



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

D2.5 Measures and Meta Model Suite interoperability

Vanessa Vogt, Akkodis Germany Solutions

20/10/2025



**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.



Table of Contents

1. Introduction	13
1.1. Context.....	13
1.2. A Review of Foundational Standards for a Federated Data Ecosystem	14
1.3. Objectives.....	16
1.4. Structure of the deliverable	17
2. Objectives and Task Description	19
3. Methodological Framework.....	22
4. The Assessments of the Starring Labs.....	25
4.1. Interoperability Assessment Matrix (Interoperability Assessment).....	25
4.1.1. Thessaloniki’s DISCO-Xs interoperability	26
4.1.2. Helsinki’s DISCO-Xs interoperability	31
4.1.3. Ghent’s DISCO-Xs interoperability	33
4.1.4. Copenhagen’s DISCO-Xs interoperability.....	37
4.2. Cross Living Lab Analysis	40
4.2.1. Common Interoperability Patterns	40
4.2.2. Common Challenges	41
4.2.3. Comparative Analysis of Living Lab Architectures	42
4.2.4. Requirements DISCO-X Solutions.....	43
5. The compatibility assessment as part of the DISCO Meta-Model Suite.....	46
6. Digital Data Infrastructure and Readiness for Interoperability	50
7. Compliance with EU Interoperability Standards.....	53
7.1. International Data Spaces Association (IDSA).....	55
7.2. Gaia-X Federation Services	56
7.3. Connecting Europe Facility (CEF) Building Blocks	56
7.4. eIDAS (electronic IDentification, Authentication and trust Services).....	56
7.5. Compliance Summary Table	58
8. Conclusion.....	59
References.....	60
Appendix 1: Weighted and classified Requirements	63
Appendix 2: Data Collection Sheet	75



Thessaloniki Data Collection Sheet	75
Helsinki Data Collection Sheet.....	87
Ghent Data Collection Sheet	100
Copenhagen Data Collection Sheet.....	113



Executive Summary

The present deliverable presents a comprehensive framework to enable and assess the interoperability of modular urban logistics services, drawing on insights from real-world implementations in the Thessaloniki, Helsinki, Ghent and Copenhagen Living Labs. As the Physical Internet paradigm requires an interconnected network of solutions, this work addresses the critical need for a systematic methodology to evaluate how the different DISCO-X innovations can function together as a cohesive ecosystem. At the core of the approach is a multi-layered analytical framework that synthesizes the European Interoperability Framework and the Capability Maturity Model. The methodology that was developed evaluates the interactions between each pair of DISCO-X innovations against six defined parameters (Shared Data Types, Direct Data Flow, Shared Platform, Standardized Connectivity, Operational Synergy and Shared Governance). The resulting analysis produces a quantifiable interoperability index for each interaction, which is then classified as accordingly. The process was applied to each of the four Starring Living Labs, generating interoperability matrices that reveal the distinct patterns of integration achieved in each urban context. Next, the cross-living lab analysis identified three distinct but equally successful patterns for achieving interoperability: "Deep Operational Integration" (exemplified by Ghent), where tools are integrated into a single operational system; "Shared Data Ecosystem Integration" (exemplified by Thessaloniki), where distinct tools are connected to a central dataspace; and "Strategic Data Integration" (exemplified by Copenhagen), where a central analytical hub connects otherwise separate pilots. A consistent finding across all successful models was the crucial role of DISCOLLECTION as a universal data backbone. Finally, the deliverable details are on how these analytical findings have been integrated within the DISCO Meta-Model Suite. The assessment framework now powers a "Technical Compatibility Checkpoint" within the user journey of the MMS. In this stage, a city performs a self-assessment against a generalized checklist of "Must Have" and "Nice to Have" requirements for a recommended DISCO-X innovation. Based on a weighted calculation, the MMS provides a clear, data-driven verdict on whether the solution can be deployed, thus de-risking the innovation process for future cities.



Summary sheet

Deliverable No.	D1.10
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)	Vanessa Vogt (AKKA)
Peer Review	CERTH, KLU
Quality Assurance Committee Review	FIT
Date	20/10/2025
Status	Final
Dissemination level	Public
Work Package No.	2
Work Package Title	The DISCO urban logistics and planning PI-led Digital Transition
Programme	Horizon Europe 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 Coordinator	IT	FIT
RUPPRECHT CONSULT-FORSCHUNG & BERATUNG GMBH	DE	RC
INLECOM INNOVATION ASTIKI MI KERDOSKOPIKI ETAIREIA	EL	INLE
PNO INNOVATION SL	ES	PNO
INTERNATIONAL DATA SPACES EV	DE	IDSA
FM LOGISTIC IBERICA SL	ES	FM
Akkodis Germany Solutions GmbH	DE	AKKA
FONDAZIONE ISTITUTO SUI TRASPORTI E LA LOGISTICA	IT	ITL
JLL	UK	JLL
ETHNIKO KENTRO EREVNAS KAI TECHNOLOGIKIS ANAPTY XIS	EL	CERTH
LINDHOLMEN SCIENCE PARK AB	SE	LSP
KUHNE LOGISTICS UNIVERSITY GGMBH	DE	KLU
INSTITUT DE RECHERCHE TECHNOLOGIQUE SYSTEM X	FR	IRTX
STICHTING BREDA UNIVERSITY OF APPLIED SCIENCES	NL	BUAS
POLIS - PROMOTION OF OPERATIONAL LINKS WITH INTEGRATED SERVICES, ASSOCIATION INTERNATIONALE	BE	POLIS
EUROPEAN PARKING ASSOCIATION EPA EV	DE	EPA
ALLIANCE FOR LOGISTICS INNOVATION THROUGH COLLABORATION IN EUROPE	BE	ALICE
ERASMUS CENTRE FOR URBAN, PORT AND TRANSPORT ECONOMICS BV	NL	ERASMUS

INTERUNIVERSITAIR MICRO-ELECTRONICA CENTRUM	BE	IMEC
VLAAMS INSTITUUT VOOR DE LOGISTIEK VZW	BE	VIL
FUNDACION ZARAGOZA LOGISTICS CENTER	ES	ZLC
BE-MOBILE	BE	BE-MOBILE
STAD GENT	BE	GENT
OPLEIDINGSCENTRUM VOOR HOUT EN BOUW VZW	BE	OHB
CITYLOGIN IBERICA SL	ES	CITYLOGIN
UNIVERSITAT POLITECNICA DE CATALUNYA	ES	UPC
AJUNTAMENT DE BARCELONA	ES	BCN
VENICE INTERNATIONAL UNIVERSITY	IT	VIU
FUNDACION DE LA COMUNIDAD VALENCIANA PARA LA INVESTIGACION, PROMOCION Y ESTUDIOS COMERCIALES DE VALENCIAPORT	ES	VPF
FUNDACION DE LA COMUNITAT VALENCIANA PARA LA PROMOCION ESTRATEGICA EL DESARROLLO Y LA INNOVACION URBANA	ES	LAS NAVES
T-BOX DELIVERY & SOLUTIONS SL	ES	T-BOX
AYUNTAMIENTO DE ZARAGOZA	ES	ZARAGOZA
FUNDACION ZARAGOZA CIUDAD DE CONOCIMIENTO	ES	FZCC
FORUM VIRIUM HELSINKI OY	FI	FVH
KOBENHAVNS KOMMUNE	DK	COPENHAGEN
REGION HOVEDSTADEN DK Partner	DK	REGIONH
COMUNE DI PIACENZA	IT	PIACENZA
MESTSKA CAST PRAHA 6 / District Prague	CZ	PRAHA
REGIONAL MANAGEMENT NORDHESSEN GMBH	DE	RMNH

AARHUS KOMMUNE	DK	AAKS
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	28/05/2025	AKKA	Definition of ToC
0.2	24/06/2025	AKKA	Draft 1
0.3	29/08/2025	AKKA	Draft 2
0.5	30/09/2025	AKKA	Third and final draft, sent to reviewers Peer-reviewing partners: 1st: CERTH, 2nd: KLU
0.6	13/10/2025	CERTH, KLU	Draft sent back to AKKA with comments from peer-reviewers
0.7	17/10/2025	AKKA	Inclusion of comments in final draft.



1	20/10/2025	FIT	<u>The final version is ready to be submitted.</u>
---	------------	-----	--

List of acronyms

API	Application Programming Interface
B2A	Business-to-Administration
B2B	Business-to-Business
CEF	Connecting Europe Facility
CEN	European Committee for Standardization
CMM	Capability Maturity Model
CO₂	Carbon Dioxide
D	Deliverable
DATEXII	European CEN standard for exchanging traffic and travel-related information
eID	electronic IDentification
eIDAS	electronic IDentification, Authentication and trust Services
EIF	European Interoperability Framework
GDPR	General Data Protection Regulation
GIS	Geographic Information System
GXFS	Gaia-X Federation Services
IDS	International Data Spaces
IDSA	International Data Spaces Association
IDS-RAM	IDS Reference Architecture Model
JSON	JavaScript Object Notation



LEZs	Low Emission Zones
LL	Living Lab
LSP	Logistics Service Provider
MMS	DISCO Meta Model Suite
PI	Physical Internet
SULP	Sustainable Urban Logistics Plan
TC	Technical Compatibility
UAC	Urban Access Control
UF	Urban Freight
UFDS	Urban Freight Data Space
UI	User Interface
ULDThess	Local Urban Logistics Dataspace PoC of Thessaloniki
UVARs	Urban Vehicle Access Regulations
WaaS	Warehouse-as-a-Service
WP	Work Package

List of tables

Table No.	Title	Page
Table 1	Interoperability Matrix for the DISCO-X Measures of Thessaloniki	24



Table 2	Interoperability Matrix for the DISCO-X Measures of Helsinki	27
Table 3	Interoperability Matrix for the DISCO-X Measures of Ghent	29
Table 4	Interoperability Matrix for the DISCO-X Measures of Copenhagen	31
Table 5	Compliance Summary Table – EU Interoperability Standards	35
Table 6	Weighted and Classified Requirements for DISCO-X Solutions	45
Table 7	Reference Table	49



1. Introduction

1.1. Context

Urban freight transport is undergoing a profound transformation as cities strive to balance economic efficiency, environmental sustainability, and livability. Digitalization and data-driven services are central to this transformation, yet their success depends critically on the ability of technical components, platforms, and applications to interoperate seamlessly. Within the DISCO project, interoperability is not understood merely as a technical ambition, but as a prerequisite for creating transferable, scalable, and modular solutions that can function across heterogeneous European urban contexts.

The guiding paradigm for this transformation is the Physical Internet, a concept first articulated by Professor Benoit Montreuil (Montreuil, 2011; Crainic, Klibi & Montreuil, 2023). The PI envisions a fundamental reorganization of how physical goods are moved, stored, and handled, drawing a direct metaphor from the architecture of the digital Internet (Crainic, Klibi & Montreuil, 2023; Ballot, Montreuil, & Meller, 2014). Instead of operating within closed, proprietary, and fragmented logistics networks, the PI proposes an open, interconnected "Logistics Web" where assets and resources are shared (Ballot, Montreuil, & Meller, 2014; Crainic, Klibi & Montreuil, 2023). In this model, goods are encapsulated in standardized, modular, and intelligent containers (termed π -containers) and routed dynamically through a network of shared, multi-functional logistics hubs (π -nodes) (Montreuil, 2011; Ballot, Montreuil, & Meller, 2014).

This vision is firmly embedded within the EU's strategic policy frameworks. The new EU Urban Mobility Framework explicitly calls for the development of zero-emission urban logistics, the modernization of multimodal hubs, and the deployment of new digital solutions and services to manage the complexities of last-mile delivery and growing e-commerce demand (European Commission, 2021). Further operationalizing this vision, the ALICE Roadmap to Physical Internet provides a strategic timeline for implementation, outlining a phased evolution through successive "generations" of logistics nodes, networks, and governance systems, with a target of advanced PI implementations by 2030 and a fully autonomous system by 2040 (Imec, 2025). The DISCO project, which counts ALICE among its partners, represents a direct effort to implement and validate these early-generation PI concepts in real-world urban settings.

This deliverable responds to that challenge by introducing the DISCO Measures and Meta Model Suite Interoperability, a framework designed to harmonize requirements, enable cross-city comparability, and provide a foundation for interoperability. Early in the project, the requirements of the individual DISCO-X solutions were defined in close alignment with the pre-pilot phase. These requirements reflected specific local circumstances and pilot objectives. However, the experience of the pilots demonstrated that highly context-dependent requirements risk limiting



scalability and transferability. Consequently, a structured generalization process was undertaken: the original requirements were revisited, consolidated, and abstracted to identify those that are broadly applicable across multiple cities and operational contexts.

To ensure practical relevance, the generalized requirements were classified in collaboration with Living Lab partners, distinguishing between elements essential to core functionality (“Must Have”) and those considered desirable but not indispensable (“Nice to Have”). This classification provided the basis for weighting and technical compatibility assessments, ensuring that the most critical dependencies of each solution are accurately reflected. The resulting tables of weighted requirements form a transparent, quantitative basis for evaluating how well DISCO-X services can be implemented and integrated into varying digital and institutional landscapes.

Beyond requirements management, the deliverable also addresses standards and protocols for data interoperability, assesses implementation in the Living Labs, and introduces the DISCO Meta Model Suite architecture alongside the Digital Transition Assessment Tool. Together, these outputs establish both the methodological and technical foundations for achieving cross-city interoperability in urban logistics. They not only support modular deployment of individual DISCO-X solutions but also foster a federated ecosystem aligned with the Physical Internet paradigm.

1.2. A Review of Foundational Standards for a Federated Data Ecosystem

To critically evaluate the DISCO project's approach to interoperability, it is essential to first establish a benchmark of relevant European and international standards. These frameworks provide the architectural blueprints and common languages necessary for creating a truly federated, secure, and semantically coherent data ecosystem for logistics.

Data Sovereignty and Trust: The International Data Spaces (IDSA) and GAIA-X Frameworks

At the highest level of data governance, two European initiatives, IDSA and GAIA-X, define the principles and architecture for trusted, cross-organizational data sharing.

The International Data Spaces (IDSA) initiative aims to facilitate secure and standardized data exchange while guaranteeing data sovereignty for the data owner (IDSA, 2022). This core principle ensures that the entity providing data retains full control over its use, defining specific usage policies (e.g., data can only be used for a specific purpose, for a limited time, or cannot be copied) that are technically enforced throughout the data exchange process (IDSA, 2022). The IDSA Reference Architecture Model (IDS-RAM 4.0) provides the blueprint for this ecosystem, defining a multi-layered architecture (Business, Functional, Information, Process, System) and key



components like the IDS Connector, which acts as a secure data gateway for each participant (IDSA, 2022).

Complementing this, GAIA-X seeks to create a federated, secure, and sovereign data infrastructure for Europe, founded on values of transparency, openness, and data protection (Gaia-X, 2025). Rather than building a new cloud platform, GAIA-X establishes a set of rules, policies, and specifications that enable existing cloud and data services to interoperate within a trusted ecosystem, thereby avoiding vendor lock-in and ensuring data portability (Gaia-X, 2025). The operational backbone of this ecosystem is a decentralized network of Gaia-X Federation Services (GXFS) and Digital Clearing Houses, which manage identity, compliance, and cataloguing functions to ensure trust and interoperability among participants (Gaia-X, 2025).

A crucial aspect of both IDSA and GAIA-X is that they are not merely technical standards but comprehensive governance frameworks. They necessitate a significant organizational and legal commitment from participants, who must be certified and adhere to a common rulebook. Data must be described with rich, standardized metadata, and usage policies must be explicitly defined and enforced. For a project like DISCO, which involves a diverse consortium of large corporations, SMEs, and municipal bodies, the complexity and cost of implementing the full architectural stack of IDSA or GAIA-X could present a formidable barrier. This raises a critical question regarding the project's stated compliance with these frameworks. It is essential to determine whether this reflects a full architectural implementation or a more general alignment with the high-level principles of sovereignty and trust. "Compliance" in this context is not a binary state but a spectrum, and a key task of this analysis is to locate DISCO's various implementations along it.

Semantic Interoperability in Mobility: DATEX II and APDS

While IDSA and GAIA-X provide the governance and trust layer, semantic standards are required to ensure that different systems can understand the meaning of the data being exchanged. In the transport and mobility domain, two standards are particularly relevant to the DISCO project.

DATEX II is the European CEN standard for exchanging traffic and travel-related information. It provides a common, machine-readable, and language-independent data model for a wide range of mobility data (CEN, 2020). While initially focused on inter-urban traffic, its scope has been explicitly broadened to encompass urban mobility, logistics, and the digital representation of traffic regulations (CEN, 2020). Of direct relevance to DISCO is the DATEX II profile for Urban Vehicle Access Regulations (UVARs). This user domain provides a standardized data model for exchanging detailed information about access restrictions, such as Low Emission Zones (LEZs), loading/unloading zones, and time-based access windows, including complex rules for permits and exemptions (CEN, 2020). This is precisely the type of information required by solutions like Ghent's Urban Access Control (UAC) and Helsinki's DISCOCURB.



