DISCO

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

D5.3 Evaluation Handbook

LSP

26/06/2026

Funded by the European Union

This project has received funding from the European Union's Horizon Europe research and innovation programme under grant agreement No 101103954. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or CINEA. Neither the European Union nor the granting authority can be held responsible for them.

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Abstract

Padua, Zaragoza, Barcelona, and Valencia serve as the Twinning Living Labs (TLLs) within the DISCO project, hosting the second demonstration phase of data-driven and Physical Internet (PI)-led urban logistics innovations. Within this deliverable D5.3, the operational performance and systemic impacts of 11 deployed DISCO-X innovations at the TLLs are evaluated.

The evaluation setup applies the standardized, multi-perspective methodology and dashboard infrastructure developed in Task 4.6. The assessment follows a sequential three-step approach consisting of a data-driven KPI assessment, an ELTIS-based Sustainable Urban Logistics Plan (SULP) compliance check, and a qualitative mapping against the United Nations Sustainable Development Goals (SDGs) at the target level. To accurately evaluate the tactical humanitarian logistics pivot necessitated by the October 2024 flood catastrophe in Valencia, this standard framework was adaptively expanded to include specific resilience KPIs, newly proposed SULP guidelines for disaster management, and additional humanitarian-focused SDG targets.

The empirical outcomes confirm measurable efficiency gains across the TLLs, demonstrating substantial improvements in last-mile transport distances, localized fleet emissions, and curbside data accuracy. Beyond localized performance, this deliverable synthesizes findings across all eight Living Labs to evaluate the overarching replication and upscaling potential of PI-led solutions. The report concludes with a formalized set of strategic guidelines and lessons learned designed to support municipal authorities and private stakeholders in establishing resilient, carbon-neutral urban freight frameworks.

Summary sheet

Deliverable No.	D5.3
Project Acronym	DISCO
Full Title	DATA-DRIVEN, INTEGRATED, SYNCHROMODAL, COLLABORATIVE AND OPTIMISED URBAN FREIGHT META MODEL FOR A NEW GENERATION OF URBAN LOGISTICS AND PLANNING WITH DATA SHARING AT EUROPEAN LIVING LABS
Grant Agreement No.	101103954
Responsible Author(s)	Florian Herrmann, Janis Danebergs
Peer Review	INLE, BUAS
Quality Assurance Committee Review	FIT
Date	30/06/2026
Status	Final
Dissemination level	Public
Work Package No.	5
Work Package Title	The Twinning Living Labs
Programme	HORIZON Innovation Actions
Coordinator	FIT CONSULTING SRL
Website	https://discoprojecteu.com/
Starting date	01/05/2023
Number of months	42 months

Project partners

Organisation	Country	Abbreviation
FIT CONSULTING SRL	IT	FIT
RUPPRECHT CONSULT-FORSCHUNG & BERATUNG GMBH	DE	RC
INLECOM INNOVATION ASTIKI MI KERDOSKOPIKI ETAIREIA	EL	INLE
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DIMOS THESSALONIKIS	EL	THESSALONIKI

DIETHNIS EKTHESI THESSALONIKI AE	EL	TIF HELEXPO
ACS TACHIDROMIKES IPIRESIES MONOPROSOPI ANONYM	EL	ACS
ROLAN OY	FI	ROLAN
ASOCIACIÓN LOGÍSTICA INNOVADORA DE ARAGÓN	ES	ALIA
A to B Finland Oy	FI	A2B
GETPLUS srl IT Partner	IT	NEXT
COMUNE DI PADOVA IT	IT	ComPADUA

Document history

Version	Date	Organisation	Main area of changes
0.1	12/12/2025	LSP	Definition of ToC
0.2	12/02/2026	BARC, BUAS, LSP, PAD, VAL, ZAR	Input from workshops with TLLs on KPIs and data collection
0.3	22/05/2026	BARC, BUAS, LSP, PAD, VAL, ZAR	Input from TLLs on SULP compliance and SDG contribution
0.4	05/06/2026	LSP	Final draft for internal peer review
0.5	16/06/2026	INLE / BUAS/ZLC	Comments from Reviewers + Input on DISCOCURB for Zaragoza
0.6	26/06/2026	INLE / BUAS	Final comments from Reviewers on Zaragoza chapter
1.0	26/06/2026	LSP	Ready for Submission

List of acronyms

AI	Artificial Intelligence
API	Application Programming Interface
CO_2	Carbon dioxide
D	Deliverable
Del.	Delivery
DISCO	Data driven, Integrated, Syncromodal, Collaborative and Optimised urban freight meta model
DISCO-X	General reference to the suite of DISCO modules or individual innovations
EDC	Eclipse Dataspace Components
EUR	Euro
EV	Electric Vehicle
GAIA-X	European Federated Data Infrastructure Project
IDS	International Data Spaces
Inh	Inhabitants
IoT	Internet of Things
kg	Kilogram
KPI	Key Performance Indicator
LL	Living Lab
LEZ	Low Emission Zone
L/U	Loading and Unloading
LUZ	Loading / Unloading Zone

LSP	Logistics Service Provider
NEXT	Advanced smart transportation system based on modular electric vehicles
NGO	Non-Governmental Organization
PI	Physical Internet
PUMS	Piano Urbano della Mobilità Sostenibile
SETR	Societal, Economic, Technical, Regulatory
SDGs	Sustainable Development Goals
SME	Small and Medium-sized Enterprise
SLLs	Starring Living Labs
SPRO	Smart Parking Operations
SULP	Sustainable Urban Logistics Plan
SUMP	Sustainable Urban Mobility Plan
TLLs	Twinning Living Labs
TMS	Transport Management System
ToC	Table of Contents
TRL	Technology Readiness Level
UAC	Urban Access Control
UFDS	Urban Freight Data Space
WP	Work Package

Executive Summary

Within the Horizon Europe DISCO project, Work Package 5 organizes the second demonstration phase across the four Twinning Living Labs (TLLs): Padua, Zaragoza, Barcelona, and Valencia, which serve as host environments for Physical Internet (PI)-led urban logistics innovations. Building directly upon Deliverable 5.2—which documented the local contexts, deployment, and initial validation of these measures—this report (Deliverable 5.3) executes the full cross-site evaluation. It provides the in-depth key performance indicator (KPI) computation, SULP compliance checks, and SDG impact analyses necessary to assess the operational performance and systemic impacts of the 11 deployed DISCO-X measures. In addition, a synthesis of findings and lessons learned across all eight project environments (both Starring and Twinning Living Labs) is presented.

Evaluation Setup and Methodological Alignment

The evaluation framework implemented in this deliverable builds directly upon the evaluation methodology, data processing workflows, and dashboard infrastructure established in Task 4.6 (Deliverable "4.3 Evaluation of impacts at Starring LLs"). To systematically analyse the generated impacts, the evaluation framework maintains the sequential three-step approach validated during the first evaluation round:

1. KPI Assessment: Evaluating the direct, quantifiable operational and environmental performance of the deployed measures.
2. Compliance to SULPs: Assessing the alignment of these innovations with local Sustainable Urban Logistics Plans and city-level planning frameworks based on the European ELTIS guidelines.
3. Contribution to SDGs: Measuring the qualitative macro-level impact toward specific United Nations Sustainable Development Goals at the target level.

To accurately evaluate the humanitarian logistics pivot necessitated by the October 2024 DANA flood catastrophe in Valencia, the framework was adaptively expanded. It incorporates a resilience perspective comprising specific resilience KPIs, newly proposed SULP guidelines for disaster management, and additional humanitarian-focused SDG targets.

Summarized Results per DISCO-X Measure

While the project encompasses a total of 25 measures across all eight LLs, this section details the outcomes of the 11 innovations deployed specifically during the Twinning phase, framed within the common conclusions and shared trade-offs of the broader DISCO-X innovation areas.

DISCOCURB (Barcelona, Padua, Zaragoza): Across the cities, the implementations revealed critical insights into transitioning from static to dynamic curb management. In Barcelona, the deployment of AI-driven computer vision sensors provided objective, high-fidelity monitoring, revealing an actual physical occupancy rate of 91.8% and exposing a massive underestimation within legacy manual applications (41.84% self-reported). Padua successfully transitioned to digitally bookable loading zones to manage dynamic infrastructure assets, while Zaragoza validated a replicable macro-spatial assessment based on stochastic queuing theory to evaluate city-wide capacities without the need for physical sensors. Common conclusions and shared trade-offs: A shared operational reality is that technical readiness outpaces institutional maturity. Digital curb systems cannot function effectively without aligned municipal enforcement, cross-departmental coordination, and local regulatory updates to prevent illegal stall occupation.

DISCOPROXI (Padua, Zaragoza, Valencia): Implemented across three TLLs, these measures demonstrated substantial optimizations in last-mile efficiency and emissions. In Padua, operating mobile dynamic lockers (NEXT pods) combined with a data-driven "WAITING" allocation policy reduced fleet distance travelled by 47.65% and failed first-attempt deliveries by 53.34% compared to random routing. Zaragoza's establishment of an inner-city proximity microhub utilizing electric pushcarts achieved a 33.3% reduction in localized CO_2 emissions per kilometre. In Valencia, the deployment of route planning software and zero-emission fleets enabled serving 10% of the affected population with stepwise increasing delivery efficiency and low emission service. Common conclusions and shared trade-offs: A shared lesson is the conflict of objectives inherent in zero-emission modes; shifting to cargo bikes, delivery robots or pods often increases delivery times or requires initial cost premiums. Broad commercial viability relies heavily on public sector regulatory incentives or Low Emission Zone (LEZ) mandates to monetize external societal benefits.

DISCOBAY (Valencia): Utilizing peri-urban transport infrastructure proved critical for system elasticity. Valencia rapidly established a critical crisis logistics hub in an out-of-town warehouse in Alcàsser, delivering a 40% higher service capacity than comparable relief facilities. Common conclusions and shared trade-offs: Leveraging external transport infrastructure compresses response times (from 24 to 12 hours in Valencia), serving effectively for both daily commercial consolidation and extreme crisis resilience.

DISCOESTATE (Valencia): Exploring the multi-purpose repurposing of building infrastructure revealed both high structural barriers and vast optimization potential. While Starring labs highlighted the capital investment requirements and complex data structuring needed for retrofitting logistics real estate, Valencia demonstrated profound digital elasticity by developing a custom web platform for aid requests to streamline local supplies. Common conclusions and shared trade-offs: A fundamental operational conflict exists between rigid, long-term commercial leasing structures and the necessity for dynamic, short-term asset flexibility. While the flexible, multipurpose use of urban building assets can dramatically optimize land use and reduce localized societal deprivation costs, achieving this agility requires low-barrier digital coordination layers to bypass high physical retrofitting costs and traditional zoning bottlenecks.

DISCOLLECTION (Barcelona, Padua, Zaragoza): Acting as the digital backbone for evidence-based planning, this measure enabled advanced data fusion and decentralized cross-sector integration. In Barcelona, crossing empirical camera detections with legacy self-reported application logs neutralized the human-error element, generating a validated data baseline essential for the city's future Sustainable Urban Logistics Plan (SULP). Padua successfully integrated data flows into the federated Urban Freight Dataspace using the decentralized Eclipse Dataspace Components (EDC) framework. Meanwhile, Zaragoza delivered vital analytical groundwork by deploying predictive demand-modelling techniques to guide long-term network capacity planning. Common conclusions and shared trade-offs: Advanced data fusion and federated architectures successfully eliminate legacy data silos and human error, providing a highly reliable empirical baseline for municipal planning. However, a critical shared trade-off is the immense upfront investment required for data cleaning, API standardization, and overcoming legacy software fragmentation. The core bottleneck for scaling decentralized urban data spaces is ultimately not technical interoperability but establishing cross-sector governance frameworks and data-sharing trust among competing private and public stakeholders.

Replication Potential and Strategic Synthesis

The convergence of evidence across all eight Living Labs—encompassing 14 measures from the first evaluation round (Starring Living Labs) and 11 from the current Twinning phase, for a total of 25 deployed DISCO-X innovations—indicates that while the technical integration of multi-source datasets via decentralized data spaces is highly viable, long-term replication and scaling fundamentally depend on two core pillars: economically vital business models and structurally aligned public-private collaboration.

While data sharing remains a baseline governance and trust challenge, true commercial scalability requires moving beyond grant-funded pilots toward business models with self-sustaining financial viability. Furthermore, wide-scale replication relies on close collaboration between private logistics operators and public authorities. This requires a deep alignment of both data and process flows, ensuring that the operational realities and strategic plans of private actors directly interlock with municipal frameworks. Ultimately, to safeguard European transport networks against accelerating climate hazards and urban congestion, the synthesis derived from this deliverable recommends that metropolitan strategies transition from reactive management to proactive planning by integrating explicit contingency and emergency response frameworks directly into future Sustainable Urban Logistics Plans (SULPs).

1. Introduction

Urban freight transportation is indispensable for modern supply chains, yet it generates significant negative externalities, including congestion, greenhouse gas emissions, noise, and land-use conflicts. In line with the European Green Deal and the EU Urban Mobility Framework, DISCO aims to transform this system by moving away from fragmented, siloed logistics toward a hyperconnected, data-driven, and collaborative model. Consequently, the evaluation of the impacts of the introduced measures represents a critical task within the framework of the DISCO project. This is intended to capture the contribution of these measures to Physical Internet–inspired sustainability transitions in urban logistics, where freight flows become more modular, interconnected, and resource-efficient through shared assets, collaborative processes, and open data exchange.

As part of WP 4, a first evaluation of the Starring Living Labs (M12-M28) was conducted, which made clear that the implemented DISCO-X measures serve as highly effective levers for reorganizing urban logistics, validating the transition from theoretical concepts to scalable, real-world solutions. Specifically, the evaluation outcomes highlighted that:

- **Environmental Impact & Fleet Decarbonization:** Deployed microhub concepts and zero-emission delivery methods (such as cargo bikes and delivery robots) demonstrated a substantial capacity to reduce CO_2 emissions—as evidenced in Copenhagen and Helsinki — and showcased the long-term potential of physical and industrial infrastructure retrofitting (e.g., the Høje Taastrup terminal).
- **Traffic & Operational Efficiency:** Digital innovations like Ghent's Urban Access Control (UAC) system successfully optimized dynamic routing by integrating urban vehicle access regulations directly into logistics planning tools, thereby increasing delivery density and enhancing tr safety.
- **Asset Optimization through Smart Technologies:** The evaluation proved that shared, regulated asset networks—such as Thessaloniki's blockchain-enabled dynamic locker ecosystem —and advanced curbside monitoring (DISCOCURB) drastically improve spatial resource utilization efficiency.
- **Data-driven Governance & Interoperability:** Through the implementation of the DISCOLLECTION measure, a unified data infrastructure was established across all Living Labs. By integrating multi-source datasets into local Urban Freight Dataspaces and city digital twins, the project successfully moved past siloed environments toward collaborative, open data exchange.

While the technical robustness of these frameworks has been successfully demonstrated, the evaluation also brought forward critical operational trade-offs and institutional hurdles. For instance, shifting to a decentralized last-mile modes (cargo bikes/delivery robots) can introduce a cost premium or lower localized delivery speeds due to capacity limitations. Furthermore, findings indicate that technical deployment must be preceded by stronger regulatory alignment, multi-actor trust building, and advanced data cleansing to tackle inconsistent baseline registries.

Building on this solid baseline from the WP 4 evaluation, the purpose of this document is to provide a comprehensive evaluation of the measures implemented in the four Twinning Living Labs (TLLs) of the DISCO project within Work Package 5. It builds directly on Deliverable D5.2, which documented the context, rationale, and implementation of the measures deployed in Padua, Zaragoza, Barcelona, and Valencia. While D5.2 focused on what was implemented and why, this deliverable focuses on how these measures were evaluated and what impacts they generated, both locally and in relation to the wider project ambitions of DISCO. This particularly includes:

- **Monitoring the impact** of the measures implemented in the TLLs to show replicability potential of DISCO-X to scale-up successful data-driven and PI-led solutions,
- **Application of the methodology** developed in Task 4.6 as well as dashboard for data collection, data processing and evaluation,
- **Transferring knowledge** from SLL implementation and deriving guidelines and lessons learnt from the LL evaluations due to overarching analysis across all LLs.

Within the TLLs – Padua, Zaragoza, Barcelona, and Valencia – a total of 11 DISCO-X innovations were successfully implemented, surpassing the original project target of nine planned innovations. This extensive deployment took place during the second and final demonstration phase of the project, covering project months 18 to 42 (November 2024 – May 2026).

While the Living Labs in Padua, Zaragoza, and Barcelona operated within the planned DISCO framework, a severe weather catastrophe in Valencia in October 2024 required an immediate tactical shift. Consequently, the Valencia Living Lab pivoted its deployment into an ad-hoc humanitarian logistics hub, demonstrating the exceptional resilience and real-world adaptability of the DISCO-X solutions under crisis conditions.

In response to these extraordinary circumstances, the evaluation methodology developed in WP4 was adaptively refined to capture these dynamic changes. Despite these additions, the evaluation strictly maintains the fundamental structural layers of Task 4.6. To systematically analyse the impacts generated across all sites, the evaluation framework follows a sequential three-step approach:

- **1. KPI Assessment:** Evaluating the direct, quantifiable operational and environmental performance of the implemented DISCO-X measures,

- **2. Compliance to SULPs:** Assessing how effectively these innovations align with and support future Sustainable Urban Logistics Plans and city-level planning frameworks,
- **3. Contribution to SDGs:** Measuring the macro-level impact and long-term transferability of the solutions toward specific United Nations Sustainable Development Goals on target level.

Chapter 2 outlines the evaluation methodology, incorporating important updates necessitated by the specific conditions of the second evaluation round. In chapters 3 to 6 the evaluation results for each Twinning Living Lab are presented, structured as described above. Chapter 7 synthesises the results, barriers and enablers for scaling measures in line with PI principles. In Chapter 8, a more overarching approach is adopted to derive guidelines to support future evaluations in the context of urban logistics measures. Additionally, lessons learnt from both evaluation rounds are presented, structured according to the five DISCO-X innovations.

2. Evaluation Methodology & Dashboard

The individual elements of the evaluation methodology (KPI-Assessment, SULP compliance and contribution to SDGs) are presented below and are built upon work described in DISCO deliverable D4.3.

A typical evaluation process can be divided into different phases (see Figure 1). It starts with the definition of the evaluation set-up and goals (phase 1). Building on this, the evaluation concept is developed (phase 2). In the subsequent phase, the actual evaluation is carried out by collecting and analysing information and data (phase 3). Following on from this, the findings are documented and communicated (phase 4) and utilised to improve measures (phase 5).

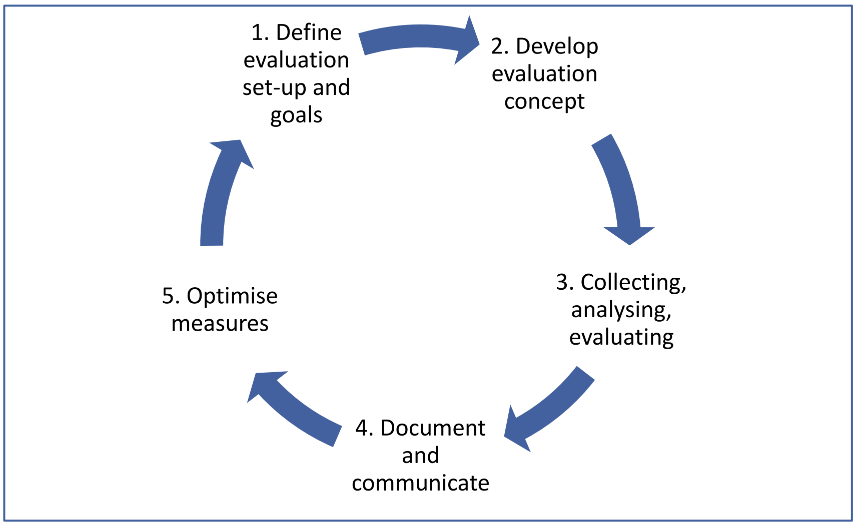
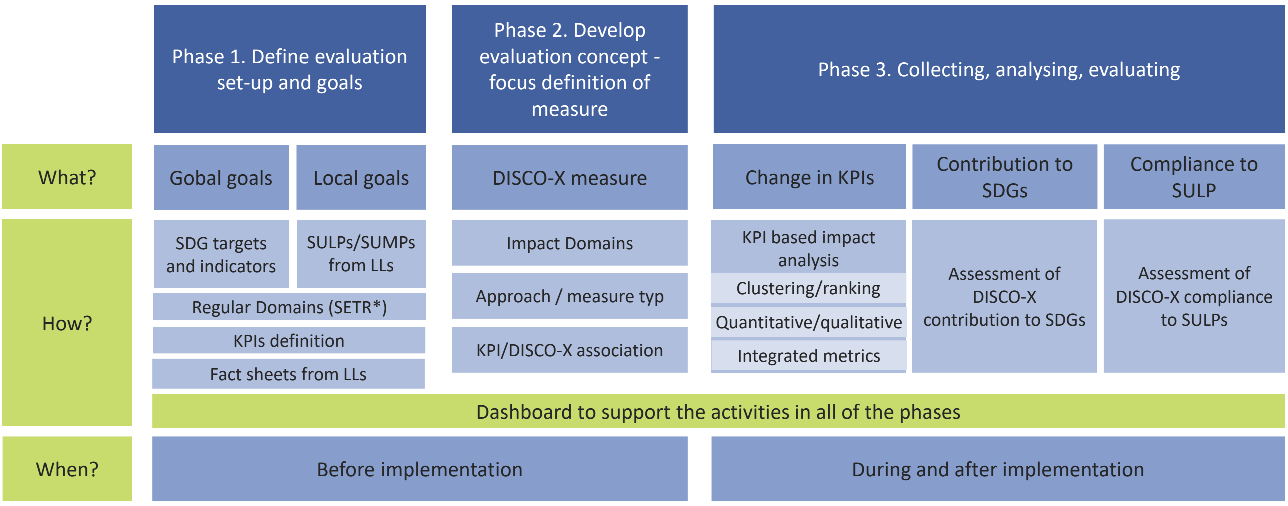


Figure 1: Typical process and phases of a project evaluation (based on: IN_FORM_Leitfaden_Evaluation.pdf)

This process-oriented approach was used as a common thread for the diverse evaluation works. The main work with the first two phases are shortly summarized in this chapter. While the execution of the evaluation in the four Twinning LLs is described separately and is the subject of Chapters 3, 4, 5, and 6.

2.1. Guide to Evaluation for Living Labs – The Evaluation Framework

The findings from DISCO deliverable D4.3 have been summarised in the following framework. This comprises the first three phases of a typical evaluation process and contains the essential elements and content of the evaluation, from the definition of objectives at the global and local levels, through the definition and categorisation of measures, to the approaches used in the execution of the evaluation.



**SETR = societal, economic, technical, regulatory*

Figure 2: Evaluation Framework (Phase 1-3)

Questions that support the application of the framework are, for example:

Phase 1:

- Are there already existing sustainable urban logistics plans (SULPs) or can those be developed in the context of the project?
- Which basic categories should be considered and can be used for defining the set-up and goals with respect to a holistic approach (e.g., societal, economic, technical, regulatory)?
- Which indicators can be used to assess the implementation and determine the impact of measures? How can these be classified in relation to the project setting (e.g., through assignment to Impact Domains, Regular Domains or SDGs)?
- Which indicators reflect the local goals of reducing congestion and emissions, increasing efficiency by deploying the Physical Internet paradigm in urban logistics?
- Has the most important information regarding the planned measures been prepared in a structured manner, and is it available to the stakeholders involved?

Phase 2:

- What is the primary Impact Domain of a DISCO-X measure: Shared solutions, Connected logistics, Smart logistics, Urban network management, Agile storage and last-mile distribution?
- What are the characteristics of the individual DISCO-X measures? (e.g., can it be classified as a physical measure, a digital measure, or a measure focusing on business activities?)
- Is an assignment of DISCO-X measures to KPIs possible, and is quantitative/qualitative data or information available?

2.2. Evaluation set-up

PI-led metrics based on the KPIs were developed in the deliverable D4.3. The KPIs as well as the weighting scheme are listed in the Annex. They cover themes such as resource sharing, cooperation and stakeholder engagement, and resource efficiency—as key levers for sustainability transitions.

These KPI's are processed in the following manners:

- Clustering and ranking of KPIs regarding the importance from a Living Lab perspective (Living Lab perspective)
- Evaluation based on KPIs with respect to KPI Value Changes before and after implementation (Data-driven perspective)
- Evaluation based on KPIs with respect to a normalised KPI Weighting (Evaluation perspective)
- Evaluation based on KPIs with respect to an integrated metric (System perspective)

The KPIs capture both process and impact characteristics, enabling a comprehensive understanding of the potential and challenges of the measures.

A special adaption was made for Valencia LL, for which additional KPIs were added to evaluate in a relevant manner the emergency response work supported by DISCO-X measures. These KPIs are can also be found in the full KPI list in the Annex.

In the following the four perspectives are presented which build the basis for the KPI assessment in the Living Labs.

Living Lab perspective – Evaluating the importance of KPIs

Within this perspective, the importance of each KPI is ranked by the specific city representatives in clustering the KPIs into four groups in a first step. The first Cluster A includes the most relevant ones, the second Cluster B includes the important ones, the third Cluster C includes the less important ones, and the fourth Cluster D includes the ones that are not applicable. In a second step, a rating of the KPIs within the four clusters regarding their specific rank is conducted. This approach allows a prioritisation of KPIs' respective measurements and serves as input for the later KPI-assessment. The LL leaders were consulted to carry out the clustering and ranking since they have continuously interacted with all the other stakeholders in the LL, including logistic service providers, businesses, citizens, public authorities, and so on. As a consequence, their clustering is informed by the vision, perceptions, and characteristics of different types of stakeholders in the city.

KPI Number	KPI	Description and data format	*Example* Cluster	*Example* Rank in Cluster
1	Traffic Flow	Total freight kilometers driven per 10000 inh	B (important)	1
2	Distance Travelled	Average distance per delivery	A (very important)	4
3	Failed Deliveries	Percentage of unsuccessful deliveries with the 1st attempt	C (less important)	1
4	Delivery time	Average delivery time per route	A (very important)	2
5	Delivery Density	Number of deliveries per km	D (not applicable)	0
6	Cost per parcel	Cost of delivery per km	C (less important)	3
7	Operational Cost per day	Total delivery cost	C (less important)	2
8	CO2 Emissions per km	Total kg of CO2 emissions per km	A (very important)	3
9	CO2 Emissions per parcel	Total kg of CO2 emissions per parcel	A (very important)	1
...	...	...	...	...

Figure 3: Extract from questionnaire to cluster and rank KPIs from a Living Lab perspective

Data-driven perspective – Determining the achievements

The evaluation focuses on the KPIs before and after the Living Lab implementation period. The change in data points per KPI between the first and second survey is compared and displayed as a percentage increase or decrease, by dividing the KPI value of the second survey by the KPI value of the first survey and subtracting 1 from the result.

Value Change KPI$_n$ = $\frac{ValueKPIn(t2)}{ValueKPIn(t1)} - 1$; with $n \in \{1, 2, 3, ...20\}$

This evaluation step, based on real data, enables an exact measurement of progress in the form of a valid percentage value, e.g. for expert discussions on how to further reduce or improve a value. The KPI Value Change can be calculated for KPIs 1-20. For the KPIs 21-25, which are likely to start at 0, intervals based on the actual values rather than percentages are used.

