported by a traceability system, tracking routes and optimising them, which was essential given the variability and uncertainty regarding the condition and occupancy of roads and streets in the area.

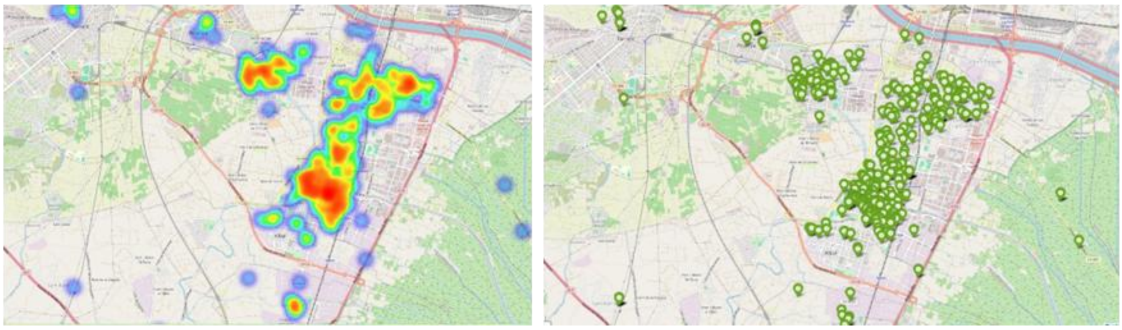


Figure 45 Demand density

DISCOPROXI

To undertake the last mile distribution operation, work shifts were planned for volunteers who offered their vans to make deliveries, and a collaboration agreement was signed with Amazon so that several teams of drivers affected by the flood (who were thus able to continue working) could be counted on. Their role was essential in ensuring maximum efficiency in deliveries, given the chaotic traffic conditions and obstruction of streets and access to the affected towns.

Figure 46 Initial delivery was done by military vehicles, followed by Amazon vans when water subsided

The entire process was supported by a traceability system, tracking routes and optimising them, which is essential given the variability and uncertainty regarding the condition and occupancy of roads and streets in the area.

Once it became possible and the road conditions permitted, electric motorcycles such as the Scoobic light and Scoobic Mousse (see the picture below) were also introduced, offering a clean, efficient alternative for urban mobility. These vehicles operated with zero direct emissions, allowing transportation to take place without contributing to environmental impact.

Figure 47 Scoobic zero emission vehicle used for deliveries once conditions allowed (Source: t box).

2.4.7. Results

At peak capacity, the Alcàsser base served around 3,000 families, approximately 10,000 people. Projections indicated that replicating the model across six to eight points around the affected area could have covered 50,000 to 70,000 people weekly, rising to over 120,000 with fortnightly rotations.

To design the full network structure required for complete population coverage, eight clusters were determined using the k means algorithm, with centroids located and areas of influence calculated using Voronoi polygons and the sf geographic projection package, subject to the constraint of walking distance from affected areas.

The supply chain was established within 48 hours and fully operational within 72, outperforming comparable relief chains active at the same time. Compared to three similar facilities operating during the crisis, Alcàsser delivered over 42% more service capacity in trips and deliveries. Direct access to the affected zone via secondary roads insulated operations from the regional bottleneck that constrained other hubs, while simultaneously maintaining clear access for the army and emergency services. Currently, the emergency plan promises a supply chain set up time of 12 24 hours, improving the response time and decreasing risk significantly.

Table 6 Deliveries per affected cities (Source: t box)

City	Population	Deliveries		Parcels		Articles	
La Torre (Valencia)	630	2,12%	129	1,55%	1.888	**4.681**	0,30%
Picanya	11.876	3,15%	192	4,48%	5.457	**76.015**	4,88%
Paiporta	27.748	15,31%	933	20,24%	24.651	**314.392**	20,17%
Alfafar	22.131	20,39%	1.242	18,56%	22.610	**288.355**	18,50%
Sedaví	10.908	3,75%	228	2,83%	3.449	**43.992**	2,82%
Lloc Nou	121	1,10%	67	0,90%	1.096	**1.990**	0,13%
Benetusser	16.322	5,43%	331	7,62%	9.281	**133.000**	8,53%
Massanassa	10.327	2,27%	138	2,34%	2.850	**16.983**	1,09%
Catarroja	30.142	42,06%	2.561	37,12%	45.212	**623.260**	39,98%
Albal	17.157	2,39%	146	2,69%	3.281	**41.844**	2,68%
Beniparrell	2.089	2,03%	124	1,66%	2.022	**14.528**	0,93%
	149.451		**6.090**		**121.800**	**1.559.040**	