The Alliance for Parking Data Standards (APDS) provides a global standard designed to create a "common language" for parking, curbside, and mobility data (APDS, 2025). Its data model covers essential elements such as the static location of parking/loading zones, dynamic occupancy status, pricing, and transactional information (APDS, 2025). This standard is directly applicable to the DISCOCURB solution, which focuses on the dynamic management, monitoring, and booking of curbside loading zones. The convergence of these standards is evident, as the official CEN Parking Publication within DATEX II has been revised to align with the APDS standard, reinforcing APDS's position as the definitive model for this specific domain

The existence of these mature semantic standards exposes a potential "specificity gap" in many innovation projects. The DISCO project documentation frequently refers to the use of REST APIs and JSON format for data exchange. This ensures *syntactic* interoperability—meaning systems can parse the data structure. However, it does not guarantee *semantic* interoperability—the ability for systems to unambiguously understand the *meaning* of the data. For example, two systems might both use a JSON field named "availability," but one might define it as a Boolean (true/false) while another defines it as a percentage. Without a common data model, such as that provided by APDS or DATEX II, this ambiguity leads to integration failures or the need for costly, custom-built data translators. A crucial line of inquiry for this report, therefore, is whether DISCO's data schemas are custom defined for the project or are direct implementations of these established semantic models. A choice to create custom models, while potentially faster for internal pilot purposes, represents a significant barrier to external integration and long-term scalability.

1.3. Objectives

The purpose of this deliverable is to provide a comprehensive overview of the conceptual and methodological framework guiding the development and evaluation of the DISCO solutions. In line with the overall goals of the project, this section defines the scope of work, the boundaries of analysis, and the specific aims that the subsequent chapters seek to address. The intention is to ensure that the proposed measures and models are not only theoretically sound but also practically applicable within diverse European urban contexts.

A central aim is to identify requirements, tools, and evaluation criteria that support the interoperability of digital logistics solutions. The Living Labs in Thessaloniki, Helsinki, Ghent, and Copenhagen serve as real-world testing grounds that provide empirical evidence for the design and implementation of DISCO solutions. By analyzing these pilots, the project develops transferable insights that extend beyond the local level and contribute to the creation of scalable, Europe-wide frameworks. This scope ensures that the project results can directly inform both municipal strategies and European policies such as the Sustainable and Smart Mobility Strategy (European Commission, 2020).

Furthermore, the need to connect technological development with governance, policy, and societal aspects. The scope of this deliverable therefore extends beyond technical interoperability



to include semantic, organizational, and legal dimensions. This reflects the European Interoperability Framework (European Commission, 2017), which highlights that sustainable digital transformation depends on alignment across multiple layers. The objectives thus include not only developing tools such as DISCOPROXI, DISCURB, or DISCOESTATE, but also embedding them into governance structures and ensuring their compliance with EU regulations such as GDPR and eIDAS.

The deliverable also aims to contribute to the broader vision of the European Physical Internet (Montreuil, 2011), where goods, data, and infrastructures interconnect seamlessly across networks and borders. By positioning DISCO solutions within this vision, the project ensures that its outputs are not limited to urban pilot contexts but serve as foundational components of a federated, pan-European logistics ecosystem. This alignment with long-term EU strategies ensures both the relevance and the sustainability of the work undertaken.

In summary, the objectives of this document are threefold:

- To define the analytical scope and methodological framework for evaluating DISCO solutions.
- To establish how local Living Lab insights contribute to generalized, transferable knowledge.
- To align project activities with European policy priorities and long-term visions for interoperability and sustainability.

1.4. Structure of the deliverable

Section 2 articulates the methodological foundations underpinning the evaluation of DISCO solutions. It delineates the criteria for assessing interoperability and describes the integration of empirical data and stakeholder feedback from the Living Labs to ensure the rigor and relevance of project outcomes. In **Section 3**, the technical, organizational, and legal prerequisites for enabling seamless collaboration among DISCO tools are systematically identified. The chapter leverages real-world scenarios from pilot cities to illustrate both facilitating factors and obstacles, thereby synthesizing lessons for cross-city deployment.

Section 4 presents an in-depth review of pilot initiatives conducted in Thessaloniki, Helsinki, Ghent, and Copenhagen. It analyzes implementation strategies, documents best practices and challenges, and draws actionable insights regarding the successful application of DISCO solutions under varying local conditions.

Section 5 introduces the Meta Model Suite, detailing its architectural components and the mechanisms by which it harmonizes data, standards, and processes. The suite's contributions to facilitating interoperability among diverse logistics systems are explicitly outlined.

In **Section 6**, the evaluation methodology and results are presented, demonstrating how the proposed solutions align with project objectives and relevant EU regulatory frameworks.



Performance metrics and compliance outcomes are discussed, highlighting areas for iterative improvement.

Finally, **Section 7** synthesizes key findings, offers policy recommendations for urban logistics and digital transformation, and provides a strategic roadmap for the broader adoption and scalability of DISCO solutions throughout Europe. It ensures alignment with overarching EU strategies and long-term sectoral visions. And **Section 8** concludes this deliverable.



2. Objectives and Task Description

Deliverable 2.5, "Measures and Meta Model Suite interoperability," serves as a critical component within the DISCO project, integrating the theoretical frameworks of Work Package 2 with the empirical evidence generated from the pilot activities in Work Package 4. Its primary role is to analyse and formalize how the various DISCO-X innovations and their enabling tools can work together harmoniously, a foundational requirement for creating a true Physical Internet (PI)-led ecosystem.

This deliverable does not exist in isolation; it is intrinsically linked to the inputs from preceding tasks and provides essential outputs that will guide subsequent project activities.

Inputs to this Deliverable

The analysis presented in this document is built upon the findings and outputs of several key deliverables:

- **D2.1 - Urban Logistics Transition Requirements:** This document provided the foundational needs and specifications from the Living Labs, defining the context and goals for each of the DISCO-X measures. The interoperability scenarios assessed here are a direct response to the need for these measures to function within a single, cohesive urban environment.
- **D4.2 - Starring LL measures implementation:** This is the most crucial input. It delivers the empirical evidence and real-world lessons from the 24-month implementation of the measures in the Starring Living Labs. The successes and challenges of integrating tools like the Urban Access Control (UAC) system in Ghent or connecting the WareM&O platform in Thessaloniki provide the practical basis for the interoperability analysis conducted here.
- **WP3 - The Urban Freight Data Space:** The architecture and principles of the DISCO Urban Freight Data Space are a core input. As the central mechanism for data exchange, the UFDS defines the technical environment within which all DISCO-X tools must interoperate. The analysis in D2.5 evaluates how effectively the tools connect to and leverage this shared data ecosystem.

Outputs from this Deliverable

The interoperability framework and validated scenarios detailed in this document will serve as a foundational resource for several other work packages and tasks:

- **The Meta Model Suite (MMS):** The findings will directly inform the functionality of the MMS website. The generalized transition paths and interoperability guidelines developed



here will be integrated into the MMS to provide practical, evidence-based advice to new cities on how to combine different DISCO-X solutions effectively.

- **WP7 - Policy and Dissemination:** The analysis of which standards (e.g., **DATEX II, APDS**) and protocols facilitate interoperability provides a key evidence base for policy recommendations. The generalized framework can be disseminated as a best-practice guide for cities across Europe seeking to build integrated smart logistics systems, in line with the EU's goals for digital and sustainable mobility

The development of modular digital tools for urban logistics within the DISCO framework is based on a structured set of functional requirements, categorized into **planning** and **operational** tools. Each component is designed to address specific challenges in urban freight systems and integrate seamlessly into digital infrastructures.

- **DISCOCURB** supports curbside management through digital twins, simulation tools, and predictive analytics to optimize loading zone usage.
- **DISCOPROXI** focuses on micro-hub planning and cargo bike routing, offering GIS-based site analysis and simulation platforms.
- **DISCOESTATE** enables the repurposing of underutilized buildings via 3D models, availability analytics, and matchmaking tools.
- **DISCOBAY** offers strategic planning and real-time booking solutions for consolidation centers and shared logistics facilities.
- **DISCOLLECTION** provides data-driven insights with tools for freight demand forecasting, access control, and system integration.

The methodology for assessing DISCO-X service interoperability involves breaking each service into key data features, which are then classified as either essential ("Must Have") or beneficial but optional ("Nice to Have"). Each feature is assigned a numerical importance score (10 or 1), and these are normalized to create weights for each feature. The actual availability of each data feature in a target environment is surveyed, with availability recorded as a binary value. A technical compatibility score is then calculated by combining these weights and availability values, producing a score on a 1–5 scale.

This method allows for a **quantitative and reproducible compatibility assessment** that highlights the degree to which a DISCO-X service can be integrated into a given urban ecosystem. By explicitly distinguishing between essential and optional data features, the approach ensures that the most critical dependencies of a service are weighted accordingly.

Furthermore, because the method yields a **normalized, comparable score**, it can be used across different cities, living labs, and contexts. This supports:



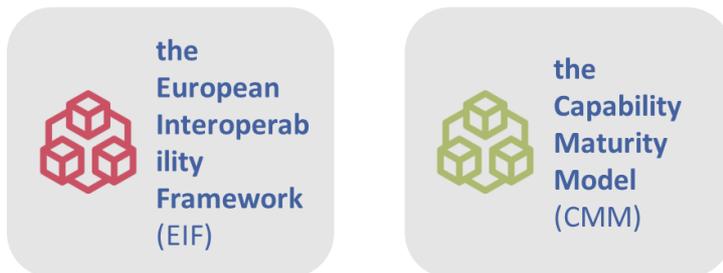
- **Modular deployment** of services
- **Interoperability analysis** across urban infrastructures
- **Strategic planning** for scaling services to new contexts

In this way, the technical compatibility assessment provides a robust foundation for evaluating the feasibility of deploying DISCO-X services in heterogeneous technological and institutional environments.

3. Methodological Framework

The complex, multi-stakeholder environment of projects like DISCO, coupled with the ambitious, PI-led vision for a "network-of-networks," necessitates a new approach to assessing interoperability. Standard, off-the-shelf models are often insufficient for this domain. A purely technical framework, focused on API compatibility and data formats, would fail to capture the critical organizational, legal, and governance challenges that are often the true barriers to synergy. Conversely, a high-level administrative framework may lack the technical depth required to evaluate the sophisticated data-sharing platforms at the heart of modern logistics.

To provide a systematic assessment of the interoperability between the DISCO-X innovations, a multiple-layered framework was decided to be developed. This methodology is specifically designed to be fit-for-purpose, translating the complex, multi-faceted interactions observed in the Living Labs into a clear, quantifiable score. The approach is a synthesis of two widely recognized and established frameworks:



The assessment is grounded in established models to ensure its validity and replicability.

- **The European Interoperability Framework:** The EIF provides a holistic, multi-layered approach to interoperability, recognizing that seamless interaction is not merely a technical issue. It defines four distinct layers: technical, semantic, organisational, and legal. It is considered suitable for assessing the DISCO ecosystem, which involves not just software platforms but also complex data-sharing agreements, aligned business processes, and multi-stakeholder governance structures.
- **The Capability Maturity Model:** To quantify the *level* of interoperability, we adopted the principles of the Capability Maturity Model (CMM). The CMM is a well-established methodology for assessing the maturity and capability of an organization's processes, moving through defined levels from initial and ad-hoc to fully optimized and integrated. Assessing interoperability is not a binary (yes/no) question; it is a measure of maturity. Our scoring rubric (0-3) represents a simplified, practical application of CMM, allowing us to map qualitative evidence from the Living Labs to a specific maturity level.



But why we consider it as fit-for-purpose for our work in T2.4 for DISCO? The answer is for several key reasons:

1. **It is Evidence-Based:** The scoring is not theoretical. It is directly based on the empirical evidence of the tools, data flows, and stakeholder agreements that were actually implemented and documented in the Starring Living Labs (as reported in Deliverable 4.2).
2. **It is Holistic:** By incorporating the EIF's layers, the methodology captures more than just technical connections. It assesses the crucial semantic alignment of data and the organizational synergies that are central to the Physical Internet paradigm.
3. **It is Measurable and Repeatable:** The use of defined parameters and a clear CMM-based scoring rubric makes the assessment objective, transparent, and repeatable by other researchers or cities.

The assessment is conducted by applying a scoring rubric to each pair of DISCO-X innovations, based on evidence from the Living Labs. The score for each cell in the final matrix is the sum of scores from six specific sub-parameters as presented in the Figure below.

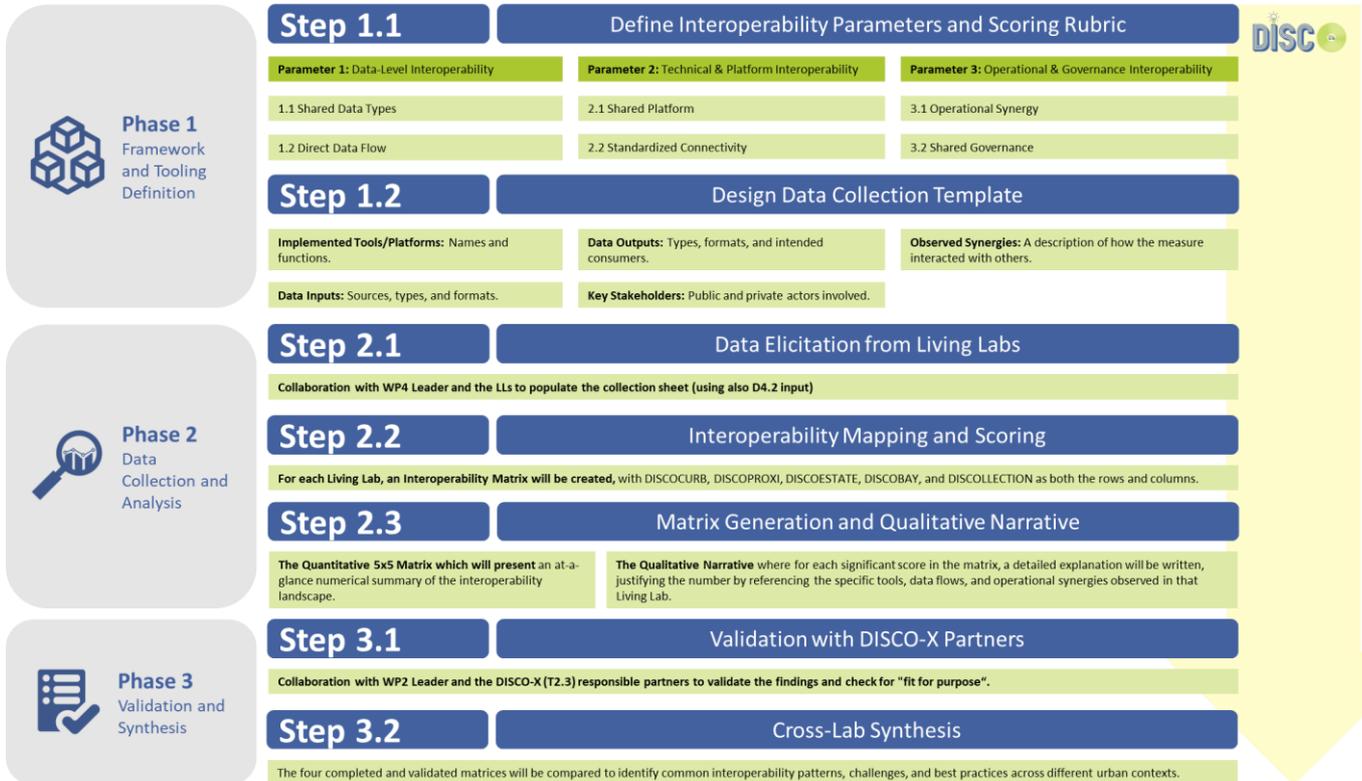


Figure 1: The framework for interoperability assessment between the DISCO-Xs of a living lab



Phase 1: Define Interoperability Parameters

For each pair of innovations, six sub-parameters are assessed, grouped into three main categories derived from the European Interoperability Framework (EIF).

In the category of **Data-Level Interoperability**, two aspects are considered. First, *Shared Data Types* examines whether the innovations use the same types of data. Second, *Direct Data Flow* evaluates whether the output of one tool serves as a direct input for another. Under **Technical & Platform Interoperability**, the assessment includes *Shared Platform*, which checks if the enabling tools operate on a single shared platform. It also considers *Standardized Connectivity*, determining whether the tools connect via the Urban Freight Data Space (UFDS) or a common API. The third category, **Operational & Governance Interoperability**, looks at *Operational Synergy*, which asks whether the operation of one innovation directly depends on or enhances another. It also evaluates *Shared Governance*, assessing whether both innovations are governed by the same stakeholders or business models.