Evaluation perspective – Evaluation of the achievements

In the next step, the improvements made due to the implemented measures are weighted on a scale from minus 3, meaning significant worsening, to plus 3, significant improvements. This is called a weighted achievement. This assessment allows the KPI changes to be compared across the Living Labs without showing the exact value of the change. In addition, a quick overview of the changes can be obtained in the form of a graphic visualisation, e.g. in the form of a heat map guiding different stakeholders through the relevant discussions. The intervals for the conversion of the percentage values have been set preliminarily and have been validated after the completion of the ex-post measurements. The following figure illustrates the weighing approach by showing some examples with respect to KPIs 1-4.

			Weights							Interval
			Very bad	Bad	Poor	None	Fair	Good	Very good	
Label	Description and data format	Unit	-3	-2	-1	0	1	2	3	
Traffic Flow	Total freight kilometers driven per 10000 inh	km/10000 inh:	> +20%	+11-20%	+1-10%	0	-1-(-10)%	-11-(-20)%	< -20%	10%
Distance Travelled	Average distance per delivery	km/del	> +30%	+16-30%	+1-15%	0	-1-(-15)%	-16-(-30)%	< -30%	15%
Failed Deliveries	Percentage of unsuccessful deliveries with the 1st attempt	%	> +30%	+16-30%	+1-15%	0	-1-(-15)%	-16-(-30)%	< -30%	15%
Delivery time	Average delivery time per route	mins	> +20%	+11-20%	+1-10%	0	-1-(-10)%	-11-(-20)%	< -20%	10%
...										

Figure 4: Extract from the weighting table

For KPIs where measurements are lacking, a qualitative judgement can be made. The scale applied is: -3: Very bad, -2: Bad, -1: Poor, 0: None, 1: Fair, 2: Good, 3: Very Good.

System perspective – Contextualising results

As a result of the three previous steps (perspectives), a specific KPI Value for each of the 25 KPIs can be derived. This value can be seen as an integrated metric combining the input from the LLs regarding the importance of the KPIs and the achievement made due to the implementation of a measure.

KPI$_n$ Value = $WeightKPIn\ (-3 \ldots +3)\ \cdot\ ClusterWeightKPIn\ (0 \ldots +3)$;
with Cluster A = 3 points, Cluster B = 2 points, Cluster C = 1 point, Cluster D = 0 points.

The resulting standardised and weighted KPIs allow for a comparison across dimensions within the LL, as they clearly show what are the biggest achievements and weaknesses of each measure based on the needs and objectives of the LL. The KPI value can range from -9 (very poor) to +9 (very good).

Beside the presented perspectives for the KPI assessment the evaluation also covers a SULP compliance check as well as an assessment regarding contribution of the DISCO-X measures to the Sustainable Development Goals on a target level. Both elements are described briefly in the following sections.

Compliance with SULPs and SULP guidelines

In addition to the four perspectives described above, a module for assessing SULP compliance has been integrated. This is provided for two different types of SULP compliance assessment.

- Alternative 1: A SULP in the city already exists or is currently under development
- Alternative 2: There is not yet a plan or associated activities that enable the utilisation of targets

In the first case, the existing objectives from the SULP can be used, and the measures of a Living Lab can be compared regarding their compliance. In addition to this comparison, a compliance check is also carried out using already formulated guidelines. In the second case, where no SULP or related activities are available, the compliance check is based solely on these guidelines.

For this purpose, we utilised the SULP Guidelines from the European Local Transport Information Service (ELTIS). The Guidelines address important goals and aspects within the “Socio-economic,” “Commercial,” “Operational,” and “Technical” dimensions. With the help of this structure, the DISCO-X measures are checked for compliance with the formulated guidelines. For doing this, we have used the following scale:

- 3 = High compliance – no need for adaptation,
- 2 = Medium compliance – short-time adaptation,
- 1 = Low compliance – long-time adaptation.

The findings from this assessment can be used to optimise measures for higher compliance or to introduce further measures.

Contributions to SDG

In the previous work with the evaluation method in total 7 SDGs (3, 8, 9, 11, 12, 13, 17) and associated 11 SDG targets (3.9, 8.2, 8.4, 9.1, 9.4, 11.3, 11.6, 11.A, 12.6, 13.2, 17.16) were identified as relevant for the activities within DISCO.

The different DISCO measures were evaluated qualitatively if they contributed directly or indirectly towards the identified SDG targets.

To fairly evaluate the Valencia LL, both additional SDGs (1 and 6) and SDG targets (1.5, 6.2, 11.5, 11.B, 13.1, 13.3) were selected to address in a relevant way the emergency responses measure it implemented.

The full list of the 17 addressed SDG targets can be found in the Annex.

2.3. Evaluation Dashboard

As a support tool for the evaluation; an evaluation dashboard is used to support the following objectives, which essentially address phase 3 ‘Collecting, analysing, evaluating’ of the evaluation cycle described at the beginning of Chapter 2:

- Interface for collecting and providing data in a comparable way,
- Association and clustering of KPIs regarding relevant categories,
- Processing and analysing of data input from the Living Labs,
- Visualisation of indicator changes and impact of the implemented measures.

The four objectives and the associated work on the dashboard (conducted within Task 4.6) are described in more detail below.

From Input Data to Output Data

The figure below illustrates the calculation method for KPIs. Each KPI is derived from a unique set of Baseline Data points using a predetermined formula. For instance, KPI 9 is calculated using a specific formula that pulls values from cells D3, D4, D5, and D6 in the DISCOCURB sheet. This calculation occurs in the background, with the final value displayed in the corresponding KPI sheet. A key feature of this system is its dynamic nature; any updates made to the Baseline Data will automatically and instantly recalculate the relevant KPI.

Baseline Data

	Description baseline data	Unit
1	The population of the city during the last year	Inhs
2	Total number of freight vehicles operating in the pilot area daily	vehs
3	Average freight kilometres per day per vehicle in the pilot area	km/vehs
4	Weighted average of eq.CO2 emissions per km of vehicles in the pilot area	kgCO2/km
5	Average number of deliveries per vehicle at each day within the pilot area	dels/vehs
6	Average number of parcels per delivery at each day within the pilot area	parc/del
7	Number of freight/commercial EV vehicles operating daily in the pilot area	vehs
8	Number of cargo bikes operating daily in the pilot area	vehs
9	Percentage of companies operating with cargo bikes in the city	-
10	Percentage of deliveries performed with cargo bikes	%
11	...	

KPIs

N.	Label	Description and data format	Unit
1	Traffic Flow	Total freight kilometers driven per 10000 inh	km/10000 inhs
2	Distance Travelled	Average distance per delivery	km/del
3	Failed Deliveries	Percentage of unsuccessful deliveries with the 1st attempt	%
4	Delivery time	Average delivery time per route	mins
5	Delivery Density	Number of deliveries per km	del/km
6	Cost per parcel	Cost of delivery per km	€/km
7	Operational Cost per day	Total delivery cost	€
8	CO2 Emissions per km	Total kg of CO2 emissions per km	eCO2/km
9	**CO2 Emissions per parcel**	Total kg of CO2 emissions per parcel	eCO2/parcel
10	EV Adoption Rate	Percentage of electric freight vehicles in the delivery fleet	%
11	Cargo bike adoption rate	Number of cargo bikes in the local delivery fleet	-

KPI 9 = ('Baseline DISCOCURB'!D4 * 'Baseline DISCOCURB'!D3) / ('Baseline DISCOCURB'!D5 * 'Baseline DISCOCURB'!D6)

Figure 5: From Baseline Data to KPI - Example KPI 9: CO_2 Emissions/parcel

Analyse and evaluate based on categorisations

To analyse and evaluate data or visualise results, the dashboard uses various linking and clustering approaches as well as **categorisations**. Those are:

- DISCO-X measures
- 7 Sustainability Development Goals (3,8,9,11,12,13,17) on target level
- the 5 impact domains of DISCO
- SETR dimensions (societal, economic, technical, regulatory)
- dimensions of energy efficiency gains

Normalisation from the weighting approach

In addition to the categories listed above, information from the Living Labs on the importance of the KPIs is processed and combined with the weighting approach.

To enable a more nuanced evaluation, the Evaluation Dashboard normalises KPIs through a system of clustering and weighting. This method generates a final score that reflects both the importance and the performance of each KPI. First, each Living Lab assigns an "importance" rating to their KPIs, based on a framework developed by Lindholmen Science Park and ITL. The ratings are converted to a numerical score:

- “Very Important”: 3 points,
- “Important”: 2 points,
- “Less Important”: 1 point,
- “Not Applicable”: 0 points.

Secondly, a weight is assigned based on the KPI's percentage change from the value of the KPI before implementation to after the implementation. This performance is exemplified below in one of the KPIs, “Traffic flow”, as follows:

- Improvement of > 20%: 3 points,
- Improvement of 11% - 20%: 2 points,
- Improvement of 1% - 10%: 1 point,
- a change of -1% - (-10%): -1 point,
- a change of -11% - (-20%): -2 points,
- a change of > 20%: -3 points.

Calculating the KPI value

Finally, the clustering score is multiplied by the weighting to produce a single, comprehensive value for each KPI, providing a clearer quantitative or qualitative assessment. The figure below shows an example of how a KPI value is calculated. In the example, we give the KPI value change a rating between -3 and 3 based on the percentage of change. The weight is multiplied by the rating of the clustering, and the KPI is assigned a quantitative value. By multiplying the clustering with the weight, the KPI value is normalised. This allows a comparison across KPIs in the evaluation process.

N.	Label	Cluster A (very important, 3), Cluster B (important, 2), Cluster C (less important, 1), Cluster D (not applicable, 0).	Value before implementation	Value after implementation	KPI Value Change in %	Weight
1	Traffic Flow	2	4.85	5.31	10%	-1
2	Distance Travelled	1	0.33	1.52	354%	-3
3	Failed Deliveries	2	0.35	1.00	186%	-3

Helsinki DISCOPROXI – KPI Value
-2
-3
-6

Figure 6: Determination of KPI Value (Example DISCOPROXI - Helsinki Living Lab)

3. Undertaking the Evaluation in the Twinning LLs – Padua

3.1. Introduction to Padua LL

The Padua Living Lab consists of DISCOCURB, DISCOPROXI and DISCOLLECTION. The overall purpose of those three DISCO measures is to find ways to overcome existing challenges in last-mile delivery and with this exploit potential that lies within this element of the transport system. See overview in Figure 7.

From an economic point of view the last-mile delivery can be seen as the most expensive and inefficient link in the chain. More than half of shipping costs occur here, eroding margins and threatening the sustainability of e-commerce. This cost pressure is worsened by fragmentation. Operators rarely share assets, so fleets duplicate trips through already congested city centres. At the same time, fixed lockers and rigid infrastructure cannot adapt to peaks and valleys in demand, while curbside space is either overcrowded or underused, with double-parking that undermines both safety and efficiency. The result is not only inefficiency but also a poor customer experience — missed deliveries, inflexible schedules, even parcel theft. And municipalities, lacking real-time data, struggle to design effective policies or enforce fair use of space.

CHALLENGES	Why it matters
High Cost & Inefficiency	>50% of shipping costs occur in the last mile, cutting profits and endangering e-commerce
Lack of shared means	Fragmented last-mile fleets duplicate trips, increasing congestion, costs and emissions
Rigid delivery infrastructure	Fixed lockers cannot adapt to variable demand, leading to failed or inefficient deliveries
Inefficient curb use	Double parking, conflicts and uneven use of loading zones reduce reliability and safety
Poor Customer Experience	Inflexible schedules and parcel theft cause customer damage brand
Absence of real-time data	Municipalities lack visibility on curb occupancy, making it hard to design fair and effective policies
OPPORTUNITIES	**Why it matters**
Growth of Out-of-Home (OOH)	Consumers demand flexible, secure delivery options, opening space for innovation
IoT & data availability	Sensor data and connectivity open new ways to monitor flows and design responsive policies
Emerging business models	Digital platforms and on-demand services enable flexible answers to variable demand.
Push for Sustainability	Cities seek concrete tools to meet EU decarbonisation and climate-neutrality goals

Figure 7: Challenges within Last-mile delivery

Yet these challenges open strong opportunities. Consumers are increasingly turning to out of home delivery solutions that are more secure and more convenient. IoT and data connectivity now allow flows to be monitored in real time, offering cities the tools to respond dynamically. New business models based on digital platforms and on-demand services are emerging, capable of matching variable demand. And finally, the push for sustainability — anchored in the EU Climate Neutral Cities mission — creates a unique momentum: cities are actively looking for innovations that can reduce congestion and emissions. This is exactly the context in which DISCOCURB and DISCOPROXI provide value.

DISCOPROXI introduces the dynamic locker, a zero-emission solution designed for shared, flexible delivery. Unlike fixed lockers, this system is mounted on modular NEXT pods, meaning it can move where demand arises. With its data-driven approach routes and stops adapt dynamically to actual delivery demand, ensuring resources are not wasted and consumers are reached where they need their parcels. It is also transparent and interoperable, as it connects to the Urban Freight Data Space, allowing integration with other logistics platforms. From the user perspective, it is very simple: once notified, the customer receives a code via email and can access the locker directly through a keypad, picking up the package. By combining sustainability, flexibility, and user-friendliness, the dynamic locker addresses key last-mile challenges while fitting perfectly with the vision of shared, data-driven logistics.

With the DISCOCURB measure, Padua is pioneering on-demand loading and unloading zones, transforming the curb into a smart, bookable resource. Operators can reserve a slot in advance through the municipal platform, ensuring one vehicle, one space, and multiple deliveries. What makes the system innovative is its IoT backbone. Connected variable message signs show in real time which vehicle is authorized and for how long, while all bookings generate historical data for policy design. The service is fair and open to every logistics operator, free of charge, and backed by municipal ordinance with enforcement by the local police. Crucially, these zones enable dynamic lockers to operate legally and safely, while remaining interoperable with traditional deliveries. By digitising curb management and linking it to the Urban Freight Data Space, Padua tries to take a concrete step towards the Physical Internet and more sustainable, synchromodal logistics.

Within the DISCOLLECTION measure, the data collected in the other two measures is transferred to the Urban Freight Dataspace (UFDS), thereby enabling the use of data-driven services, optimization, and collaboration.

3.2. Evaluation set-up and preliminary remarks

In the Padua Living Lab above three distinct DISCO-X measures were implemented to address the city's urban logistics challenges. The following table provides a compact summary of the characteristics of each of these measures.

Table 1: DISCO-X characteristics Padua

	DISCOCURB	DISCOPROXI	DISCOLLECTION
Impact Domain	Agile storage and last-mile distribution	Urban network management	Urban network management
Typology	Physical / digital	Physical / digital	Digital
Implementation approach	On-demand curb zones, bookable in advance for lockers and traditional logistics	Implementing the mobile locker concept. Testing of mobile locker allocation policies.	Connecting the data sources from DISCOCURB and DISCOPROXI based on the Eclipse Dataspace Components (EDC) framework
Supporting Technology	IoT-enabled: Signs and booking platform (App) give real-time and historical occupancy data	Modular NEXT-pods, Algorithms related to each allocation approach	Eclipse Dataspace Components (EDC) framework (IDS), Urban Freight Data Space connector (Sovity Connector)
Focus area	3 locations in the city of Padua	3 locations in the city of Padua	Associated to DISCOCURB and DISCOPROXI measure
Partners	Venice International University, Padua Municipality, NEXT	Venice International University, Padua Municipality, NEXT	Venice International University, Padua Municipality, NEXT
Data sources used	Number of slots and timeslots they booked from the platform	Historical data on demand used to generate the realistic demand for early deployment	Data from DISCOCURB and DISCOPROXI
Evaluation approach	Quantitative and qualitative	Quantitative and qualitative	Quantitative and qualitative
Addressed KPIs	1, 16, 17, 21, 22, 23, 25	2, 3, 5, 6, 7, 21, 22, 25	21, 22, 25

3.3. Assessment of KPI importance

The clustering and rating of KPIs for the Padua Living Lab reflect their relevance to the DISCOCURB pilot objectives and the role of the dynamic locker-based urban logistics system.

Traffic Flow (KPI 1) was rated A as it represents the primary indicator for assessing the impact of the pilot on urban mobility performance and curbside management efficiency. It directly captures changes in traffic conditions resulting from the implementation of DISCOCURB measures. Reliability of sensors and cameras (KPI 16) and Transport infrastructure offer (KPI 17) were classified in Cluster B, as they are important enabling factors for the proper functioning of the DISCOCURB system. However, they are considered supporting indicators, since they mainly reflect operational robustness rather than direct policy or impact outcomes of the pilot. Number of partnerships for collaborative logistics (KPI 23) was included in Cluster C, as to it was expected to provide useful information on stakeholder engagement and collaboration dynamics, but without having direct relation to the core performance of the solutions. This rating is also justified by the fact that at the beginning of the project, several stakeholders were involved, however, during the course of the project, several stakeholders dropped out, limiting the availability and relevance of the data.

From a DISCOPROXI perspective the most important KPI is Cost per parcel (KPI6) since it represents the primary economical and technical driver to guide the feasibility of the mobile locker business model. Even though the dimension and the nature of the early operations couldn't fully capture the real dimension of the KPI, it was still a fundamental analysis to fix the starting point of the evaluation, build projections and assess the competitive advantage. KPI 3, Failed Deliveries, on the other hand represents an important metric to evaluate the operational effectiveness of the dynamic locker system, and, in this context, the users' level of engagement. Furthermore, it serves as a parameter to forecast the magnitude of undelivered goods to be managed to prepare when scaling up to a standard service level. KPI 2, Distance Travelled, is an important parameter for understanding the efficiency of the mobile locker service with respect to alternative last-mile delivery systems. Even though, as for the KPI 6 case, the dimension of the operations couldn't return a fully realistic result, it serves as a useful baseline to project expectations when scaling-up the service.

KPI Numl	KPI	Description and data format	Cluster
8	CO2 Emissions per km	Total kg of CO2 emissions per km	A (very important)
1	Traffic Flow	Total freight kilometers driven per 10000 inh	A (very important)
6	Cost per parcel	Cost of delivery per km	A (very important)
25	SULP	Number of locally politically approved SULP or freight logistics plan	A (very important)
3	Failed Deliveries	Percentage of unsuccessful deliveries with the 1st attempt	B (important)
15	Space Utilization Efficiency	Average occupancy of parking spaces	B (important)
2	Distance Travelled	Average distance per delivery	B (important)
9	CO2 Emissions per parcel	Total kg of CO2 emissions per parcel	B (important)
7	Operational Cost per day	Total delivery cost	B (important)
5	Delivery Density	Number of deliveries per km	B (important)
21	Data sources used	Number of data sources or platforms that are connected to the data space	B (important)
16	Reliability of Sensors and Cameras	Average time that sensors were not working properly	B (important)
19	Lockers volume	Percentage of freight volume delivered through lockers	C (less important)
22	Data Utilization	Number of new/enhanced services utilizing old/new data collected	C (less important)
23	Number of partnerships for collab. logistics	Number private-private and -or public-private partnerships for last mile deliveries	C (less important)
10	EV Adoption Rate	Percentage of electric freight vehicles in the delivery fleet	C (less important)
4	Delivery time	Average delivery time per route	D (not applicable)
11	Cargo bike adoption rate	Number of cargo bikes in the local delivery fleet	D (not applicable)
12	Cargo bike deliveries	Percentage of the total deliveries performed by cargo bikes	D (not applicable)
13	Companies electrification	Percentage of companies that operate with cargo bikes	D (not applicable)
14	Parking fines	Parking fines per 10000 inh	D (not applicable)
17	Transport infra offer	Average offered space of a transport infrastracture to be used as (shared) space for logistics	D (not applicable)
18	Warehouse offer	Average offered space of a warehouses be used as (shared) space for logistics operations	D (not applicable)
20	Microhub Capacity Utilization	Average utilization rate of a parcel locker	D (not applicable)
24	Investment plans	Number of investment logistics plans of local private entities operating in Urban logistics	D (not applicable)

Figure 8: Clustering and ranking of KPIs Padua

3.4. Evaluation of DISCO-X measures

In the following, the three DISCO-X measures implemented in the Padua Living Lab are evaluated on three different levels. In a first step, a KPI assessment based on the 25 KPIs defined in DISCO is carried out (operational level). This assessment uses the methodology described in Chapter 2, considering the different perspectives. From a data point of view, qualitative and quantitative information before and after implementation is used. Following up on this, their compliance with the ELTIS SULP Guidelines is reviewed and aligned with the existing PUMS (adopted 2020, approved 2025) and the draft of a planned SULP (March 2024). This task represents a more local level of assessment. In a final step, their contribution to the SDGs at the target level is assessed (global level).

3.4.1. KPI-Assessment

The three DISCO-X measures implemented in the Padua Living Lab are evaluated using the KPIs defined as DISCO before and after implementation. The methodology described in Chapter 2 is used, considering the different perspectives.

DISCOCURB

Within the framework of the implementation of the DISCOCURB measure, important knowledge about the functionality of the system could be gained. In addition to quantitative insights, qualitative statements were also included in the evaluation.

With regard to the KPI 1 - Traffic Flow, no quantitatively measurable data were available that would have allowed the determination of the change of this factor. Nevertheless, it was confirmed in discussions with those responsible for the measure that the measure contributes to a reduction in the kilometres driven and thus to an improvement in traffic flow. Due to the fact that only two vehicles were used within the implementation phase of the pilot, the qualitative assessment was relatively low with a rating of 1 (fair). However, scaling up the measure holds great potential to further reduce the kilometres driven by the logistics operators (currently 12 operators active in the city area).

KPI 16 – Reliability of sensors and cameras takes into consideration the time that those are not running properly. For Padua Living Lab there are in sum 32 sensors installed dedicated to control logistics operators' activities in the city area. The DISCOCURB measure had provided a significant benefit, as it was recognized through the project work that most of the sensors were not functional. In fact, the number of functional sensors before implementation was 5. As a result of the work during the implementation, it was possible to ensure that 16 of the total 32 sensors were working properly. Even though this was not the primary goal of the measure, it can still be understood as an important component, since the project partially fixed a pre-existing failure. The evaluation of KPI 16 therefore assumes that 27 of the 32 sensors were not functioning before implementation and were therefore out of operation 100% of the time. After implementation, it is assumed that 16 of the 32 sensors were permanently operational and 16 of them inactive. This evaluation is presented in the table as a percentage value that describes the unavailability of the sensors and not their downtime in minutes.

With respect to KPI 17 – Transport infra offer the DISCOCURB measure led to the effect that the existing infrastructure consisting of 150 stalls (12,5 sqm each) was expanded by 5 additional stalls. Beside this quantitative increase in the offer also the quality of the newly added stalls changed since they offer more space for logistics operations (17,5 sqm each).
Regarding KPI 21 Data sources used it can be stated that during the measure implementation a comprehensive data sample was provided and added to the dataspace by CodaQ. This dataset contains historic information on the usage of the stalls and the behaviour of the logistics operators (status regarding availability and booked stalls, info on who is booking and for how long, etc.). This data could be useful to review the location and number of these zones in the future according to their level of utilisation.

KPI 22 on the other hand exactly captures the digital booking platform which was developed for the operational operation of DISCOCURB and which provided the data that is linked to KPI 21.

Within the DISCOCURB measure a partnership with Cityporto was established (KPI 23). Cityporto, which constitutes a specifically operational unit of Interporto, handles micro-logistics, namely the logistics concerning the urban area of Padua. In particular, it manages approximately 50% of urban logistics activities, while the remaining 50% is entirely and independently handled by different private operators. Interporto is responsible for managing the macro-logistics related to the city of Padua, or more precisely, to the Padua "node" in the TEN-T transport network.

Table 2: KPI Assessment DISCOCURB Padua

KPI	Cluster	KPI (before)	KPI (after)	KPI Value Change	Weight	Qualitative rating	KPI Value (integrated)
1 - Traffic flow	A	-	-	-	-	1	3
16 – Reliability of sensors and cameras	B	84,4%	50%	-40,8%	3		6
17 – Transport infra offer	B	1875 m^2	1962,5 m^2	+ 4,7%	1		2
21 - Data sources used	B	0	1	Not applicable	1		2
22 - Data Utilization	C	0	1	Not applicable	1		1
23 - Number of partnerships for collaborative logistics	C	0	1	Not applicable	1		1

DISCOPROXI

In the following the results of the DISCOPROXI measure are discussed. As a fundamental assumption, the RANDOM policy (randomly selects the stall for the day) is defined as the baseline. The reasons for this are on the one hand that DISCOPROXI due to its novel approach can hardly be compared with the existing logistics processes and on the other hand it was decided that the main focal point of the measure is to find out the concrete impact of different policies.

The following results show the evolution in the KPIs comparing the baseline against the WAITING policy, which builds on the greedy approach but adds a fairness mechanism to prevent popular locations from dominating assignments. Due to the operation strategy, it is furthermore predefined that one parcel equals one delivery.

The evaluation of the results shows that the application of the WAITING policy can reduce the distance travelled (KPI 2) by nearly 48%. The failed deliveries (KPI 3) on the other hand were reduced by more than 53% to a percentage of 22,81 unsuccessful deliveries with the 1st attempt. This result builds upon the fact that the initial surveys showed a strong preference for Stall A (20 volunteers) over Stall B (12 volunteers) and Stall C (5 volunteers). This concentration of demand meant that under the WAITING policy, Stall A was served significantly more often. The volunteers at Stalls B and C were less reliable, with success rates of 68% and 57% respectively, compared to 78% for Stall A. Because Stalls B and C have fewer volunteers, individual delivery failures have a much larger impact on the overall percentage. This is further compounded by the fact that these stalls were served more frequently under the RANDOM policy.

The Delivery Density (KPI 5) was increased by more than 90% which corresponds to the development of KPI 2 under the assumption that a delivery is equivalent to a parcel.

In addition to improving the efficiency- and reliability-oriented metrics, the application of the WAITING policy also improved the cost situation compared to the RANDOM policy. The Cost per parcel (KPI 6) decreased by 16% and the Operational cost per day (KPI 7) decreased even more by 22%. This comparison provides important insights into which implementation policy is most cost-effective. Nevertheless, it must be mentioned that this cost statement does not represent a comprehensive analysis. While the parcel cost included the driver's allocated time and vehicle energy costs maintenance and depreciation costs were excluded in the calculation due to the prototype character of the vehicles and the low delivery volume. Including those factors would have disproportionately inflated the cost per delivery.

With respect to KPI 21 - Data sources used the team utilized historical data about deliveries to model the delivery demand for the early deployment of the system. The required data was provided by Cityporto and equally flowed into the application of the various policies; therefore, this indicator did not change.

Regarding the indicator Data utilization (KPI 22) an e-mail system was set up to inform the volunteers and provide them with needed information, e.g. pin codes to access the vehicle etc. This system was used for all policies. In addition, a dynamic locker allocation algorithm was utilized for the WAITING policy.

Table 3: KPI-Assessment DISCOPROXI Padua

KPI	Cluster	KPI (before) [1]	KPI (after)	KPI Value Change	Weight	Qualitative rating	KPI Value (integrated)
2 - Distance Travelled	B	2.77	1.45	-47.65%	3		6
3 – Failed Deliveries	B	48.89	22.81	-53.34%	3		6
5 – Delivery Density	B	0.36	0.69	91.5%	3		6
6 – Cost per parcel	A	8.87	7.42	-16.28	2		6
7 – Operational cost per day	B	90.80	70.82	-22%	3		6
21 - Data sources used	B	2	2	0	0		0 (no change)
22 - Data Utilization	C	1	2	100%	2		2

Beside the above discussed KPIs, the DISCOPROXI measure also contributed to other indicators. Since the NEXT pods are fully electric the metrics for CO_2 Emissions per km (KPI 8), CO2 Emissions per parcel (KPI 9) as well as EV Adoption Rate (KPI 10) are fully met. The demonstrated concept thus proves that it has suitability for later scaling to fundamentally change the existing logistics system.