The demonstration showed that rapid, adaptive logistics can offset these risks. Integrating satellite and remote sensing data with real time ground level information reduced uncertainty and improved decision making in a volatile environment. The combination of temporary hub deployment, digital demand aggregation, and low emission last mile distribution proved feasible and efficient, with Alcàsser outperforming comparable facilities by over 40% in service capacity.

Key performance indicators confirm the model's operational strength. CO_2 emissions fell by 54.88% as conditions improved and the fleet transitioned from diesel to predominantly electric vehicles, from 0.3484 to 0.1572 kg CO_2/km. Delivery cost reached approximately €2.176 per package and €0.17 per item, comparing favourably to the €2.75 recorded by the URBANE Project for the Bologna case. Inventory management achieved zero product obsolescence and a turnover rate of 1.5 times per day, demonstrating that hub integration into the supply chain optimised far more than routing alone.

The Valencia model demonstrates that temporary hubs, digital demand aggregation, and green last mile delivery can provide rapid, scalable, and low carbon logistics in post disaster contexts. Its replicability across European cities offers actionable guidance for integrating climate resilience into urban logistics planning and strengthening preparedness against increasingly frequent extreme weather events.

2.4.8. Lessons Learnt: Transferability and Replication

The VLL team's ability to act immediately on 31 October drew directly from **having a structured urban logistics methodology in place before the crisis** due to their involvement in the DISCO project. This prior planning enabled rapid integration of agents, supply chains, stakeholders, and helpdesk functions into what has been recognised as the most integrative and complete emergency logistics operation deployed during the crisis.

The overwhelming volume of incoming donations created an immediate bottleneck that threatened logistics across the province of Valencia. Conventional supply chains proved unable to adapt, confirming that **Demand Chain Management is the critical lever for designing resilient last mile operations.** The most urgent priority was therefore to generate **demand first, and build last mile operations from there**, as demonstrated at the Alcàsser Logistics Platform.

The supply chain was designed around four principles:

- **Resilience**, enabling an adaptive response from which Valencian citizens, companies, and society could emerge with collective learning.
- **Elasticity,** allowing the chain to evolve across distinct recovery phases: basic necessities in the first six months, housing fit out materials from month three, and household goods from month four onwards.
- **Effectiveness**, ensuring reliable delivery to affected populations, noting that under Spanish civil protection legislation all donated goods legally belong to the affected population, meaning any logistical inefficiency constitutes a potential breach of the National Civil Protection System's sanctioning regime.
- **Ephemerality,** as the system was designed to dissolve once living conditions and economic development are fully restored, a process not expected in under three years.

The economic urgency of rapid recovery is significant. The Valencia Chamber of Commerce estimates losses across 68 affected municipalities at €21,819 million in GDP terms, representing an opportunity cost of approximately €60 million per day of delayed recovery. For the 32 most severely affected municipalities alone, the figure reaches €36 million per day.

Replicability

The Valencia logistics disaster management model is replicable and offers a robust framework for designing European level contingency plans. The human and economic scale of the disaster underscores the urgency.

The Triple Effect: combining adverse meteorological events, urban population concentration, and demographic ageing, is emerging as a central risk factor across Europe. Meteorological, climatic, and hydrological hazards already account for 50% of all disasters, 45% of reported deaths, and 74% of economic losses globally, with economic impacts increasing sevenfold over the past two decades.

The Valencia model meets the key criteria applied by municipal authorities when evaluating innovation adoption:

- Social and cultural acceptability, as emergency preparedness concerns every municipality and citizen.
- Economic efficiency, through significant direct benefits and loss mitigation relative to operational costs.
- Equity distribution, with particular safeguard mechanisms for vulnerable groups including the elderly, the sick, and children.
- Operational viability, demonstrated by a plan driven response that outperformed larger, more centralised institutions.
- Legality, with full backing from local, regional, and national government and compliance with Spanish civil protection legislation.
- Resilience, providing structured certainty and responsiveness under conditions of inherent uncertainty.