Phase 2: Apply the Scoring Rubric

Each of the six sub-parameters is scored from 0 to 3 based on the Capability Maturity Model (CMM) scale. A score of 0, labeled *Non-Existent*, indicates no evidence of interoperability for the parameter. A score of 1, *Initial / Potential*, suggests an indirect or potential link exists, where the connection is ad-hoc and not formally integrated, for example, when measures address a similar goal but lack a technical link. A score of 2, *Managed / Defined*, reflects a formal, repeatable process for interaction. This means the connection is planned and implemented, such as two tools from separate platforms sharing data via the UFDS. Finally, a score of 3, *Optimized / Integrated*, denotes deep and seamless integration between the two innovations. Their processes are intertwined, often operating on a shared platform to create a single, fluid operational workflow.

Phase 3: Calculate the Final Interoperability Index

The scores from the six sub-parameters are summed to produce the final interoperability index for that cell in the matrix. This final number provides a quantifiable measure of the overall strength of the connection between the two innovations within the specific Living Lab.



4. The Assessments of the Starring Labs

This chapter offers a comprehensive overview of the interoperability assessment conducted across all Staring Living Labs. The section details the rigorous scoring methodology (as highlighted in the previous section), which evaluates how pairs of DISCO-X innovations interact within each Living Lab context. Emphasis is placed on analysing the unique characteristics and integration levels of each lab, such as Thessaloniki's complex urban logistics environment, by applying a structured framework that covers data, platform, and governance interoperability.

Crucially, this chapter moves beyond isolated analysis by conducting a cross-lab comparison. This cross analysis enables identification of patterns, best practices, and persistent challenges in interoperability, facilitating a deeper understanding of how different local deployments can inform broader, scalable strategies for urban logistics across Europe. By systematically comparing the interoperability indices across all Staring Living Labs, the section highlights the potential for harmonization and mutual learning, setting the foundation for the development of Europe-wide standards and collaborative innovation in urban freight management.

4.1. Interoperability Assessment Matrix (Interoperability Assessment)

The section details the scoring method, explains how final interoperability indices are calculated, and sets up the context for applying this methodology to real-world Living Lab scenarios, by analyzing all Staring Living Labs. The maximum possible score for any interaction is **18** (6 sub-parameters x a maximum score of 3 each). Based on this, we can define the following classes:

- **Low Interoperability (Score: 0-6):** This class represents a weak or purely potential connection. Interactions in this category are typically limited to sharing similar strategic goals or having potential future links, but they lack significant technical, data, or operational integration.
- **Medium Interoperability (Score: 7-12):** This class indicates a defined and functional connection. Interactions here are often characterized by tools sharing data through a standardized interface like the UFDS, but they operate on separate platforms and have limited operational dependency. It signifies a managed but not fully integrated relationship.
- **High Interoperability (Score: 13-18):** This class represents a deep and seamless integration. Interactions in this category typically involve tools running on a **shared platform**, having direct automated data flows, and demonstrating strong operational synergies where one measure is a prerequisite for or directly enables another. This is the most mature level of interoperability.



4.1.1. Thessaloniki's DISCO-Xs interoperability

Thessaloniki's Living Lab serves as a key testbed for assessing the interoperability of DISCO-X innovations in a complex, real-world urban logistics environment. This chapter introduces how multiple services—such as DISCOPROXI, DISCOESTATE, and DISCOLLECTION—interact within a shared digital ecosystem to improve last-mile logistics and urban freight management. Drawing on the methodological framework established in this section, it evaluates interoperability across data, platform, and governance layers, using the standardized scoring rubric to quantify the level of integration. By focusing on Thessaloniki's pilot deployments, the analysis highlights both the technical synergies and operational benefits of using a common platform (such as the WareM&O Warehouse-as-a-Service solution) and the Urban Freight Data Space (UFDS) as central nodes for data exchange. This introductory section thus sets the stage for the detailed assessment of each DISCO-X interaction, illustrating how local implementation can inform scalable, Europe-wide interoperability strategies.



Interaction: DISCOPROXI & DISCOESTATE

The interaction between DISCOPROXI and DISCOESTATE is based on a strategic, rather than a direct operational, synergy. The primary tool for DISCOPROXI is the analytical optimal lockers location model, while the primary tool for DISCOESTATE is the operational WareM&O platform.

Shared Data Types: The two primary tools use fundamentally different data models. The locker location model uses courier demand data, market share and geospatial data, whereas the WareM&O platform uses a data model for warehouse/building specifications and availability. The only minor overlap is the use of geospatial data.	Score: 1
Direct Data Flow: In the context of the pilot, there was no direct data flow between the optimal locker location model and the operational WareM&O platform used for the DISCOESTATE measure. The output of the planning tool did not feed directly into the WaaS platform.	Score: 0
Shared Platform: The tools are distinct and serve different purposes. The optimal location model is a standalone analytical tool, while WareM&O is an operational marketplace platform. They are not shared.	Score: 0
Standardized Connectivity: While the tools themselves are not directly connected, they both provide their output data to the central ULDTThess dataspace (DISCOLLECTION). This central dataspace acts as a standardized point of data integration for the wider ecosystem.	Score: 2
Operational Synergy: There is a strong potential operational synergy. The successful relocation of the ACS depot to the TIF-HELEXPO hub (the achievement of DISCOESTATE) creates a major consolidation point. This hub is the logical source of parcels that would supply a last-mile delivery network using the smart lockers planned by the DISCOPROXI tool. The synergy is strategic and planned but was not fully realized operationally during the pilot.	Score: 2
Shared Governance: Both measures fall under the same strategic planning effort led by CERTH/HIT and the Municipality of Thessaloniki.	Score : 2
Total Score	7



Interaction: DISCOBAY & DISCOPROXI

This interaction is based on shared data for planning and a common data ecosystem, but separate primary tools.

Shared Data Types: Both measures contribute to and use the Logistics Real Estate Database . DISCOBAY contributes data on underutilized rail and port assets, while DISCOPROXI contributes data on the locations of existing and planned smart lockers.	Score: 3
Direct Data Flow: The data from both measures is fed into the same database, which is then consumed by the central ULDTThess dataspace (DISCOLLECTION), creating a direct data flow to a central aggregator.	Score: 3
Shared Platform: The primary tools are distinct. DISCOPROXI's core tool is the analytical optimal location model, while DISCOBAY's main tool is the Logistics Real Estate Database itself.	Score: 0
Standardized Connectivity: Both measures provide their data to the central dataspace via a REST API, providing a standardized point of data integration.	Score: 2
Operational Synergy: A strong strategic synergy exists. The multimodal hubs identified by DISCOBAY are the logical consolidation points for freight that would then be distributed to the last-mile locker network planned by DISCOPROXI. This synergy remained at the planning stage in the pilot.	Score: 2
Shared Governance: Both measures fall under the same strategic planning effort led by CERTH/HIT and the Municipality of Thessaloniki.	Score: 2
Total Score	12

Interaction: DISCOBAY & DISCOESTATE

This interaction is also characterized by strong data and strategic synergy, focused on activating underutilized assets.

Shared Data Types: The data from both measures—available buildings via the WareM&O platform (DISCOESTATE) and available rail/port infrastructure via the Logistics Real Estate Database (DISCOBAY)—are both types of "logistics real estate" and are aggregated in the central dataspace.	Score: 2
Direct Data Flow: Both measures feed their respective data into the central ULDTThess dataspace (DISCOLLECTION), creating a direct flow to the central aggregator.	Score: 3
Shared Platform: The primary tools used (WareM&O for DISCOESTATE, the Logistics Real Estate Database for DISCOBAY) are distinct platforms.	Score: 0
Standardized Connectivity: Both platforms connect to the central dataspace via a REST API, providing a standardized point of data integration.	Score: 2
Operational Synergy: There is a strong strategic synergy, as both measures focus on the same PI principle “activating underutilized assets” (buildings for DISCOESTATE, transport infrastructure for DISCOBAY) for logistics use.	Score: 3



Shared Governance: Both measures are part of the same strategic planning effort led by CERTH/HIT and the Municipality. **Score: 2**

Total Score 12

Interaction: DISCOLLECTION with all others

The relationship remains High because the ULDTThess dataspace (DISCOLLECTION) was explicitly designed to be the central data aggregator for all the other distinct tools and data sources.

Shared Data Types: The dataspace ingests all relevant data types from the other measures, including warehouse/locker locations, availability, real estate information, and stakeholder data. **Score: 3**

Direct Data Flow: There is a direct, automated data flow from the WareM&O platform (DISCOESTATE), the optimal location model outputs (DISCOPROXI), and the Logistics Real Estate Database (DISCOBAY) to the ULDTThess dataspace via REST API. **Score: 3**

Shared Platform: The platforms are distinct, but they were all designed as part of a single, integrated city-level ecosystem with the ULDTThess as the central hub. **Score: 1**

Standardized Connectivity: The connection is explicitly designed as a standardized REST API interface between the operational/analytical tools and the central data hub. **Score: 3**

Operational Synergy: The dataspace (DISCOLLECTION) provides the essential city-wide overview and "single source of truth" necessary for the strategic planning and monitoring of all other measures. **Score: 3**

Shared Governance: The dataspace is the central element of the shared governance framework, managed by CERTH/HIT and the Municipality, and it serves all other measures. **Score: 2**

Total Score 15

Applying this classification to the scores calculated previously, the Thessaloniki matrix is as follows:

Table 1: Interoperability Matrix for the DISCO-X measures of Thessaloniki

	DISCOCURB 	DISCOPROXI 	DISCOESTATE 	DISCOBAY 	DISCOLLECTION 
DISCOCURB 	-	N/A	N/A	N/A	N/A
DISCOPROXI 	N/A	-	Medium	Medium	High
DISCOESTATE 	N/A	Medium	-	Medium	High
DISCOBAY 	N/A	Medium	Medium	-	High
DISCOLLECTION 	N/A	High	High	High	-

The interoperability matrix for the Thessaloniki Living Lab reveals a highly cohesive and integrated ecosystem, where interoperability is achieved primarily through a shared data strategy and strong strategic alignment, rather than through a single, shared operational platform.

The standout feature remains the central role of DISCOLLECTION, which achieves a high level of interoperability with all other implemented measures. This is because its main tool, the local Urban Freight Dataspace (uldthess.imet.gr), was successfully designed and implemented to be the central data aggregator. It ingests data from the distinct tools of DISCOPROXI, DISCOESTATE, and DISCOBAY, creating a "single source of truth" and proving the effectiveness of a "hub-and-spoke" model for data interoperability.

The Medium interoperability between DISCOPROXI, DISCOESTATE, and DISCOBAY accurately reflects their relationship. These innovations do not share a primary operational platform; rather, their distinct enabling tools (the optimal locker location model for DISCOPROXI, the WareM&O



platform for DISCOESTATE, and the Logistics Real Estate Database for DISCOBAY) are connected through a common data ecosystem (the ULDDThess dataspace) and a shared strategic vision. The synergy is strong—the hubs identified by DISCOBAY are the logical consolidation points for the locker network planned by DISCOPROXI—but it is at the planning and data level, not at the level of direct, real-time operational integration.

4.1.2. Helsinki’s DISCO-Xs interoperability

Helsinki’s Living Lab provides a rich environment to test the scalability and flexibility of DISCO-X innovations in a Nordic urban setting. This chapter introduces the city’s pilots, which emphasize dynamic curb management, multimodal routing, and real-time data sharing between public and private stakeholders. Building on the interoperability framework established in Chapter 3, the analysis assesses how services such as DISCURB and other Helsinki deployments connect to the Urban Freight Data Space (UFDS) and integrate with existing city logistics infrastructure. By quantifying data-level, platform, and governance interoperability, this section highlights Helsinki’s role as a model for adaptive curbside management and smart city logistics. It also draws lessons on policy alignment and stakeholder coordination that can inform replication in other European contexts.

Interaction: DISCOLLECTION & DISCOCURB

This pair demonstrates high interoperability. The **DISCOLLECTION** measure was defined by the integration of data from the **DISCOCURB** pilots into a central data hub.

Shared Data Types: Both measures use real-time occupancy and geospatial data.	Score: 3
Direct Data Flow: Real-time loading zone usage data from the monitoring tools was directly fed into the Helsinki Mobility Data Catalog	Score: 3
Shared Platform: The tools are distinct (sensor platforms vs. city data catalog)	Score: 0
Standardized Connectivity: The Helsinki Mobility Data Catalog acted as the standardized ingestion point for the UFDS.	Score: 2
Operational Synergy: The data from curb monitoring (DISCOCURB) was the essential input for the data aggregation and visualization goals of DISCOLLECTION.	Score: 3
Shared Governance: Both measures were managed by the same city department (FVH, Urban Environment Division).	Score: 2
Total Score	13

Interaction: DISCOLLECTION & DISCOPROXI

This pair shows medium-to-high interoperability. A direct data flow was established from the multi-actor micro-hub at the **Ruoholahti shopping center** to the **Helsinki Mobility Data Catalog** (DISCOLLECTION).

Shared Data Types: Both measures use operational data on logistics hubs. **Score: 2**



Direct Data Flow: Operational data from the Ruoholahti micro-hub was fed into the Helsinki Mobility Data Catalog (DISCOLLECTION).	Score: 2
Shared Platform: The platforms are distinct.	Score: 0
Standardized Connectivity: The data was shared for integration into the central data catalog.	Score: 2
Operational Synergy: The operational data from the micro-hub was crucial for the city to understand the viability of the multi-actor model, a key goal of the DISCOLLECTION data analysis.	Score: 3
Shared Governance: Both measures were managed by the same city department.	Score: 2
Total Score	11

Interaction: DISCOCURB & DISCOPROXI

This pair demonstrates medium interoperability, primarily at the strategic and operational levels rather than through direct technical integration.

Shared Data Types: The data types are different (curb occupancy vs. hub operations).	Score: 1
Direct Data Flow: There was no direct data flow between the tools.	Score: 0
Shared Platform: The platforms are distinct.	Score: 0
Standardized Connectivity: No direct technical connection.	Score: 0
Operational Synergy: Efficient loading zones (DISCOCURB) directly support the last-mile deliveries from the micro-hub (DISCOPROXI), creating a strong operational link.	Score: 3
Shared Governance: Both measures were part of the City's "Action Plan for City Logistics" and managed by the same core stakeholders.	Score: 2
Total Score	6

Table 2: Interoperability Matrix for the DISCO-X measures of Helsinki

	DISCOCURB 	DISCOPROXI 	DISCOESTATE 	DISCOBAY 	DISCOLLECTION 
DISCOCURB 	-	Low	N/A	N/A	High
DISCOPROXI 	Low	-	N/A	N/A	Medium
DISCOESTATE 	N/A	N/A	-	N/A	N/A
DISCOBAY 	N/A	N/A	N/A	-	N/A
DISCOLLECTION 	High	Medium	N/A	N/A	-

The Helsinki matrix highlights an interoperability strategy focused on data integration for strategic planning. The High score between DISCOLLECTION and DISCOCURB demonstrates the success of this approach; real-time sensor data was not just collected but successfully integrated into a central city data catalog and a widely used commercial application (Tietorahti), providing immediate value. The interoperability between other measures was more operational and strategic, driven by shared governance under the city's logistics action plan rather than by shared technical platforms. The absence of DISCOESTATE and DISCOBAY measures is reflected in their low scores. Helsinki's experience shows that even without deeply integrated operational platforms, significant interoperability can be achieved through a strong, centralised data strategy.

4.1.3. Ghent's DISCO-Xs interoperability

Ghent's Living Lab represents a dense and historic European urban context where access control, sustainable mobility, and adaptive logistics practices converge. This chapter introduces how the city's DISCO-X innovations—particularly the Urban Access Control (UAC) system—are integrated with other modular solutions to manage low-emission zones and optimize last-mile deliveries. Using the same scoring rubric from Chapter 3, the analysis evaluates Ghent's approach to



semantic and operational interoperability, focusing on how standardized data models (such as DATEX II) and shared governance arrangements enable seamless interactions. This section demonstrates how Ghent’s emphasis on regulatory compliance and multimodal hubs can serve as a blueprint for balancing heritage conservation with innovative urban freight strategies.

Interaction: DISCOPROXI & DISCOLLECTION

The Ghent Living Lab is a prime example of deep technical and operational interoperability, where different DISCO-X measures were designed from the start as components of a single, cohesive system: the Urban Access Control platform.

Shared Data Types: Both measures use UVAR data, but one produces it (DISCOLLECTION) and the other consumes it (DISCOPROXI).	Score: 3
Direct Data Flow: The standardized DATEX II data from the Smart Data Platform (DISCOLLECTION) is the direct and essential input for the UAC's route-checking engine (DISCOPROXI).	Score: 3
Shared Platform: The UAC and the Smart Data Platform were designed to work as a single, integrated architecture.	Score: 2
Standardized Connectivity: The connection is a core, designed feature via API.	Score: 3
Operational Synergy: The UAC's core function is to apply the rules provided by the DISCOLLECTION data layer, making the synergy absolute.	Score: 3
Shared Governance: Both were developed by the same core partners for the City of Ghent.	Score: 2
Total Score	16

Interaction: DISCOBAY & DISCOPROXI

This pair shows a strong medium interoperability, as the DISCOBAY measure was integrated as a specific feature within the DISCOPROXI workflow.