DISCOLLECTION

The evaluation of DISCOLLECTION takes into consideration the achievements regarding data-related activities within both measures DISCOCURB and DISCOPROXIS as well as the establishment of the appropriate infrastructure for making the data available to stakeholders within the DISCO community. CodaQ acted as the main core partner for the city as subcontractor responsible for the data management. Within DISCOCURB the company also developed the service to support the booking of the DISCOCURB stalls. The data of the online platform included, for example, availability of the stalls, parking duration or license numbers of the vehicles.

Furthermore, Cityporto provided historic data about deliveries that was utilized to model the delivery demand for the early deployment of the DISCOPROXI system. In comparison to the data

[1] Random policy allocation as baseline

managed by CodaQ this data was not added to the dataspace. Regarding KPI 25 in total three data sources were used (and added to the data space).
To operate the DISCOCURB and DISCOPROXI pilots, three data-based applications were developed and used (KPI 22). The online booking platform for DISCOCURB as well as a dedicated mailing system to inform the volunteers (e.g. providing information on pin codes to access the vehicle). In addition, a dynamic locker allocation algorithm was utilized (after implementation).

With regard to the API interface provided by CodaQ, it should be said that it will continue to be used for the further operation of the DISCOCURB measure.

Table 4: KPI-Assessment DISCOLLECTION Padua

KPI	Cluster	KPI (before)	KPI (after)	KPI Value Change	Weight	Qualitative rating	KPI Value (integrated)
21 – Data sources used	B	2	3	50%	3		6
22 – Data Utilization	C	1	3	200%	3		3

3.4.2. Compliance to SULPs

Padua has a PUMS (Piano Urbano della Mobilità Sostenibile), which corresponds to a Sustainable Urban Mobility Plan (SUMP), It was adopted in 2020 and subsequently approved by the City Council in 2025. In addition, there are preliminary strategic guidelines and policy directions that lay the foundations for urban logistics planning, which can be seen as an initial step towards a more structured SULP framework in the future.

The guidelines are also aligned with the ELTIS urban logistics framework and include operational measures such as the regulation and digital management of loading/unloading areas (Intervention 5), supporting a gradual implementation approach. Preparatory work on these guidelines had already been ongoing in 2023, prior to the start of the project, in the form of early drafting and development activities. The SULP guidelines were then formally drafted and consolidated in March 2024 and made available as a technical and policy basis for a potential future urban logistics plan for the city of Padua. At present, however, no official SULP has yet been drawn up.

In the following a comprehensive compliance check for DISCOCURB is presented. Building upon this, selected aspects for DISCOPROXI and DISCOLLECTION are discussed.

DISCOCURB

Socio-economic perspective *Guidelines evaluated: Reducing traffic impacts in the historical centre (2), Increasing livability of urban environment (1), Enhancing local economic development (1)*

From a socio-economic perspective, both the PUMS (adopted 2020, approved 2025) and the draft SULP (March 2024) establish a solid strategic vision aimed at reducing congestion and improving urban quality of life. The introduction of additional loading and unloading bays contributes to a slight reduction in traffic pressure in the historical centre, as delivery vehicles experience less circulation in search of parking spaces. This leads to a marginal improvement in urban livability, reflected in reduced congestion and a modest enhancement of environmental conditions in central areas. However, in terms of enhancing local economic development, no specific commercial or economic policy measures have been introduced within the current framework. We therefore assign a score of 1 across all socio-economic guidelines, as benefits are still limited in scale and not yet fully materialized.

Commercial perspective *Guidelines evaluated: Generate benefits on competitiveness of business (1), Optimize logistics operation (3), Reduce cost/improve knowledge of delivery cost (1)*

From a commercial perspective, the number of stakeholders currently involved remains limited, and no substantial business-level benefits have yet been observed in terms of competitiveness or cost transparency. The system does not yet include a fully developed ecosystem capable of generating direct economic advantages for operators, nor are there structured tools in place for real-time cost analysis or data-driven commercial optimization. However, moderate improvement can be identified in the optimization of logistics operations (2). This is mainly linked to the reorganization of urban freight space through the introduction of additional loading and unloading bays, which has helped improve delivery efficiency and reduce operational friction in last-mile logistics activities. This development has been enabled by the implementation of Municipal Ordinance No. 2026/62/0106 of 04/02/2026, which formalizes the reallocation and expansion of dedicated freight stopping areas. Overall, while operational efficiency has improved, the commercial dimension remains limited in terms of direct economic impact, as benefits are currently restricted to logistics of flow optimization rather than broader market or business transformation.

Operational perspective *Guidelines evaluated: Improved city access regulation (2), Support adoption/use of sustainable vehicles (2), Measures supporting transportation operators' market (3)*

From an operational perspective, the framework shows a moderate level of implementation across all indicators (2). City access regulations have improved through the formal reorganization and expansion of loading and unloading areas, supported by Municipal Ordinance No. 2026/62/0106 of 04/02/2026, which enhances the structure of urban freight access. The support for sustainable vehicles is indirectly strengthened by more efficient freight operations and reduced circulation times. Similarly, transportation operators benefit from improved infrastructure and greater operational reliability, but without significant market restructuring or advanced coordination tools.

Technical perspective *Guidelines evaluated: Systems to optimize fleet delivery operation (2), Systems to optimise logistics operation (2), Improved integration of logistics in urban operation (2)*

From a technical perspective, the system shows a moderate and coherent level of maturity across all indicators (2). The introduction of additional loading and unloading bays, together with the implementation of Municipal Ordinance No. 2026/62/0106, has contributed to the optimisation of fleet operations by reducing time spent searching f or parking and improving delivery efficiency. These measures also support overall logistics optimisation by making last-mile operations more predictable and less time-consuming. In addition, the formalisation of curbside management through the ordinance enhances the integration of logistics within urban operations, by structurally embedding freight activities into the city's regulatory framework.

DISCOPROXI

DISCOPROXI is consistent with the SULP strategy aimed at developing microhubs and proximity logistics spaces, designed to reduce last-mile traffic and promote low-emission delivery modes (electric vehicles, and pedestrian-based distribution). Nevertheless, the overall assessment is low, as the available pilot implementations remain limited both in scale and operational maturity. In any case, the measurement of expected benefits in terms of emissions reduction, congestion alleviation, and improved logistics efficiency has shown a slight improvement. The model therefore requires additional implementation steps at a larger and more structured scale to be properly validated and made replicable, since more in-depth traffic analyses fall outside the scope of the DISCO project.

DISCOLLECTION

DISCOLLECTION is consistent with the SULP guidelines in its focus on strengthening urban logistics data collection, monitoring and integration systems, enabling a more real used governance of freight flows. The approach supports the development of shared data infrastructures for tracking freight movements, basic vehicle access to urban areas, loading/unloading activities, and the detailed definition of logistics performance indicators. This aligns with the objective of the SULP guidelines of improving decision-making through more granular, timely, and interoperable data sources. The overall assessment is low since the lack of a consolidated urban logistics data ecosystem significantly reduces the potential for real-time monitoring and advanced planning capabilities.

Mobility Governance: Services and measures	SULP guidelines		DISCO X		
			DISCOPROXI	DISCOCURB	DISCOLLECTION
	Socio-economic	Reducing traffic impacts in the historical centre	1	2	1
		Increasing livability of urban environment	1	1	1
		Enhancing local economic development	1	1	1
	Commercial	Generate benefits on competetiveness and business	1	1	1
		Optimise logistics operation	2	3	1
		Reduce costs, improve knowledge of delivery cost	1	1	1
	Operational	Improved city access regulation	1	2	2
		Support adoption/use of sustainable vehicles	3	2	1
		Measures supporting transportation operators market	2	3	2
	Technical	Systems to optimise fleet delivery operation	3	2	2
		Systems to optimise logistics operation	3	2	2
		Improved integration of logistics in urban mobility	3	2	2

State of compliance of technology, service and business model will be scored according to the following general criteria:	1,83	1,83	1,42
3 = High compliance - no need for adaptation			
2 = Medium compliance - short time adaptation			
1 = Low compliance - long time adaptation			

Figure 9: PI compliance to SULP-Guidelines Padua

Regarding KPI 25 – SULP, Padua had already initiated preparatory work prior to the official launch of the DISCO project. As early as 2023, the local team developed an initial draft for the SULP guidelines. Building on this momentum, the first official SULP guidelines were subsequently issued in 2024, falling directly within the project's active runtime.

Table 5: KPI 25 - SULP Evaluation Padua

KPI	Cluster	KPI (before)	KPI (after)	KPI Value Change	Weight	Qualitative rating	KPI Value (integrated)
25 - SULP	A	drafted[2]	Issued	Formula not appl.	2		6

3.4.3. Contribution to SDGs

In this step the contribution of the DISCO-X measures to the Sustainable Development Goals (SDGs) is evaluated. To be able to make a sufficiently precise statement here, the use of the target level of the SDGs is chosen. The association of KPIs to SDGs as well as the association of KPIs to DISCO-X measures serve as input for the assessment. In correlation with the 7 SDGs that are addressed by the DISCO activities 11 SDG targets were identified and compared with the four measures

[2] This rating corresponds to the early SULP related activities in Padua before the project start in 2023.

implemented in the Padua LL. The scale used is green = Direct contribution, light green = indirect contribution no colour = no contribution. In addition, comments were made to clarify the contribution of the respective measure.

Table 6: Contribution to SDGs Padua LL

SDG target	DISCO-X		
	DISCOCURB Addr. KPIs: 1, 16, 17, 21, 22, 23, 25	DISCOPROXI Addr. KPIs: 2, 3, 5, 6, 7, 21, 22, 25	DISCOLLECTION Addr. KPIs: 21, 22, 25
3.9: Reduce the amount of deaths produced by dangerous chemicals and the pollution of the air, water and soil (…) Ass. KPIs: 1, 2, 3, 5, 8-13	**[Indirect Contribution]** Contribution due to expected minor reduction of CO_2	**[Direct Contribution]** Clear contribution as the hub use case was implemented	
8.2: Achieve higher levels of economic productivity (…) Ass. KPIs: 6, 7, 24, 25		**[Direct Contribution]** Clear contribution as the hub use case was implemented	**[Indirect Contribution]** It improved the availability of operational logistics data, supporting more efficient planning of delivery operations.
8.4: Improve (…) global resource efficiency in con-sumption and production (…) Ass. KPIs: 1, 2, 5, 10		**[Direct Contribution]** It increased efficiency by decreasing the total number of km travelled	
9.1: Develop quality, reliable, sustainable and resilient infrastructure (…) Ass. KPIs: 1, 5, 15, 17, 18, 20		**[Indirect Contribution]** The service infrastructure behind last-mile deliveries becomes more reliable and sustainable as we expect a reduction in the failed deliveries.	
9.4: (…) upgrade infrastructure and retrofit industries to make them sustainable (…) Ass. KPIs: 17-20	**[Direct Contribution]** Transforms static curbside spaces into digitally managed and dynamically allocated infrastructure assets.	**[Direct Contribution]** Switching from a fixed to a dynamic infrastructure that can be shared among multiple logistics operators based on electric vehicles.	
11.3: (…) enhance inclusive and sustainable urbanisation and capacity for participatory, integrated and sustainable human settlement planning and management (…) Ass. KPIs: 11, 19, 20			**[Direct Contribution]** Provided structured real-time and historical data on curbside usage to support evidence-based urban planning decisions.

11.6: (…) reduce the adverse per capita environmental impact of cities (…) Ass. KPIs: 8-13	**[Direct Contribution]** Reduced congestion due to better allocation of stalls.	**[Direct Contribution]** Clear contribution was observed when the hub use case was implemented, as it integrated EVs and aimed to reduce the kilometres travelled by commercial vehicles in last-mile deliveries.	**[Indirect Contribution]** It enabled better quantification of environmental impacts associated with urban freight activities.
11.A: Support positive economic, social and environmental links between urban, peri-urban and rural areas by strengthening national and regional development planning Ass. KPIs: 24, 25	**[Indirect Contribution]** Potential replicability of curbside management model	**[Indirect Contribution]** Potential replicability of dynamic locker model	**[Indirect Contribution]** It enabled data exchange between urban and regional logistics systems, supporting more coordinated planning.
12.6: Encourage companies (…) to adopt sustainable practices and to integrate sustainability information into their reporting cycle Ass. KPIs: 13, 23	**[Indirect Contribution]** It supported transparency and monitoring of logistics operations within municipal governance frameworks.	**[Direct Contribution]** Clear contribution was observed when the hub use case was implemented, as it renovated operational fleets with sustainable EVs.	**[Direct Contribution]** Generated structured operational data on curbside usage, enabling sustainability reporting for urban freight activities.
13.2: Integrate climate change measures into national policies, strategies and planning Ass. KPIs: 25	**[Indirect Contribution]** Supported the development of future policy measures aimed at reducing transport-related environmental impacts.	**[Direct Contribution]** Clear contribution was observed when the hub use case was implemented, as it renovated operational fleets with sustainable EVs.	**[Direct Contribution]** It supported the development of data-driven climate policies by improving the availability of freight-related environmental indicators.
17.16: Enhance the Global Partnership for Sustainable Development (…) Ass. KPIs: 23	**[Indirect Contribution]** Supported collaborative governance models for urban freight and curbside management.	**[Direct Contribution]** Clear contribution was observed since the developed solution can be shared among multiple logistics operators based on electric vehicles.	

4. Undertaking the Evaluation in the Twinning LLs – Zaragoza

4.1. Introduction to Zaragoza LL

Zaragoza's urban freight distribution is based on the PLAZA logistics platform located about 15 kilometres outside of the city centre. This geographical separation leads to numerous challenges in the context of last mile deliveries. The current fleet consists mostly of diesel-powered vehicles, which results in significant emissions and traffic congestion, especially during rush hours when the vehicles are operating in the city centre. A key operational inefficiency is the lack of integration between logistics data and available urban infrastructure. While underutilized commercial spaces exist in the city centre, they are not currently leveraged to optimize freight flows or revitalize pedestrian-heavy areas. However, the city possesses a robust infrastructure asset base ready for digitalization. Zaragoza manages 779 geolocated loading and unloading areas. These zones are standardized (~25 meters in length), fully regulated with signage and specific time windows, and monitored for activity status. This existing regulated network provides the critical physical foundation for the DISCO project's proposed data-driven optimization measures.

Within the DISCOPROXI measure Zaragoza established a new model of collaboration between the last-mile operator (Citylogin) and the City Council to identify currently underutilized urban space and install/test a micro-logistics centre equipped with electric charging points to support last-mile operations. The facility is operated by CityLogin (LSP) and will house part of its low-emission fleet.

DISCOCURB: As introduced in Deliverable 5.2 DISCO Twinning Lab Implementation (section 2.2.4), Zaragoza Living Lab included at a later stage in the project the DISCOCURB measure by developing a replicable, macro-spatial infrastructure assessment methodology. The ultimate goal was to validate Loading and Unloading Zones (LUZ) model for Zaragoza. Rather than relying on computationally heavy micro-agent simulations, the implementation established a practical framework based on stochastic queuing theory and Poisson distribution to evaluate the city's 779 Loading and Unloading Zones (LUZ). By integrating georeferenced open data with structured questionnaires distributed to consumers, retailers, and delivery operators, the measure successfully modelled combined B2B and B2C freight demand against existing physical infrastructure capacities to optimize future urban curb space allocation.

The DISCOLLECTION measure, on the other hand, fostered data-driven logistics services to support local initiatives and sustainable freight transport by implementing digital innovations with intensive use of urban freight data. Specifically, a predictive model—the E-commerce Demand Potential Index (EDPI)—was developed and successfully validated using real-world operational data from the local logistics service provider (Citylogin). This allowed the assessment of local demand patterns and the optimization of resource allocation and Quality of Service (QoS). While DISCOLLECTION was successfully implemented as a strategic planning and analytical optimization tool, advancing from TRL 2 to TRL 5, it did not deploy autonomous real-time physical or dynamic API infrastructures during this phase. Consequently, its impact cannot be measured through classic operational transport flow metrics (such as vehicle-kilometers or direct emission reductions) within the developed evaluation framework. Therefore, this measure is not part of the following evaluation. Nevertheless, qualitative learnings from the measure are included in Chapter 7 and 8. For deeper insights into its methodology and planning outcomes, reference is made to Deliverable D5.2.

4.2. Evaluation set-up and preliminary remarks

As described above, Zaragoza focused on the operational introduction of the DISCOCURB and DISCOPROXI measures. In addition, valuable analytical groundwork was conducted regarding the DISCOLLECTION measure. To gain a better understanding of the following evaluation scope, the table below illustrates the key characteristics and operational status of these measures.

Table 7: DISCO-X characteristics Zaragoza

	DISCOCURB (introduced at a later stage in the project)	DISCOPROXI	DISCOLLECTION (excluded from evaluation due to differing implementation approach)
Impact Domain	Agile storage and last-mile distribution	Smart logistics	Smart logistics
Typology	Digital	Business	Digital
Implementation approach	Development of a replicable, macro-spatial infrastructure assessment methodology based on stochastic queueing theory and Poisson distribution to evaluate the city's 779 Loading and Unloading Zones (LUZ).	Microhub as a consolidation point for deliveries from PLAZA. From there goods are delivered to urban areas using electric vehicles, cargo bikes and assisted delivery carts.	Development of a predictive model to estimate local demand and last-mile deliveries. Role-model to attract more logistics service providers to share data.
Supporting Technology	Stochastic queueing models and structured stakeholder questionnaires (consumers, retailers, drivers).	Two assisted delivery vehicles + TMS system (urbantz)	Machine learning predictive model
Focus area	City-wide LUZ network	LEZ (historical center) within the east part of the City Centre	Zaragoza

Partners	Fundación Zaragoza Logistics Center, ALIA – Clúster Logístico de Aragón, CITYlogin, Zaragoza Ayuntamiento	Fundación Zaragoza Conocimiento (FZC), ALIA – Clúster Logístico de Aragón, CITYlogin, Zaragoza Ayuntamiento	Fundación Zaragoza Conocimiento (FZC), ALIA – Clúster Logístico de Aragón, CITYlogin, Zaragoza Ayuntamiento
Data sources used	Georeferenced open data, commercial licenses, fieldwork, and stakeholder questionnaire data.	Activity data (demand related) and fleet data (how is demand covered by vehicles)	Activity data, warehouse data, fleet data
Evaluation approach	Quantitative and qualitative	Quantitative and qualitative	No evaluation possible
Addressed KPIs	5, 15, 17, 21, 22, 25	1, 2, 3, 4, 5, 6, 7, 8, 9, 21, 22, 23, 25	-

4.3. Assessment of KPI importance

The way Zaragoza prioritized its 25 KPIs reflects a clear focus on the city's strategic goals, particularly the implementation of the updated Low Emission Zone (LEZ) regulations and the targets set in the Sustainable Urban Mobility Plan (SUMP). At the heart of this strategy is the massive reduction of greenhouse gases and traffic impacts in the historic centre, which explains why CO_2 metrics and electric vehicle adoption rates were placed at the very top of the list (Cluster A). Tracking these changes directly supports local policymakers in measuring compliance and reshaping urban logistics spaces, such as integrating the San Vicente de Paúl market hub into the inner-city network. Furthermore, Zaragoza is leveraging these pilot insights to update their current Sustainable Urban Mobility Plan (SUMP). Given the high strategic priority assigned to this policy integration within Cluster A, the resulting policy metric (KPI 25) underscores how tightly the technical solutions are bound to the city's long-term planning. Similarly, the quantification of available loading and unloading zones (KPI 17), directly informed by the DISCOCURB capacity assessment, enables the city to identify where curb space allocation must be adjusted to support, rather than undermine, the LEZ's objectives.

This political and environmental focus connects to the daily operational needs of the logistics partners. While indicators like operational costs or delivery time are secondary to the city's green targets, they remain highly important to prove that proximity logistics can be financially viable and reliable in the long run. Similarly, data-related KPIs—such as tracking the data sources used or data utilization—are treated as necessary tools to enable smarter urban planning through the DISCOLLECTION platform, rather than being an end goal themselves.

On the other hand, metrics that offer very little local impact or simply do not apply to Zaragoza's specific technical setup were intentionally ranked low or excluded. For instance, distance travelled is less important because the DISCOPROXI e-carts operate within a very compact, 10-minute walk radius around the hub, which naturally keeps vehicle kilometres to a minimum. Furthermore, indicators tracking hardware reliability, like camera or sensor downtime, were given zero weight because the DISCOCURB approach focused on macro-spatial mathematical modeling and stakeholder questionnaires instead of physical street-level sensors. This also applies to automated parcel lockers, as the pilot strictly focused on direct parcel delivery and cross-docking workflows.

KPI Numl	KPI	Description and data format	Cluster	Rank in Cluster
9	CO2 Emissions per parcel	Total kg of CO2 emissions per parcel	A (very important)	1
8	CO2 Emissions per km	Total kg of CO2 emissions per km	A (very important)	2
10	EV Adoption Rate	Percentage of electric freight vehicles in the delivery fleet	A (very important)	3
1	Traffic Flow	Total freight kilometers driven per 10000 inh	A (very important)	4
25	SULP	Number of locally politically approved SULP or freight logistics plan	A (very important)	5
17	Transport infra offer	Average offered space of a transport infrastructure to be used as (shared) space for logistics operations	A (very important)	6
18	Warehouse offer	Average offered space of a warehouses be used as (shared) space for logistics operations	A (very important)	7
7	Operational Cost per day	Total delivery cost	B (important)	1
4	Delivery time	Average delivery time per route	B (important)	2
3	Failed Deliveries	Percentage of unsuccessful deliveries with the 1st attempt	B (important)	3
6	Cost per parcel	Cost of delivery per km	B (important)	4
15	Space Utilization Efficiency	Average occupancy of parking spaces	B (important)	5
11	Cargo bike adoption rate	Number of cargo bikes in the local delivery fleet	B (important)	6
21	Data sources used	Number of data sources or platforms that are connected to the data space	B (important)	7
22	Data Utilization	Number of new/enhanced services utilizing old/new data collected	B (important)	8
23	Number of partnerships for coll. logistics	Number private-private and -or public-private partnerships for last mile deliveries	B (important)	9
2	Distance Travelled	Average distance per delivery	C (less important)	1
5	Delivery Density	Number of deliveries per km	C (less important)	2
12	Cargo bike deliveries	Percentage of the total deliveries performed by cargo bikes	C (less important)	3
14	Parking fines	Parking fines per 10000 inh	C (less important)	4
13	Companies electrification	Percentage of companies that operate with cargo bikes	D (not applicable)	
16	Reliability of Sensors and Cameras	Average time that sensors were not working properly	D (not applicable)	
19	Lockers volume	Percentage of freight volume delivered through lockers	D (not applicable)	
20	Microhub Capacity Utilization	Average utilization rate of a parcel locker	D (not applicable)	
24	Investment plans	Number of investment logistics plans of local private entities operating in Urban logistics	D (not applicable)	

Figure 10: Clustering and ranking of KPIs Zaragoza

4.4. Evaluation of DISCO-X measures

In the following, the DISCO-X measures implemented in the Zaragoza Living Lab are evaluated on three different levels. In a first step, a KPI assessment based on the 25 KPIs defined in DISCO is carried out (operational level). This assessment uses the methodology described in chapter 2.1, considering the different perspectives. From a data point of view, qualitative and quantitative information before and after implementation is used. Following up on this, their compliance with the ELTIS SULP Guidelines is reviewed and aligned with the developed SULP recommendations 2025 (local level). In a final step, their contribution to the SDGs at the target level is assessed (global level).

4.4.1. KPI-Assessment

Unlike the sensor-based DISCOCURB implementations in Barcelona and Padua, the Zaragoza measure was operationalised as a macro-spatial infrastructure assessment methodology based on stochastic queueing theory and structured stakeholder questionnaires. This methodological choice was deliberate and documented in Deliverable 5.2, where Zaragoza committed to developing a replicable, data-driven framework capable of evaluating the full Loading and Unloading Zones network (LUZ) without relying on computationally intensive micro-agent simulations. The outputs presented in this section fulfil that commitment by establishing the analytical baseline against which future LUZ interventions can be measured, and they generate the quantified evidence base required to inform concrete SUMP/SULP policy actions.

The relevance of this baseline is reinforced by the institutional context in which it has been produced. In June 2025, the city hall and AECOC (the national association representing over 34,000 manufacturers and distributors) signed a formal cooperation protocol to develop a new model for efficient, intelligent, and sustainable urban goods distribution for the city. The protocol explicitly commits both parties to sharing data, defining new DUM models based on demand analysis, and translating findings into operational actions. The district-level capacity assessments, delivery density estimates, and temporal demand profiles generated by the DISCOCURB analysis constitute precisely the kind of data infrastructure this public-private partnership requires to move from diagnosis to implementation. Two policy pathways connect the LUZ analysis directly to Zaragoza's existing SUMP framework. First, the temporal demand profile provides the empirical foundation for time-differentiated curb management (Programme ED-03 of the SUMP Freight Chapter), which proposes flexible time-slot allocation for loading zones and the introduction of digital reservation mechanisms. The DISCOCURB results now supply the district-level demand data that this programme explicitly requires before it can be designed and prioritised, by directly informing KPI 15 (Space Utilisation Efficiency) and KPI 17 (Transport Infrastructure Offer). Second, the district-level capacity analysis supports targeted physical adaptation and enforcement prioritisation (Programme ED-01 of the SUMP Freight Chapter), which calls for an inventory-based review of LUZ spaces and the creation of a data-driven action plan for their expansion or relocation.

Data collection as baseline

The assessment integrates five data sources covering the three sides of the urban delivery transaction (operators, retailers, general population as freight generator through e-commerce); the survey questions used as inputs to the analysis can be found in the Annex. The municipal LUZ inventory (791 daytime zones, 14,154 metres, 2,538 nominal bays) and the business license registry (9,739 unique establishments across 36 activity types) provide the structural supply-and-demand backdrop. Three DISCOCURB stakeholder surveys capture the behavioural parameters that neither open data nor municipal records contain. The consumer survey (n = 703) establishes that 72% of residents shop online, with home delivery as the dominant channel across product categories; the retailer survey (n = 138) quantifies B2B delivery frequency at 3.9 deliveries per week on average, with food and pharmacy establishments generating the highest trip rates (6.5 and 7.2 per week); and the driver survey (n = 40) reveals actual dwell times at curb (11.2 minutes), multi-drop consolidation ratios (4.1 deliveries per parking stop), and the experienced blocking rate when bays are unavailable (30% of attempts). Taken together, these datasets feed the queueing model parameters and define the pre-intervention state of Zaragoza's loading and unloading system (KPI 21 – Data Sources Used: from 2 to 5 integrated sources). It should be noted, however, that the DISCOCURB databases generated through this assessment are not currently connected to the DISCO data space.

Impact of loading and unloading zones based on the queuing simulations

The core analytical tool is a stochastic queueing model of the M/M/c/c type — known as the Erlang-B loss system. This model is designed for situations where arriving customers (delivery vehicles) either find a free server (an available bay) and are served, or, finding all servers busy, leave without waiting. This zero-wait assumption is empirically validated by the driver survey: 60% of drivers report that they do not wait at all when a bay is occupied, and none waits more than five minutes, confirming that blocked vehicles immediately convert to illegal parking rather than queuing. The model's two key outputs are the traffic intensity (ρ), which measures the ratio of incoming demand to available capacity and directly maps to KPI 15 (Space Utilisation Efficiency), and the Erlang-B blocking probability, which gives the fraction of arrival attempts that cannot be served under a given demand-capacity combination.