The model's replicability rests ultimately on its capacity to establish a common vision across actors. Having moved beyond pilot status through real world deployment, it represents a transferable framework for integrating climate resilience and demand driven last mile logistics into urban contingency planning across Europe.

This model is also evidencing replicability as it is being applied by T Box through a connection with the Red Crescent organisation made during the emergency response. Currently T Box and the Red Crescent are facilitating this humanitarian response in Algeria.

2.4.9. Beyond DISCO

Emergency logistics management has grown significantly as a discipline over the past 30 years, driven by the exponential increase in humanitarian operations and the rising frequency and intensity of extreme weather events. Between 2000 and 2020, an average of 386 disasters occurred globally each year, rising to 416 in 2020 alone. Storms and floods are consistently identified as the most dangerous events in terms of human impact, as demonstrated by the Valencia catastrophe of 29 October 2024.

Humanitarian logistics is defined as the efficient planning, implementation, and control of goods flows from origin to destination in order to alleviate the suffering of affected populations. It is recognised as a complex socio technical problem integrating social sciences and analytical research, with logistics costs representing up to 82% of total humanitarian activity costs. Despite its importance, the discipline remains underdeveloped relative to commercial logistics, with relief teams still frequently operating on intuition rather than analytical tools.

A central concept in humanitarian logistics is deprivation cost, representing the economic value an individual would offer to end a state of scarcity of vital resources. This cost increases rapidly after 10 hours and reaches the value of life itself at the potential moment of death. Beyond a threshold called hysteresis, suffering becomes irreversible regardless of eventual supply restoration.

The Valencia Living Lab represents a significant methodological contribution to this field. Where conventional humanitarian response frameworks typically require 72 hours to become operational, the Valencia model achieved full operational capacity within 24 hours, compressing the critical window during which deprivation costs escalate most steeply. This acceleration directly reduced human suffering and economic loss across the affected municipalities.

The Valencia experience also addresses a recognised gap in the literature, namely the scarcity of documentation grounded in real world humanitarian operations. By combining demand driven last mile logistics, data informed decision making, and infrastructure reuse, the Valencia model offers both an operational benchmark and a replicable framework for future European contingency planning.

3. Synthesis of Demonstration Results

3.1. Cataloguing Lessons Learnt

3.1.1. DISCOCURB

Across Padua, Zaragoza, and Barcelona, DISCOCURB showed an important gap cities; routinely lack objective, baseline data on how loading and unloading zones actually function before attempting to regulate them. Barcelona's transition from self-declaration via the SPRO app to AI powered computer vision is an illustration of this. The camera system produced the first validated, objective baseline of DUM zone activity for the monitored areas, revealing discrepancies between declared and actual occupancy that prior policy design had simply not been able to see.

Physical and institutional conditions, however, condition that readiness. Padua's experience of illegal stall occupation, interdepartmental scheduling conflicts, and the Italian Road Code's prohibition on permanent exclusive curb allocation revealed that no booking or monitoring system functions without aligned enforcement capacity and coherent governance across municipal departments. Barcelona's finding that existing powered urban infrastructure such as light poles and traffic signals dramatically reduces deployment cost and civil works burden points to a practical pathway that most cities already have available to them.

The strongest cross cutting lesson from DISCOCURB is that digital curb management solutions are technically mature but institutionally immature. The bottleneck is not the technology; it is the absence of regulatory frameworks, interdepartmental coordination protocols, and enforcement capacity that give the technology operational authority.

3.1.2. DISCOPROXI

Zaragoza delivered the most analytically complete DISCOPROXI demonstration in the project, surpassing what Helsinki had achieved at Starring level. Over 7,000 packages were delivered from a repurposed municipal food market microhub, and the team developed the EDPI, a demand driven microhub and parcel locker siting index that outputs priority deployment locations when fed with local logistics and population data. Zaragoza did not replicate the Starring Lab model; it advanced beyond it.