Shared Data Types: The data types are distinct but complementary (barge service vs. route planning).	Score: 1
Direct Data Flow: The UAC system (DISCOPROXI) was designed to actively <i>suggest</i> the barge service (DISCOBAY) as a "Green Last Mile" alternative to truck-based deliveries. This represents a direct flow of recommendations.	Score: 2
Shared Platform: The platforms are distinct.	Score: 0
Standardized Connectivity: The connection is facilitated through the UAC platform.	Score: 2
Operational Synergy: The barge-to-bike model was presented as a direct, alternative workflow within the UAC, creating a very strong operational link.	Score: 3
Shared Governance: Both were part of Ghent's Sulp and involved the same core stakeholders.	Score: 2
Total Score	10



Interaction: DISCOLLECTION & DISCOBAY

This interaction is facilitated by the **Urban Access Control (UAC) system**, which uses the standardized data from DISCOLLECTION to suggest the barge service (DISCOBAY) as a Green Last Mile alternative.

Shared Data Types: The core data types are different (digital access rules vs. operational barge logistics data), but they are used in a complementary way within the UAC.	Score: 1
Direct Data Flow: The UAC, which is powered by the standardized data from DISCOLLECTION, directly outputs a <i>recommendation</i> for the DISCOBAY service, creating a one-way flow of information.	Score: 2
Shared Platform: The tools are distinct (UAC/Smart Data Platform vs. waterway logistics management).	Score: 0
Standardized Connectivity: Both are designed to be part of the same UFDS ecosystem, with the UAC acting as a key node.	Score: 2
Operational Synergy: There is a strong operational synergy, as the intelligence provided by the DISCOLLECTION data within the UAC directly enables and promotes the use of the DISCOBAY service as a viable alternative.	Score: 3
Shared Governance: Both measures were part of Ghent's Sulp and involved the same core group of stakeholders (City of Ghent, VIL, OHB).	Score: 2
Total Score	10

Table 3: Interoperability Matrix for the DISCO-X measures of Ghent

	DISCOCURB 	DISCOPROXI 	DISCOESTATE 	DISCOBAY 	DISCOLLECTION 
DISCOCURB 	-	N/A	N/A	N/A	N/A
DISCOPROXI 	N/A	-	N/A	Medium	High
DISCOESTATE 	N/A	N/A	-	N/A	N/A
DISCOBAY 	N/A	Medium	N/A	-	Medium
DISCOLLECTION 	N/A	High	N/A	Medium	-

The interoperability matrix for the Ghent Living Lab reveals a strategy of deep technical and process integration centred around the Urban Access Control (UAC) system. The High interoperability between DISCOPROXI and DISCOLLECTION is the core of the pilot; they are not separate measures but an integrated system where standardized data (DISCOLLECTION) enables intelligent logistics operations (DISCOPROXI). The UAC system acts as the central technical hub that binds these innovations together. The successful standardization of complex municipal rules into a common format (DATEX II) was the key enabler for this advanced, interoperable service. The interoperability between DISCOBAY and the other key measures is classified as Medium. This is because the barge-to-bike service (DISCOBAY) was designed as a "Green Last Mile" alternative that the UAC system (powered by DISCOLLECTION's data and a core tool of DISCOPROXI) could actively suggest to users. This creates a strong operational synergy and a defined data link through the UAC, even though the platforms themselves are not fully integrated.



4.1.4. Copenhagen’s DISCO-Xs interoperability

Copenhagen’s Living Lab illustrates how DISCO-X solutions can be embedded into a mature digital and policy environment to drive sustainability and multimodal integration. This chapter introduces the city’s pilots, which combine advanced data platforms, stakeholder collaboration, and green transport modes to test next-generation logistics services. Applying the interoperability assessment methodology developed in Chapter 3, the analysis focuses on Copenhagen’s use of open APIs, modular infrastructures, and federated governance to achieve cross-system compatibility. By examining how data, operations, and policy frameworks converge, this section highlights Copenhagen’s role as a frontrunner in creating resilient, interoperable urban freight systems that align with Europe’s long-term decarbonization and digitalization goals. The Copenhagen pilot focused on using a Digital Twin as a central analytical tool to gather evidence for its new Sustainable Urban Logistics Plan (SULP). Interoperability was therefore strongest at the data and strategic planning levels.

Interaction: DISCOLLECTION & DISCOCURB

This interaction is defined by the Digital Twin (DISCOLLECTION) using data from the curbside management pilot (DISCOCURB) for simulation.

Shared Data Types: The DT was designed to ingest real-time parking and curbside usage data.	Score: 3
Direct Data Flow: A direct data flow was established, with data from the "Coding the Curbs" pilot and other parking apps feeding into the data platform that supplied the Digital Twin.	Score: 2
Shared Platform: The tools are distinct (LIAISON platform for the DT vs. "Coding the Curbs" app).	Score: 0
Standardized Connectivity: The data platform acted as a standardized ingestion point for the DT.	Score: 2
Operational Synergy: The data from the DISCOCURB pilot was crucial for the DT to simulate the impact of reducing parking spaces, a key policy question for the city. This represents a strong analytical synergy.	Score: 3
Shared Governance: Both measures were managed by the Municipality of Copenhagen as part of the same SULP development process.	Score: 2
Total Score	12



Interaction: DISCOLLECTION & DISCOPROXI

This interaction involves the Digital Twin (DISCOLLECTION) using data from logistics partners to simulate the impact of micro-hubs (DISCOPROXI).

Shared Data Types: The DT was designed to use LSP route data, which is the primary data type for planning micro-hub operations.	Score: 3
Direct Data Flow: A direct data flow was established through 13 partnership agreements , where 11 companies provided anonymized route data for the DT.	Score: 3
Shared Platform: The platforms are distinct (LIAISON vs. LSP operational systems).	Score: 0
Standardized Connectivity: The data platform acted as a standardized ingestion point.	Score: 2
Operational Synergy: The LSP data was essential for the DT to simulate the effectiveness of a shared consolidation hub like Køleskabet, creating a strong analytical synergy.	Score: 3
Shared Governance: Both were governed by the same Sulp process, advisory board, and data-sharing agreements.	Score: 2
Total Score	13

Interaction: DISCOPROXI & DISCOBAY

This interaction connects the planning of urban micro-hubs (DISCOPROXI) with the potential use of a major peri-urban terminal (DISCOBAY).

Shared Data Types: Both deal with logistics hub capacity and freight flow data.	Score: 2
Direct Data Flow: No direct data flow was implemented between the two measures during the pilot.	Score: 0
Shared Platform: The initiatives were separate.	Score: 0
Standardized Connectivity: Both were intended to feed data into the same DISCOLLECTION data ecosystem.	Score: 2
Operational Synergy: The strategic link is clear: the peri-urban hub (DISCOBAY) would serve as a consolidation point feeding the inner-city micro-hubs (DISCOPROXI). This was explored in planning and simulation.	Score: 2
Shared Governance: Both were discussed and planned under the same Sulp framework and stakeholder groups.	Score: 2
Total Score	8

Table 4: Interoperability Matrix for the DISCO-X measures of Copenhagen

	DISCOCURB 	DISCOPROXI 	DISCOESTATE 	DISCOBAY 	DISCOLLECTION 
DISCOCURB 	-	Low	N/A	Low	Medium
DISCOPROXI 	Low	-	N/A	Medium	High
DISCOESTATE 	Low	Low	-	Low	Low
DISCOBAY 	Low	Medium	N/A	-	High
DISCOLLECTION 	Medium	High	N/A	High	-

The Copenhagen matrix demonstrates an interoperability model focused on strategic simulation and policy planning, rather than real-time operational integration. The central element of the pilot was the Digital Twin, which is why DISCOLLECTION achieves a high level of interoperability with the other implemented measures. The success of the Copenhagen LL in establishing an extremely significant number of data-sharing partnership agreements with major logistics providers was a significant achievement in organisational interoperability. This allowed for a direct and robust flow of real-world data to the Digital Twin, enabling it to run high-impact simulations. The results of these simulations—such as the potential 83% CO₂ reduction from a Zero-Emission Zone—provided the city with the evidence needed to inform its new SULP. This represents a mature, data-driven approach to policy development. In contrast, the interoperability between the operational measures themselves (DISCOCURB, DISCOPROXI, DISCOBAY) was Low to Medium.



These measures were largely executed as standalone pilots designed to generate data and insights for the Digital Twin, rather than to be technically integrated with each other during the pilot phase. For example, the "Coding the Curbs" pilot and the micro-hub planning were strategically linked, but there was no direct data flow or shared platform connecting their real-time operations. This reflects the LL's primary goal: to use individual pilots as data sources to build a powerful, city-wide analytical tool for future planning.

4.2. Cross Living Lab Analysis

The comparison of the four completed and validated interoperability matrices from Thessaloniki, Helsinki, Ghent, and Copenhagen reveals distinct patterns, recurring challenges, and transferable best practices for achieving interoperability in diverse urban contexts. While each Living Lab tailored its approach to its specific local needs, a cross-lab analysis provides a richer understanding of how PI-led solutions can be scaled and replicated.

4.2.1. Common Interoperability Patterns

This section synthesizes the findings from the four Living Labs to identify common interoperability patterns that transcend individual city contexts. By comparing Thessaloniki, Helsinki, Ghent, and Copenhagen, it highlights recurring data flows, platform architectures, and governance arrangements that enable DISCO-X innovations to work together seamlessly. Building on the scoring rubric and methodological framework established in Chapter 3, this analysis distills the technical, semantic, and organizational elements that consistently support interoperability across diverse urban logistics systems. The resulting patterns provide actionable insights for scaling DISCO solutions beyond pilot deployments, guiding cities and stakeholders in adopting interoperable, standards-aligned approaches to urban freight and last-mile delivery. Three distinct but equally successful patterns for achieving interoperability emerged from the analysis:

1. The highest level of real-time interoperability was observed where different DISCO-X innovations were integrated as components of a single, operational tool. The prime example is in Ghent, where the Urban Access Control (UAC) system (the core of DISCOPROXI) was designed to directly consume the standardized DATEX II data produced by the DISCOLLECTION measure. One function could not operate without the other, demonstrating a deep, designed-for-purpose integration. The tightest operational interoperability is achieved when solutions are co-developed as part of a single, unified system.
2. A different but highly effective pattern was demonstrated in Thessaloniki. Here, interoperability was not achieved through a single shared operational platform, but through a shared data ecosystem. The distinct enabling tools for DISCOPROXI (the optimal



locker location model), DISCOESTATE (the WareM&O platform), and DISCOBAY (the Logistics Real Estate Database) were all designed to feed their data into ULDTThess (DISCOLLECTION). This created a "single source of truth" and a cohesive system at the data level, even though the operational tools remained separate.

3. A third pattern, focused on strategic planning, was observed in Copenhagen. Here, the individual operational pilots for DISCOCURB and DISCOPROXI were not directly connected to each other. Instead, they were all connected to the Digital Twin (DISCOLLECTION), which served as a central analytical hub.

Across all three of these successful patterns, one element was consistent: DISCOLLECTION as the Universal Data Backbone. Whether through a formal local dataspace (Thessaloniki), an integrated data pipeline (Ghent), or a simulation-focused Digital Twin (Copenhagen), the data layer consistently served as the primary enabler of interoperability.

4.2.2. Common Challenges

The living labs demonstrated three different models of interoperability. Ghent focused on achieving real-time operational interoperability through a single, integrated tool. Thessaloniki achieved interoperability by connecting multiple, distinct tools to a central data-offering hub. In contrast, Copenhagen prioritized strategic interoperability, using its Digital Twin to analyze data from standalone pilots to inform long-term policy. While all are valid, the strategic model is often easier to achieve in the short term as it requires data sharing agreements rather than deep technical integration of live systems.

1. The living labs demonstrated two different models of interoperability. Ghent and Thessaloniki focused on achieving real-time operational interoperability, where tools directly interact to manage logistics flows. In contrast, Copenhagen prioritized strategic interoperability, using its Digital Twin to analyze data from standalone pilots to inform long-term policy. While both are valid, the latter is often easier to achieve in the short term as it requires data sharing agreements rather than deep technical integration of live systems.
2. The success of data sharing and, therefore, interoperability was universally dependent on establishing strong stakeholder agreements. Copenhagen's important number of partnership agreements were crucial for its Digital Twin. Thessaloniki's success with DISCOESTATE hinged on the agreement between TIF-HELEXPO and ACS Courier. This highlights that organizational and legal interoperability are often prerequisites for technical and semantic interoperability.
3. The scope of interoperability was heavily influenced by local context. In Helsinki, strict permit processes for using public space limited the physical links that could be built between micro-hubs, thus constraining the potential for operational interoperability between them. In Ghent, the complexity of existing traffic regulations was the very driver

for creating the highly interoperable UAC system. This shows that interoperability is not a one-size-fits-all concept and must be adapted to the specific regulatory and physical environment of the city.

4.2.3. Comparative Analysis of Living Lab Architectures

The four Living Labs demonstrate that there is no single, one-size-fits-all solution for urban logistics data interoperability. Their approaches range from the highly integrated model of Thessaloniki to the fragmented, siloed model of Copenhagen, with Helsinki and Ghent representing intermediate points on this spectrum. This diversity reflects the varying local priorities, legacy systems, and stakeholder dynamics at play. The following table provides a structured comparison of the interoperability models implemented in each Living Lab, highlighting the strategic choices made and the outcomes observed.

Table 5: Comparative Analysis of Living Lab Architectures

	Thessaloniki	Helsinki	Ghent	Copenhagen
Primary Interoperability Strategy	Centralized Dataspace	Point-to-Point API Integration	Regulation-Centric Federation	Siloed Simulation
Key Enabling Platform(s)	WareM&O & Urban Logistics Dataspace	Tietorahti Platform	Urban Access Control (UAC) & Gent Open Data Portal	Individual Digital Twins per solution
Data Governance Model	Central Hub with REST API access	Private data sharing via a dedicated application	Integration of public open data with private systems	Internal and confidential data use; no sharing
Stated Compliance with EU Standards	Aligned with IDSA/GAIA-X principles	Aligned with IDSA/GAIA-X principles	Aligned with IDSA/GAIA-X principles	Aligned with IDSA/GAIA-X principles
Primary Challenge Encountered	Physical infrastructure bottlenecks (e.g., storage space)	Slow municipal permitting for physical infrastructure	Manual effort for data standardization	Commercial data confidentiality and partner unwillingness to share

Despite their differences, the Living Labs faced common challenges. Securing permits and overcoming physical infrastructure limitations were recurring themes in Helsinki and Thessaloniki, respectively. The high effort of data standardization was a key bottleneck in Ghent, while



commercial data silos proved insurmountable in Copenhagen. These findings collectively indicate that the non-technical aspects of implementation—regulation, governance, and business agreements—are often more challenging than the development of technology itself.

4.2.4. Requirements DISCO-X Solutions

The identification and generalization of requirements for DISCO-X solutions is fundamental to ensuring their scalability, interoperability, and replicability across European cities. The initial phase of the project showed that each Living Lab generated highly context-specific requirements, reflecting local infrastructures, regulations, and priorities. However, to avoid the risk of isolated pilot solutions, it was necessary to move beyond this fragmentation and establish a unified methodology for capturing, classifying, and validating requirements. This ensures that the innovations developed in Thessaloniki, Helsinki, Ghent, and Copenhagen can evolve into transferable components of a European-wide urban logistics ecosystem.

The methodological approach followed a multi-step process inspired by established systems engineering and interoperability research. At first, requirements were elicited through participatory workshops and surveys, giving voice to municipal authorities, logistics providers, infrastructure managers, and technology developers. This “bottom-up” elicitation helped capture the diversity of needs, such as temporary use of idle buildings in Thessaloniki, dynamic curb management in Helsinki, and multimodal water-based solutions in Ghent. Once collected, the requirements were compared across cases to identify similarities and divergences. In line with Chen, Doumeingts and Vernadat’s (2008) principle of “abstraction for interoperability,” they were then elevated from local, implementation-specific expressions to generalized requirements suitable for multiple contexts. This abstraction process created a shared conceptual layer where different cities could align without losing sight of their individual needs.

To make the requirements operationally useful, they were classified into “Must Have” and “Nice to Have.” The first group refers to indispensable elements without which a solution cannot function, such as GDPR-compliant data exchange for digital platforms or real-time occupancy data for curbside management. The second group refers to enhancements that improve efficiency or user experience but are not essential for minimal operation. For example, advanced simulation models supporting urban planners in long-term decisions would add value but are not critical for the functioning of a booking platform. This classification echoes agile development practices that distinguish between core and extended functionalities (Beck et al., 2001). Importantly, such differentiation supports gradual adoption: cities with limited digital maturity can start with “Must Have” features, while more advanced cities can integrate “Nice to Have” features for optimization and innovation.