To account for parameter uncertainty, the model is run under four scenarios combining two sets of inputs: retailer-reported delivery frequencies (R) and driver-reported delivery frequencies (D) for demand, and retailer-reported (R) and driver-reported (D) dwell times for service duration, yielding four combinations (R-R, R-D, D-R, D-D). This sensitivity structure tests whether conclusions are robust across the plausible range of field conditions. One methodological refinement adjusts nominal bay capacity downward: the driver survey reveals that 75% of bays are effectively available to freight vehicles at any given moment (α = 0.75), with the remainder occupied by private cars. A further refinement applies a Non-Homogeneous Poisson Process across four daily time windows (07:00–10:00, 10:00–14:00, 14:00–17:00, 17:00–20:00) to capture the pronounced temporal concentration of arrivals rather than assuming a uniform daily rate.

The ratio value of traffic intensity (ρ) has the important tipping point at value 1, where a value lower than 1 indicates more parking bays than demand while for values higher than 1 indicates the opposite. The traffic intensity results from the simulation reveals that the city faces a highly localised infrastructure problem rather than a systemic one. Under the baseline scenario, ρ ranges from 0.04 in *Casablanca* to 1.57 in *Santa Isabel*, with a city-wide weighted average of approximately 0.25. *Santa Isabel* is the only district where demand structurally exceeds capacity: during peak morning hours, 57% more vehicles seek a bay than can be served, and the Erlang-B blocking probability reaches 42.8%. The model was evaluated under four parameter scenarios combining retailer- and driver-reported inputs. *Santa Isabel* remains critical under all four (ρ = 1.01 to 2.61), confirming that no combination of demand-side interventions resolves the deficit without physical resizing.

All other districts operate below ρ = 0.50 at the aggregate level. However, the persistent gap between the model's near-zero district-level blocking and the 30% blocking rate independently reported by drivers confirms that aggregate statistics mask severe street-level saturation. This discrepancy constitutes the strongest argument for progressing to individual LUZ-level analysis as a next step.

The time-varying analysis (Non-Homogeneous Poisson Process across four daily windows) shows that *Santa Isabel* exceeds ρ > 1.0 in both morning windows (07:00–10:00: ρ = 1.42; 10:00–14:00: ρ

= 1.40), while the afternoon shows near-zero ρ everywhere. This temporal asymmetry, with over 93% of B2B deliveries arriving before 14:00, means the morning peak is the binding constraint, and that during the second half of the day the LUZ infrastructure is idle.

Impact taking into consideration the DISCO KPIs

The DISCOCURB activities within Zaragoza LL present both implementation results (Table 8) as well as important insights from the simulation work to support future city policy for LUZ (Table 9). The latter shows the results from the simulations compared to values used in the latest SUMP.

*Table 8: KPI Assessment DISCOCURB Zaragoza**

KPI	Cluster	KPI (before)	KPI (after)	KPI Value Change	Weight	Qualitative rating	KPI Value (integrated)
17 – Transport infra offer	A	~14,000 m / ~2,500 bays (nominal)	~14,000 m / ~2,500 bays (nominal)	0%	0		0
21 – Data sources used	B	2	5	+150%	3		6
22 – Data utilisation	B	0	1	Formula not appl.	1		2

For KPI 17 (Transport Infrastructure Offer), the LUZ inventory quantifies 14,154 metres and 2,538 nominal bays. Accounting for driver-reported private vehicle occupation (α = 0.75), effective capacity reduces to approximately 1,904 bays. A notable discrepancy for Santa Isabel, with 11 bays in the municipal plazas field versus 30.3 from the length-based computation, warrants verification with the Ayuntamiento of Zaragoza.

Regarding KPI 21 (Data Sources Used), the assessment integrates five data sources: the municipal LUZ inventory, the business license registry, and three stakeholder surveys covering consumers, retailers, and drivers. Each source captures a different and non-substitutable dimension of the LUZ system. Particularly, the surveys provide the behavioural parameters (e.g., dwell times, consolidation ratios, blocking rates, channel preferences) that neither open data nor municipal records contain. It is noted that the DISCOCURB databases generated through this assessment are not currently connected to the DISCO data space.

Regarding KPI 22 (Data Utilisation), one new analytical tool was developed within the measure, that is, the queueing evaluation framework. It converts survey-derived parameters into district-level capacity assessments and minimum bay requirements. This tool is directly reusable by the Zaragoza City Hall for future LUZ planning without requiring external simulation software, and constitutes the primary new service generated by the DISCOCURB measure (from 0 to 1).

Table 9: KPI comparison between values used in latest SUMP and simulation results

KPI	Cluster	KPI (SUMP)	KPI (Simulation)	KPI Value Change	Qualitative statement
5 – Delivery Density	C	~525 deliveries/ km	~1,600 deliveries/km city-wide	+204%	The simulations show city wide results, while data from SUMP is an average from few specific areas.
15 – Space Utilization Efficiency	B	~65%	City avg: 25%	-61.5%	The simulations show city wide results, while data from SUMP is an average from few specific areas.

Regarding KPI 5 (Delivery Density), the assessment quantifies approximately 1,600 deliveries per km of LUZ city-wide, ranging from over 3,800 in Santa Isabel to below 300 in Casablanca. This figure is derived from survey-calibrated demand data applied across all 15 districts, combining B2B delivery frequencies from the retailer survey with B2C demand volumes from the consumer survey, scaled by the driver-reported consolidation ratio of 4.1 deliveries per parking stop. While no prior city-wide estimate existed, the SUMP field observations on high-density commercial streets (2012) recorded 505–544 deliveries per km on the most conflictive corridors, confirming the order of magnitude of the DISCOCURB estimate for equivalent urban typologies.

Related to KPI 15 (Space Utilisation Efficiency), the traffic intensity ρ (the central output of the Erlang-B model) provides the direct measure of LUZ occupancy across all 15 districts. The city-wide weighted average is $\rho = 0.25$ (25% occupancy), masking extreme localised saturation: Santa Isabel reaches $\rho = 1.57$ under the baseline scenario and $\rho = 1.01$ to 2.61 across all four parameter scenarios, meaning demand structurally exceeds capacity regardless of input assumptions. The SUMP field observations (2012) recorded a pooled average occupancy of approximately 65% on high-density commercial corridors, reflecting the upper tail of the distribution that the city-wide average does not capture.

What consumers, retailers, and drivers reveal

Beyond the queueing model outputs, the stakeholder surveys yield structural insights that inform the broader DISCO evaluation framework. From the consumer perspective, e-commerce home delivery now generates 2.4 times more curb demand than commercial supply chains. In 10 of 15 districts, B2C van-stops at peak hour exceed B2B arrivals. The consumer survey also reveals that 57.4% of residents perceive LUZ infrastructure in their neighbourhood as insufficient or occupied by private cars, indicating the gap is already visible to the population it affects.

From the retailer perspective, 42.0% report that delivery vehicles serving their establishment typically park illegally (35.5% double-row, 6.5% sidewalk), confirming that infrastructure failure translates directly into observable urban externalities. The extreme temporal concentration (93% of deliveries before 14:00) would indicate the morning window is the binding constraint on capacity.

From the driver perspective, three findings materially revise the baseline. First, the consolidation ratio of 4.1 deliveries per stop reduces the estimated B2C pressure on curb space by 68% relative to the literature default. Second, 47.5% of drivers identify private vehicle occupation as their primary problem, more than any other factor. Third, the loss model is empirically validated: 60% of drivers do not wait at all when a bay is full, and none waits more than 5 minutes, confirming that blocked vehicles immediately convert to illegal parking rather than forming queues.

Recommendations

The analysis supports four operational recommendations. First, enforcement of existing LUZs against private vehicle occupation should be the immediate priority: raising effective availability from 75% to 95% would increase functional capacity by 27% city-wide without infrastructure changes. Second, and in line with the analysis made, *Santa Isabel* requires physical expansion (at least 10 additional bays, which is approximately 68 metres of curb), as it is the only district critical under every scenario. Third, the near-zero afternoon ρ values suggest time-differentiated curb management (permitting alternative uses after 14:00) could improve overall space utilisation without significantly affecting delivery operations. Fourth, the corridor-weighted prioritisation developed of the assessment should guide investment sequencing, directing resources toward districts where saturated LUZs sit on arterial corridors rather than quiet residential streets. Finally, individual LUZ-level analysis is recommended as the next step, since the data infrastructure already exists to evaluate each of the 791 zones individually. Fifth, building on the booking platform demonstrated in Padua and the institutional framework of the AECOC–Ayuntamiento cooperation protocol, a digital LUZ reservation pilot would be a proportionate next step, converting the district-level demand parameters already produced by DISCOCURB into an operational management tool.

DISCOPROXI

On the KPI level the DISCOPROXI intervention created positive change in the majority of the relevant KPI's. The complete overview of the relevant KPI's and their evaluation is gathered in Table 10. Below is discussed the driving factors of the KPI development.

Both number of vans and the distance travelled by the van were reduced when parcels were delivered to a microhub instead of using van for deliveries to end-customers. It led to significant reduction in KPI "1 – Traffic flow" and "2 – Distance travelled" and increase in KPI "5 – Delivery density". The reduced kilometres driven by vans using fossil fuels also reduces KPI "8 - CO2 Emissions per km" and "9 - CO2 Emissions per parcel". Since KPIs 1, 2, and 9 are directly linked to the consolidation of two van routes into a single van feeding a microhub, they share the same change in KPI values (see Table 10).

Another benefit identified is a clear reduction in KPI "3 – Failed Deliveries". Traffic jams and difficulties to find parking lots was an ever-present uncertainty when last mile distribution by van was planned and often affected significantly the timeline. As the package delivery moved outside the time window communicated to the end-customer it increases the risk of unsuccessful delivery.

With a microhub and pushcart it was easier to match the distribution schedule with the execution and by that deliver the parcels within the promised time window.
The idea behind KPI "4 – Delivery Time" with unit min/route is difficult to apply as the manner of distribution changes, so it is adapted to minutes required to serve the entire test area before and after. To serve the area the entire route of one van was dedicated for this area and a half of a route of the second van, in total 1,5 vans were needed. Each route is approximately 480 min, total 720 min. After the implementation the distribution was split into two distinct stages, daily feeding the microhub (120 min with van) and a distribution stage with two pushcarts. The second stage took approximately 360 min per pushcarts. When summing up the work with the feeder van and the two pushcarts it totals in 840 min.

The implementation of the DISCOPROXI measure created additional employee cost which slightly increased the KPI "7 – Operational cost per day". The cost increase was multiplied in KPI "6 – Cost per parcel" in an unfortunate way based on the definition of this KPI (€/km). The main reason for the increase in KPI 6 has been a significant decrease in kilometres driven by combustion vehicles. It is a desired outcome for efficient urban logistics but drives the KPI 6 in an undesired direction.

The slightly increased daily operational costs can swiftly change in favour to the DISCOPROXI measure. As an example, the USA-Iran war and following closure of the Strait of Hormuz which has increased the cost of fossil fuels moves the KPI 7 more into favour of usage of electric pushcarts instead of fossil fuel consuming vans. The risk of general fuel shortage has also significantly increased due to the war and the DISCOPROXI measure provides a less fossil fuel intensive solution increasing the last-mile resilience.

Within DISCOPROXI two new digital services were also initiated (KPI 22): an analysis tool to identify the best locations for microhubs (ALIA) and a new module in the transport management system for operational optimization for distribution by foot.

Finally, the KPI 23 refers to the initiated partnership between CityLogin and Zaragoza municipality.

Table 10: KPI Assessment DISCOPROXI Zaragoza

KPI	Cluster	KPI (before)	KPI (after)	KPI Value Change	Weight	Qualitative rating	KPI Value (integrated)
1 – Traffic flow	A	1.26	0.52	-58.6%	3		9
2 – Distance Travelled	C	0.73	0.30	-58.6%	3		1
3 – Failed Deliveries	B	10%	4%	-60.0%	3		6
4 – Delivery Time	B	720	840	+17%	-2		-4
5 – Delivery Density	C	1.38	3.33	+141.7%	3		1

6 – Cost per parcel	B	4	10.17	+154.0%	-3		-6
7 – Operational cost per day	B	348	366	+5.1%	-1		-2
8 – CO2 Emissions per km	A	0.28	0.19	-33.3%	2		6
9 – CO2 Emissions per parcel	A	0.13	0.056	-58.6%	3		9
21 – Data sources used	B	0	4	Formula not appl.	3		6
22 – Data Utilization	B	0	2	Formula not appl.	2		4
23 – Number of partnerships for collaborative logistics	B	0	1	Formula not appl.	1		2

4.4.2. Compliance to SULPs

Zaragoza has a Sustainable Urban Mobility Plan (SUMP), originally approved in 2006 and revised in 2019. A new, next-generation plan is expected to be approved in 2027. While the current 2019 framework does not feature a standalone Sustainable Urban Logistics Plan (SULP), it explicitly incorporates urban logistics within a dedicated section on Urban Freight Distribution (*Distribución Urbana de Mercancías*)[3], alongside initial provisions for zero-emission and low-emission areas. With respect to the compliance to SULP assessment based on the ELTIS guidelines, the following illustration shows the result of the evaluation. Selected aspects are discussed in more detail hereafter.

[3] PMUS PROPUESTAS DISTRIBUCIÓN URBANA MERCANCÍAS

Mobility Governance: Services and measures	SULP guidelines		DISCOPROXI	DISCOCURB
	Socio-economic	Reducing traffic impacts in the historical centre	3	1
		Increasing livability of urban environment	3	2
		Enhancing local economic development	1	1
	Commercial	Generate benefits on competetiveness and business	1	2
		Optimise logistics operation	2	2
		Reduce costs, improve knowledge of delivery cost	1	1
	Operational	Improved city access regulation	1	2
		Support adoption/use of sustainable vehicles	2	1
		Measures supporting transportation operators market	1	2
	Technical	Systems to optimise fleet delivery operation	3	2
		Systems to optimise logistics operation	2	2
		Improved integration of logistics in urban mobility	3	2

State of compliance of technology, service and business model will be scored according to the following general criteria:	1,92	1,67
3 = High compliance - no need for adaptation		
2 = Medium compliance - short time adaptation		
1 = Low compliance - long time adaptation		

Figure 11: PI compliance to SULP-Guidelines Zaragoza

Socio-economic perspective

The DISCOPROXI measure directly improves the quality of life for local citizens by reclaiming pedestrian spaces in the historic city centre. By avoiding the use of conventional diesel vehicles and employing pedestrian delivery teams with high-capacity, electrically assisted carts, it drastically reduces urban emissions and revitalizes neighbourhood liveability. Furthermore, the ergonomic design of the equipment improves the work-life balance and physical well-being of the delivery workers.

The DISCOCURB assessment does not directly reduce traffic in the historical centre, as it is a diagnostic measure rather than a physical intervention, which justifies the low compliance score for the first guideline. However, by quantifying the temporal concentration of deliveries (93% of B2B arrivals before 14:00 and near-zero LUZ utilisation in the afternoon) it provides the municipality with the evidence base to implement time-differentiated curb policies that would reclaim street space for pedestrians and local commerce during off-peak hours. This indirect but actionable contribution to liveability justifies the moderate score. No direct impact on local economic development was observed. Additionally, the finding that private vehicle occupation reduces effective bay availability to 75% identifies cruising behaviour (a primary source of freight-related congestion in central streets) as directly addressable through enforcement rather than new infrastructure. It should be noted, however, that the basis for this assessment is theoretical rather than empirical since the outputs derive from a stochastic queueing model and are calibrated on survey data rather than from real-time sensor monitoring. The compliance scores therefore reflect the analytical potential of the measure to inform traffic-reducing policies, contingent on the translation of these findings into operational interventions by the municipality.

Commercial perspective

Implementing the DISCOPROXI logistics approach carries a slightly higher initial cost and cannot be applied universally to all local delivery scenarios. While it might not drive massive commercial growth or standard market competitiveness on its own, it proves that zero-emission operations are economically viable in dense urban zones. The equipment is already commercially available, meaning other logistics providers can rapidly adopt this model.

The DISCOCURB assessment establishes quantified benchmarks (e.g., delivery density per km, district-level space utilisation, and fleet composition) that were not previously available to logistics operators or the municipality. This baseline enables future evidence-based allocation of LUZ resources, which indirectly benefits the competitiveness of operators who currently lose time and incur fines due to inadequate infrastructure. The queuing model output directly supports the optimisation of logistics operations by identifying where interventions would have the highest return. Knowledge of delivery costs was not a primary output of the measure, justifying the lower score.

Operational perspective

From an operational standpoint, the DISCOPROXI solution adapts to the challenges of historic city centres. The electric assistance allows the delivery teams to easily navigate narrow pedestrian walkways and handle areas with steep slopes. Using a microhub as a consolidation point allows the logistics service provider to optimize daily distribution and maintain a high quality of service where conventional vans struggle to operate.

The city-wide capacity assessment provides a structured, data-driven foundation for redesigning LUZ access regulations; particularly the recommendation to enforce existing zones against private vehicle occupation, which would increase effective capacity by 27% without infrastructure changes. This directly supports improved city access regulation. The measure does not address sustainable vehicle adoption, as it focuses on infrastructure capacity rather than fleet composition, resulting in a low compliance score. Regarding support for transportation operators, the corridor-weighted prioritisation framework and minimum bay requirements provide actionable guidance for the municipality to allocate curb space where operators face the greatest operational friction.

Technical perspective

The technical approach of DISCOPROXI relies on a physical microhub infrastructure combined with assisted delivery vehicles and a digital Transport Management System (TMS). While its broader impact on the overall transportation market is limited—as it does not significantly alter municipal access control systems or existing transit regulations—the technical setup serves as a scalable role-model to demonstrate how private operators can successfully comply with strict SULP frameworks.

The queueing evaluation tool developed within the measure converts survey-derived parameters into district-level capacity assessments and minimum bay requirements, constituting a reusable planning instrument for the city hall. While it does not optimise fleet operations in real time (as a sensor-based system would), it provides the analytical backbone, i.e., time-varying demand profiles, ρ values, blocking probabilities, that informs where and when fleet operations face infrastructure bottlenecks. The integration of three stakeholder perspectives (consumers, retailers, drivers) into a single modelling framework supports the broader integration of logistics into urban mobility planning, consistent with the SUMP's objective of incorporating freight distribution into the city's updated mobility strategy.

Regarding the KPI assessment for KPI 25 SULP, the city addresses urban logistics within a comprehensive, integrated section on Urban Freight Distribution (*Distribución Urbana de Mercancías*). This framework proposes strategic measures like Urban Distribution Platforms (UDPs) and break-bulk points to optimize last-mile delivery. However, rather than having a standalone, fully institutionalized SULP, these actions remain embedded inside the general mobility plan. While the integrated chapter outlines clear operational programs and metric tables, it historically lacked the distinct, long-term governance arrangements and continuous monitoring systems required for a dedicated SULP framework. In order to appreciate this initial situation and the efforts towards the development of a new framework, the existing SULP rating scale (see Weighting Table in the Annex) is being adjusted.

Table 11: KPI 25 - SULP Evaluation Zaragoza

KPI	Cluster	KPI (before)	KPI (after)	KPI Value Change	Weight	Qualitative rating	KPI Value (integrated)
25 - SULP	A	Approved SUMP (2019) with section on Urban Freight Distribution	Currently in the process of developing an updated mobility plan (exp. 2027)	Formula not appl.	1		3

4.4.3. Contribution to SDGs

In the following, the contribution of the DISCO-X measures to the Sustainable Development Goals (SDGs) is evaluated. To be able to make a sufficiently precise statement here, the use of the target level of the SDGs is chosen. The association of KPIs to SDGs, as well as the association of KPIs to DISCO-X measures, serve as input for the assessment. In correlation with the 7 SDGs that are addressed by the DISCO activities, 11 SDG targets were identified and compared with the three measures implemented in the Zaragoza Living Lab. The scale used is green = Direct contribution, light green = indirect contribution, no colour = no contribution. In addition, comments were made to clarify the contribution of the respective measure.

Table 12: Contribution to SDGs Zaragoza Living Lab

SDG target	DISCO-X	
	DISCOCURB Addr. KPIs: 5, 15, 17, 21, 22, 25	DISCOPROXI Addr. KPIs: 2, 3, 4, 5, 6, 7, 8, 9, 21, 22, 23, 25
3.9: Reduce the amount of deaths produced by dangerous chemicals and the pollution of the air, water and soil (…) Ass. KPIs: 1, 2, 3, 5, 8-13	**[Indirect Contribution]** The capacity assessment identifies districts where LUZ saturation forces delivery vehicles to double-park or cruise for bays, generating localised pollution. The delivery density baseline (KPI 5) provides the activity denominator needed for emission estimation once standard emission factors are applied.	**[Direct Contribution]** Reducing kilometres driven implies a reduction in accidents and risk to both pedestrians and workers, as well as damage to property.
8.2: Achieve higher levels of economic productivity (…) Ass. KPIs: 6, 7, 24, 25	**[Indirect Contribution]** The queuing evaluation tool is directly reusable by the Ayuntamiento for future LUZ planning, improving institutional productivity in freight infrastructure management without requiring external simulation software.	**[Direct Contribution]** The impact of the model requires a greater weight of workforce, given that the local implementation model reinforces the creation of local jobs in the community, making the local operation more resilient and reliable.
8.4: Improve (…) global resource efficiency in con-sumption and production (…) Ass. KPIs: 1, 2, 5, 10	**[Direct Contribution]** The time-varying analysis reveals that LUZ infrastructure is idle for half the operating day, identifying a concrete opportunity to improve the utilisation of existing curb space through time-differentiated policies rather than building new infrastructure.	**[Direct Contribution]** The use of assisted delivery vehicles requires less overall energy consumption per kilogram moved. It is also less dependent on fossil fuels, relying on an electric ecosystem, and therefore more resilient to price fluctuations or supply shortages. It does not require special electrical infrastructure, as it can be charged using a standard outlet, increasing operational flexibility and reducing the resources needed for adapting spaces for logistical use.
9.1: Develop quality, reliable, sustainable and resilient infrastructure (…) Ass. KPIs: 1, 5, 15, 17, 18, 20	**[Direct Contribution]** The assessment identifies where LUZ infrastructure must be expanded and where enforcement of existing	**[Direct Contribution]** Being located in a public local market with several operators increases the usability of infrastructure because it

	capacity would be more effective than physical construction.	takes it beyond a single operator who might be left out at some point; being supported by the local economy also increases the perception as something belonging to the community that should be taken advantage of.
9.4: (…) upgrade infrastructure and retrofit industries to make them sustainable (…) Ass. KPIs: 17-20	**[Direct Contribution]** The minimum bay requirements, corridor-weighted prioritisation, and effective capacity analysis ($\alpha = 0.75$) provide the sizing and sequencing criteria for upgrading LUZ infrastructure in alignment with the LEZ strategy.	
11.3: (…) enhance inclusive and sustainable urbanisation and capacity for participatory, integrated and sustainable human settlement planning and management (…) Ass. KPIs: 11, 19, 20	**[Direct Contribution]** The simultaneous integration of consumer, retailer, and driver perspectives into a single modelling framework supports evidence-based, multi-stakeholder urban freight planning — a methodology directly transferable to the updated SUMP expected in 2027.	
11.6: (…) reduce the adverse per capita environmental impact of cities (…) Ass. KPIs: 8-13	**[Indirect Contribution]** The delivery density baseline (KPI 5) and space utilisation analysis (KPI 15) provide the activity and infrastructure data needed to quantify the environmental impact of urban freight once emission factors are applied, enabling the municipality to monitor per capita freight emissions.	**[Direct Contribution]** Eliminating road traffic and replacing it with pedestrian equipment allows for a direct reduction in particulate and CO_2 emissions.
11.A: Support positive economic, social and environmental links between urban, peri-urban and rural areas by strengthening national and regional development planning Ass. KPIs: 24, 25	**[Indirect Contribution]** The assessment methodology is replicable for other Spanish cities and contributes to the evidence base for metropolitan-scale logistics planning.	
12.6: Encourage companies (…) to adopt sustainable practices and to integrate sustainability information into their reporting cycle Ass. KPIs: 13, 23	**[Indirect Contribution]** The three-stakeholder survey framework creates transparency on delivery patterns, illegal parking rates, and infrastructure utilisation, supporting data-driven sustainability reporting within the municipal governance framework.	**[Direct Contribution]** Developing an infrastructure that is already shared can serve as an example and overcome resistance to operating in joint spaces between competing operators.

13.2: Integrate climate change measures into national policies, strategies and planning Ass. KPIs: 25	**[Direct Contribution]** The capacity assessment and its recommendations (enforcement, resizing, time-differentiated curb management) are designed to feed directly into the updated SUMP/SULP framework expected for approval in 2027.	
17.16: Enhance the Global Partnership for Sustainable Development (…) Ass. KPIs: 23		**[Direct Contribution]** By planning from the same location, with the same conditions of use for all involved, the commitment of all stakeholders to follow the same global sustainability objectives is strengthened, operational improvements are shared, and progress towards more sustainable models is made in a co-creative way, as opposed to the one-actor innovation that is the norm in the sector.

5. Undertaking the Evaluation in the Twinning LLs – Barcelona

5.1. Introduction to Barcelona LL

Barcelona faces a multitude of loading and unloading (L/U) operations within the city which cause major traffic problems. Since available curb occupancy data is highly inaccurate due to several aspects (drivers not using the existing app (SPRO), unauthorized parking, etc.) there is the ambition to generate a new freight digital platform based on on-street sensors and data-driven prediction algorithms, to drive the implementation of freight measures. To achieve this, two measures are being developed and implemented within the framework of the Living Lab.

DISCOCURB can be seen as an innovative curb operations management process for parking slots in loading and unloading areas based on available space.

Table 13: Key exploitable results of the lab demonstration DISCOCURB

Qualitative targets	• Inefficiencies of the parking policy • Feedback from stakeholders • User acceptance among delivery personnel • Overall satisfaction among city authorities
Quantitative targets	• Peak usage times, areas of high demand, type of vehicles, and potential inefficiencies in the current system. • Results of targeted surveys from various stakeholders.
Physical Internet requirements	• Make use of open and standardized data to define policies.
Links to (future) SULP	• The more accurate usage data can serve as an additional resource when implementing a future SULP.

DISCOLLECTION on the other hand provides advanced data analytics solutions supporting the efficiency of the operations.

Table 14: Key exploitable results of the lab demonstration DISCOLLECTION

Qualitative targets	• Information on the real usage patterns of loading and unloading zones and the reliability of the SPRO platform.
Quantitative targets	• Occupancy rates, average duration of stay, and SPRO compliance rates. • The accuracy of predictions made by our deep learning models.
Physical Internet requirements	• Freight parking space data gathering. • Share specific freight parking space data across a decentralised network. • Standardized data output.
Links to (future) SULP	• Obtaining improved usage data will enable more informed analysis and decisions for DUM zones.

5.2. Evaluation set-up and preliminary remarks

Within the Barcelona Living Lab, the two measures DISCOCURB and DISCOLLECTION were implemented. As a starting point for the following discussion of the evaluation results, a summary of the most important characteristics of these measures is given in Table 15 and further below described the measure and shortly the observed data.