The economic finding from Zaragoza deserves direct policy attention. The proximity model carries approximately a 9.5 percent cost premium over conventional last mile delivery under current conditions. The premium reflects a regulatory gap, not a structural inefficiency. Reduced infrastructure wear, lower health externalities, freed public space, and better working conditions for delivery personnel are real public benefits that current pricing and incentive structures do not account for. SULP alignment, LEZ enforcement, and municipal space pricing are the instruments that close this gap.

Padua and Zaragoza both confirmed that equipment specification and location selection are non negotiable prerequisites. Off the shelf lockers proved poorly suited to pod installation. Locations without sufficient pedestrian traffic or last mile demand volumes underperform regardless of infrastructure quality. Getting these decisions right before deployment, not during it, is the defining operational lesson for replication.

3.1.3. DISCOLLECTION

The central finding, confirmed in both Zaragoza and Padua, is that data integration is not primarily a technical challenge. It is a governance challenge. In Zaragoza, the most critical enabler was the formal agreement between the city council and CityLogin, which established data sharing responsibilities, KPIs, and roles before any platform investment was made, once a partner defaults on their agreement, this creates a gap which slows down the progress of the living lab. In Padua, the failure to specify Urban Freight Data Space interoperability in the original tender led to iterative API refinements after the first release, each requiring additional coordination with INLECOM.

Barcelona demonstrated the ceiling of what DISCOLLECTION can achieve when it is integrated with objective sensor data rather than self declared inputs. Cross referencing AI camera outputs against the SPRO dataset produced greater quality of evidence than either source could provide alone. Data pipelines built to feed city Digital Twins and data lakes via standard APIs multiply this value further. The analytical framework gains full credibility only when validated through real logistics activity; DISCOLLECTION requires operational data to demonstrate its analytical power, not just technical connectivity.

Cities do not need to build full federated data space connectivity to start generating value from DISCOLLECTION. They need institutional alignment first on what value is to be gained by all parties, data governance clarity second, and technical sophistication third.

3.1.4. DISCOBAY and DISCOESTATE

Valencia's pivot to emergency humanitarian logistics following the October 2024 DANA floods produced the most unexpected significant evidence of the entire DISCO programme. The Alcàsser Hub, built on a repurposed fruit warehouse, delivered aid to 154,699 residents across eleven municipalities, outperforming every comparable emergency logistics facility active during the crisis by over 40 percent in service capacity at a cost of approximately EUR 2.18 per package.

The insight this force is a reframing of how urban logistics resilience should be understood in European planning contexts. The question is no longer whether data driven logistics models can outperform conventional systems under stable conditions. Padua, Zaragoza, and Barcelona confirm they can. The more important question, given accelerating climate risk, demographic ageing, and urban concentration, is whether they outperform under maximum stress. Valencia answers that question with documented evidence.

Three enabling conditions made this possible. First, Valencia had a structured urban logistics methodology already in place through DISCO, which enabled immediate mobilisation. Second, the respondents generated verified demand first, then built the supply chain from that base. Third, the DISCOESTATE web portal enabled demand aggregation at scale, converting chaotic incoming donations into a structured, traceable distribution operation within 72 hours. The combination of these three factors produced a system that conventional humanitarian actors could not match.

The replicability of the Valencia model is not limited to disaster contexts. It is being actively applied by T Box through a partnership with the Red Crescent in Algeria. Cities that do not integrate adaptive logistics frameworks into contingency planning are carrying a compounding risk that the Valencia data now quantifies. It is crucial that resilience planning be embedded into SULP's

3.2. Cross Cutting Synthesis

Policy frameworks must precede, not follow, technical deployment. Barcelona needs SULP provisions that give camera monitoring legal authority. Zaragoza needs municipal space pricing and LEZ enforcement to close the proximity logistics cost gap. Padua needs road code reform or permitting clarity to enable permanent exclusive curb allocation. In each case, the technology was operationally ready before the policy environment was. This sequencing problem is the defining structural barrier to DISCOCURB and DISCOPROXI replication at scale, and it is a policy design problem, not a technology one.