A further step involved assigning weights to the requirements to quantify their relative importance. Each requirement was given a score, with “Must Have” items weighted significantly higher than “Nice to Have” items. This numerical weighting enabled the creation of Technical Compatibility (TC) scores for different cities and solutions. The TC score functions as a diagnostic



tool, showing how well a particular solution matches the technical and governance readiness of a city. A city with strong sensor infrastructure may achieve a high compatibility score for curbside management solutions but may face difficulties with estate-sharing platforms if underutilized buildings are scarce. Conversely, a city with vacant real estate but weaker digital infrastructure may be more compatible with building-sharing solutions than with sensor-heavy platforms. This evidence-based assessment allows municipal decision-makers to prioritize solutions aligned with their infrastructural and institutional realities.

The categories of requirements that emerged from this process encompass more than technical considerations. They include data and information requirements, such as standardized data models (DATEX II, APDS) and interoperable exchange mechanisms compliant with International Data Spaces Association principles. They also include functional requirements like booking systems, digital twins, and multimodal coordination tools. Governance and regulatory requirements address compliance with GDPR, municipal permitting, and environmental regulations, while infrastructure requirements cover cloud-native architectures, APIs, and sensor deployments. Finally, stakeholder and business model requirements acknowledge that solutions must not only function technically but also be embedded in sustainable economic and institutional arrangements. These categories underline the socio-technical nature of urban logistics systems, where governance, collaboration, and trust are just as crucial as technical performance (Janssen et al., 2017).

The implications of this requirements framework are far-reaching. By systematically generalizing and classifying requirements, DISCO ensures that its solutions can be scaled beyond individual pilots. Cross-city interoperability becomes possible because requirements are aligned with European standards and data models. Scalability and replicability are supported by the transparent weighting system, which allows cities to identify gaps and prepare for adoption. Governance challenges are also directly addressed, acknowledging that interoperability is not only a technical matter but also depends on institutional coordination and regulatory alignment. Moreover, the generalized requirements can directly inform EU-level policy initiatives such as the New Urban Mobility Framework (European Commission, 2021) and the ALICE Roadmap to the Physical Internet (ALICE, 2022), reinforcing the connection between local innovation and European strategy.

The structured approach to requirements analysis therefore represents more than an internal project exercise; it provides a methodological blueprint for other urban innovation initiatives. By combining participatory elicitation, conceptual abstraction, prioritization, and quantitative assessment, the DISCO project demonstrates how local innovations can be translated into generalized, transferable solutions. This is essential for realizing the vision of a European Physical Internet, where urban logistics systems interconnect seamlessly across borders. In this sense, the generalization of requirements is not only a technical necessity but also a strategic contribution to the European agenda on sustainable and interoperable urban mobility.





5. The compatibility assessment as part of the DISCO Meta-Model Suite

The analysis in the previous chapters establishes a clear framework for understanding interoperability between the DISCO-X innovations. This chapter details how that framework is operationalized within the DISCO Meta Model Suite (MMS). The MMS translates the high-level concept of interoperability into a practical, interactive tool that guides a city through a crucial technical compatibility assessment, ensuring that a selected innovation is a viable fit for the city's specific capabilities.

A city's journey through the MMS begins with a two-part assessment to establish its baseline capabilities: the **PI-led Innovation Readiness** questionnaire and the **PI-led Digital Transition and Maturity** questionnaire.

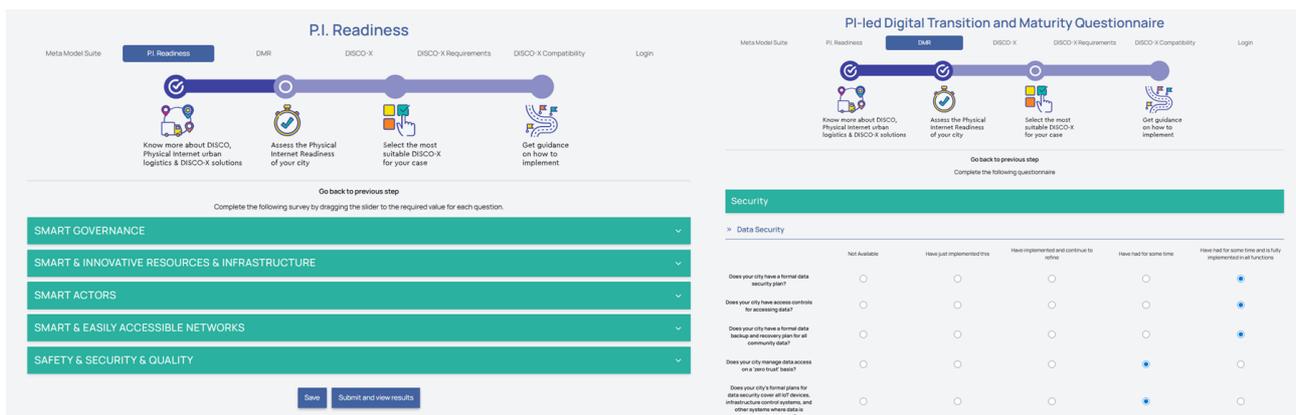


Figure 2: the PI-led Innovation Readiness questionnaire and the PI-led Digital Transition and Maturity questionnaire of the MMS

Based on the city's responses, the MMS's internal logic, informed by the results from the DISCO Living Labs, provides a user-tailored recommendation for the most suitable DISCO-X innovation to pursue. Once a DISCO-X innovation is recommended, the user reaches a critical new stage within the MMS which is the **Interoperability and Technical Compatibility Checkpoint**.

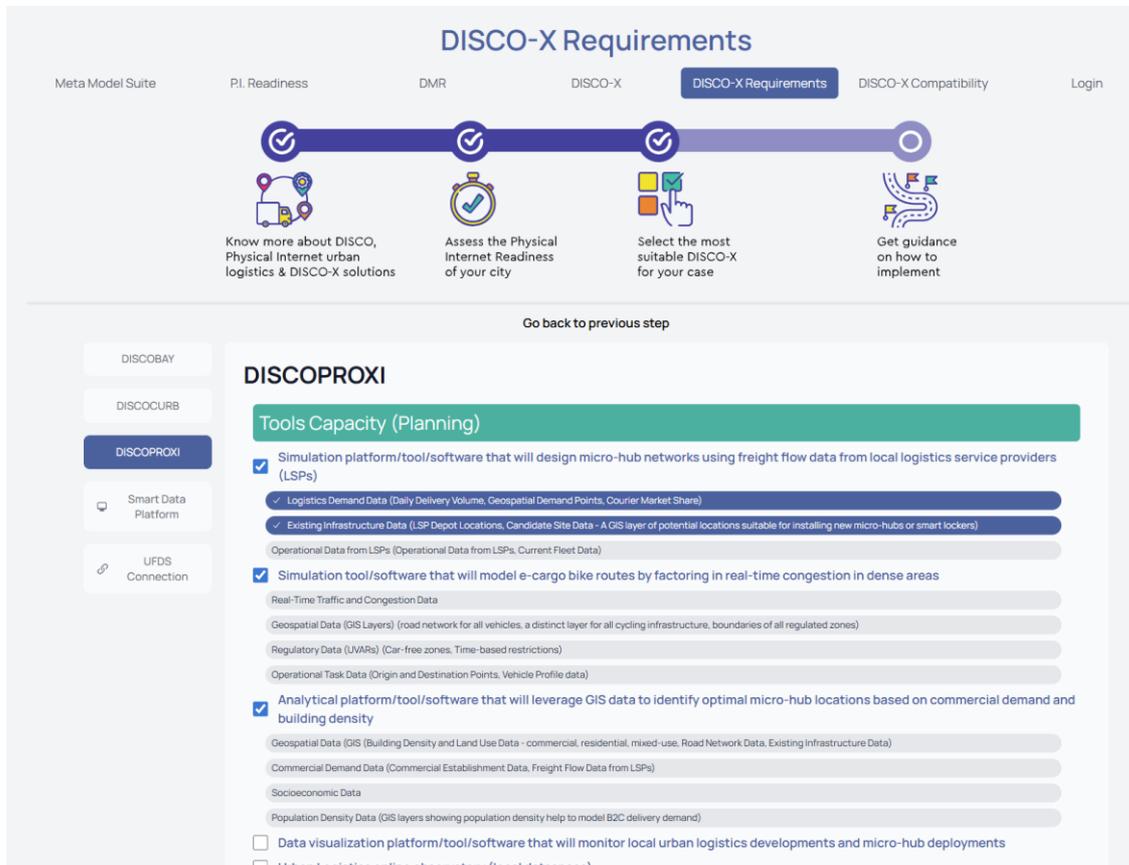


Figure 3: Generalized DISCO-X requirements

This is a significant evolution from the initial requirements outlined in D2.1. The DISCO-X responsible partners have now generalized the requirements for each innovation into a standardized checklist.

The user is presented with a list of specific capacities and requirements needed to successfully deploy the recommended DISCO-X. These are categorized into five key areas:

- **Tools Capacity** (both for planning and operations)
- **The above tools' Data Capacity**
- **Infrastructure Capacity**
- **Regulatory & Policy Capacity**
- **Stakeholder & Business Capacity**

Each requirement in the checklist is pre-classified by the DISCO-X experts as either a **"Must Have"** or a **"Nice to Have."** The user must then perform a self-assessment, checking which of these requirements their city currently satisfies. After the user completes the checklist, the MMS applies a calculation to the responses. This calculation weighs the user's answers against the "Must Have" and "Nice to Have" classifications.

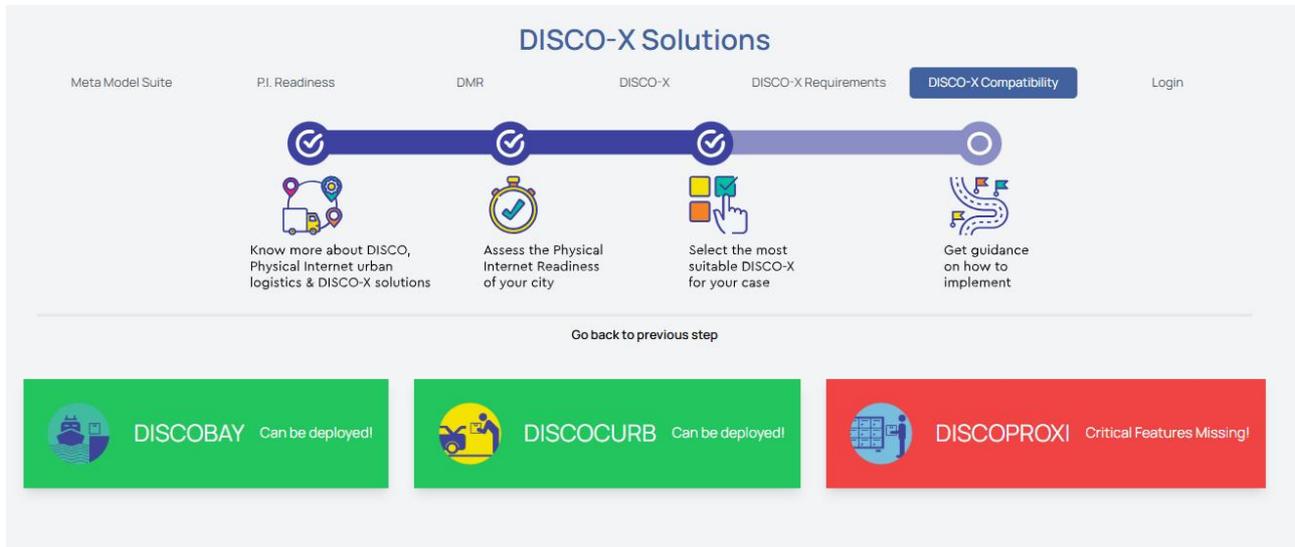


Figure 4: The technical compatibility verdicts step of the MMS

Based on the result of this calculation, the user receives one of two clear, data-driven verdicts:

1. **DISCO-X Can be deployed!** This verdict indicates that the city possesses the critical mass of required capabilities, especially the "Must Have" items, to proceed with a successful implementation.
2. **DISCO-X Critical features missing.** This verdict indicates that the city currently lacks one or more of the essential "Must Have" capabilities. The MMS would then highlight the specific missing components.

The calculation that powers this verdict is based on the principle that each DISCO-X service can be broken down into distinct data features. The following analytical procedure is used:

1. **Identification and Classification of Data Features:** Each service is segmented into its constituent data features (e.g., sensor inputs, geospatial datasets). To capture their relative importance, each feature is categorized as either a **"Must Have"** (essential for core functionality) or a **"Nice to Have"** (useful but not essential).
2. **Assignment of Importance and Weight Calculation:** A numeric importance score (li) is assigned to each category (10 for "Must Have," 1 for "Nice to Have"). These scores are then used to calculate a normalized weight (w_i) for each feature, ensuring the sum of all weights equals 1.0.

$$\sum_{i=1}^n w_i = 1.0$$



3. The formula is:

$$W_i = \frac{I_i}{\sum I_i}, \text{ where } I_i \text{ is the classification importance for feature } I_i.$$

4. **Assessment of Data Feature Availability:** A survey-based procedure assesses if each data feature is available in the target environment, captured as a binary variable (a_i): 1 for Available, 0 for Not Available.
5. **Computation of Technical Compatibility (TC):** The final score is derived by combining the feature weights with their availability. The weighted sum is then rescaled to a five-point scale using the following formula, providing an intuitive and interpretable metric:

$$TC = \left\lceil 5 \cdot \sum_{i=1}^n w_i \cdot a_i \right\rceil$$

TC : Technical Compatibility score

w_i : Normalized weight of feature I_i

a_i : Availability of feature I_i (1 if available, 0 if not)

n : Total number of data features

The ceiling function ensures that the final score is rounded up to the nearest integer on a 1–5 scale

As a next step, these verdicts will be enhanced to provide more detailed guidance. If critical features are missing, the MMS will direct the user to the MMS DISCO-X Tools Library to explore potential solutions and tools that can help them build the missing capacity. Furthermore, it will guide them on how to engage with the DISCO Urban Freight Dataspace through the Smart Data Platform (DISCOLLECTION), enabling them to begin the process of building the necessary data infrastructure for their PI-led transition.



6. Digital Data Infrastructure and Readiness for Interoperability

The establishment of a robust digital data infrastructure is a cornerstone for the transformation of urban logistics into an interoperable, sustainable, and resilient system across Europe. While technological innovations such as micro hubs, digital twins, or multimodal routing platforms provide significant advances in localized efficiency, their true impact depends on the extent to which they are embedded in shared digital ecosystems. Interoperability in this sense cannot be reduced to the mere exchange of information between technical systems; it must encompass semantic, organizational, and governance dimensions. The European Commission has emphasized repeatedly that digitalization and data-sharing form the backbone of the European Green Deal and the Strategy for Sustainable and Smart Mobility (European Commission, 2020). Against this backdrop, the DISCO project positions itself as a testbed for advancing digital readiness and for operationalizing interoperability principles in urban freight.

The first critical element of digital infrastructure readiness is the adoption of standardized data formats and exchange mechanisms. Without common standards, data exchange across cities and platforms remains fragmented, creating barriers to scalability. The experience of the Living Labs shows that while each city has developed its own data systems, differences in structure, semantics, and governance often inhibit integration. To overcome this, DISCO aligns its solutions with established standards such as DATEX II for road traffic and vehicle access regulations and the Alliance for Parking Data Standards (APDS) for curbside management. This mirrors broader research on interoperability, which highlights the necessity of semantic harmonization to ensure that data exchanged across systems carries the same meaning (Chen, Doumeingts & Vernadat, 2008). Furthermore, the project draws on principles from the International Data Spaces Association (IDSA) and Gaia-X, embedding the values of data sovereignty, trust, and federated architectures. In doing so, DISCO anticipates the European ambition of creating sector-specific data spaces, including a Common European Mobility Data Space.

The technical architecture underpinning interoperability readiness must also be resilient, scalable, and secure. Cloud-native infrastructures provide this flexibility by enabling elastic scaling of services and modular integration of new functionalities. Containerization and orchestration tools such as Docker and Kubernetes have become best practices for ensuring that digital platforms remain portable and interoperable across heterogeneous urban environments. Research in information systems highlights that modular and open architectures not only facilitate technical integration but also encourage innovation, as they lower the barriers for new entrants to connect to the system (Janssen, Konopnicki, Snowdon & Ojo, 2017). DISCO's commitment to open APIs and interoperable cloud architectures demonstrates how urban logistics platforms can be designed to evolve in tandem with rapidly changing technologies and policy requirements.



Beyond technical architectures, interoperability readiness demands robust data governance frameworks. Urban logistics involves multiple stakeholders with varying interests and capacities: municipalities, logistics operators, technology providers, and citizens. Ensuring that these actors trust the data infrastructure requires transparent governance structures addressing issues such as ownership, access rights, and responsibilities for data quality. Empirical studies of smart city initiatives have shown that lack of trust and unclear governance are among the main barriers to sustainable data-sharing (Scholl., 2022). DISCO addresses this by aligning its governance practices with the principles of the European Data Governance Act, which seeks to create trust through standardized contractual arrangements, data intermediaries, and certification mechanisms. This governance dimension is essential, as purely technical interoperability will remain underutilized if stakeholders lack confidence in how data is managed and shared.