Table 15: DISCO-X characteristics, Barcelona

	DISCOCURB	DISCOLLECTION
Impact Domain	Agile storage and last-mile distribution	Connected logistics
Typology	Physical / Digital	Digital
Implementation approach	Object detection and tracking via cameras installed in light poles near the L/U areas, including license plate recognition to cross-check operations against SPRO data	Collection and processing of data from the camera system and the SPRO app using AI algorithms
Technology	Sensor system consisting of cameras, computers, and AI algorithms	Dataspace with the L/U areas usage/occupancy information, fed by the AI algorithms
Focus area	3 parking areas in the city (chamfered areas, pedestrian priority streets)	Currently linked to the 3 parking areas, plan to roll-out the approach over the city of Barcelona

Partners	Ajuntament de Barcelona, B:SM, CARNET, CITYLogin, UPC	Ajuntament de Barcelona, B:SM, CARNET, CITYLogin, UPC
Data sources used / integrated	Camera data regarding objects and license plates. Type of vehicle and emissions could be derived from license plate / vehicle (pot. In future). Data from the SPRO app is combined with camera data for higher data accuracy.	Collected data from the camera system, data from the SPRO app.
Evaluation approach	Quantitative and qualitative as well as extrapolation	Quantitative and qualitative
Addressed KPIs	10, 15, 16, 25 (explorative 14, 17)	21, 22, 25

Description of the measures

The Barcelona pilot focuses on the monitoring and analysis of Urban Goods Distribution (DUM) areas through the installation of cameras combined with computer vision software (DISCOCURB). The goal is to obtain reliable, real-time data on occupancy, dwell time, and vehicle turnover in loading and unloading zones. The existing SPRO app cannot provide this information, as drivers frequently omit registering their stays or do it incorrectly, particularly short ones. By combining the real-time data, data from SPRO app as well as review logistic operation create a deeper and data-driven understanding of how urban logistics work and quantify its bottlenecks.

In DISCOCURB a total of 4 cameras were deployed across 3 DUM areas selected to represent distinct and relevant urban typologies in Barcelona. DUM 3177 and DUM 1293 are chamfered parking areas, a format that is widespread throughout the city. These spots were chosen as among the most heavily used of their kind, making them representative cases for this typology. DUM 4703 is located on Carrer del Consell de Cent, a pedestrian priority street within the Superilles (superblocks) program, a recent urban transformation initiative by Barcelona City Council. This area was selected for its strategic interest: the coexistence of cargo vehicle activity and pedestrian use in a shared space raises specific management challenges worth studying.

The present report covers two of the three monitored areas. DUM 1293 was monitored during the same period, but there were unforeseen works in the area, so no cars were staying for most of the pilot time, leaving insufficient data for analysis.

DUM 4703 was monitored during January and February 2026, while DUM 3177 was monitored from mid-December 2025 through March 2026. All analysis is restricted to the active hours of each DUM: 08:00-20:00 for DUM 3177, and 07:00-08:00 and 10:00-16:00 for DUM 4703, with the 08:00-10:00 slot also included in the analysis for simplification purposes.

DUM 3177— Chamfered Parking (València street / Sicília street)

DUM 3177 is a loading and unloading area located at the chamfered corner of Carrer de València and Carrer de Sicília, a typology that is very typical in Barcelona's Eixample grid. The area comprises 4 slots distributed across the two sides of the chamfer. A single camera was installed on a traffic light across the street, providing an angled frontal view of the entire area. The system identifies and tracks vehicles using vehicle detection and tracking and license plate recognition, with each slot defined by a dedicated detection zone overlaid on the camera feed. A 30-second frame interval was chosen given the nature of loading and unloading operations, where stays are long enough that higher capture frequencies would add no meaningful information.

The main technical challenge of this configuration is occlusion: when a vehicle stops in front of the area, it can partially or fully block the view of the slot behind it. This is addressed through license plate tracking, since a vehicle cannot physically leave if another is parked in front of it. The system uses the last recorded detection as the end of its stay in cases where a departure occurs within a 30-second interval without a clear exit event being captured.

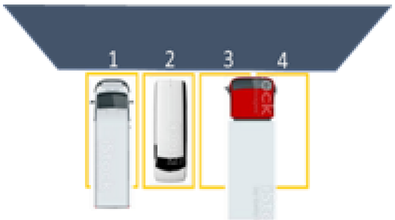


Figure 12: Chamfered areas typical distribution

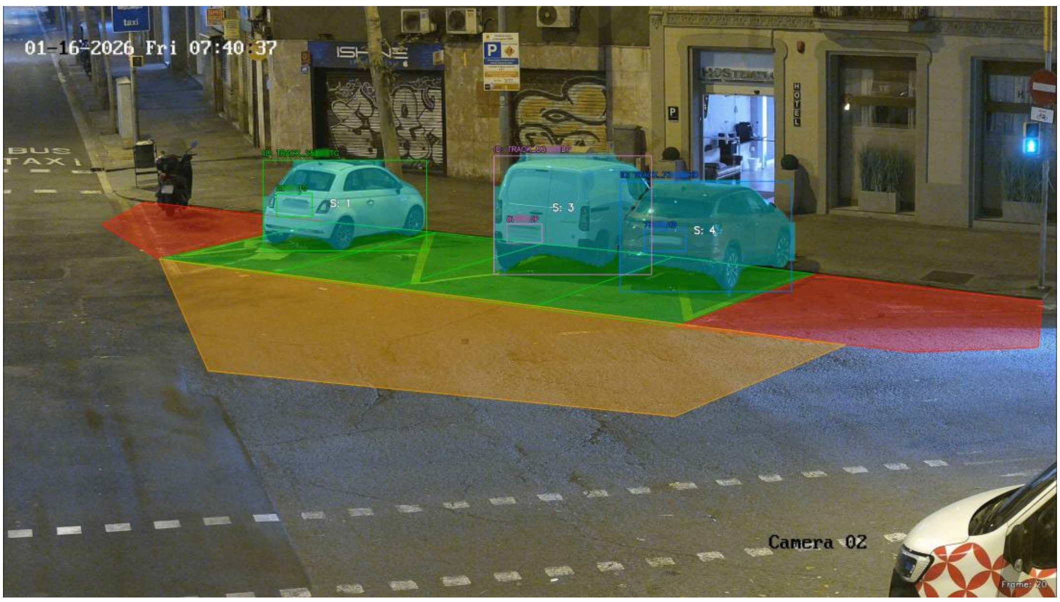


Figure 13: DUM 3177 view from camera and detection/segmentation of vehicles and parking spots

DUM 4703— Pedestrian Priority Street parking (Consell de Cent street, Superilles)

DUM 4703 is located on Carrer del Consell de Cent, a pedestrian priority street within the Superilles (superblocks) program of Barcelona City Council. The monitored stretch spans approximately 100 meters and encompasses 10 loading and unloading slots, which are not physically painted on the ground. Two cameras were deployed: one at the entrance and one at the exit of the street, to capture all vehicle flows in and out of the area.

The main analytical challenge in this configuration comes from the presence of private parking garages along the monitored stretch. Vehicles accessing these garages might enter or exit in longer stays and even on different days, which could alter the analytics. This could result in an overestimation of the average time of stays. Additionally, the pedestrian priority setting creates a shared space dynamic between cargo vehicles and pedestrians that is of particular interest to the City Council, as it directly informs the ongoing evaluation of the Superilles programme.

Analysis of gathered data and examples

The analytical pipeline applied across both DUM areas is based on vehicle detection, multi- object tracking, and license plate recognition (LPR). For each detected vehicle, a track is constructed across frames, and a license plate number is assigned through a voting mechanism that aggregates the plate readings obtained across multiple frames of the same track, selecting the most consistent result. From each confirmed track, the system extracts the following metrics: average temporal distribution (number of vehicles present at each point in the day, their registration status in the SPRO app and vehicle sustainability label), dwell time distribution (how long each vehicle stays), and parking occupancy distribution (percentage of time with a given number of vehicles). These metrics provide insights on how DUM areas are used in practice, how saturated they are, how long vehicles occupy the space. Passive registration systems like SPRO cannot reliably capture this type of information.

The following figures illustrate example outputs from DUM 4703, showing the three main analysis products generated for each area:

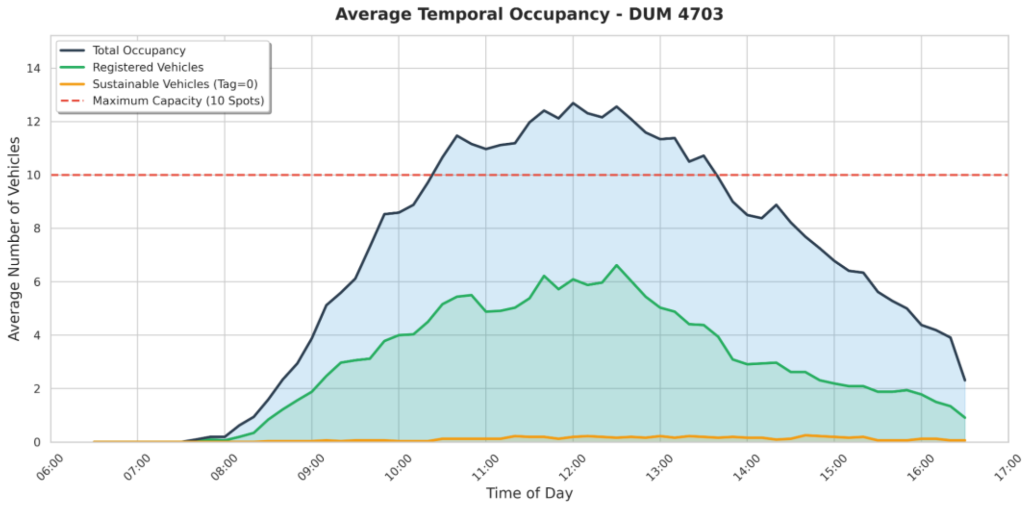


Figure 14: Average temporal occupancy throughout the day, broken down by total vehicles, registered vehicles, sustainable vehicles, and reference capacity

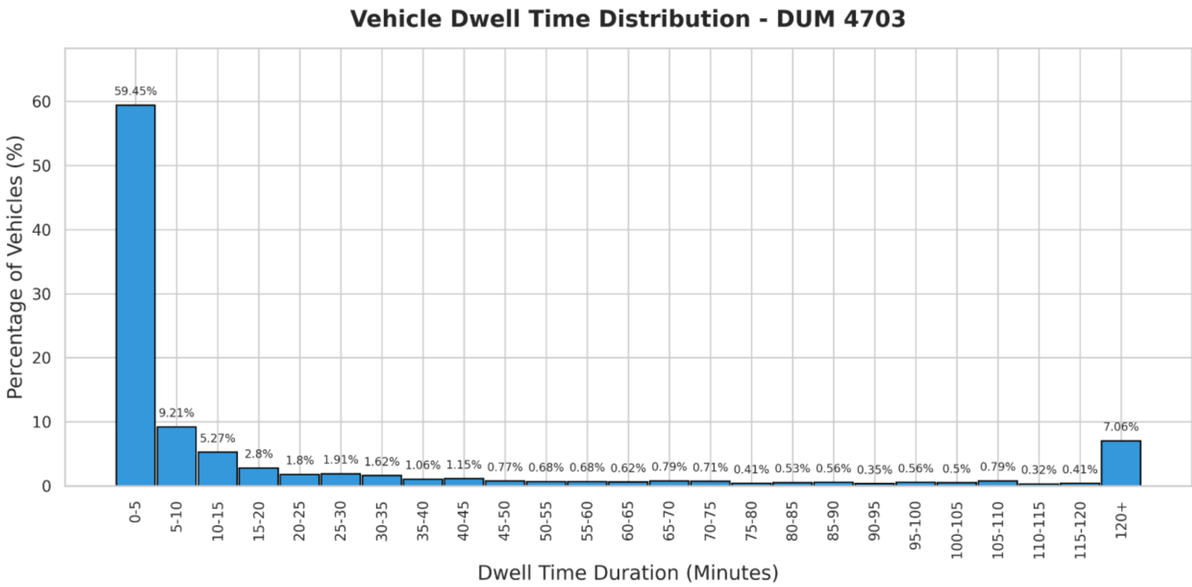


Figure 15: Vehicle dwell time distribution, showing the percentage of vehicles per stay duration bracket

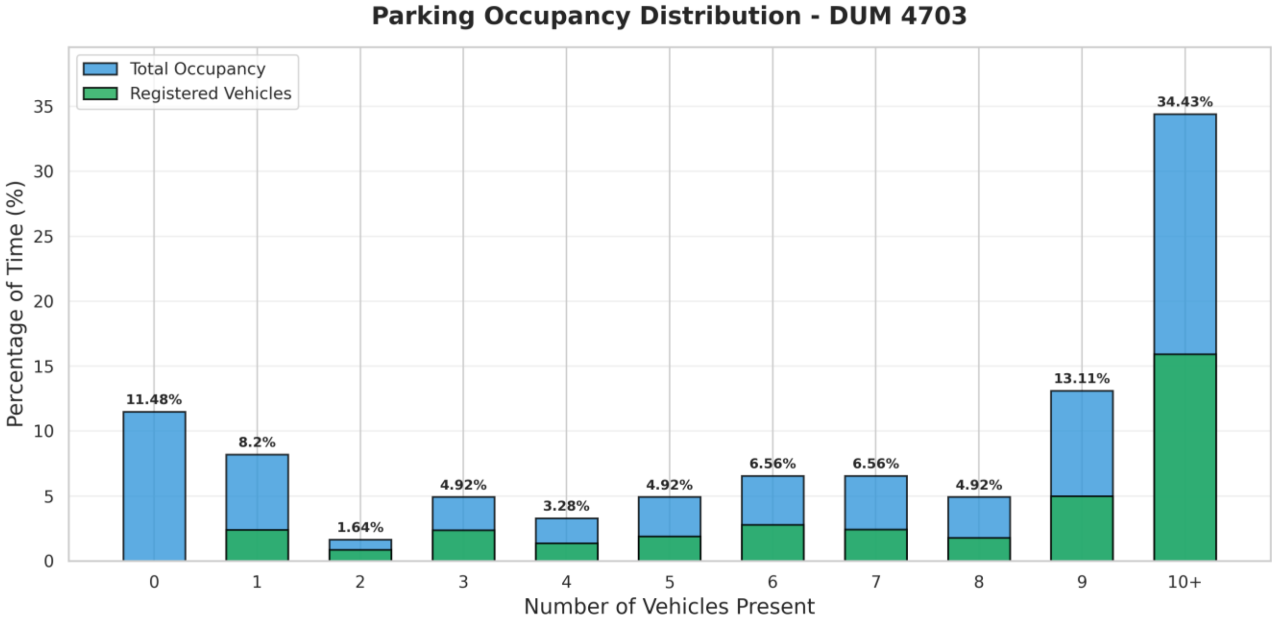


Figure 16: Distribution of simultaneous vehicle counts, showing the percentage of time the area operates at each occupancy level

Similar results were observed for DUM 3177. As shown in Figures 14 and 16, while the total number of vehicles exceeds the DUM zone's capacity for a considerable portion of the day, the number of registered vehicles never surpasses the limit.

5.3. Assessment of KPI importance

The clustering and rating of the KPIs were defined according to their relevance to the DISCOCURB pilot objectives and the feasibility of obtaining reliable data during the monitoring period. Cluster A includes the KPIs most directly linked to the pilot's core functionalities, such as curb occupancy monitoring, sensor reliability, and data usage. Cluster B contains indicators related to collaboration and data integration, which are important for deployment and future scalability. Cluster C groups complementary operational indicators, such as delivery performance or parking fines, which provide useful context but are less directly impacted by the pilot itself. Finally, Cluster D includes

KPIs that were considered not applicable due to data unavailability, limited feasibility within the pilot scope, or because the pilot was not expected to generate a measurable impact on them.

KPI Number	KPI	Description and data format	Cluster	Rank in Cluster
15	Space Utilization Efficiency	Average occupancy of parking spaces	A (very important)	1
16	Reliability of sensors and cameras	Average time that sensors were not working properly	A (very important)	2
22	Data Utilization	Number of new/enhanced services utilizing old/new data collected	A (very important)	3
25	SULP	(Number of) locally politically approved SULP or freight logistics plan	A (very important)	4
21	Data sources used	Number of data sources or platforms that are connected to the data space	B (important)	1
23	Number of partnerships for collab. logistics	Number private-private and -or public-private partnerships for last mile deliveries	B (important)	2
14	Parking fines	Parking fines per 10000 inh	C (less important)	1
17	Transport infra offer	Average offered space of a transport infrastructure to be used as (shared) space for logistics operations	C (less important)	2
10	EV Adoption Rate	Percentage of electric freight vehicles in the delivery fleet	C (less important)	3
4	Delivery time	Average delivery time per route	D (not applicable)	
5	Delivery Density	Number of deliveries per km	D (not applicable)	
2	Distance Travelled	Average distance per delivery	D (not applicable)	
1	Traffic Flow	Total freight kilometers driven per 10000 inh	D (not applicable)	
3	Failed Deliveries	Percentage of unsuccessful deliveries with the 1st attempt	D (not applicable)	
6	Cost per parcel	Cost of delivery per km	D (not applicable)	
7	Operational Cost per day	Total delivery cost	D (not applicable)	
8	CO2 Emissions per km	Total kg of CO2 emissions per km	D (not applicable)	
9	CO2 Emissions per parcel	Total kg of CO2 emissions per parcel	D (not applicable)	
11	Cargo bike adoption rate	Number of cargo bikes in the local delivery fleet	D (not applicable)	
12	Cargo bike deliveries	Percentage of the total deliveries performed by cargo bikes	D (not applicable)	
13	Companies electrification	Percentage of companies that operate with cargo bikes	D (not applicable)	
18	Warehouse offer	Average offered space of a warehouses be used as (shared) space for logistics operations	D (not applicable)	
19	Lockers volume	Percentage of freight volume delivered through lockers	D (not applicable)	
20	Microhub Capacity Utilization	Average utilization rate of a parcel locker	D (not applicable)	
24	Investment plans	Number of investment logistics plans of local private entities operating in Urban logistics	D (not applicable)	

Figure 17: Clustering and ranking of KPIs Barcelona LL

5.4. Evaluation of DISCO-X measures

In the following, the two DISCO-X measures implemented in the Barcelona Living Lab are evaluated on three different levels. In a first step, a KPI assessment based on the 25 KPIs defined in DISCO is carried out (operational level). The assessment uses the methodology described in chapter 2.1, which considers the different perspectives. From a data perspective, qualitative and quantitative information before and after implementation is used. In this Living Lab is also explored the possible impact on KPI based on the data gathered during implementation and upon which additional measures could be built. Following up on the KPI review, the measures compliance with the ELTIS SULP Guidelines is reviewed and aligned with the existing SULP (local level). In a final step, their contribution to the SDGs at the target level is assessed (global level).

5.4.1. KPI-Assessment

The two DISCO-X measures implemented in the Barcelona Living Lab are evaluated using the KPIs defined as DISCO before and after implementation. The methodology described in Chapter 2 is used, considering the different perspectives. This subchapter begins by evaluating KPI's related to DISCOCURB, then DISCOLLECTION and finally potential impact is explored if a more active management of curb side based on gathered data would be implemented.

DISCOCURB

The following KPIs have been directly calculated from pilot data in DUM areas 4703 and DUM 3177. For KPI 10 the data is cross-referenced the data with that from the SPRO application.

KPI 10 - EV Adoption Rate: 2,55%

This indicator measures the share of vehicles accessing the DUM areas that carry a Spanish ecological label 0 (zero-emission vehicles), showing the environmental profile of last-mile delivery activity in the monitored zones.

Just using the official municipality data (SPRO) for vehicles staying in the Barcelona pilot DUM areas we obtain that the EV adoption rate is around **2,7%.** However, from the data gathered in the pilot DUM areas using the camera system the percentage stands at **2,55%**.

Both figures are low, especially in the context of a pilot that analyses pedestrian priority streets, where reducing the environmental impact of urban freight is essential. The data suggests that the transition to zero-emission delivery vehicles in this sector is still limited, and that most vehicles accessing the monitored DUM areas still rely on conventional combustion engines. The small variation of 0,15% it most certainly due to the vehicles not registering or incorrectly registering stays in the SPRO app but we can consider both percentages are consistent. Since the deviation is quite small, future analyses should carefully check how the data accuracy regarding these two data sources behaves as the proportion of electric vehicles increases.

After DISCOCURB implementation, the municipality could promote measures fostering the use of electric vehicles for the last mile distribution.

KPI 15 - Space Utilization Efficiency: 91,8%

This indicator measures the percentage of active time during which the DUM area is occupied by at least one vehicle, reflecting how intensively the allocated space is used relative to its available capacity.

Before implementation, the only available data source was the SPRO platform, which relies on drivers voluntarily registering their stays in DUM areas. Based on these records, the estimated Space Utilization Efficiency was **38,34%** for DUM 4703 and **50,53%** for DUM 3177, resulting in a weighted average of **41,84%**. These values significantly underestimated the real occupation levels, as unauthorized and non-registered vehicles were not captured by the system.

After implementation we found the real percentages of usage including vehicles not registered:

DUM 4703 presents a utilization rate of **88,52%**, indicating that the street is occupied most active hours. Combined with the occupancy distribution results showing that the area exceeds its reference capacity of 10 spots nearly 60% of the time, this points to a zone under significant and sustained pressure throughout the monitored period.

DUM 3177 presents a utilization rate of **100%**, the area is never fully empty (0% of time with 0 vehicles), and occupancy at 3 or 4 out of 4 slots accounts for over 66% of active time. The available capacity is therefore concentrated in individual slots rather than the area, and turnover dynamics, including the presence of long-stay vehicles that affect the practical availability of the space.

The weighted average Space Utilisation Efficiency across both DUM areas is **91,8%**.

KPI 16 - Reliability of sensors and cameras

The implemented sensor-based monitoring system demonstrated a high level of operational reliability throughout the evaluation period and provided a consistent, objective source of observational data. Compared with the previous SPRO app-based approach, the camera system enables a more comprehensive assessment of DUM area usage and supports a better understanding of curbside activity and vehicle behaviour. Although occasional missed detections may occur due to occlusions, the system has proven to be a dependable tool for monitoring and evaluating usage patterns in the study areas. During the monitoring period, the camera systems experienced approximately 2400 minutes of downtime due to unexpected installation and operational issues; however, these interruptions did not materially affect the overall usefulness of the collected data.

Table 16: KPI Assessment DISCOCURB Barcelona

KPI	Cluster	KPI (before)	KPI (after)	KPI Value Change	Weight	Qualitative rating	KPI Value (integrated)
10 – EV Adoption rate	C	2,7% of vehicles with tag=0	2,55% of vehicles with tag=0	6%	-1		-1
15 – Space Utilization Efficiency	A	41,84% of time it was not empty	91,8% of time it was not empty	119%	3		9
16 – Reliability of Sensors and Cameras	A	-	-	-	3	Although some downtime, camera systems were reliable and	9

						led to higher data accuracy	

DISCOLLECTION - Obtained from pilot data

Before the DISCO interventions, all parking information for the targeted DUM zones relied exclusively on self-reported records from the municipal SPRO application. This dataset logs parking events, capturing parameters such as arrival and departure times, vehicle license plates, and the authorization status of the operation. However, the reliability of this baseline data is fundamentally limited. User compliance is inconsistent; numerous drivers fail to register their operations entirely, or provide incomplete logs (e.g., recording an arrival without a corresponding departure timestamp).

Following the implementation of the pilot measures, the evaluation leverages a newly generated, high-fidelity dataset. This outcome is achieved by fusing the legacy SPRO records with the empirical, real-time data captured by the DISCOCURB street camera sensors. While this integrated dataset maintains the same structural variables as the original SPRO logs (timestamps, license plates, and authorization status), it outputs corrected and validated information, effectively neutralizing the human-error element of the manual application.

To provide broader operational context for the project, the evaluation also integrates a proprietary dataset provided by the logistics operator CityLogin. This dataset supplies comprehensive telematics and routing information for commercial deliveries across the Barcelona metropolitan area, encompassing variables such as route origins and destinations, precise operational timestamps, and specific vehicle typologies.

KPI 21 - Data Sources Used: 3

Prior to the implementation, only one main data source was available for analysing DUM operations: the SPRO platform records managed by B:SM. Following the implementation of DISCOLLECTION, three complementary datasets were integrated: SPRO registration data, AI-processed camera data generated by UPC, and operational delivery data provided by CityLogin.

The integration and comparison of these datasets enabled the validation and enrichment of curbside activity records, allowing the identification of unregistered operations, overstays, and discrepancies between declared and observed DUM usage. The resulting harmonized dataset provides a more accurate and comprehensive representation of urban freight activity in the monitored areas.

KPI 22 - Data Utilisation

Prior to the implementation, no enhanced services using integrated and accurate DUM data were available. Following the implementation of DISCO, one new data-driven service was developed based on the integration of SPRO records, AI-processed camera detections, and logistics operator

This service enables the validation and analysis of curbside activity data, supporting the identification of unregistered operations, overstays, and compliance patterns in DUM areas. The resulting harmonized dataset provides a more reliable basis for monitoring and future policy-making related to urban freight operations.

KPI 23 - Number of partnerships for collaborative logistics: 3

This indicator measures the number of external partners involved in the implementation of the solution. Prior to DISCOCURB, no collaborations related to curbside management were in place.

During the implementation, collaboration was established with three partners: two installation companies (specialized in traffic light and street light infrastructure) and one provider of the camera/router system. These partners contributed technical expertise on installation and system requirements, helping adapt the solution to meet budgetary and operational constraints. While an additional provider was involved during early prototyping, the value of **3** reflects the partners considered relevant for a potential scale-up of the system.

Table 17: KPI Assessment DISCOLLECTION Barcelona

KPI	Cluster	KPI (before)	KPI (after)	KPI Value Change	Weight	Qualitative rating	KPI Value (integrated)
21 – Data Sources used	B	1	3	200%	3		6
22 – Data Utilisation	A	0	1	Formula not appl.	1		3
23 - Number of partnerships for collaborative logistics	B	0	3	Formula not appl.	3		6

Potential impact of a more active curbside management

The information gained from the DISCO-X measures provides valuable insight in urban freight and curbside management. If a more active management of curbsides would be implemented based on this data, it would have impact on several additional DISCO-X evaluation KPI's as explored and described below.

KPI 14 - Parking Fines per 10.000 Inhabitants

This indicator contextualizes enforcement activity relative to the local population, providing a normalized measure of DUM non-compliance during the pilot period. Barcelona City Council's municipal services company (B:SM), responsible for parking among other activities, provided information that a total of 28 parking fines were recorded during the pilot. Using the Eixample district population (~270,000 inhabitants) as the reference, we obtain a rate of 1,04 fines per 10.000 inhabitants.

As can be seen in Figure 15, almost 60% of the vehicles parked in the DUM zones are unauthorized, and a significant increase in the parking fines could be expected when using the data from DISCOCURB in daily enforcement operation. We have estimated that around 10% of the non-compliant vehicles could be fined after implementation of the DISCO project. This conservative estimate is based on factors such as information campaigns and the required presence of humans in the parking issuing process are reducing significantly number of fines produced. Based on these assumptions, an estimate of 88 fines (3,26 fines per 10.000 inhabitants) would be achieved during the analysed period (four months), an increase of more than 200%.

There is no intrinsic value in executing more parking fines, however it could alleviate the urban logistics challenge of insufficient loading-unloading areas which in the worst case creates more urban traffic or traffic jams.

KPI 17 - Average Offered Space of Transport Infrastructure

This indicator estimates the average physical space available for shared logistics use across the monitored DUM areas, computed as the unoccupied portion of each area weighted by its free time rate. DUM 3177 contributes 1,39m² (4 spots available x 12,5 m² x 8,33% time) and DUM 4703 contributes 14,35 m² (10 spots x 12,5 m² x 11,48% free time), with a combined average offered space of 15,74 m². The contrast between the two areas is notable: DUM 4703 offers more available shared space due to its substantially higher vacancy rate compared to the more saturated DUM 3177.

After the implementation of DISCOCURB, the average offered space is expected to increase significantly due to the reduction of unauthorized occupation in DUM areas. Considering the assumptions described in KPI 14, where non-compliant occupation decreases by 10% and would make the effective free time of the monitored DUM areas increase substantially.