Stakeholder misalignment caused operational disruption in Padua through the hesitance of logistics service providers, slowed progress in Zaragoza, and constrained UFDS engagement in Barcelona. The inverse, demonstrated most clearly in Valencia, where a single vision and agreement to prioritise peoples, livelihoods was in place, and where operators felt genuine ownership of objectives, teams adapted rapidly and maintained momentum under pressure. Agile functioned effectively across WP5 not as a governance system but as a values framework. The ceremonies were less important than the relational infrastructure they were designed to build. Future urban logistics programmes should invest as much in stakeholder engagement and change management as in technical planning.

Knowledge transfer in DISCO was bidirectional and generative, not hierarchical. Zaragoza surpassed Helsinki's DISCOPROXI scope. Barcelona advanced beyond Copenhagen's sensor monitoring logic. Padua drew directly on Copenhagen's Coding the Curbs methodology. The Twinning Labs did not simply replicate Starring Lab solutions; in several cases they extended them. This finding has direct implications for how Follower cities engagement is designed: the frameworks should be positioned as a peer learning network because replication is not always possible but adaptation to local contexts with support from frontrunners could facilitate rapid upscaling.

The DISCO framework produced measurable results across four contexts that were regulatory, climatic, institutional, and operational extremes. The EDPI, Next Pod locker system and Dynamic Curbside solutions, Barcelona's AI camera methodology, and Valencia's UrbanPort Emergency Response plan model are each deployable in other European cities. The post project challenge is not generating more evidence. It is ensuring this evidence becomes embedded in SULP frameworks, European urban freight policy guidance, and municipal procurement strategies before the institutional memory of the demonstrations dissipates.

It is also important to note the ability of lessons to cross over from projects such as the Zaragoza DISCOCURB initiative, however, as it stands, the knowledge is held in the institutions (or rather the very people) that were involved in previous projects and it is difficult to replicate if the organizations are not part of the project. A framework that enables this knowledge application even without reference people would greatly improve the ability of Horizon projects to build on each others learning. The Meta Model Suite provides such a framework, the Meta Model Suite generation is based on the lessons learned from the Starring living labs in its second version and currently from the Twinning Living Lab, this validates and empowers the tool to address the needs of cities who would like to implement any of the DISCO innovations. A greater drive needs to be made to empower this tool beyond the DISCO project as well as incorporate the experiences of previous projects, as such, instead of redefining the wheel and creating fragmented efforts and tools, there can be move towards a physical internet enabled reality. More information regarding how the Twinning labs have fed into the MMS and how cities can begin implementing the DISCO suite can be found in the WP2 deliverable D2.6.

4. Conclusions

The Twinning Living Labs have delivered on their core mandate, to transfer lessons from the Starring Living Labs into practice across four new European city contexts, and to generate evidence of the adaptability, transferability, and policy relevance of the DISCO innovation suite.

The finding is not just that data driven logistics models outperform conventional systems under stable conditions, as Padua, Zaragoza, and Barcelona confirm this. The more significant contribution is Valencia's demonstration that agile and data driven logistics frameworks retain and exceed their operational advantage under conditions of maximum institutional and environmental stress. A 40% performance differential, documented during a live humanitarian emergency affecting 154,699 residents, represents evidence that European urban freight policy has not previously had available.

Three structural lessons recur across all four Living Labs. First, policy frameworks must precede technical deployment rather than follow it. Second, stakeholder alignment and relational investment determine operational resilience more than procedural governance. Third, knowledge transfer within DISCO was bidirectional and generative: the Twinning Labs did not simply replicate Starring Lab solutions but in several cases extended them, confirming that peer learning networks are more effective replication models than top down transfer.

The post project challenge is not evidence generation. It is ensuring that the EDPI, the AI camera methodology, the UrbanPort Emergency Response model, the urban freight data space frameworks and the broader DISCO Meta Model Suite become embedded in SULP frameworks, European freight policy guidance, and municipal procurement strategies before the institutional memory of these demonstrations is lost.

Finally, deliverable D5.3. will deliver a full cross site evaluation which includes full key performance indicator computation, quantitative insights, reflection on the cities SULP and SUMP positioning as well as a discussion on the impact of the demonstrations on achieving the sustainable development goals (SDG's). This upcoming deliverable is expected to be published publicly in July 2026.

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