Interoperability readiness also encompasses the ability of cities to measure and monitor their digital maturity. DISCO contributes to this by developing an assessment framework that evaluates not only technical aspects but also governance, sustainability, and stakeholder engagement. Drawing inspiration from maturity models used in e-government and industry (Lahrmann et al., 2011), the framework allows cities to benchmark their readiness across dimensions such as security, interoperability, energy efficiency, and social responsibility. Such self-assessment is crucial for identifying gaps and prioritizing investments. For example, a city with strong data infrastructures but weak governance processes may need to focus on institutional reforms, while another with robust governance but outdated technical systems may prioritize infrastructure upgrades. In this way, interoperability readiness becomes a dynamic and evolving capability rather than a static achievement.

The integration of environmental and social dimensions into digital infrastructure further strengthens the European relevance of DISCO. Urban logistics systems are not only technical constructs but also critical elements of sustainable urban development. The European Green Deal calls for reducing greenhouse gas emissions by 90% in transport by 2050, and digital infrastructures play a pivotal role in enabling such reductions. Studies have shown that integrated logistics data systems can reduce empty runs, optimize routes, and shift freight to more sustainable modes, thus contributing directly to decarbonisation goals (Allen, Browne & Woodburn, 2012). In parallel, social aspects such as inclusiveness, accessibility, and equity must also be considered. A truly interoperable data infrastructure ensures that data-driven logistics innovations serve not only private operators but also public policy objectives, enhancing quality of life in cities.

Finally, interoperability readiness must be seen in the context of resilience. The COVID-19 pandemic and subsequent supply chain disruptions have illustrated the vulnerability of urban freight systems to external shocks. Research by Ivanov (2022) highlights the importance of integrating resilience into supply chain design through redundancy, agility, and data-driven adaptability. By creating interoperable digital infrastructures that allow real-time re-routing, multimodal switching, and adaptive use of infrastructure, cities can strengthen their ability to



withstand disruptions. DISCO's work on digital twins and predictive analytics illustrates how interoperability readiness contributes not only to efficiency and sustainability but also to resilience, ensuring that European urban logistics systems remain viable under uncertainty.

In conclusion, the expansion of digital data infrastructures and the advancement of interoperability readiness are indispensable for achieving the European objectives of sustainable, smart, and resilient urban logistics. By adopting standardized data formats, building modular and cloud-native architectures, developing governance frameworks aligned with EU regulation, and embedding assessment tools for digital maturity, the DISCO project provides a blueprint for cities across Europe. Interoperability readiness must be understood as a socio-technical achievement, requiring alignment of technology, governance, policy, and societal goals. By demonstrating how these dimensions can be combined in practice, DISCO contributes to the realization of a European Physical Internet, positioning urban freight as a driver of digital and sustainable transformation at continental scale.



7. Compliance with EU Interoperability Standards

Interoperability has become a central priority for the European Union in its ambition to create a digital single market and to foster cross-border, sustainable, and resilient mobility systems. Within the domain of urban freight and logistics, interoperability does not merely refer to the technical capacity of systems to exchange data, but extends to semantic, organizational, and governance layers that ensure common understanding, trust, and coordinated action. The EU's long-term vision, expressed in initiatives such as the European Green Deal, the Sustainable and Smart Mobility Strategy, and the European Interoperability Framework, makes clear that local innovations must be designed to fit into larger federated architectures and data spaces (European Commission, 2017; European Commission, 2020). In this context, the DISCO project must demonstrate that its solutions are not isolated prototypes but are compatible with, and actively contribute to, the evolving European digital ecosystem.

The European Interoperability Framework (EIF) provides the most comprehensive guidance on how digital services across the Union should be designed to ensure cross-border compatibility. The EIF stresses that interoperability has four interlinked layers: legal, organizational, semantic, and technical. Legal interoperability requires that different jurisdictions harmonize their regulatory frameworks to enable mutual recognition of data and transactions. Organizational interoperability emphasizes the alignment of processes and responsibilities across actors and institutions. Semantic interoperability ensures that information exchanged retains the same meaning across contexts, while technical interoperability relates to the technical standards and protocols enabling the exchange. The relevance of these layers for urban logistics is clear: booking a curb space, accessing a multimodal hub, or sharing microhub capacity across cities all require more than just data transfer; they demand that the transaction is legally valid, organizationally supported, semantically unambiguous, and technically feasible (Codagnone & Wimmer, 2007). DISCO's solutions need to demonstrate readiness along all four layers if they are to scale beyond pilot implementations.

One of the most critical areas where DISCO aligns with EU standards is in the field of data sovereignty and federated data spaces. The International Data Spaces Association (IDSA) has developed a reference architecture for secure and sovereign data sharing, emphasizing that data providers retain control over usage conditions through enforceable policies (Otto et al., 2021). Similarly, the Gaia-X initiative seeks to create federated European cloud and data infrastructures that ensure transparency, interoperability, and reversibility. By aligning its data-sharing mechanisms with these principles, DISCO not only increases its technological robustness but also its legitimacy in the European policy environment. The ability of DISCO solutions to operate within federated data spaces is key to their future adoption, as cities and logistics operators will only engage if they trust that their data remains secure, private, and compliant with European values.



Another cornerstone of EU interoperability lies in the Connecting Europe Facility (CEF) building blocks, which provide reusable digital services for secure and standardized cross-border interactions. Components such as eDelivery, eID, and eSignature are designed to ensure that transactions conducted digitally are both trustworthy and legally binding across Member States. Their relevance for urban logistics is significant: booking a delivery time window in one city, contracting temporary use of a building for logistics purposes, or exchanging freight-related documents between municipalities and operators all require secure digital transactions. Research on digital trust highlights that without mechanisms ensuring authenticity, integrity, and legal enforceability, digital services fail to achieve widespread adoption (Meijer, Lips & Chen, 2019). The implementation of CEF building blocks in DISCO solutions will therefore not only ensure compliance but also support market acceptance and long-term scalability.

The emphasis on interoperability also directly supports the ambition of the European Physical Internet, a concept promoted by ALICE, the European Technology Platform for logistics. The Physical Internet envisions logistics systems where data, services, and infrastructures interconnect seamlessly across modes and borders, much like information flows through the digital Internet (Montreuil, 2011). Achieving this requires harmonized standards for describing logistics assets, services, and transactions. DISCO contributes to this ambition by ensuring that its solutions use open and standardized data models such as DATEX II for traffic and access regulation data, APDS for curbside management, and other emerging standards relevant to urban freight. By avoiding proprietary, city-specific solutions and instead embracing open standards, DISCO paves the way for integration into larger European logistics networks. Academic work on standardization has shown that open standards not only enable interoperability but also create competitive markets and spur innovation (Hanseth, Monteiro & Hatling, 1996). Thus, DISCO's alignment with EU interoperability standards is also a driver of innovation and market growth.

From a governance perspective, interoperability is as much about institutional arrangements as it is about technology. Research on digital government emphasizes that interoperability initiatives often fail when they overlook the organizational and cultural barriers between actors (Scholl, 2022). In the context of urban logistics, this means that cities, logistics companies, property owners, and technology providers must align their practices and incentives. DISCO supports this by embedding governance requirements directly into its solutions, for example through mechanisms for cost-sharing, regulatory compliance, and public-private partnerships. By designing its tools to respect governance complexity and to support collaborative arrangements, DISCO reflects the EU's insistence on socio-technical alignment as part of interoperability readiness.

The European regulatory environment is also increasingly emphasizing trust and accountability in digital transactions. The eIDAS regulation on electronic identification and trust services is particularly relevant for the types of digital contracts envisioned in DISCO solutions, such as renting a space through DISCOESTATE or reserving access to multimodal hubs. The ability to execute legally binding digital transactions across borders ensures that such services can scale and



be adopted widely. Empirical research on e-government adoption confirms that the availability of secure identification and trust services is one of the main drivers of user acceptance (Carter & Bélanger, 2005). DISCO's future integration with eIDAS services will thus be critical for its credibility and uptake.

Finally, the conformity of DISCO with EU interoperability standards must be understood as a dynamic process rather than a static condition. Standards, frameworks, and regulatory instruments continue to evolve, and projects such as DISCO must remain adaptable to stay aligned. The lessons from Living Labs show that cities are at different levels of readiness, and the path to interoperability is uneven. However, by embedding European standards at the core of its design, DISCO increases the likelihood that its solutions will remain relevant and compliant as EU policies advance. Moreover, by demonstrating concrete use cases of EU interoperability principles in action, DISCO provides valuable evidence that can inform future policymaking and standardization efforts.

In summary, conformity with EU interoperability standards is not a mere compliance exercise for the DISCO project; it is a strategic enabler of scalability, trust, and policy alignment. By aligning with the European Interoperability Framework, embracing federated data space principles from IDSA and Gaia-X, integrating CEF building blocks, and preparing for eIDAS-compliant digital transactions, DISCO ensures that its solutions are embedded in the broader European digital ecosystem. This positioning enhances their long-term sustainability, supports the realization of the European Physical Internet, and demonstrates how local innovations can contribute to continental policy goals. For the EU, DISCO serves as a living example of how urban logistics innovations can be both locally impactful and fully interoperable at the European scale.

7.1. International Data Spaces Association (IDSA)

The IDSA framework is designed to enable secure, cross-organizational data exchange while guaranteeing data sovereignty for the data owner. This is achieved through the IDS Reference Architecture Model (RAM), which specifies a set of roles, processes, and core technical components, most notably the IDS Connector, to enforce data usage policies at a technical level. The DISCO architecture aligns with the foundational principles of IDSA. This is explicitly demonstrated in the requirements for the DISCOLLECTION service, where "secure and interoperable data exchange under IDSA or similar standards" is classified as a "Must Have" feature. Operationally, this is implemented through secure, consent-based data sharing protocols using REST APIs with token-based authentication and OAuth2 mechanisms. However, the current implementations in the Living Labs do not utilize the specific IDS Connector component for granular, technically enforced data usage control. Instead, access control is managed at the API gateway and application level. Therefore, the compliance is at a principled and protocol level rather than a full architectural implementation of the IDS-RAM.



7.2. Gaia-X Federation Services

Gaia-X aims to create a federated, secure, and sovereign data infrastructure for Europe by establishing a set of rules, policies, and specifications that allow existing services to interoperate. The technical backbone of this ecosystem is a decentralized network of **Gaia-X Federation Services (GXFS)**, which manage identity, compliance, and cataloguing functions to ensure trust and interoperability among participants.

The DISCO-X solutions are designed with the Gaia-X goals of cloud interoperability and self-sovereign data governance in mind. The architecture supports data portability through the use of standardized data formats (e.g., JSON-LD, GeoJSON) and open APIs. However, the current deployment models within the Living Labs do not constitute a Gaia-X federation. For instance, the Thessaloniki dataspace operates as a centralized hub, and the Copenhagen digital twins remain siloed due to commercial constraints. While the services are architecturally *ready* for a federated environment, they do not yet leverage core GXFS components like the Federated Catalogue or Organisation Credential Manager for cross-ecosystem discovery and trust.

7.3. Connecting Europe Facility (CEF) Building Blocks

The CEF provides a suite of reusable digital service infrastructures designed to facilitate cross-border services. For the logistics domain, two building blocks are particularly relevant for future scaling of the DISCO-X services:

- **eDelivery:** This building block utilizes the **AS4 messaging protocol** to create a secure and reliable network for exchanging electronic documents. For DISCO, this would enable the replacement of paper-based B2A and B2B processes (e.g., transport orders, regulatory filings) with standardized, auditable digital exchanges.
- **eID:** This component enables secure cross-border electronic identification for individuals and businesses, based on the eIDAS regulation. In a scaled DISCO ecosystem, eID would provide a standardized and reliable method for authenticating all participants (e.g., LSPs, municipal authorities, hub operators), forming a critical trust foundation.

While full technical integration of these building blocks was not part of the initial pilot phase, the DISCO Meta Model Suite is designed to incorporate them in future iterations to enhance B2A and B2B interoperability.

7.4. eIDAS (electronic IDentification, Authentication and trust Services)



The eIDAS Regulation provides a predictable legal framework for electronic transactions, ensuring that electronic signatures, seals, and timestamps have the same legal standing as their paper-based equivalents. This framework is not directly applicable to the current operational data exchanges within the DISCO pilots. However, it is of critical importance for the future commercial scaling of DISCO-X solutions that involve legally binding transactions. For services like DISCOCURB (booking and payment for loading slots) and DISCOESTATE (short-term space usage contracts), the integration of eIDAS-compliant Qualified Trust Services would be essential to ensure the legal validity of digital agreements and provide the non-repudiation required for robust, cross-border commercial operations.



7.5. Compliance Summary Table

The following table provides a consolidated overview of the compliance level of the DISCO-X service suite against the identified interoperability criteria.

Table 6: DISCO-X services compliance summary table

Interoperability Framework	Core Technical Principle/Component	Relevant DISCO-X Service(s)	Compliance Level & Justification
IDSA	Data Sovereignty & Consent	DISCOLLECTION, DISCOBAY	Principled Alignment: The architecture enforces consent-based sharing via secure APIs, fulfilling a "Must Have" requirement. Data sovereignty is a guiding design principle.
IDSA	Technical Usage Control	DISCOLLECTION, DISCOBAY	Partial Implementation: Data usage is controlled at the API and application layers. The specific IDS Connector for granular policy enforcement is not implemented.
Gaia-X	Federated Architecture	All DISCO-Xs	Architecturally Prepared: The services are modular and use open standards, making them suitable for a federated environment. However, current deployments are either centralized or siloed, not federated via GXFS.
Gaia-X	Data Portability	All DISCO-Xs	Implemented: Use of standardized formats (JSON-LD, GeoJSON) and documented OpenAPI 3.1 schemas ensures a high degree of data portability.
CEF	Secure Document Exchange (eDelivery)	DISCOLLECTION, DISCOBAY	Future Integration: The architecture is designed to incorporate the AS4 protocol for future B2A/B2B document exchange, but it is not part of the current implementation.
eIDAS	Trusted Participant Identity (eID)	All DISCO-Xs	Future Integration: Cross-border participant authentication via eID is identified as a key enabler for scaling but is not implemented in the pilots.
eIDAS	Legally Binding Transactions (Trust Services)	DISCOCURB, DISCOESTATE	Future Integration: Qualified Trust Services (e.g., eSignatures) are not used at present but are necessary for future commercial scaling involving binding digital contracts.



8. Conclusion

This report presents a comprehensive framework to enable interoperability, scalability, and reusability of modular urban logistics services across European cities. Drawing on insights from real-world implementations in Thessaloniki, Helsinki, Ghent, and Copenhagen, it outlines how functional requirements can be harmonized, digital architectures aligned, and cross-city integration achieved through a structured methodology and federated infrastructure.

At the core of the approach is a systematic classification of service requirements into “Must Have” and “Nice to Have” features. These are weighted to reflect their functional relevance and aggregated into a Technical Compatibility score. This metric provides a transparent and comparable means of assessing whether a given solution can be deployed in a specific urban context, considering both technological readiness and institutional frameworks. The classification process was conducted in close collaboration with local stakeholders to ensure practical relevance.

The document also presents applied interoperability scenarios based on Living Lab implementation of measures, demonstrating how individual services—such as micro-hub coordination, curbside management, temporary logistics real estate, multimodal distribution, and freight data collection—can be combined within a shared digital ecosystem. Examples include the integration of real-time curb occupancy data with dynamic micro-hub routing in Helsinki, or the synchronization of building repurposing tools with multimodal logistics scheduling in Thessaloniki. These scenarios highlight both technical synergies and policy alignment potentials.

In parallel, the analysis addresses the alignment of digital infrastructures with key European frameworks such as the International Data Spaces Association, GAIA-X, and the CEF Building Blocks. Common data models, open API schemas, and semantic standards (e.g. DATEX II, APDS) are presented as the backbone for modular integration. The architecture includes a Meta Model Suite and a Digital Transition Assessment Tool, which help cities evaluate their digital maturity and identify pathways for transformation.

To ensure coherence across the project, the interoperability scoring system is linked with the evaluation dashboards of other work packages, allowing unified monitoring of implementation progress, technical readiness, and replication potential.

In essence, this work underscores that interoperability is not merely a technical feature, but a strategic capability. It enables cities to design and deploy flexible, data-driven logistics systems that are compatible with local needs while remaining connected to a wider European vision of sustainable, intelligent urban freight ecosystems.