Under these assumptions, the available shared logistics space in DUM 3177 is estimated to increase from 1,39 m² to approximately 12,50 m², assuming at least one full parking spot remains available during most active periods. For DUM 4703, the available shared space is estimated to increase from 14,35 m² to approximately 30,00 m² as occupancy pressure decreases significantly. The combined average offered space across both monitored areas would therefore increase from 15,74 m² to approximately **42,50 m²**, reflecting a 170% increase in curbside availability for freight operations.

5.4.2. Compliance to SULPs

The implementation of DISCOCURB and DISCOLLECTION aligns directly with Barcelona's local regulatory framework, specifically the Estratègia de Distribució Urbana de Mercaderies 2030 (EDUM 2030), which serves as the city's specialized Sustainable Urban Logistics Plan (SULP). A core objective of EDUM 2030 is to transition toward a more efficient, digital, and sustainable model for managing loading and unloading (DUM) zones, heavily relying on the expansion and technological improvement of the SPRO application.

Increasing the quality of online data through DISCOCURB will allow the municipality to fulfill EDUM 2030's mandate to implement more flexible and responsive DUM policies. The accurate, real-time information provided by camera sensors facilitates the early detection of non-compliant parking, optimizing the municipal human resources allocated to enforcement and reducing congestion caused by unauthorized use. Furthermore, the advanced analytics from DISCOLLECTION will allow the municipality to move away from the rigid 30-minute free parking rule toward the dynamic models proposed in the EDUM strategy, such as variable time slots based on vehicle typologies, extended delivery hours, or digital reservation systems.

	SULP guidelines		DISCO X	
			DISCOCURB	DISCOLLECTION
Mobility Governance: Services and measures	Socio-economic	Reducing traffic impacts in the historical centre	3	3
		Increasing livability of urban environment	3	3
		Enhancing local economic development	3	3
	Commercial	Generate benefits on competetiveness and business	2	2
		Optimise logistics operation	2	2
		Reduce costs, improve knowledge of delivery cost	2	2
	Operational	Improved city access regulation	1	1
		Support adoption/use of sustainable vehicles	2	2
		Measures supporting transportation operators market		
	Technical	Systems to optimise fleet delivery operation	2	2
		Systems to optimise logistics operation	2	2
		Improved integration of logistics in urban mobility	1	1
	State of compliance of technology, service and business model will be scored according to the following general criteria:		2,09	2,09
	3 = High compliance - no need for adaptation			
	2 = Medium compliance - short time adaptation			
	1 = Low compliance - long time adaptation			

Figure 18: PI compliance to SULP-Guidelines Barcelona LL

Based on the ELTIS SULP Guidelines and the defined evaluation scale (3 = High compliance, 2 = Medium compliance, 1 = Low compliance), the compliance of the DISCOCURB and DISCOLLECTION measures with the EDUM 2030 framework is justified as follows:

Socio-economic perspective *Guidelines evaluated: Reducing traffic impacts in the historical centre (3), Increasing livability of urban environment (3), Enhancing local economic development (3).*

A key pillar of EDUM 2030 is rationalizing the use of public space to improve urban livability. When DUM zones are severely congested, delivery vehicles are forced to cruise for parking or park illegally, increasing localized pollution, noise levels, and stress for commercial drivers. Reducing DUM zone congestion simplifies last-mile deliveries and directly cuts down the emissions associated with cruising. This fosters a safer, more liveable city, which indirectly promotes local economic development by making streets more attractive for small commerce. We have scored the DISCOCURB and DISCOLLECTION technologies with a maximum rating of **3** across these guidelines. The technology, in its current state, requires no further adaptation to directly detect non-compliances, determine exact occupancy percentages, and provide the in-depth usage analysis required by the EDUM 2030 roadmap to plan new policies.

Commercial perspective *Guidelines evaluated: Generate benefits on competitiveness of business (2), Optimize logistics operation (2), Reduce cost/improve knowledge of delivery cost (2).*

EDUM 2030 aims to make Barcelona a testbed and hub for innovative logistics technologies that improve business competitiveness. From a commercial perspective, the implemented measures will assist local commerce and logistics providers in optimizing their operations. More predictable and faster deliveries translate directly to reduced operational costs. Traffic congestion and parking difficulties are primary sources of delays and operational friction. Once DISCOCURB and DISCOLLECTION are fully integrated, operators will be able to adjust their planning based on new data-driven scenarios. We assign a rating of **2** (medium compliance) because unlocking these commercial benefits requires short-term adaptations—specifically, the establishment of data-sharing interfaces to push this real-time information from the city's backend to the logistics operators.

Operational perspective *Guidelines evaluated: Improved city access regulation (1), Support adoption/use of sustainable vehicles (2), Measures supporting transportation operators' market (0 / Not rated).*

We rated "Improved city access regulation" with a **1** (low compliance / long-time adaptation). While the EDUM strategy explores future access regulations, the new data-driven DUM policies must be implemented and analyed over a few years to evaluate their real effects on delivery traffic before they can directly dictate broader city access rules. Conversely, "Promoting the use of sustainable vehicles" received a rating of **2**. Because DISCOCURB collects license plate data, the municipality can cross-reference this to determine the sustainability rating and CO_2 emissions of any vehicle using the curb. This directly supports EDUM 2030's goal of reducing the carbon footprint of urban freight. The municipality can use this data to grant parking priority or extended time slots to zero-emission vehicles. However, this relies on short-term adaptations like implementing dynamic pricing or SPRO app updates, justifying the rating of 2. Our technology does not directly address "Measures supporting transportation operators' market," so this guideline was left unrated.

Technical perspective *Guidelines evaluated: Systems to optimize fleet delivery operation (2), Systems to optimise logistics operation (2), Improved integration of logistics in urban operation (1).*

We rated both "Systems to optimize fleet delivery operation" and "Systems to optimise logistics operation" with a **2**. Knowing in advance which hours or zones have more available spaces will have a massive impact on fleet optimization. However, achieving this requires short-term technical adaptation: the city council must first integrate this camera data fully into the SPRO ecosystem or an open API to share the collected data with logistics providers, which is currently in development. We rated "Improved integration of logistics in urban operation" with a **1**, as achieving full, seamless integration across all metropolitan municipalities (another key EDUM 2030 goal) is a long-term endeavour that depends heavily on future regulatory alignments.

Regarding the assessment of KPI 25 SULP it can be stated that Barcelona does not possess a formally approved SULP as a standalone legislative instrument, but it has a politically approved and active Urban Goods Distribution Strategy (DUM) 2023–2030. This strategy is deeply integrated into its overarching Urban Mobility Plan (PMU). Therefore, Barcelona already operates within a mature, officially sanctioned strategic framework for urban logistics, even as it transitions into its next PMU planning cycle.

Table 18: KPI 25 - SULP Evaluation Barcelona

KPI	Cluster	KPI (before)	KPI (after)	KPI Value Change	Weight	Qualitative rating	KPI Value (integrated)
25 - SULP	A	approved[4]	approved	Formula not appl.	3		9

5.4.3. Contribution to SDGs

In this step the contribution of the DISCO-X measures to the Sustainable Development Goals (SDGs) is evaluated. To be able to make a sufficiently precise statement here, the use of the target level of the SDGs is chosen. The association of KPIs to SDGs as well as the association of KPIs to DISCO-X measures serve as input for the assessment. In correlation with the 7 SDGs that are addressed by the DISCO activities, 11 SDG targets were identified and compared with the four measures implemented in the Barcelona Living Lab. The scale used is green = Direct contribution, light green = indirect contribution, no colour = no contribution. In addition, comments were made to clarify the contribution of the respective measure.

[4] Approved as 'Urban Goods Distribution Strategy (DUM) 2023-2030', which is politically adopted and functions de facto as the city's SULP framework.

Table 19: Contribution to SDGs Barcelona LL

SDG target	DISCO-X	
	DISCOCURB Addr. KPIs: 10, 14, 15, 16, 17, 25	DISCOLLECTION Addr. KPIs: 21, 22, 25
3.9: Reduce the amount of deaths produced by dangerous chemicals and the pollution of the air, water and soil (…) Ass. KPIs: 1, 2, 3, 5, 8-13	**[Indirect Contribution]** By reducing the time delivery vehicles spend cruising for parking in DUM zones, localized emissions of NOx and particulate matter (PM) are proportionately reduced.	**[Indirect Contribution]** Data models will enable the city to design low-emission priority zones or time slots for zero-emission delivery vehicles.
8.2: Achieve higher levels of economic productivity (…) Ass. KPIs: 6, 7, 24, 25	**[Direct Contribution]** Represents a major technological upgrade to urban infrastructure, shifting from manual app-based monitoring to AI-driven computer vision.	**[Indirect Contribution]** Replaces static, generalized parking rules with advanced data analytics, indirectly improving the operational productivity of the urban logistics sector.
8.4: Improve (…) global resource efficiency in consumption and production (…) Ass. KPIs: 1, 2, 5, 10	**[Direct Contribution]** Optimizes the utilization of a scarce and highly demanded urban resource (curbside public space) without requiring the construction of new physical infrastructure.	**[Direct Contribution]** Maximizes the efficiency of existing municipal data streams by combining historical SPRO app records with real-time camera data.
9.1: Develop quality, reliable, sustainable and resilient infrastructure (…) Ass. KPIs: 1, 5, 15, 17, 18, 20	**[Direct Contribution]** The installation of edge-computing cameras directly upgrades the physical reliability and resilience of the city's loading and unloading infrastructure.	**[Indirect Contribution]** Feeds critical predictive data into the city's analytics systems, supporting the long-term resilience of urban mobility planning.
9.4: (…) upgrade infrastructure and retrofit industries to make them sustainable (…) Ass. KPIs: 17-20	**[Direct Contribution]** Retrofits existing urban elements (light poles, traffic signals) with sensor technology to manage freight traffic sustainably.	**[Indirect Contribution]** Provides the data necessary for logistics operators (the industry) to retrofit their routing algorithms for maximum efficiency.
11.6: (…) reduce the adverse per capita environmental impact of cities (…) Ass. KPIs: 8-13	**Indirect Contribution]** License plate recognition allows the city to monitor the environmental footprint (EV vs. ICE vehicles) of the fleet utilizing the DUM zones.	**[Indirect Contribution]** Facilitates the creation of policies that actively penalize or restrict high-polluting vehicles from over-utilizing central DUM spaces.
11.A: Support positive economic, social and environmental links between urban, peri-urban and rural areas by strengthening national and regional development planning Ass. KPIs: 24, 25	**[Indirect Contribution]** Smoother last-mile operations in the city centre directly benefit the peri-urban logistics hubs and consolidation centres serving Barcelona.	**[Indirect Contribution]** Enhances the predictability of the entire supply chain, strengthening the operational link between regional warehouses and urban retail.
13.2: Integrate climate change measures into national policies, strategies and planning Ass. KPIs: 25	**[Direct Contribution]** Generates the empirical, real-world baseline data required to justify aggressive climate interventions in urban freight.	**[Direct Contribution]** Directly informs and shapes the upcoming iterations of the city's Sustainable Urban Logistics Plan (the EDUM 2030 strategy).

6. Undertaking the Evaluation in the Twinning LLs – Valencia

6.1. Introduction to Valencia LL

The Valencia Living Lab consists of DISCOBAY, DISCOPROXI and DISCOESTATE. The initial plan foresaw the implementation of a Supply Chain Hub (SCH), a flexible logistic facility in which several supply chains that serve the B2B/B2C last mile can be managed. Supported by AI the aim was the consolidation and regrouping of loads as well as the unification of distribution in a single fleet of zero-emission vehicles for a more efficient last mile distribution.

Due to an extreme weather event in October 2024 the region suffered from severe flooding and a massive power outage. Because of this, the original planned measures were redesigned with focus on emergency response and support of the residents of the city and surrounding municipalities with the overall goal to strengthen the resilience of the system. Within the Evaluation of the Valencia LL the question regarding the impact of the redesigned measures as a consequence of the extreme situation is in the centre of the investigation.

The strategy, based on a Logistics Disaster Management Plan, was built around three key components to ensure an effective and sustainable emergency response. First, a Logistics Hub was established in Alcàsser, strategically located near the most affected areas (DISCOBAY). Second, a Web Platform for Aid Requests was developed to streamline the distribution process by allowing affected communities to specify their needs (DISCOESTATE). Thirdly, as road conditions improved, the plan incorporated Distribution with Electric Vehicles for last mile distribution of goods (DISCOPROXI).

With regard to the evaluation task within the framework of DISCO, it must be said that no uniform baseline is available, which would be necessary to determine the KPIs development over the demonstration period. Nevertheless, the following chapters will provide answers from a quantitative as well as qualitative perspective explaining the evolution from zero zone to progressive road recovery on a weekly / monthly basis and milestones. The experiences made and the lessons learned from this overarching use case of “disaster emergency planning” shall be shared with other cities and regions so that resilience can be strengthened and negative impacts of extreme events can be minimized.

6.2. Evaluation set-up and preliminary remarks

Valencia implemented the DISCOBAY, DISCOPROXI, and DISCOESTATE measures within the Living Lab. As a basis for the discussion of the evaluation results, a compact summary of the most important characteristics of the measures is given.

Table 20: DISCO-X characteristics Valencia

	DISCOBAY	DISCOPROXI	DISCOESTATE
Impact Domain	Smart logistics	Connected logistics	Connected logistics
Typology	Physical	Business	Physical
Implementation approach	Implementation of the UrbanPort Model / Logistics/distribution base in a fruit and vegetable warehouse in Alcàsser close to zero zone.	Electric vehicles (Scoobic light and Scoobic Mousse) were used for the last mile distribution when road conditions permitted.	Development of a digital platform for requesting specific needs on a community basis. Focus on efficiency and optimization of distribution routes for vans
Supporting Technology	Satellite information on sites, machine learning to analyse the ground evolution	Electric vehicles, IT partner delivered route planning tool (Routaplan)	Web platform based on Python
Focus area	L'Horta Sud	L'Horta Sud	L'Horta Sud
Partners	Las Naves, Fundacion Valencia Port, t-box	Las Naves, Fundacion Valencia Port, t-box	Las Naves, Fundacion Valencia Port, t-box
Data sources used	Satellite information based on Copernicus (Sentinel 2 and 5).	Routaplan tool utilizes real-time vehicle geolocation data, fleet loading capacities, and open-source mapping data, such as OpenStreetMap	Routaplan tool utilizes smart phone signals from users to derive geolocations
Evaluation approach	Quantitative and qualitative	Quantitative and qualitative	Quantitative and qualitative
Addressed KPIs	2, 3, 4, 5, 8, 9, 10, 16, 17, 18, 22, 23, 25, plus additional KPIs (26-34)		

6.3. Assessment of KPI importance

Since the case represents a unique situation due to the flooding in October 2024, the circumstances should also be considered within the framework of this KPI evaluation. Regarding the clustering and ranking of the KPIs in terms of their relevance, a two-step approach is therefore undertaken. In the first step, the existing set of 25 KPIs is assessed for their relevance from the perspective of the

Valencia LLs. This assessment is carried out under the question 'How important are those commonly used KPIs for managing the disaster?' In a second step, new KPIs are introduced, which played a crucial role during the disaster period and are suitable for a better assessment of disaster management. These KPIs were developed, defined, and evaluated in collaboration with the Valencia LL team. This means the focus shifted from the evaluation of commonly used KPIs for Urban Delivery (e.g. Transport efficiency, CO_2 Emission reduction, etc.) to the evaluation of most relevant KPIs linked to the redesign of the Valencia measures to efficiently deploy an emergency response providing necessities to the affected inhabitants.

Regarding the original 25 KPIs, it becomes evident that due to the strong focus on optimizing distribution routes, indicators such as 'distance travelled' and 'delivery time' were classified as very important. Additionally, performance characteristics like cost-effective and reliable delivery outweighed emission-related indicators. Furthermore, data availability and the utilization of digital tools emerged as major levers for guaranteeing supply chains and accurately understanding community needs.

KPI Number	KPI	Description and data format	Cluster	Rank in Cluster
4	Delivery time	Average delivery time per route	A (very important)	1
16	Reliability of Sensors and Cameras	Average time that sensors were not working properly	A (very important)	2
22	Data Utilization	Number of new/enhanced services utilizing old/new data collected	A (very important)	3
18	Warehouse offer	Average offered space of a warehouses be used as (shared) space for logistics operations	A (very important)	4
23	Number of partnerships for collab. logistics	Number private-private and -or public-private partnerships for last mile deliveries	A (very important)	5
17	Transport infra offer	Average offered space of a transport infrastracture to be used as (shared) space for logistics operations	A (very important)	6
2	Distance Travelled	Average distance per delivery	A (very important)	7
3	Failed Deliveries	Percentage of unsuccessful deliveries with the 1st attempt	A (very important)	8
25	SULP	Number of locally politically approved SULP or freight logistics plan	B (important)	1
10	EV Adoption Rate	Percentage of electric freight vehicles in the delivery fleet	B (important)	2
9	CO2 Emissions per parcel	Total kg of CO2 emissions per parcel	C (less important)	1
8	CO2 Emissions per km	Total kg of CO2 emissions per km	C (less important)	2
5	Delivery Density	Number of deliveries per km	C (less important)	3
1	Traffic Flow	Total freight kilometers driven per 10000 inh	D (not applicable)	
6	Cost per parcel	Cost of delivery per km	D (not applicable)	
7	Operational Cost per day	Total delivery cost	D (not applicable)	
11	Cargo bike adoption rate	Number of cargo bikes in the local delivery fleet	D (not applicable)	
12	Cargo bike deliveries	Percentage of the total deliveries performed by cargo bikes	D (not applicable)	
13	Companies electrification	Percentage of companies that operate with cargo bikes	D (not applicable)	
14	Parking fines	Parking fines per 10000 inh	D (not applicable)	
15	Space Utilization Efficiency	Average occupancy of parking spaces	D (not applicable)	
19	Lockers volume	Percentage of freight volume delivered through lockers	D (not applicable)	
20	Microhub Capacity Utilization	Average utilization rate of a parcel locker	D (not applicable)	
21	Data sources used	Number of data sources or platforms that are connected to the data	D (not applicable)	
24	Investment plans	Number of investment logistics plans of local private entities operating in Urban logistics	D (not applicable)	

Figure 19: Clustering and ranking of KPIs Valencia LL (original KPIs)

As can be seen from the following illustration, the newly defined KPIs cover a range of different aspects in the context of disaster management. Moreover, they extend the existing framework by prioritizing human well-being through the integration of socio-economic metrics, such as Deprivation Costs and population coverage, alongside traditional logistics performance indicators like response time and inventory turnover. The scope further expands to the operational agility of the system, measuring the rapid creation of improvised supply chains and the integration of diverse product verticals to ensure a standardized response after a disruption. Finally, these metrics capture the critical mobilization of human and financial resources, specifically tracking daily volunteer engagement and ad-hoc financial support as essential drivers for a successful disaster response deployment.

KPI Number	KPI	Description and data format	Cluster	Rank in Cluster
26 (added)	Response time	The logistics system's ability to deliver aid to those affected in the shortest possible time after a disaster.	A (very important)	1
27 (added)	Deprivation Costs	Economic valuation of human suffering resulting from a lack of access to life-sustaining goods and services. Defined as a time-dependent function, these costs increase non-linearly (exponentially) with the duration of the shortage, measuring the impact of supply chain failure on human well-being.	A (very important)	2
28 (added)	Supply Chains created	Measuring the rapid establishment of improvised, socio-technical delivery networks in post-disaster environments.	A (very important)	3
29 (added)	Daily Volunteers	Number of persons at zero zone supporting per day (citizens)	A (very important)	4
30 (added)	Ad-hoc Financial Response	Total amount of financial support generated specifically for the deployment of a crisis response.	A (very important)	5
31 (added)	Population coverage ratio	Share of continuously supported population by set-up aid solutions (measured at the end of the pilot)	A (very important)	6
32 (added)	Inventory turnover	The frequency with which the total stock at the Alcàsser Logistics Center is replaced within a given period. It measures the efficiency of the Valencia LL Logistics System by calculating the ratio between the volume of aid delivered and the average inventory levels held at the center.	A (very important)	7
33 (added)	Integrated supply verticals	Number of different types of products whose supply can be efficiently organized and standardized after a disruption.	A (very important)	8
34 (added)	Using available data sources	Number of available online data sources used to plan and operate at an emergency response	A (very important)	9

Figure 20: Clustering and ranking of KPIs Valencia LL (newly defined KPIs)

6.4. Evaluation of DISCO-X measures

In the following, the DISCO-X measures implemented in the Valencia Living Lab are evaluated on three different levels in line with the developed methodology within DISCO. However, each of the steps has been adapted to match the extraordinary circumstances of emergency response within which they were carried out. The evaluation on the operational level with KPI assessment has been adapted based on progressing stages for an emergency response instead of evaluating before and after states. In addition, analysis is extended with additional, emergency response relevant, KPI's.

Following up on this, the measures compliance with the ELTIS SULP Guidelines is reviewed (local level). This part includes suggestion of extended SULP guidelines including aspects of preparedness for disaster management.

In a final step, their contribution to the SDGs at the target level is assessed (global level). This part also needed to be extended to cover additional, relevant SDG's focusing on building resilience and alleviating people affected by disaster.

6.4.1. KPI-Assessment

The impact assessment for the Valencia Living Lab is adapted in several ways to the situation in which the Living Lab was demonstrated as an emergency response to a sever disaster and not an improvement of an existing, functioning urban freight distribution system.

The emergency response was executed as all societal functions were wiped away in the area and a total new, temporal logistics system was needed. Such a system was created through different stages from an initial solution to a more elaborated system where several DISCO-X measures where integrated. The development can be gathered in following three stages:

- Stage 1 Picanya temporary solution to start with, October 30 till November 10th
- Stage 2 Consolidated work with DISCOBAY, November 11th to November 20th
- Stage 3 optimizing with DISCOESTATE and introducing DISCOPROXI November 21st to 15th March

As the different measures were built upon each other in an integrated manner, a common evaluation across DISCOBAY, DISCOESTATE and DISCOPROXI is made. It is similar to evaluation of Thessaloniki LL (described in project deliverable D4.3).

As the starting point of an emergency response is a lack of a functioning system, it was not meaningful to compare the system state before and after implementation. Instead, the focus is laid on the development between the different stages, especially between stage 2 and 3 where the logistic operation was more established and more data could be collected despite operation in highly demanding conditions.

The evaluation is focusing on qualitative assessment of the individual unique KPI values and no integrated KPI values are assessed as the Valencia LL was executed in a totally different context than the integrated KPI methodology was designed for.

Below is first shown the evaluation based on the relevant DISCO KPI's and further down the assessment of emergency response KPI's is shown.

Assessment of DISCO KPI's

In Table 20 can be seen the development of the relevant DISCO KPI's. A large share of data was not available in stage 1 as focus was to organize and initiate logistic operations directly after the flooding. However, only was 2-3 weeks after the disaster (during stage 2) both efficient logistic operations was executed and relevant data collected. An operational efficiency gain can be seen when the demonstration stepped into stage 3 as the recovery work continued and DISCOESTATE and DISCOPROXI measures where implemented.

Table 21: Valencia pilot KPI Assessment (all measures integrated)

KPI name	Unit	Cluster	Stage 1	Stage 2	Stage 3	Achievement (Stage 2/ Stage 3)	Qualitative statement
2 - Distance Travelled	km/del	A		3.87	3.69	-5%	Decrease due to optimized routing
3 - Failed Deliveries	%	A		27.0%	0.0%	-100%	All customers were contacted in beforehand. Created a weekly distribution schedule.
4 - Delivery time	mins	A		27.00	23.00	-15%	Decrease due to optimized routing
5 - Delivery Density	parcels/km	C		5.17	5.42	5%	Improvement due to optimized routing
8 - CO_2 Emissions per km	kg_{CO2eq}/ km	C		2.09	0.94	-55%	Decrease due to EV adoption
9 - CO_2 Emissions per parcel	kg_{CO2eq}/ parcel	C		0.07	0.03	-57%	Decrease due to EV adoption
10 - EV adoption rate	%	B		0%	83%	N/A	EV's are put into service. 2 Scoobic and 3 e-VAN
16 – Reliability of Sensors and Cameras		A		25%	5%	-80%	Estimate of failing cellular network
17 - Transport infra offer	sq.m	A	7,252	66,302	66,302	0%	Summary of all available space (not offered space)
18 - Warehouse offer	sq.m	A	5,329	6,576	6,576	0%	Changed location from Picanya (stage 1) to Alcàsser (stage 2&3), actually used sq.m.
22 – Data Utilization	TB	A	1	2	3		1 st stage Rutaplan, 2nd stage Application Ayuda Valencia, 3rd stage a Tool in order to locate new warehouses was developed (Voronoi diagrams)
23 - Number of partnerships for collaborative logistics	-	A	7	27	27	0%	Public authorities, military and emergency forces, private logistics companies, and civil society volunteer networks.

Cost of the operation is an important parameter, but a complete cost picture could not be achieved in the first and second stage. During stage 3 the cost per parcel was calculated to €2.18 per parcel. When calculating this value into DISCO KPI's by combining it with other input data, the "Operational cost per day" was €2 945 and the "Cost per parcel" calculated as €/km was €11,8. The relatively high cost of delivery per km is driven by the large amount of parcels per vehicle (average 226 parcels).

The KPI “16 – Reliability of Sensors and Cameras” is referring of failing cellular network when gathering geolocation data from smartphones and data from air pollution (PM2.5) sensors. In stage 2 approximately 20 smartphones were used, increasing in stage 3 to 50 smartphones and 2 air quality sensors. The air quality sensors were needed to assess the air quality which was significantly affected from material left after the flooding. The information from these sensors was used to select routes with least impact for drivers and limit health hazard for the community.

Assessment of emergency response KPI’s

In Table 21 can be seen the additional KPI’s for Valencia LL describing the impact when the logistic system was consolidated and DISCO-X measures implemented through the different stages.

Table 22: Extended KPI for Valencia pilot measuring DISCO-X impact when recovery from a disaster.

	Unit	Stage 1	Stage 2	Stage 3	Achievement (Stage 2/ Stage 3)	Qualitative statement
26 Response time	h	24	24	12	-50%	Knowledge about the ground, the facilities implemented as well as the used methodology based on the DISCO-project philosophy helped to reduce the response time.
27 Deprivation Costs	€	127.50	127.50	54.64	-57%	Direct relationship between response time and deprivation costs evolution.[5]
28 Supply Chains created	#	0	0	1	-	The lack of institutional organisation and need to maintain deliveries pushed the DISCO-team to implement new supply chain.
29 Daily Volunteers	#	8	80	80	0%	The lack of institutional leadership pushed the team to select and manage directly groups of volunteers in order to support different kinds of activities. From stage 2 and onwards collaboration with national group of volunteers.
30 Ad-hoc Financial Response	€	0	150000	300000	100%	Private partnerships supported the work with increasing financial support. The impact of the performance generated helped to get more financial support (gain in reliability and transparency of the work).
31 Population coverage ratio	%	N/A	10%	10%	0%	Group was able to response quickly because of the creaton of the independent supply chain. This helped to maintain a solid coverage ratio due to optimization of supply and avoiding disruptions.

[5] More information about the relationship between time and deprivation cost can be found in the report “Deprivation Cost, concepts and applicability on the Valencia LL.” by Alberto Moreno Mas (T-Box)

32 Inventory turnover	-	N/A	N/A	1.5	-	The integration of material requirement planification into the system allowed the reduction of waste and an optimal utilization of the goods.
33 Integrated supply verticals	#	4	6	8	33%	The organisation into different verticals over time allowed to create a consolidation picking system optimizing the load factor for each vehicle.
34 Using available data sources	#	6	11	11	-	Satellite and meteorological observations, proprietary real-time geolocation, and open public records combining mapping and socio-demographics.