References

- Allen, J., Browne, M., & Woodburn, A. (2012). The London freight data report 2012. Transport for London. <https://westminsterresearch.westminster.ac.uk/item/w359x/warehousing-in-the-uk-operations-planning-and-decarbonisation-full-briefing-report>
- Alliance for Logistics Innovation through Collaboration in Europe. (2022). Roadmap to the Physical Internet. ALICE ETP. (https://www.etp-logistics.eu/wp-content/uploads/2022/11/Roadmap-to-Physical-Internet-Executive-Version_Final-web.pdf)
- Alliance for Parking Data Standards. (2025). APDS specification. Retrieved October 7, 2025, from <https://allianceforparkingdatastandards.org/specifications/>
- Ballot, E., Montreuil, B., & Meller, R. D. (2014). The Physical Internet: The network of logistics networks. La Documentation Française. (Accessed: https://www.researchgate.net/publication/265595072_The_Physical_Internet)
- Beck, K., Beedle, M., van Bennekum, A., Cockburn, A., Cunningham, W., Fowler, M., Grenning, J., Highsmith, J., Hunt, A., Jeffries, R., Kern, J., Marick, B., Martin, R. C., Mellor, S., Schwaber, K., Sutherland, J., & Thomas, D. (2001). Manifesto for agile software development. Agile Alliance. <https://www.researchgate.net/profile/Godfried-Adaba/post/Looking-for-papers-on-the-software-development-process-Any-recommendations-will-be-appreciated/attachment/59d639e579197b8077997172/AS%3A403742915612673%401473271220194/download/Manifesto+of+Agile+Software+Development.pdf>
- Carter, L., & Bélanger, F. (2005). The utilization of e-government services: Citizen trust, innovation and acceptance factors. *Information Systems Journal*, 15(1), 5–25. <https://doi.org/10.1111/j.1365-2575.2005.00183.x>
- Chen, D., Doumeingts, G., & Vernadat, F. (2008). Architectures for enterprise integration and interoperability: Past, present and future. *Computers in Industry*, 59(7), 647–659. <https://doi.org/10.1016/j.compind.2007.12.016>
- Crainic, T. G., Klibi, W., & Montreuil, B. (2023). Hyperconnected city logistics: A conceptual framework. In E. Marcucci, V. Gatta, & M. Le Pira (Eds.), *Handbook on City Logistics and Urban Freight* (pp. 398–421). Edward Elgar Publishing. <https://doi.org/10.4337/9781800370173.00032>
- Eitel, A., Jung, C., Brandstädter, R., Korth, B., Bader, S., Böhm, C., Nagel, L., Steinbuß, S., Wowra, J., Qarawlus, H., Schüßler, J., & Wolf, J. H. (2021). Position paper: Usage control in the International Data Spaces (Version 3.0). International Data Spaces Association.



<https://internationaldataspaces.org/wp-content/uploads/2021/04/IDS-Position-Paper-Usage-Control-3.0.pdf>

European Commission. (2017). European Interoperability Framework – Implementation Strategy (COM(2017) 134 final).(<https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52017DC0134>)

European Commission. (2020). Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions: Sustainable and Smart Mobility Strategy – putting European transport on track for the future (COM(2020) 789 final).(<https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52020DC0789>)

European Commission. (2021). Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions: The New EU Urban Mobility Framework (COM(2021) 811 final).(<https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52021DC0811>)

European Committee for Standardization. (2020). Intelligent transport systems - DATEX II data exchange specifications for traffic management and information - Part 8: Traffic management publications and extensions dedicated to the urban environment (CEN/TS 16157-8:2020).

Gaia-X European Association for Data and Cloud AISBL. (n.d.). About us. Retrieved October 7, 2025, from <https://gaia-x.eu/about/>

Hanseth, O., Monteiro, E., & Hatling, M. (1996). Developing information infrastructure: The tension between standardization and flexibility. *Science, Technology, & Human Values*, 21(4), 407–426. <https://doi.org/10.1177/016224399602100402>

Imec. (2025). A blueprint for the Physical Internet. Physical Internet Living Lab Project.(<https://www.imec-int.com/sites/default/files/2025-03/A-Blueprint-for-the-Physical-Internet.pdf>)

International Data Spaces Association. (2022). IDS reference architecture model. GitHub. Retrieved October 7, 2025, from(<https://github.com/International-Data-Spaces-Association/idsa>)

Ivanov, D. (2022). Viable supply chain model: Integrating agility, resilience and sustainability perspectives—lessons from and thinking beyond the COVID-19 pandemic. *Annals of Operations Research*, 319(1), 1411–1431. <https://doi.org/10.1007/s10479-020-03640-6>

Janssen, M., Konopnicki, D., Snowdon, J. L., & Ojo, A. (2017). Driving public sector innovation using big and open linked data. *Information Systems Frontiers*, 19(2), 189–195. <https://doi.org/10.1007/s10796-017-9746-2>



- Lahrman, G., Marx, F., Winter, R., & Wortmann, F. (2011). Business intelligence maturity: Development and evaluation of a theoretical model. In Proceedings of the 44th Hawaii International Conference on System Sciences (pp. 1–10). IEEE.
<https://doi.org/10.1109/HICSS.2011.90>
- Meijer, A. J., Lips, M., & Chen, K. (2019). Open governance: A new paradigm for understanding urban governance in an information age. *Frontiers in Sustainable Cities*, 1, Article 3.
<https://doi.org/10.3389/frsc.2019.00003>
- Montreuil, B. (2011). Toward a Physical Internet: Meeting the global logistics sustainability grand challenge.
- Scholl, H. J. (2022). Digital government research: A diverse domain. In L. Carter, M. Janssen, L. F. Luna-Reyes, & H. J. Scholl (Eds.), *Scientific foundations of digital governance and transformation* (pp. 37–56). Springer Cham. https://doi.org/10.1007/978-3-030-92945-9_3
- Wimmer, M. A., Codagnone, C., & Ma, X. (2007). Developing an e-government research roadmap: Method and example from E-GovRTD2020. In M. A. Wimmer, H. J. Scholl, & Å. Grönlund (Eds.), *Electronic Government (Lecture Notes in Computer Science, Vol. 4656, pp. 1–12)*. Springer. https://doi.org/10.1007/978-3-540-74444-3_1



Appendix 1: Weighted and classified Requirements

In the further course of the project, it became clear that the previously defined requirements for the DISCO-X solutions need to be generalized. This will allow for better interoperability. The classification of the requirements into "Must have" and "Nice to have" was carried out by the Living Lab partners. Below, the classified and weighted requirements of the different DISCO-X solutions are presented in tabular form.



DISCOCURB	Classification	Importance	Weight
Simulation platform/tool/software that will predict peak loading times at the city center	Nice to have	1	0,009803922
Simulation tool/software that will integrate real-time traffic data (using open-source GIS layers) to model curb usage scenarios	Nice to have	1	0,009803922
Virtual simulation tool/software that will facilitate planning and simulating curb-space scenarios and parking constraints	Nice to have	1	0,009803922
Analytical platform/tool/software that will map and prioritize curb spaces, aligning with cycling infrastructure	Nice to have	1	0,009803922
Operational tool/software that will manage booking and dynamic scheduling of loading/unloading slots in real time	Must have	10	0,098039216
Mobile application/tool/software that will deliver live sensor and camera-based monitoring of curb occupancy	Must have	10	0,098039216
Operational platform/tool/software that will handle the allocation, payment, and management of curb space usage	Must have	10	0,098039216
Automated detection tool/software that will identify vehicles misusing loading bays via sensors and cameras	Must have	10	0,098039216
Real-time parking occupancy data	Must have	10	0,098039216
Integration of sensor, traffic, and environmental data	Nice to have	1	0,009803922
City Geospatial Data	Must have	10	0,098039216
Land Use Data	Nice to have	1	0,009803922
Urban Logistics demand and transport operations data (company data)	Nice to have	1	0,009803922
Sensors/cameras at loading zones to detect occupancy	Must have	10	0,098039216
Digital signage that shows available loading spots, integrated with a city traffic control center	Nice to have	1	0,009803922
Time-based or vehicle-type-based curb restrictions to prioritize zero-emission freight.	Must have	10	0,098039216
Integration with Low-Emission Zones (LEZ)	Nice to have	1	0,009803922
Potential introduction of curb usage fees at peak hours for non-compliant vehicles	Nice to have	1	0,009803922



Collaboration among city authorities, parking operators, freight carriers, retailers	Must have	10	0,098039216
Potential cost-sharing or subscription-based curb usage model	Nice to have	1	0,009803922
Partnerships for joint investment in sensor infrastructure	Nice to have	1	0,009803922



DISCOESTATE	Classification	Importance	Weight
Simulation platform/tool/software that will model underutilized municipal or private spaces in 3D for testing logistics conversion scenarios	Nice to have	1	0,00724638
Analytical software/tool that will assess real-estate availability for short-term logistics usage near city ring roads, integrating building code data	Nice to have	1	0,00724638
Digital platform/tool/software that will match property owners with last-mile freight operators for temporary space usage	Must have	10	0,07246377
Operational tool/software that will track real-time building occupancy and manage timeslot usage among multiple logistics service providers (LSPs)	Must have	10	0,07246377
Operational tool/software that will trigger alerts when building spaces become available for short-term logistics usage near high-demand areas	Nice to have	1	0,00724638
Operational dashboard/tool/software that will oversee arrivals, departures, and overall building capacity management during logistics operations	Must have	10	0,07246377



Inventory data, warehouse occupancy, and delivery/replenishment schedules	Must have	10	0,07246377
Structural, safety, and regulatory compliance data	Nice to have	1	0,00724638
APIs that match available real-estate with short-term logistics needs (e.g., WMS queries).	Must have	10	0,07246377
Building occupancy data, structural stability (to ensure load-bearing capacity), and usage scheduling to avoid occupant conflicts.	Must have	10	0,07246377
Product Data: Volumes / Delivery time / Delivery restrictions, in case / Type of products (palletized, bulk, dangerous, dimensions, etc.)	Must have	10	0,07246377
Everyone who participate in DISCOESTATE should use the same standard label .	Must have	10	0,07246377
Underused municipal or private buildings (exhibition centers, warehouses) with basic logistics infrastructure (ramps, loading docks).	Nice to have	1	0,00724638
IT and communication infrastructure to support building repurposing	Nice to have	1	0,00724638



Security and Access Control Systems	Must have	10	0,07246377
Network connectivity (Wi-Fi/5G) for real-time occupancy tracking	Must have	10	0,07246377
Temporary repurposing regulations to speed up building usage changes (e.g., pilot programs)	Nice to have	1	0,00724638
Safety codes for multi-tenant usage (fire exits, building code compliance)	Must have	10	0,07246377
Tax or permit incentives to encourage property owners to allow short-term logistics usage	Must have	10	0,07246377
Partnerships with building owners, real estate investors, and municipal authorities	Must have	10	0,07246377
Municipalities creating one-stop permits to reduce red tape/bureaucratic delays	Nice to have	1	0,00724638



DISCOLLECTION	Classification	Importance	Weight
Analytical platform/tool/software that will model and forecast city/regional cargo trends on a daily/weekly basis	Nice to have	1	0,027027027
Predictive analytics tool/software that will identify the peak cargo demand windows for dynamic access control	Nice to have	1	0,027027027
Integration platform/tool/software that will update and integrate new data from LSP partners into the Sulp framework	Nice to have	1	0,027027027
Operational data visualization tool/software that will aggregate live feeds on vehicle locations, warehouse occupancy, and curb availability for integrated monitoring	Nice to have	1	0,027027027
Operational tool/software that will integrate data from various sensors and provide operational insights into traffic, route performance, and facility usage	Nice to have	1	0,027027027
Automated operational tool/software that will detect anomalies in route performance and automatically adjust driver instructions in real time	Nice to have	1	0,027027027



Operational tool/software that will monitor real-time occupancy of shared warehouse facilities used by multiple LSPs	Nice to have	1	0,027027027
Vehicle tracking (GPS) + sensor data on traffic flow, curb usage, warehouse occupancy	Nice to have	1	0,027027027
Historical datasets for predictive modeling of peak periods (weekdays, holiday seasons)	Nice to have	1	0,027027027
Anonymized LSP data ensuring compliance with GDPR and IDS-based secure sharing	Nice to have	1	0,027027027
IoT sensor array for collecting data on curb usage, port operations, route analytics	Nice to have	1	0,027027027
City-run or private data centers hosting shared data services, with high security standards	Nice to have	1	0,027027027
Data-sharing regulations that allow city authorities to request anonymized real-time data from LSPs	Nice to have	1	0,027027027
Requirements for secure and interoperable data exchange under IDSA or similar standards	Must have	10	0,27027027
Mechanisms to handle privacy (GDPR compliance) and liability for real-time routing or dynamic access decisions	Nice to have	1	0,027027027
Partnerships with tech providers for data-driven dashboards and route optimization	Nice to have	1	0,027027027



Engagement with municipal transport departments to coordinate dynamic vehicle access	Nice to have	1	0,027027027
Business models focusing on subscription or pay-per-route fees for real-time intelligence	Nice to have	1	0,027027027
Integration into a federated data and service ecosystem for seamless operations across cities	Must have	10	0,27027027



DISCOBAY	Classification	Importance	Weight
Simulation platform/tool/software that will optimize warehouse floor plans, capacity, and material flow	Nice to have	1	0,00729927
Analytical platform/tool/software that will evaluate rail/water connectivity and identify potential cross-dock points outside the city center	Must have	10	0,072992701
Operational tool/software that will allow on-demand scheduling of deliveries at shared or newly designated warehouse/consolidation sites	Must have	10	0,072992701
Operational system/tool/software that will integrate scheduling across short-sea shipping, rail, and last-mile distribution services	Must have	10	0,072992701
Operational application/tool/software that will enable real-time coordination of goods between inbound and outbound flows, including zero-emission last-mile vehicles	Nice to have	1	0,00729927
Shared warehouse occupancy monitoring platform in case of shared operations under the same transport infra	Nice to have	1	0,00729927
Inventory data, warehouse occupancy, and delivery/replenishment schedules	Must have	10	0,072992701
Multimodal transport timetables (rail, water, road) to align inbound/outbound flows	Must have	10	0,072992701



Shared warehouse occupancy data among multiple LSPs	Nice to have	1	0,00729927
Connectivity to city/regional freight data bases/spaces/lakes to identify major shipping routes	Must have	10	0,072992701
Large / shared distribution centers or smaller consolidation nodes near the city borders	Must have	10	0,072992701
Infrastructure to handle multimodal freight transitions (rail ↔ truck, water ↔ truck, etc.)	Must have	10	0,072992701
In/out scanning hardware to manage inventory in real time	Nice to have	1	0,00729927
City or regional policies encouraging shared distribution facilities among LSPs	Must have	10	0,072992701
Potential public funding or co-financing for multi-modal hubs (especially if tied to emissions reductions)	Must have	10	0,072992701
Compliance with warehousing standards and urban planning guidelines	Must have	10	0,072992701
Coordination with national railway or port authorities for facility usage approvals.	Nice to have	1	0,00729927
Warehouse operators partnering with LSPs to share capacity	Must have	10	0,072992701
Collective agreements among 3PLs, carriers, or retailers to use a single distribution center	Nice to have	1	0,00729927



Potential involvement of railway or port authorities for smoother multi-modal integration (especially in Thessaloniki or Copenhagen)

Must have

10

0,072992701



Appendix 2: Data Collection Sheet

Thessaloniki Data Collection Sheet

Question / Description	Expected Data	DISCOPROXI	DISCOESTATE	DISCOBAY
Short description of the purpose of Disco-X measures in general	Summary	Introduces shared parcel lockers and proximity-based micro-hubs for last-mile deliveries. These hubs can reduce delivery fragmentation and increase efficiency by placing lockers or micro-hubs close to end users, such as at urban corners or residential areas. <i>The measure demonstrates the facilitation of smart lockers in strategically positioned public space locations to pave the way for them to be utilized by multiple last mile delivery companies.</i>	Focuses on the retrofitting and dynamic use of underutilized building spaces, such as commercial or residential properties, to act as temporary logistics hubs. This measure addresses the scarcity of affordable urban space for logistics activities.	Uses multimodal transport hubs (e.g., metro stations, railway stations, waterways) to consolidate last-mile deliveries, focusing on using green modes of transport such as electric vehicles and bicycles for final delivery stages.