As an indication that DISCO-X measures are a successful methodology for emergency and humanitarian logistics response, the concept has already been replicated in the humanitarian crisis of the Sahrawi refugee camps in Tindouf, through cooperation with NGOs such as Asociación de Trabajadores y Técnicos sin Fronteras (ATTsF) and in coordination with the Spanish Agency for International Development Cooperation (AECID), World Food Programme (WFP) and Media Luna Roja Saharaui (MLRS).

6.4.2. Compliance to SULPs

Similar to the KPI assessment, the compliance to SULPs task was also adapted to the specific circumstances of the Valencia case (see methodology chapter). Therefore, only selected guidelines from the existing framework were evaluated, but a completely new category in the context of resilience and disaster management was added to the framework. These new guidelines were developed in collaboration with the representatives of the Living Lab and are intended in particular to serve as guidance for other cities and municipalities. The developed guidelines should be incorporated into strategic plans such as SULPs as needed in order to be proactively prepared for disasters and to make preparations. The following describes selected evaluations regarding already existing as well as newly added guidelines. The overview of the entire compliance to SULP task is shown in Figure 21.

Existing category 'Commercial':

Within the commercial category, compliance checks were conducted for two specific guidelines. Regarding the guideline 'Optimise logistic operations', a high compliance level was confirmed (rating of 3). This was justified by the fact that the experience gained during the DISCO project—particularly in implementing logistics measures—proved decisive in developing comprehensive emergency planning, including the corresponding business plan.

Regarding the guideline, 'Reduce costs, improve knowledge of delivery costs', a compliance rating of 2 was assigned. The DISCO project actions proved instrumental in identifying specific delivery demands and item categories. As a direct consequence, optimized supply chains and new supply verticals were successfully established. In this, the reduction of costs as well as the acquisition of knowledge about it represented an important component. However, this was not the main focus of the work.

Existing category 'Technical':

The guideline 'Systems to optimise fleet delivery operations' was rated as medium compliant (rating of 2). The reasoning behind this score is that fleet deployment and route optimization must dynamically adjust to changing conditions, meaning that a certain period of adaptation will always be necessary.

The guideline 'System to optimise logistics operations' achieved a high compliance level (rating of 3). This score was justified by the full integration of localized ground knowledge with route planning, dynamic demand integration, and a comprehensive material requirements planification system.

The guideline, 'Improved integration of logistics in urban mobility', received a low compliance rating of 1. This score is attributed to a structural deficit, specifically the general lack of emergency logistics integration within existing urban mobility policies.

Resilience perspective (new):

In order to comprehensively represent the special situation of the Valencia Case, a total of six new guidelines with focus on Resilience and disaster management were developed together with the representatives of the Living Lab. These are:

1. Collect data, analyse current situation and different scenarios to improve knowledge about current cargo operation in the city and metropolitan area.
2. Identify main agents and stakeholder, and potential spots for consolidation centres, loading/unloading spots and explore Public-Private Partnership.
3. Improve agility and response capacity (e.g. response time)
4. Secure social equity and basic supply (Deprivation costs / population coverage)
5. Adapt infrastructure and supply chains (e.g. supply verticals)
6. Set-up / manage collaborative governance & volunteer integration (e.g. daily volunteers, partner integration)

As can be seen in the parentheses, indicators from the previous chapter were linked in order to give a better insight into how these guidelines can be measured and controlled. Regarding the compliance to SULP check a high compliance rating for the guidelines 1-3 as well as for guideline 6 was stated since the implemented Valencia measures contribute without restrictions to the described tasks. The guideline ‘Secure social equity and basic supply’ was assigned a compliance rating of 2. This moderate score reflects the fact that achieving social equity is highly contingent on the specific scale and localized impact of an emergency. Different demographic zones exhibit distinct requirements and socioeconomic clustering that prevent a one-size-fits-all approach.

Similarly, the guideline ‘Adapt infrastructure and supply chains’ received a rating of 2. The justification lies in the varying geographic and urban settings across different areas. Here, supply chain elasticity emerges as a critical performance criterion, which inherently fluctuates from city to city and region to region.

	SULP guidelines		Holistic assessment incl. DISCOBAY, DISCOPROXI & DISCOESTATE
Mobility Governance: Services and measures	Socio-economic	Reducing traffic impacts in the historical centre	not applicable
		Increasing livability of urban environment	not applicable
		Enhancing local economic development	not applicable
	Commercial	Generate benefits on competetiveness and business	not applicable
		Optimise logistics operation	3
		Reduce costs, improve knowledge of delivery cost	2
	Operational	Improved city access regulation	not applicable
		Support adoption/use of sustainable vehicles	not applicable
		Measures supporting transportation operators market	not applicable
	Technical	Systems to optimise fleet delivery operation	2
		Systems to optimise logistics operation	3
		Improved integration of logistics in urban mobility	1
	Resilient (new)	Collect data, analyse current situation and different scenarios in order to improve knowledge about current cargo operation in the city and metropolitan area	3
		Identify main agents and stakeholder, and potential spots for consolidation centres, loading/unloading spots and explore Public-Private Partnership	3
		Improve agility and response capacity (e.g. response time)	3
		Secure social equity and basic supply (Deprivation costs / population coverage)	2
		Adapt infrastructure and supply chains (e.g. supply verticals)	2
		Set-up / manage collaborative governance & volunteer integration (e.g. daily volunteers, partner integration)	3
			2,45

State of compliance of technology, service and business model will be scored according to the following general criteria:
3 = High compliance - no need for adaptation
2 = Medium compliance - short time adaptation
1 = Low compliance - long time adaptation

Figure 21: PI compliance to SULP-Guidelines Valencia LL

The discussions with the Valencia team and the evaluation activities reveal a critical deficit in public sector foresight across Spain. Currently, metropolitan strategies struggle to integrate resilience and satisfy directives for sustainable urban logistics planning. To bridge this gap, it is strongly recommended to mandate the inclusion of explicit contingency and response plans for extreme events (e.g., flash floods like the recent DANA storm, fires, or earthquakes) directly into Sustainable Urban Logistics Plans (SULPs). Furthermore, future implementation must leverage the practical expertise of organizations and individuals with real-world crisis experience. Incorporating these important insights—highly developed during the DISCO project—can ensure that the European Commission can fully recognize and capitalize on the strategic value of its funded actions.

Building upon this it must be said that Valencia currently does not have a SULP. While València has operated a Sustainable Urban Mobility Plan (SUMP) since 2013, it currently lacks a dedicated Sustainable Urban Logistics Plan (SULP), leaving urban freight heavily underrepresented. To bridge this strategic gap, València City Council is currently in a foundational preparation phase. The city is focusing its immediate efforts on capturing, mapping, and analysing urban freight distribution through targeted data collection and pilot studies. This ongoing data-gathering process is designed to establish the necessary operational and analytical baseline required to successfully develop and deploy a comprehensive, standalone SULP framework in the upcoming planning cycle.

For KPI 25 SULP, this results in a weighted rating of 1, which symbolises that there are initial activities in Valencia aiming to develop a SULP.

Table 23: KPI 25 - SULP Evaluation Valencia

KPI	Cluster	KPI (before)	KPI (after)	KPI Value Change	Weight	Qualitative rating	KPI Value (integrated)
25 - SULP	A	None	Drafted	Formula not appl.	1		3

6.4.3. Contribution to SDGs

In this step the contribution of the DISCO-X measures to the Sustainable Development Goals (SDGs) is evaluated. To be able to make a sufficiently precise statement here, the use of the target level of the SDGs is chosen. The association of KPIs to SDGs as well as the association of KPIs to DISCO-X measures serve as input for the assessment. In correlation with the 7 SDGs that are addressed by the DISCO activities, 11 SDG targets were identified and compared with the four measures implemented in the Valencia Living Lab. In addition, 7 SDG targets were added with a clear focus on resilience and disaster management. Since the measures are closely interconnected, a holistic assessment is carried out, as with the preceding chapters. Where relevant, individual measures are particularly highlighted.

The scale used is green = Direct contribution, light green = indirect contribution, no colour = no contribution. In addition, comments were made to clarify the contribution of the respective measure.

Table 24: Contribution to SDGs Valencia LL

SDG target	Holistic assessment including DISCOBAY, DISCOPROXI & DISCOESTATE (Addressed KPIs: 2, 3, 4, 5, 8, 9, 10, 16, 17, 18, 22, 23, 25, plus additional KPIs (26-34)
1.5 (added): By 2030, build the resilience of the poor and those in vulnerable situations and reduce their exposure and vulnerability to climate-related extreme events and other economic, social and environmental shocks and disasters Ass. KPIs: 6, 23, 26, 27, 28, 30, 31, 33, 34	**[Direct Contribution]** From logistic perspective: support this group with food and other goods when urgently needed. All three measures aim for this, specifically DISCOESTATE.
6.2 (added): By 2030, achieve access to adequate and equitable sanitation and hygiene for all and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations Ass. KPIs: 28, 31, 33, 34	**[Direct Contribution]** DISCO-X measures helped to provide hygiene articles. With the developed tool a clusterisation of social groups was possible.
9.1: Develop quality, reliable, sustainable and resilient infrastructure (...) Ass. KPIs: 1, 5, 15, 17, 18, 20, 28, 33, 34	**[Direct Contribution]** Especially DISCOBAY contributed to this target through the fast build-up of the logistics distribution base.
11.3: (...) enhance inclusive and sustainable urbanisation and capacity for participatory, integrated and sustainable human settlement planning and management (...) Ass. KPIs: 11, 19, 20, 26,27, 29, 31, 34	**[Direct Contribution]** e.g. community-based approach within DISCOESTATE
11.5 (added): By 2030, significantly reduce the number of deaths and the number of people affected and substantially decrease the direct economic losses relative to global gross domestic product caused by disasters, including water-related disasters, with a focus on protecting the poor and people in vulnerable situations Ass. KPIs: 26, 27, 28, 31, 33, 34	**[Direct Contribution]** All DISCO-X measures contribute to this target since they have been developed with the goal to rapidly supply essential goods in order to minimize suffering or in extreme case death. Furthermore, if the methodology is integrated in strategic plans this becomes a robust mitigation tool.
11.6: (...) reduce the adverse per capita environmental impact of cities (...) Ass. KPIs: 8-13	**[Direct Contribution]** The DISCO-X measures aimed to minimize negative impacts for the environment based on fast response and adaptation to critical situations. In order to identify zones and affected population the emergency teams e.g. utilized information from the sensors (e.g. PM2,5).

11.A: Support positive economic, social and environmental links between urban, peri-urban and rural areas by strengthening national and regional development planning Ass. KPIs: 24, 25,	**[Direct Contribution]** The methodology is not only suitable for a local municipality. The team showed that it is possible to protect several cities at the same time. Furthermore, the catastrophe showed the importance for strong collaboration and the necessity of metropolitan strategies. As an example, smaller roads were used to serve urban areas during the disaster to serve different urban areas.
11.B (added): By 2020, substantially increase the number of cities and human settlements adopting and implementing integrated policies and plans towards inclusion, resource efficiency, mitigation and adaptation to climate change, resilience to disasters, and develop and implement, in line with the Sendai Framework for Disaster Risk Reduction 2015-2030, holistic disaster risk management at all levels Ass. KPIs: 23, 25, 34	**[Direct Contribution]** This incident confirmed the urgent importance to address this target and the need to implement it into policies although Valencia and its metropolitan area is also lacking a broad implementation so far.
13.1 (added): Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries Ass. KPIs: 23, 26-34	**[Direct Contribution]** Primary goal of the Valencia measures.
13.2: Integrate climate change measures into national policies, strategies and planning Ass. KPIs: 25	**[Direct Contribution]** This incident confirmed the urgent importance to address this target and the need to implement it into national policies, strategies and planning although Valencia and its metropolitan area is also lacking a broad implementation so far.
13.3 (added): Improve education, awareness-raising and human and institutional capacity on climate change mitigation, adaptation, impact reduction and early warning Ass. KPIs: 23	**[Direct Contribution]** Through showcasing and documentation within the DISCO project.
17.16: Enhance the Global Partnership for Sustainable Development (…) Ass. KPIs: 23	**[Direct Contribution]** Spread knowledge and connect with other stakeholders to provide proactive help.

7. Discussion of the findings of the TLL evaluation regarding their replication potential

The activities in the four Twinning Living Labs play a central role in DISCO's endeavour to accelerate the process of upscaling into a new era of urban logistics and intelligent planning. This includes facilitating the transition to carbon-neutral and digital cities, developing new and innovative frameworks and tools, and transforming the paradigm of urban logistics and planning through a physical internet (PI)-led approach. Furthermore, the Valencia case strongly contributed by incorporating resilience and disaster management as a critical element for future transport systems. Based on these overarching objectives, the findings from the evaluation of the Twinning Living Labs as well as insights from D5.2 are discussed with a focus on impact and scalability of the implemented measures. To ensure good comparability, the structure of the chapter resembles that of Chapter 7 in the first evaluation report D4.3.

Reducing environmental impact and support sustainable mobility transformation

The DISCOPROXI measure implementations especially in Zaragoza and Padua highlight an enormous potential that comes with the shift to sustainable logistics solutions in combination with innovative microhub and locker concepts.

What was successfully demonstrated:

The Zaragoza measure illustrated that both the number of vans and the distance travelled by van can be significantly reduced when parcels are delivered to a microhub instead of using a van for deliveries to end-customer. With this a substantial drop in CO_2 emissions by 33% was demonstrated incorporating zero-emission last mile delivery from the hub to the end customer electric vehicles, cargo bikes and assisted delivery carts. While often CO_2 emission reduction is in the centre of observation the transition to E-carts and cargo bikes brings enormous advantages in reducing fine dust (PM10) and nitrogen oxides (NO_2), which are traditionally caused by over 30% by urban delivery traffic (see Barcelona chapter). To fully exploit those environmental potentials logistics microhubs must be integrated with the guidelines of urban environmental zones (as shown in Zaragoza).

Padua on the other hand reinvented the logistics operations by implementing the dynamic locker concept based on modular pods which led to zero-emission on a local level.

What are existing challenges:

Although it could be shown during the DISCOPROXI implementation in Padua that changing the policy was able to reduce failed deliveries by more than 50%, this indicator is still insufficiently met and must be significantly increased for a commercial scale-up.

One aspect that requires special attention in both measures is the shift in the cost situation due to changes in logistics operations. In Zaragoza, there was a slight increase in costs, while in Padua the costs on paper decreased. However, it must be taken into account that for Padua maintenance and depreciation costs were excluded in the calculation due to the prototype character of the vehicles and the low delivery volume. Both examples highlight that achieving commercial viability for these solutions depends heavily on regulatory incentives. Such frameworks are necessary to translate external cost savings (e.g., reduced infrastructure degradation and public health costs) into direct economic benefits for logistics companies and operators.

Increasing traffic efficiency

Decreasing freight kilometres and cutting down fleet sizes are powerful ways to increase traffic efficiency. To achieve this, innovative approaches such as shared consolidation hubs, locker-based solutions or digital tools to optimise operations need to be established and utilized.

What was successfully demonstrated:

Regarding traffic efficiency the evaluation work conducted with the Padua team indicates that the digital booking system of the DISCOCURB measure bears potential to reduce traffic in the city centre. This results from less circulation in search of parking spaces enabled by the smart, bookable loading and unloading bays. The DISCOCURB measure in Barcelona also stresses the benefits of a real-time availability data for reducing the time delivery vehicles spend searching for parking and thus lower cruising emissions. Another benefit that was identified is that through AI-assisted observation and bookable loading zones blocking of double rows and bike lanes is prevented, keeping the traffic flow of the entire urban network smoother. In Zaragoza, while DISCOCURB did not deploy physical infrastructure, the temporal demand analysis provides the empirical foundation for time-differentiated curb management policies that would directly reduce peak-hour delivery traffic in central streets.

What are existing challenges:

Since no quantitative data on traffic flow could be collected as part of the evaluations, the actual impact in both cities should be determined while expanding the number of bays and involving additional logistics operators.

Furthermore, the limited availability of quantitative data on delivery time and delivery density from the DISCOPROXI measures in Padua and Zaragoza (with Padua also using a different baseline due to comparing different policies) necessitates further investigation into what the optimal mix to optimize traffic efficiency should look like, e.g., in terms of the right vehicle size for the right zone. Insights from Helsinki (see D4.3) illustrated that a complete switch from large vans to smaller cargo bikes or robots can reduce delivery density and increase delivery times.

Operational efficiency enhancement

What was successfully demonstrated:

Regarding the KPI distance travelled again both DISCOPROXI measures from Zaragoza (-59%) and Padua (-48%) demonstrated great results. In addition, the “WAITING” algorithm in Padua was able to reduce failed deliveries by over 53% which leads to less reverse logistics and therefore lower costs.

DISCOCURB in Barcelona on the other hand shows that drivers often use the manual SPRO app incorrectly or not at all. The AI cameras neutralize this 'human factor' and give logisticians reliable historical data to plan routes precisely which can enhance operational efficiency.

What are existing challenges:

It should be noted, that the achievements regarding the two DISCOPROXI measures cannot be considered isolated and although the results look promising there are challenges to overcome. One example is that the absolute value for failed deliveries for DISCOPROXI in Padua is still too high. In order to establish a fully accepted and commercially viable logistics solution multiple factors such as delivery success, costs per parcel or customer satisfaction (see also Helsinki Living Lab) need to be met. Especially the highly innovative approach of Padua based on the modular NEXT pods should focus on the optimisation of the above-mentioned indicators to support a commercial scale-up.

Optimise infrastructure and space utilisation

What was successfully demonstrated:

In Padua, the Italian traffic regulations (no exclusive reservation of public space) limited the use of infrastructure. A scaling factor is therefore to adapt national traffic laws to modern logistics requirements (shared spaces). The DISCOCURB pilot reveals the potential that comes with innovative curbside measures and shows the way in which urban regulations need to be adjusted.
The DISCOCURB measure in Barcelona revealed an actual utilization of the loading zones of over 91% (instead of the assumed 41%). With the help of such data, cities can transform static rules regarding curbside usage to a more dynamic, time-based slots.

Zaragoza on the other side demonstrated that existing spaces can be transferred into logistics hubs by utilizing the old market Mercado de San Vicente de Paúl within DISCOPROXI. In addition, the measure demonstrates that due to the shift to a zero-emission last mile concept based on electric vehicles, cargo bikes and assisted delivery carts pedestrian areas can be used as delivery paths reducing conventional delivery traffic in the historic centre.

Data-driven logistics management

What was successfully demonstrated:

AI-based tools and advanced data analytics can be seen as a major enabler for optimizing logistics flows and infrastructure utilization. The activities for example in Barcelona (DISCOCURB) but also in Valencia impressively showcase how information on routes, optimization of routs and the utilization of infrastructure can benefit from the application of machine learning and AI-based computer vision. For Barcelona, the defined next step is to offer real-time curbside occupancy information as reliable data streams to commercial operators. A software interface is currently in development and will allow the city to broadcast live parking availability, translating the collected sensor data into an operational tool for fleet routing and cruising time reduction.

Another example in this category is the EDPI (E-commerce Demand Potential Index) from Zaragoza which uses demographic data to identify optimal spots for future hubs and lockers.

What are existing challenges:

One learning from Zaragoza was that data integration proved to be less a technological challenge and more a matter of governance, trust and clearly defined roles (see D5.2 report). This highlights the need for the design of formal agreements on data exchange between the city and the logistics companies. Insights from D4.3 in addition refer to the fact that partners should be integrated in an early stage also to discuss potential business opportunities and guarantee a later monetisation of data shared.

An important learning is also that the establishment of Urban Freight Data Spaces must be GDPR-compliant from the very beginning. Barcelona proves the scalability of this approach, where cameras process only metadata and license plates without storing any video streams.

Exploit new business models

What are existing challenges:

Mirroring the insights from the first evaluation round, the evaluation within the Starring Living Labs revealed distinct challenges in implementing highly innovative logistics concept. The findings from the Padua pilot indicate that the primary challenge for DISCOPROXI lies in securing a suitable operator to scale up the dynamic locker solution. As a radical innovation, this solution significantly departs from established business practices centred on fixed locker networks. This systemic divergence creates a steep barrier to commercial scale-up since prospective operators are not only forced to fundamentally overhaul their current business models, but they also face financial resistance due to the risk of stranded assets and unrecoverable prior investments in fixed infrastructure.

What are future potentials:

Building on the DISCO activities in the Valencia Living Lab, work is currently underway to develop a sustainable business model for the commercialization of the emergency logistics solutions. Supported by the EU's Booster initiative, these ongoing efforts focus on packaging the core pillars, the methodology, the digital platform, and governance model, into a viable, scalable commercial offering. The current roadmap plans for an initial market launch targeting Spanish municipalities in 2027. Following this national phase, the strategy envisions scaling the solution internationally to support other European cities from 2028 onwards. To ensure long-term viability, the proposed model explores generating revenue through a combination of digital platform licensing and complementary consulting services to assist cities with framework implementation.

Regarding DISCOCURB future business models and monetization strategies for curbside usage should be explored. Municipalities could, for instance, introduce models where logistics providers pay for guaranteed loading times (premium slots), whereas zero-emission vehicles receive free or extended access rights as an incentive.

Another aspect that must be considered related to the business dimension is the fact that the shift to E-carts (Zaragoza) allows people without a driving license to work in delivery. This opens entirely new labour markets for logistics operators during labour shortages.

Integrate resilience and disaster management into transport planning

What was successfully demonstrated:

Through the collaboration with the Valencia team, new perspectives on the DISCO project opened up. The Living Lab demonstrated that innovative urban logistics activities can be seen as drivers for emergency response and that there are multiple synergies and benefits in connecting those elements. This applies for consolidation of freight, data driven operation, the application of digital tools for communication with customers or the usage of EV's.

Within the Valencia case it got obvious that a combination of technology, innovation and knowledge were essential components that saved lives. Moreover, it got visible that innovative data usage, processing and sharing were key to realize fast response and reliable response. In the future, it will be crucial that cities have the ability to switch from logistics operations to response mode within short possible time. Regarding this Valencia demonstrated how an agile logistics infrastructure established in advance can reduce crisis response times from 24 to 12 hours, drastically reducing human suffering and economic loss.

Which action should be taken:

To pass on the knowledge gained and to carry the insights as essential impulses, dissemination to active disaster management groups in cities is highly important. Moreover, the topic of disaster management must be firmly anchored in any type of metropolitan strategy. Only when this element is an integral part of future planning, challenges like those in Valencia can be addressed and the extent of damage kept as low as possible.

More precise, it is essential to emphasize the need to include contingency and response plans for extreme events, such as flash floods, earthquakes, or fires, in Sustainable Urban Mobility Plans

(SUMPs) in general, but in Sustainable Urban Logistics Plans (SULPs) in particular. This involves identifying and engaging organizations and individuals with proven experience in real-world situations, such as the one experienced in Valencia after the DANA storm, or in European projects like DISCO. This will ensure that the European Commission itself is aware of the added value and strategic importance of each action it funds and coordinates.

8. Guidelines and lessons learnt from the LL evaluations

8.1. Guidelines to support further evaluations

The subject of DISCO's evaluation task was, in addition to conducting the two Living Labs evaluations, also the development of an appropriate evaluation methodology that takes into account the various evaluation objectives. In the course of this work, the evaluation modules, as well as an overarching framework to support further future evaluation work described in Chapter 2 were developed.

In the course of working with the stakeholders in the various Living Labs, it has become apparent that the developed evaluation methodology is suitable for assessing the various evaluation objectives. Nevertheless, it was necessary to adjust the methodology in certain places to the needs of the Living Labs. This was the case, for example, in the Padua Living Lab in the context of DISCOPROXI. Here, the Random Policy was set as a baseline to measure the impact. Another example is the evaluation work with the Valencia team. Due to the special situation of the Living Lab because of the environmental disaster, an expansion of the methodological basis was required, for example through the definition of new KPIs as well as a new SULP category, and the inclusion of new SDG targets.

In order to share essential insights gained within the framework of the evaluations, the following guidelines have emerged.

1. Involve stakeholders early for successful evaluation

An evaluation encompasses numerous different aspects and therefore quite often requires the involvement of a broad stakeholder base. To achieve the best possible evaluation results, it is therefore necessary to involve the right people at the earliest possible stage. This ensures that the evaluation objectives are known to everyone, the appropriate indicators for measuring the impact are selected, and the necessary data sources and documents match the evaluation setup.

2. Set clear goals and timelines for measure deployment

The implementation of urban mobility measures is a time-intensive process, requiring a clear goal and a structured roadmap. Practical insights from DISCOCURB show that the physical installation of required infrastructure represents a major operational effort in itself. Attempting to satisfy an extensive target framework (such as 25 KPIs) under these conditions is unrealistic. Future implementation designs should account for this reality during the scoping phase, either by streamlining the target system or by extending the implementation timeline.

In addition to this, it became apparent that increasing the TRL is not solely a technical endeavour. In the context of urban mobility, regulatory approval processes, stakeholder engagement, and public acceptance are just as critical to success as the physical hardware.

3. Allocate adequate resources for data collection, analysis, and interpretation

The KPI-based assessment of the impact of implemented measures is based on a solid data foundation. However, in order to make the best use of the potential of data, it is necessary to allocate sufficient resources. This includes not only personnel resources but also financial and infrastructural resources. The work in the Living Labs has shown that there is a significant shortage in all three categories of resources. It should therefore be ensured that trained personnel are available to work with the data, as well as financial resources and infrastructure are provided to be able to store and process larger amounts of data.

4. Prioritize data quality over data quantity

A central learning of the two evaluation rounds is that data quality must always take precedence over data quantity. An excess of indicators dilutes the focus if the underlying data is incomplete, difficult to obtain or lacking a solid baseline. Future implementations should strictly judge KPI selection based on two factors: the actual applicability of the KPI to the measure to be implemented and the practical availability of the data source. If reliable data collection cannot be guaranteed, the KPI should be omitted.

5. Build methodical frameworks with agile flexibility

The evaluation methodology developed in the course of DISCO can be understood as a framework to ensure a consistent and comparable approach across all 8 Living Labs. In this context, the modular structure of the methodology, consisting of various perspectives and components, represents an advantage. Nevertheless, it is important to respond agilely to challenges that arise during the implementation phase. In this regard, the experiences from the Valencia Living Lab can make a valuable contribution by illustrating that a necessary adjustment was made through the expansion of the existing frameworks with new KPIs, a new SULP category, as well as additional SDG targets.

8.2. Lessons learned from the evaluations of the Living Labs

This chapter summarizes the essential lessons learned from both rounds of evaluation. In addition to insights gathered by the evaluation team, experiences directly from the stakeholders of all eight Living Labs are particularly considered. An effort is made to structure the findings as effectively as possible according to the various DISCO-X measures.

As a separate final point in this chapter lessons learned from emergency response in Valencia LL is described. It is an additional dimension where DISCO-X measures can give a substantial contribution but also uncover needs of unique evaluation methodology.

Table 25: Lessons learnt from DISCOCURB implementation across SLLs and TLLs

	STARRING LIVING LABS	TWINNING LIVING LABS
	COPENHAGEN	PADUA
DISCOCURB	Deploying the smart zone sensor infrastructure and booking application at Tivoli Gardens provided valuable insights into real-world curbside utilization and loading patterns. However, making the technical infrastructure fully functional on-site represented a substantial initial challenge. The result, however, showed a functional and robust infrastructure. In order to enable a quantitative evaluation, the consideration of KPIs is already mandatory in the implementation planning.	Deploying a digital booking platform exposed critical pre-existing municipal infrastructure deficits, revealing that 27 out of 32 pre-installed street sensors were completely non-functional prior to project work. Quantitative tracking of citywide traffic flow changes is highly restricted during early implementation phases if the physical test fleet is limited to a small number of active pilot vehicles.
	HELSINKI	ZARAGOZA
	The battery-powered monitoring system achieved outstanding technical robustness with zero camera or LiDAR sensor downtime during the implementation period. A distinct operational gap was identified between real-time roadside occupancy data and the static route planning habits of fleet operators who schedule days in advance. Combining sensor data with comprehensive floating car data (FCD) models generates highly valid scenarios for low-emission zone planning.	A questionnaire and modelling approach proved viable for city-wide LUZ capacity assessment without physical sensor infrastructure, making it directly replicable for municipalities with limited investment budgets. Surveying three stakeholder groups (consumers, retailers, and drivers) revealed that each captures a different dimension of the same system. Retailers observe delivery frequency and illegal parking behaviour, consumers reveal B2C demand volumes and channel preferences, and drivers provide the operational parameters (dwell times, consolidation ratios, blocking rates) that neither of the other two groups can observe. No single survey alone would have produced a calibrated model.

		BARCELONA
		Defining optimal locations for camera and sensor installations is vital to guarantee continuous operation. Line-of-sight planning must account for larger delivery vans that can partially block the camera's view of the zone. Furthermore, physical deployment strategies must safeguard equipment against severe weather events such as heavy rain, which previously necessitated sensor replacements while ensuring easy access for regular maintenance. AI-driven computer vision revealed that voluntary data from the municipal SPRO app heavily underestimated real curbside occupancy (41.84% self-reported vs. 78.15% real) because unauthorized or unregistered vehicles are omitted by legacy tracking. In pedestrian priority areas, neighbouring private parking garages distort dwell-time analytics by artificially inflating calculated vehicle stay durations. Unforeseen municipal roadworks can also abruptly leave monitored test zones with insufficient data for complete analysis.

Table 26: Lessons learnt from DISCOPROXI implementation across SLLs and TLLs

	STARRING LIVING LABS	TWINNING LIVING LABS
	COPENHAGEN	PADUA
DISCOPROXI 	Digital twin simulations demonstrated significant CO_2emission reductions within the Medieval City scenario through full cargo bike integration. A trade-off emerged between environmental optimization and traffic efficiency, as a substantial fleet reduction forced fewer vehicles to cover longer distances. Moving from simulation models to long-term real-world applications requires public sector regulatory stability and clear evidence of economic benefits for operators.	Operating mobile dynamic lockers on modular NEXT pods proved that a "WAITING" routing policy with an integrated fairness mechanism can reduce fleet distance travelled by 47.65% and cut failed deliveries by 53.34% compared to random assignments. Operational cost assessments for early-stage prototype vehicles should exclude long-term maintenance and depreciation factors to avoid disproportionately inflating per-parcel delivery metrics. The primary commercial barrier to scaling dynamic lockers is the market challenge of securing an operator, as the solution represents

		a radical innovation that deviates sharply from fixed-locker business practices.
	GHENT	ZARAGOZA
	Integrating digitized vehicle access regulations via the Urban Access Control (UAC) API directly into planning software successfully enhanced driving safety and reduced operator stress. Due to the very small size of the pilot fleet, it was statistically difficult to isolate the exact efficiency impacts of the software from external operational shifts made independently by the operators. Complex urban access parameters require high digital maturity and integrated data streams to properly calculate citywide traffic flow variations.	Successful replication requires careful selection of microhub locations in areas with high delivery demand and good accessibility for logistics vehicles, as location strongly influences operational efficiency and scalability. Clear governance, liability and insurance arrangements between municipalities, hub operators and logistics service providers are also essential to ensure smooth implementation. In addition, long-term economic viability depends on integrating rental and facility costs into the business model beyond the pilot phase. Finally, the model provides important social benefits by lowering barriers to employment in last-mile logistics, as delivery operations can be performed without requiring driving licences and with simplified operational procedures.
	HELSINKI	VALENCIA
	Establishing a multifunctional, multi-actor microhub integrated with cargo bikes and delivery robots successfully eliminated tailpipe emissions and increased resident satisfaction. A severe conflict of objectives materialized as the slower speeds and smaller volumes of sustainable modes caused delivery density to drop by 90% and more than tripled delivery times. Relying entirely on a bottom-up approach with participating operators for location identification caused significant friction and delays regarding spatial preferences.	The Routaplan tool optimized distribution routing by dynamically fusing the collected citizen demands with open-source mapping data (OpenStreetMap) and fleet loading capacities. Environmental sensors (measuring PM2.5 emissions) were integrated into the Routaplan tool to provide immediate data on localized air quality during distribution. To ensure pinpoint accuracy despite destroyed street infrastructure, the routing tool utilized real-time vehicle geolocation data and smartphone signals from users to derive exact geolocations. Activating light electric vehicles (Scoobic/e-Vans) for the last mile as soon as road infrastructure permitted helped to reduce local CO_2 emissions and to decrease deliver times.
	THESSALONIKI	
	Stakeholder engagement and iterative negotiations, combined with dynamic database mapping, proved effective in deciding the	

	locations and eventually installing the smart lockers in public spaces. However, extensive coordination and lengthy approval processes highlight the need to better manage delays in the future.	

Table 27: Lessons learnt from DISCOESTATE implementation across SLLs and TLLs

	STARRING LIVING LABS	TWINNING LIVING LABS
	COPENHAGEN	VALENCIA
DISCOESTATE	Simulating the retrofit of the Høje Taastrup terminal highlighted a massive life-cycle emission reduction potential exceeding 70% under full fleet electrification. To fully exploit this potential, substantial financial investments are required for charging infrastructure, and new vehicle fleets are required which represent a major challenge, particularly for small and medium-sized enterprises (SMEs). Overcoming high transition costs requires targeted regulatory or market-driven incentives from the public sector to foster private entity commitment.	Developing a custom Python-based web platform for community aid requests successfully reduced crisis response times by 50% (from 24 to 12 hours) and reduced localized societal deprivation costs by 57% by streamlining supplies into structured product verticals.
	THESSALONIKI	
	Even though all partners share a common goal, differences in specific needs—such as between TIF HELEXPO space offerings and ACS operational requirements — can lead to demonstration delays. Installing pilot equipment in public spaces is inherently challenging; convincing authoritative bodies to support these initiatives requires extensive effort and a clearly articulated vision.	

Table 28: Lessons learnt from DISCOBAY implementation across SLLs and TLLs

	STARRING LIVING LABS	TWINNING LIVING LABS
	GHENT	VALENCIA
	The real-world public showcase proved the technical viability of a multimodal barge-to-bike logistics chain, showing high potential e.g. for construction logistics.	Rapidly establishing a critical crisis logistics hub in an out-of-town warehouse (Alcàsser) can be accelerated under extreme conditions by leveraging Copernicus satellite information and machine learning to analyse ground and road network recovery.

DISCOBAY	The limited duration of the single-day showcase event however did not yield continuous or reliable quantitative evaluation data for long-term tracking. Although green last-mile alternatives are currently cost-prohibitive for widespread market adoption, the Ghent case illustrated that they offer transformative scaling potential as nearly 65% of urban deliveries done in the test by using the UAC could switch immediately to this type of solution allowing immediate emission reductions.	
	THESSALONIKI	
	Some of the “legacy data” integrated into the Logistics Real Estate Database proved incomplete or inconsistent, requiring rigorous data cleaning and iterative testing to ensure accurate simulation outcomes. This resulted in the need for additional features and refined simulation parameters to better represent the unique characteristics of different warehouse assets.	

Table 29: Lessons learnt from DISCOLLECTION implementation across SLLs and TLLs

	STARRING LIVING LABS	TWINNING LIVING LABS
	COPENHAGEN	PADUA
DISCOLLECTION	Onboarding 11 logistics operators to compile operational data samples demonstrated great value for partner integration and initial baseline modelling. Moving from static digital twins to real-time data collection demands extensive parameterization and calibration work, requiring significant time and investment. Data sharing relies heavily on establishing a solid framework of trust among competitive market participants to successfully unlock predictive analytics for traffic management.	The technical integration of multiple data streams via decentralized data spaces (EDC framework) is highly viable, but the lack of a consolidated city-wide data ecosystem severely limits predictive municipal logistics planning and real-time flow governance.
	GHENT	ZARAGOZA
	Validating a decentralized data space successfully reduced individual integration barriers and expanded connectivity to multiple Flemish cities. Despite architectural success, a vast amount of manual work was still required	Governance, trust and data-sharing agreements are key enablers for data-driven urban logistics. Real operational data is essential to validate analytical models, while structured data

	to structure, clean, and digitize datasets prior to onboarding. Maximizing data utilization requires a fundamental shift in local data-sharing culture and substantial enhancements to municipal data infrastructures.	integration can be implemented before full automation. The pilot also showed the importance of assessing economic impacts and aligning logistics measures with policy objectives to support long-term scalability and replication.
	HELSINKI	BARCELONA
	Successfully incorporating real-time curbside monitoring data into the Urban Freight Dataspace marked the first time urban logistics data was added to the public Helsinki Mobility Data Catalogue. Transitioning to predictive analytics requires public authorities to actively incentivize and build trust among competitive players to ensure continuous data streams.	Fusing self-reported application logs with empirical real-time camera sensor streams effectively neutralizes the human-error element of manual parking registration apps. Unlocking actual commercial optimization and operational benefits for fleet operators requires short-term software interfaces to push this real-time data from city backends directly into private Transport Management Systems (TMS).
	THESSALONIKI	
	Expanding data collection beyond the initial focus provided comprehensive insights, supporting evidence-based urban planning. However, integrating the different-sourced data streams revealed significant challenges in data quality and consistency.	

Valencia overarching lessons learnt

Following a severe weather catastrophe in October 2024, the lab demonstrated the extreme agility and real-world elasticity of the DISCO-X solutions by dynamically converting planned commercial measures into an ad-hoc humanitarian logistics system.

Evaluating emergency logistics lacks a standardized, static baseline, requiring the methodology to adaptively track sequential operational progress across distinct tactical recovery stages.

The environmental disruption uncovered a distinct public sector foresight deficit, highlighting a critical requirement to mandate the integration of explicit contingency and extreme event response plans directly into future Sustainable Urban Logistics Plans (SULPs).

Annex

Full list of KPIs

KPIs 26-34 refer to the Valencia case

KPI No.	KPI Name	Description and data format	Unit
1	Traffic Flow	Total freight kilometers driven per 10000 inh	km/10000
2	Distance Travelled	Average distance per delivery	km/del
3	Failed Deliveries	Percentage of unsuccessful deliveries with the 1st attempt	%
4	Delivery time	Average delivery time per route	mins
5	Delivery Density	Number of deliveries per km	del/km
6	Cost per parcel	Cost of delivery per km	€/km
7	Operational Cost per	Total delivery cost	€
8	CO2 Emissions per km	Total kg of CO2 emissions per km	eCO2/km
9	CO2 Emissions per	Total kg of CO2 emissions per parcel	eCO2/parc
10	EV Adoption Rate	Percentage of electric freight vehicles in the delivery fleet	%
11	Cargo bike adoption	Number of cargo bikes in the local delivery fleet	-
12	Cargo bike deliveries	Percentage of the total deliveries performed by cargo bikes	%
13	Companies	Percentage of companies that operate with cargo bikes	%
14	Parking fines	Parking fines per 10000 inh	€/10000
15	Space Utilization	Average occupancy of parking spaces	%
16	Reliability of Sensors	Average time that sensors were not working properly	mins
17	Transport infra offer	Average offered space of a transport infrastructure to be used as (shared) space for logistics operations	sq.m
18	Warehouse offer	Average offered space of a warehouses be used as (shared) space for logistics operations	sq.m
19	Lockers volume	Percentage of freight volume delivered through lockers	%
20	Microhub Capacity	Average utilization rate of a parcel locker	%
21	Data sources used	Number of data sources or platforms that are connected to the data space	#
22	Data Utilization	Number of new/enhanced services utilizing old/new data collected	#
23	Number of partnerships	Number private-private and -or public-private partnerships for last mile deliveries	#
24	Investment plans	Number of investment logistics plans of local private entities operating in Urban logistics	#
25	SULP	Number of locally politically approved SULP or freight logistics plan	#
26 (added)	Response time	The logistics system's ability to deliver aid to those affected in the shortest possible time after a disaster	h
27 (added)	Deprivation Costs	Economic valuation of human suffering resulting from a lack of access to life-sustaining goods and services. Defined as a time-dependent function, these costs increase non-linearly (exponentially) with the duration of the shortage, measuring the impact of supply chain failure on human well-being	€
28 (added)	Supply Chains created	Measuring the rapid establishment of improvised, socio-technical delivery networks in post-disaster environments	#
29 (added)	Daily Volunteers	Number of persons at zero zone supporting per day (citizens)	#/day
30 (added)	Ad-hoc Financial Response	Total amount of financial support generated specifically for the deployment of a crisis response	€
31 (added)	Population coverage ratio	Share of continuously supported population by set-up aid solutions (measured at the end of the pilot)	%
32 (added)	Inventory turnover	Number of times the total inventory of the Logistics System is renewed daily, (for Valencia: taking as a reference the stock of the Alcàsser Logistics Center)	#/day
33 (added)	Integrated supply verticals	Number of different types of products whose supply can be efficiently organized and standardized after a disruption	#
34 (added)	Using available data sources	Satellite and meteorological observations, proprietary real-time geolocation, and open public records combining mapping and socio-demographics	#

KPI Weighting Table

Document Version 4 for the initial 25 DISCO KPIs

			Weights							Interval	Comment
			Very bad	Bad	Poor	None	Fair	Good	Very good		
Label	Description and data format	Unit	-3	-2	-1	0	1	2	3		
Traffic Flow	Total freight kilometers driven per 10000 inh	km/10000 inhs	> +20%	+11-20%	+1-10%	0	-1-(-10)%	-11-(-20)%	< -20%	10%	measure is "percentage increase or decrease in total freight km/inh"
Distance Travelled	Average distance per delivery	km/del	> +30%	+16-30%	+1-15%	0	-1-(-15)%	-16-(-30)%	< -30%	15%	measure is "percentage increase or decrease in average distance per delivery"; in this case interval should be larger than for the effort in freight kilometers reduction since there are additional levers (e.g. cargo bikes, lockers)
Failed Deliveries	Percentage of unsuccessful deliveries with the 1st attempt	%	> +30%	+16-30%	+1-15%	0	-1-(-15)%	-16-(-30)%	< -30%	15%	measure is "percentage increase or decrease of unsuccessful deliveries with the 1st attempt"
Delivery time	Average delivery time per route	mins	> +20%	+11-20%	+1-10%	0	-1-(-10)%	-11-(-20)%	< -20%	10%	measure is "percentage increase or decrease of average delivery time per route"
Delivery Density	Number of deliveries per km	del/km	< -20%	-11-(-20)%	-1-(-10)%	0	+1-10%	+11-20%	> +20%	10%	measure is "percentage increase or decrease of number of deliveries per km "
Cost per parcel	Cost of delivery per km	€/km	> +20%	+11-20%	+1-10%	0	-1-(-10)%	-11-(-20)%	< -20%	10%	measure is "percentage increase or decrease of cost of delivery per km"
Operational Cost per day	Total delivery cost	€	> +20%	+11-20%	+1-10%	0	-1-(-10)%	-11-(-20)%	< -20%	10%	measure is "percentage increase or decrease of total delivery cost"
CO2 Emissions per km	Total kg of CO2 emissions per km	eCO2/km	> +40%	+21-40%	+1-20%	0	-1-(-20)%	-21-(-40)%	< -40%	20%	measure is "percentage increase or decrease of total kg of CO2 emissions per km"; in this case interval should be larger than for the effort in freight kilometers reduction since there are additional levers (e.g. electric freight vehicles, cargobikes)
CO2 Emissions per parcel	Total kg of CO2 emissions per parcel	eCO2/parcel	> +40%	+21-40%	+1-20%	0	-1-(-20)%	-21-(-40)%	< -40%	20%	measure is "percentage increase or decrease of total kg of CO2 emissions per parcel"; in this case interval should be larger than for the effort in freight kilometers reduction since there are additional levers (e.g. electric freight vehicles, cargobikes
EV Adoption Rate	Percentage of electric freight vehicles in the delivery fleet	%	< -30%	-16-(-30)%	-1-(-15)%	0	+1-15%	+16-30%	> +30%	15%	measure is "percentage increase or decrease of electric freight vehicles in the delivery fleet"
Cargo bike adoption rate	Number of cargo bikes in the local delivery fleet	-	< -30%	-16-(-30)%	-1-(-15)%	0	+1-15%	+16-30%	> +30%	15%	measure is "percentage increase or decrease of number of cargo bikes in the local delivery fleet"
Cargo bike deliveries	Percentage of the total deliveries performed by cargo bikes	%	< -30%	-16-(-30)%	-1-(-15)%	0	+1-15%	+16-30%	> +30%	15%	measure is "percentage increase or decrease of the total deliveries performed by cargo bikes"
Companies electrification	Percentage of companies that operate with cargo bikes	%	< -20%	-11-(-20)%	-1-(-10)%	0	+1-10%	+11-20%	> +20%	10%	measure is "percentage increase or decrease of companies that operate with cargo bikes"
Parking fines	Parking fines per 10000 inh	€/10000 inhs	> +20%	+11-20%	+1-10%	0	-1-(-10)%	-11-(-20)%	< -20%	10%	measure is "percentage increase or decrease of Parking fines per 10000 inh"
Space Utilization Efficiency	Average occupancy of parking spaces	%	< -20%	-11-(-20)%	-1-(-10)%	0	+1-10%	+11-20%	> +20%	10%	measure is "percentage increase or decrease of average occupancy of parking spaces"
Reliability of Sensors and Cameras	Average time that sensors were not working properly	mins	> +30%	+16-30%	+1-15%	0	-1-(-15)%	-16-(-30)%	< -30%	15%	measure is "percentage increase or decrease of average time that sensors were not working properlys"
Transport infra offer	Average offered space of a transport infrastructure to be used as (shared) space for logistics operations	sq.m	< -20%	-11-(-20)%	-1-(-10)%	0	+1-10%	+11-20%	> +20%	10%	measure is "percentage increase or decrease of average offered space of a transport infrastructure to be used as (shared) space for logistics operations"
Warehouse offer	Average offered space of a warehouses be used as (shared) space for logistics operations	sq.m	< -20%	-11-(-20)%	-1-(-10)%	0	+1-10%	+11-20%	> +20%	10%	measure is "percentage increase or decrease of average offered space of a warehouses be used as (shared) space for logistics operations"
Lockers volume	Percentage of freight volume delivered through lockers	%	< -20%	-11-(-20)%	-1-(-10)%	0	+1-10%	+11-20%	> +20%	10%	measure is "percentage increase or decrease of freight volume delivered through lockers"
Microhub Capacity Utilization	Average utilization rate of a parcel locker	%	< -20%	-11-(-20)%	-1-(-10)%	0	+1-10%	+11-20%	> +20%	10%	measure is "percentage increase or decrease of average utilization rate of a parcel locker"
Data sources used	Number of data sources or platforms that are connect	-				0	1	2	>2	1	
Data Utilization	Number of new/enhanced services utilizing old/new d	-				0	1	2	>2	1	
Number of partnerships for collabo	Number private-private and -or public-private partner	-				0	1	2	>2	1	
Investment plans	Number of investment logistics plans of local private (	-				0	1	2	>2	1	
SULP	Number of locally politically approved SULP or freight	-				None	Drafted	Issued	Approved	N/A	

Full list of SDG targets relevant for DISCO

The added ones refer to the Valencia case.

SDG target	DISCO-X		
	DISCOCURB Addressed KPIs: to be filled in per LL	DISCOPROXI Addressed KPIs: to be filled in per LL	DISCO... Addressed KPIs to be filled in per LL
1.5: (added): By 2030, build the resilience of the poor and those in vulnerable situations and reduce their exposure and vulnerability to climate-related extreme events and other economic, social and environmental shocks and disasters Associated KPIs: 6, 23, 26, 27, 28, 30, 31, 33, 34			
3.9: Reduce the amount of deaths produced by dangerous chemicals and the pollution of the air, water and soil (...) Associated KPIs: 1, 2, 3, 5, 8-13			
6.2: (added): By 2030, achieve access to adequate and equitable sanitation and hygiene for all and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations Associated KPIs: 28, 31, 33, 34			
8.2: Achieve higher levels of economic productivity (...) Associated KPIs: 6, 7, 24, 25			
8.4: Improve (...) global resource efficiency in con-sumption and production (...) Associated KPIs: 1, 2, 5, 10			
9.1: Develop quality, reliable, sustainable and resilient infrastructure (...) Ass. KPIs: 1, 5, 15, 17, 18, 20			
9.4: (...) upgrade infrastructure and retrofit industries to make them sustainable (...) Associated KPIs: 17-20			
11.3: (...) enhance inclusive and sustainable urbanisation and capacity for participatory, integrated and sustainable human settlement planning and management (...) Associated KPIs: 11, 19, 20			
11.5: (added): By 2030, significantly reduce the number of deaths and the number of people affected and substantially decrease the direct economic losses relative to global gross domestic product caused by disasters, including water-related disasters, with a focus on protecting the poor and people in vulnerable situations Associated KPIs: 26, 27, 28, 31, 33, 34			

11.6: (…) reduce the adverse per capita environmental impact of cities (…) Associated KPIs: 8-13			
11.A: Support positive economic, social and environmental links between urban, peri-urban and rural areas by strengthening national and regional development planning Associated KPIs: 24, 25			
11.B: (added): By 2020, substantially increase the number of cities and human settlements adopting and implementing integrated policies and plans towards inclusion, resource efficiency, mitigation and adaptation to climate change, resilience to disasters, and develop and implement, in line with the Sendai Framework for Disaster Risk Reduction 2015-2030, holistic disaster risk management at all levels Associated KPIs: 23, 25, 34			
12.6: Encourage companies (…) to adopt sustainable practices and to integrate sustainability information into their reporting cycle Associated KPIs: 13, 23			
13.1: (added): Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries Associated KPIs: 23, 26-34			
13.2: Integrate climate change measures into national policies, strategies and planning Associated KPIs: 25			
13.3: (added): Improve education, awareness-raising and human and institutional capacity on climate change mitigation, adaptation, impact reduction and early warning Associated KPIs: 23			
17.16: Enhance the Global Partnership for Sustainable Development (…) Associated KPIs: 23			

Survey 1 DISCOCURB LL Zaragoza: Retailers

Section 1 - Business Profile and General Characteristics

Code	Question
P1	What industrial sector or type of economic activity does your establishment belong to?
P2	What is the approximate size of your premises? (m^2)
P2B	Does your establishment have a dedicated storage/warehouse area?
P2C	What is the approximate size of the storage area? (m^2)
P3	How many employees work at this establishment?
P4A	Does your establishment operate on a continuous (uninterrupted) schedule throughout the day?
P4B	What is the usual opening time of your premises? (continuous schedule)
P4C	What is the usual closing time? (continuous schedule)
P4BB	In the morning, what is the usual opening time of your premises?
P4CC	In the morning, what is the usual closing time?
P4D	In the afternoon, what is the usual opening time?
P4E	In the afternoon, what is the usual closing time?
P5	Does your establishment have its own parking or a private loading area (loading bay/dropped kerb) for receiving supplier deliveries?

Section 2 — Delivery Frequency and Planning

Code	Question
P6A	How frequently do you receive goods deliveries at your premises? (Daily / Several times per week / Once a week or less)
P6B	You said you receive several deliveries per week. How many exactly?
P6C	You said you receive several deliveries per day. How many exactly?
P7	Which days of the week do you usually receive the highest volume of deliveries (peak days)? (Multiple response: Mon / Tue / Wed / Thu / Fri / Sat / Sun / No peak day)
P8A	At what time do you usually receive these deliveries currently?

P8B	And if you could choose, at what time would you prefer to receive these deliveries?
P9	How many different suppliers provide goods to you on a regular basis?

Section 3 — Vehicle and Operator Profile

Code	Question
P10	What types of vehicles are most frequently used to deliver your goods? (Cargo bike / Light van <3.5t / Medium van/truck 3.5–7.5t / Heavy truck >7.5t / Mixed)
P11	In general, who physically carries out the delivery at your premises? (Carrier company employee / Supplier's own employee / Establishment owner or employee / Other / Varies)

Section 4 — Loading and Unloading Operations

Code	Question
P12	In your observation, where do the vehicles delivering your goods usually park? (Designated loading/unloading zone / Regular Street parking / Double row or illegal / Private loading dock / Varies)
P13	On average, how long does the complete delivery process take (from when the vehicle parks to when it leaves)? (<5 min / 5–10 min / 10–20 min / 20–30 min / >30 min)
P14	How are the goods physically moved from the parked vehicle into your premises? (Carried by hand / Hand truck or trolley / Pallet truck / Other mechanical means / Combined)

Survey 2 DISCOCURB LL Zaragoza: Driver / Operator

Section 1 - Operator and Route Profile

Code	Question
OP1	Type of company / operator (parcel carrier / food distributor / beverage / other B2B / mixed)
OP2	Zones or districts usually operated in
OP3	Mean number of stops per route
OP4	Mean number of deliveries per parking stop (consolidation ratio) — derived: 4.1 deliveries/stop
OP5	Vehicle type used (cargo bike / light van / medium truck / heavy truck)

Section 2 - Loading/Unloading Zone Experience

Code	Question
OP6	Mean dwell time at loading/unloading zone — derived: 11.2 minutes
OP7	How often the loading/unloading zone is occupied on arrival — derived: 30% blocking rate
OP8	Primary cause of LUZ unavailability (private car occupation / other delivery vehicle / other) — derived: 47.5% cite private vehicles as primary problem
OP9	Behaviour when zone is occupied: wait or find alternative parking — derived: 60% do not wait at all; 0% wait more than 5 minutes
OP10	Estimated percentage of LUZ bays effectively available for freight operations — derived: $\alpha = 0.75$ (75% available)

Section 3 - Operational Problems and Perceptions

Code	Question
OP11	Main operational problems in loading/unloading zones (private car occupation / insufficient zones / congestion / narrow streets / other)
OP12	Assessment of loading/unloading infrastructure in Zaragoza (adequate / insufficient / very insufficient)
OP13	Measures that would most improve loading/unloading operations (enforcement / more zones / time-differentiated access / digital reservation / other)

Survey 3 DISCOCURB LL Zaragoza: Consumers

Section 1 - dentification and Respondent Selection

Code	Question
P0A	In which of these districts of Zaragoza do you live? (1–15)
P0C	What is your age? (18–24 / 25–34 / 35–44 / 45–54 / 55–64 / 65+)
P0E	What gender do you identify with?

Section 2 - Online Shopping Frequency

Code	Question
P6B (a–c)	Frequency of online purchases by category: a) Clothing/footwear/fashion b) Electronics/DIY/home c) Leisure/books/gifts
P7	How often do you order groceries online for home delivery?
P8	How often do you order food from restaurants via delivery apps (Glovo, UberEats, etc.)?

Section 3 - Delivery / returns / perceptions

Code	Question
P12 (a–d)	Preferred delivery channel by product category: a) Food/grocery b) Clothing/fashion c) Electronics/home d) Leisure/books (Home delivery / Locker or pickup point / Physical store / Indifferent)
P16	Out of every 10 items you buy online (specially fashion/footwear), approximately how many do you return?
P20	In the last month, how many times did you fail to receive a parcel at home because you were not there when it was delivered? (0 / 1 / 2 / 3 or more)
P21	How do you perceive the problems caused by delivery vans in traffic flow, parking, and the environment of your neighbourhood? (No problem / Minor nuisance / Significant problem)
P22	Do you think there are enough loading/unloading zones in your street or neighbourhood to prevent double-parking by delivery vehicles? (Yes, sufficient / No, insufficient / No, they are occupied by private cars / Do not know)