Description of Disco-X solution as implemented in the LL	Summary/Description	<p>To demonstrate innovative business models and services for free space use, by adopting smart contracts. The city community aims to enrich with blockchain the WareM&O (Warehouse as a Service) community platform solution which already integrates a fair pricing algorithm for facilitating business agreements in WaaS. The resulting flexible and improved space management will better serve e-commerce needs, resulting in a mitigation of the negative effects on quality of life and operations. It will be done by a) identifying strategically positioned proximity areas as off-road places dedicated to L/U nearby destinations to reduce vehicle trips; and b) adopting innovative business models and services for free space utilisation with smart contracts.</p> <p>[SOURCE: DISCO Grant Agreement]</p>	<p>To demonstrate temporary/multipurpose and optimal use of strategically positioned buildings at the TIF HELEXPO Exhibition Centre as a logistics hub (when events aren't taking place) to operate with shared transport and logistics facilities (e.g., freight hotels) and their optimization through smart solutions and tools and green last mile solutions.</p> <p>[SOURCE: DISCO Grant Agreement]</p>	<p>To map underused infrastructure to be used as freight hotels and enrich the WaaS data space with other unexploited areas and land available and managed by the municipality to create an integrated space availability observatory for Thessaloniki.</p> <p>[SOURCE: DISCO Grant Agreement]</p>
		HIT/CERTH's Optimal Facility Location model, WareM&O by DISCOPROXI & DISCOESTATE	WareM&O by DISCOPROXI & DISCOESTATE	Logistics Real Estate Database



Short description of the specific Platform/Solution	Summary/Description	<p>What is WareM&O by DISCOPROXI about: A demand matching platform for warehousing needs where an operator can find available locations with free capacity to perform logistics operations. The warehouse-free space owners can add their spaces with defined availabilities in the platform and accept or reject the requests from the operators until they reach to an agreement to start performing logistics operations.</p> <p>Optimal Number of Lockers/ Planning Tool: The tool utilizes home delivery data and locker preference discrete choice model along with physical constraints (locker capacity) to optimize the locker location on a given area considering a set of location candidates and choosing the optimal subset.</p>	<p>The DISCOESTATE measure in Thessaloniki is the operational marriage between the Logistics Operator (ACS – Courier Service) and TIF-Helexpo. ACS migrated one of their most important branches from the historical centre of Thessaloniki to TIF-Helexpo premises. The whole process took place using the WareM&O platform.</p>	<p>The Thessaloniki Logistics Real Estate Database is an online platform that acts as an observatory for warehouse spaces, lockers and shops in the city of Thessaloniki, as well as the logistics demand and the "who is who" information along with detailed insights regarding the local businesses needs for last mile and loading/unloading operations.</p>
URL of the Solution	URL	http://waremo.tredit.gr:8084/vfc/home	https://uldthess.imet.gr/	https://uldthess.imet.gr/
Recent progress of the solution. Updates to scope or functionalities that differ from deliverables	Text/Location of Progress Material	Completed smart contract feature.	Completed smart contract feature.	Added extra insights for all municipal districts.
Current status of implementation	Text	Pilot Phase	Pilot Phase	Pilot Phase
Is there overlap or integrations to other solutions	Text	DISCOESTATE	DISCOPROXI	DISCOESTATE/DISCOPROXI



<p>What types of data (e.g., warehouse capacity, traffic flows, space utilization) are generated or consumed?</p>	<p>List with detailed descriptions</p>	<p>WareM&O: Warehouse Location, Warehouse Availability, Lockers dataset, Locations that are identified by the Municipality to facilitate a shared locker in the public spaces of Thessaloniki’s Municipality, Sanitary Interest Shops Dataset (Includes 1,600+ establishments categorised into three main types (Super Markets, HoReCa, Mini Markets)),</p> <p>Optimal Number of Lockers/ Planning Tool: Home delivery data, choice model data, locker candidates, final number of lockers.</p>	<p>WareM&O by DISCOPROXI & DISCOESTATE data: warehouse_id, name, type, business activity, website, description, x_coordinate, y_coordinate, date_created, date_edited, compartment_id, name, capacity_type, capacity_area, capacity_pallets, max_pallet_height, max_pallet_weight, date_created, date_edited, Compartment_id, date_from, date_to, capacity_area, capacity_pallets, min_price_per_square_meter, min_price_per_pallet</p>	<p>GAIA OSE Real Estate Registry: Warehouse Location, Warehouse capacity, Courier Demand Data – Dataset: ACS’ Daily routes and modal split from a courier service representing 33% of the Thessaloniki market, OSM – Dataset: Network data, Additional Data – Dataset: ACS’ Modal split percentages, vehicle capacities, and emissions factors.</p>
<p>Is this data publicly available?</p>	<p>Yes/No</p>	<p>For WareM&O: Yes, For Optimal Number of Lockers/ Planning Tool: No</p>	<p>Yes</p>	<p>Some of the data is publicly available, others are private</p>
<p>What is the exact format of the data generated/consumed (e.g., JSON, GeoJSON, CSV, etc.)? Include any formatting specifics, such as schema or API structure.</p>	<p>Data Format + Description</p>	<p>JSON</p>	<p>JSON</p>	<p>JSON</p>
<p>How is the data accessed? Include details on the system or API used to access data (e.g., REST API, data export, or real-time streaming).</p>	<p>Description with Access Methods</p>	<p>REST API</p>	<p>REST API</p>	<p>REST API</p>



Indicate if data is read / write.				
	URL or Location	https://uldthess-api.imet.gr/docs#/Shops/get_shops_api_v1_moth_shops_get	https://uldthess-api.imet.gr/docs#/Shops/get_shops_api_v1_moth_shops_get	https://uldthess-api.imet.gr/docs#/Shops/get_shops_api_v1_moth_shops_get
	Description of Data			
	How often is the data updated? Provide specific times (e.g., real-time, every 15 minutes, hourly, daily, monthly).	WareM&O: near real time, Optimal Number of Lockers/ Planning Tool: One shot model	near real time	near real time
	Is the data dependent on external sources (e.g., city data, third-party APIs)? If so, describe the source and reliability.	No, users enter their own data	No, users enter their own data	Yes: Municipality of Thessaloniki GIS, GAIAOSE GIS, Spitogatos real estate portal, Hellenic Telecommunications and Post Commission REST API
	Does the solution comply with any data standards (e.g., for logistics, urban data spaces, GDPR)?	GDPR regulated data for WareM&O users	GDPR regulated data for WareM&O users	No



Are IoT sensors or real-time data sources (e.g., for occupancy) used? If so, describe their role in data collection and decision-making.	Yes/No + Description	No	No	No
-				
If applicable: Describe the core operational workflow (e.g., from data input to logistics routing). Include key steps and decision points.	Workflow Description or Chart	WareM&O users must provide their own input regarding available warehouses. Potential clients can see the available warehouse via a search functionality.	TIF-HELEXPO provided the warehouse to WareM&O and ACS Courier found it, then both made an agreement so that the space is rented.	No specific workflow
if applicable: Does the workflow rely on other systems (e.g., urban transport system, micro-hubs)? Specify key systems and describe how they interact.	Yes/No + Description	No	WareM&O platform for space discovery	Not applicable
if applicable: Can the solution share resources (e.g., vehicles, hubs) with other DISCO-X solutions? Which resources are shared and how?	Yes/No + Description	No	No	Yes, warehouse/lockers/shops/insights data can be shared to anyone interested with REST APIs.



If applicable: What mechanisms are in place to avoid redundancy (e.g., overuse of the same vehicle or storage space)?	Description	Not applicable	Not applicable	Not applicable
if applicable: How are real-time changes (e.g., traffic conditions, vehicle breakdowns) handled in the solution? How does the solution coordinate these changes?	Description of real-time coordination	Not applicable	Not applicable	Automatic update of data changes
Which platforms or architectures does the solution run on (e.g., cloud-based, on-premises)? Provide details on the technology stack used (e.g., AWS, Azure, custom).	Description of platform and architecture	On premises web servers	On premises web servers	On premises web servers
What methods are available to integrate the solution (e.g., APIs, webhooks)? Describe any technical	List of integration methods + description	REST APIs. API client authentication.	REST APIs. API client authentication.	REST APIs. API client authentication.



requirements for integration.				
Which standards does your solution comply with (e.g., ISO standards, EU logistics standards, data exchange protocols)?	List of standards	ISO standards for secure computer systems, WMS data standards	ISO standards for secure computer systems, WMS data standards	ISO standards for secure computer systems
Are there technical challenges in scaling the solution with increasing data, users, or geographic expansion? Describe potential performance bottlenecks.	Yes/No + Detailed explanation	No, scaling is easy	Yes, more warehouse spaces must be found	No, scaling is easy
Are Digital Twins, real-time analytics, or smart booking systems integrated into your operations? If so, which data points do they depend on?	Yes/No + Description	Smart contract	Smart contract	No



<p>Can your system exchange real-time data with other DISCO-X solutions? Provide examples of the type of data shared (e.g., routing, vehicle status).</p>	<p>Yes/No + Detailed description</p>	<p>No</p>	<p>No</p>	<p>Near real time, warehouse/lockers/shops of sanitary interest locations</p>
-				
<p>Are there specific licenses or permits required for your solution?</p>	<p>Yes/No + Description</p>	<p>WareM&O: Warehouse providers must ensure that they add warehouses that are legally operating as a warehousing and distribution center or other type of warehouse, provided that it meets all of the requirements of applicable law for the storage of the goods and products that you claim to be able to store. Also the providers must have the right to carry out the specific economic activity (providing storage services to third parties) in the specific space and in compliance with the provisions of the current legislation.</p>	<p>License for store operation</p>	<p>No license required. Registration required for specific closed-source datasets.</p>
<p>How quickly can the solution adapt to new policies (e.g., changes in environmental laws)? Describe how the solution is designed to remain compliant.</p>	<p>Adaptation process description</p>	<p>Legal personnel to monitor warehousing-related regulations. Laws for: storage, warehouse operating permits, private contracts.</p>	<p>Legal personnel to monitor courier-related</p>	<p>No adaptation process required</p>



<p>Is the solution compliant with relevant local regulations (e.g., zoning, emissions)? Provide specific laws that have been considered in the development.</p>	<p>Yes/No + List of applicable laws</p>	<p>Yes, see above</p>	<p>No regulations to be compliant to</p>	<p>No compliance needed</p>
<p>Does the solution comply with GDPR or other privacy regulations? Include any specific data protection measures (e.g., encryption, anonymization).</p>	<p>Yes/No + Privacy compliance description</p>	<p>Yes: user authentication/authorization, consent to data processing, GDPR officer, secure data storage and encryption</p>	<p>Yes: user authentication/authorization, consent to data processing, GDPR officer, secure data storage and encryption</p>	<p>No compliance needed</p>
<p>-</p>				
<p>What infrastructure (physical or digital) is shared with other DISCO-X solutions? Provide details on shared hubs, cloud services, or sensors.</p>	<p>List + Detailed description</p>	<p>On premises web servers</p>	<p>Physical</p>	<p>On premises web servers</p>



What are the key digital infrastructure needs (e.g., bandwidth, cloud capacity, server specs)?	List + Detailed description	At least two web servers with i9 processor, 64GB RAM, 1TB SSD, Gigabit broadband internet connection	Not applicable	At least two web servers with i9 processor, 64GB RAM, 1TB SSD, Gigabit broadband internet connection
Are there known bottlenecks in physical infrastructure (e.g., limited loading docks, storage space)? Describe potential solutions.	Yes/No + Bottleneck details	Not applicable	Limited storage space and loading docks. Encourage warehouse owners to place their warehouses in WareM&O platform for more available places inside the city.	Not applicable
-				
	WareM&O:	WareM&O:	Multiple responses from various REST APIs	
	warehouse_id	warehouse_id		
	name	name		
	type	type		
	business activity	business activity		
	website	website		
	description	description		
	x_coordinate	x_coordinate		
	y_coordinate	y_coordinate		
	date_created	date_created		
	date_edited	date_edited		
	compartment_id	compartment_id		



	name	name
	capacity_type	capacity_type
	capacity_area	capacity_area
	capacity_pallets	capacity_pallets
	max_pallet_height	max_pallet_height
	max_pallet_weight	max_pallet_weight
	date_created	date_created
	date_edited	date_edited
	Compartment_id	Compartment_id
	date_from	date_from
	date_to, capacity_area	date_to, capacity_area
	capacity_pallets	capacity_pallets
	min_price_per_square_meter	min_price_per_square_meter
	min_price_per_pallet	min_price_per_pallet
	Optimal Number of Lockers/:	
	home_delivery_coordinates	
	Choice model parameters	
	Number of final lockers in the network	
	Locker Capacity (units per locker)	



Helsinki Data Collection Sheet

Helsinki Data Collection Sheet	Responsible expert who should fill out the information	Question / Description	Expected Data	DISCOPROXI	DISCURB
Measure in Short	/	Short description of the purpose of Disco-X measures in general	Summary	Introduces shared parcel lockers and proximity-based micro-hubs for last-mile deliveries. These hubs can reduce delivery fragmentation and increase efficiency by placing lockers or micro-hubs close to end users, such as at urban corners or residential areas.	Focuses on optimizing the use of city curbside space for logistics operations, such as loading and unloading zones. The measure aims to allocate curbside capacity dynamically, ensuring efficient use of public spaces for both logistics providers and other users like pedestrians and vehicles.
General Information					
Description of DISCO-X Solution	Everyone	Description of Disco-X solution as implemented in the LL	Summary/Description	The DISCOPROXI solution in Helsinki's Living Lab (LL) focuses on establishing a multifunctional micro-hub in underused urban spaces to optimize logistics operations, particularly for last-mile deliveries. This hub serve not only for logistics consolidation but also integrate a customer service point and a pick up point. In addition, Helsinki LL included a Mobile Micro Hub concept, where cargo bike fleet and eVan fleets	To implement a Fast-Track dynamic curb management system, enabling flexible use of dedicated loading/unloading zones, supporting the mobile micro-hub concept. Case 1:



		<p>dynamically utilize vans as Mobile Microhubs through dynamic virtual hub system to enable the most efficient cargo bike utilization.</p>	<p>Dynamic Curb Management: This focuses on deploying sensors and camera systems in Helsinki to monitor curbside zones in real time. The system provides logistic operators with real-time data on available zones via the Tietorahti app, which will offer route planning and traffic updates alongside parking availability data. This data will also help city planners optimize urban space usage and infrastructure development, while also intersecting with Helsinki's mobile micro hub concept for parcel delivery. In addition, floating car data will be utilised to analyse the commercial vehicle fleets' behaviour in the City to support the planning and optimising un/loading zones.</p> <p>Case 2: Dynamic Low Emission Zone (LEZ): This case studies the potential impact of low-emission zones in Helsinki by analyzing fleet data and delivery</p>
--	--	---	--



					routes before and after low-emission restrictions are applied. The focus is on gathering insights on delivery operations and vehicle use without implementing an actual low-emission zone.
Name of Solution		Multifunctional and Multiactor Microhub			DISCOCURB PI-led innovation
Description	Everyone	Short description of the specific Platform/Solution	Summary/Description	Helsinki LL established a multifunctional and multiactor Microhub in Ruholahti district. The Hub serve as a consolidation hub, where four companies utilized a common hub for last mile deliveries. The Hub was a charging point for delivery robots and eCargo bikes. The hub hosted a service point for residents and B2C customers. The hub was utilized as a consolidation hub, where the companies utilized each others fleets for greener and more flexible deliveries.	This is a Physical Internet (PI)-led innovation aimed at improving curbside management in urban areas. It facilitates dynamic allocation of curbside space for logistics operations, integrating real-time data to ensure efficient loading/unloading operations and reduce urban congestion. The solution also aligns with broader sustainable urban mobility strategies. (Source: D2.1 - Urban Logistics Transition Requirements2) Focus: Dynamic management of curbside spaces for logistics, aimed at reducing congestion and improving efficiency in loading



and unloading areas.
 This solution is mainly about curbside space management rather than warehousing or storage optimization.
 (Source: D2.1 - Urban Logistics Transition Requirements2)

Website	URL of the Solution	URL	https://www.youtube.com/watch?v=i6PpzJxxs4M	
Progress/Updates	Recent progress of the solution. Updates to scope or functionalities that differ from deliverables	Text/Location of Progress Material	Proof of Concept Stage: The solution is currently in the Proof of Concept phase, where micro-hubs are being set up and tested in select urban areas such as Ruoholahti. These micro-hubs are being evaluated for their suitability in consolidating logistics operations and integrating green mobility services like e-scooters and e-bikes. (Source: D2.1 - Urban Logistics Transition Requirements2)	Active and ongoing implementation within the Helsinki Living Lab
Status	Current status of implementation	Text	Pilot Phase	Conceptual/Exploratory Phase



Overlap/Integration		Is there overlap or integrations to other solutions	Text	Yes, DISCOPROXI and DISCOCURB. Both solutions overlap in managing urban space and improving last-mile logistics, with DISCOPROXI focusing on micro-hubs and DISCOCURB on dynamic curbside management. Additionally, both support green mobility, contributing to Helsinki's environmental goals by optimizing vehicle flow and reducing congestion.	DISCOCURB integrates with city planning tools and other logistics solutions (such as DISCOPROXI) to ensure a seamless flow of urban logistics. It also ties into Helsinki's Action Plan For Citylogistics strategy and Carbon Neutral Helsinki -strategy.
1. Shared Data Types					
Common Data Points	Technical experts like software engineers/architects	What types of data (e.g., warehouse capacity, traffic flows, space utilization) are generated or consumed?	List with detailed descriptions	Generated/Consumed Data: Data on micro-hub usage, parcel locker availability (LMAD parcel locker robots), human traffic flows, delivery demand, and routing optimization (Mobile Micro Hub). This includes logistics data from operators and in the preparatory phase, geospatial data from the kartat.hel.fi was used for optimising hub placement. (Source: D2.1 - Urban Logistics Transition Requirements2)	Generated/Consumed Data: Traffic flows, curbside occupancy, parking availability, and loading/unloading zone utilization. This data is collected using sensors, cameras and the data will be integrated into the Tietorahti platform. (Source: D2.1 - Urban Logistics Transition Requirements2)
Public Data		Is this data publicly available?	Yes/No	No	Tietorahti app visualises the data
Data Format Used		What is the exact format of the data generated/consumed (e.g., JSON, GeoJSON, CSV, etc.)? Include any formatting specifics, such as schema or API structure.	Data Format + Description	.xls	Unknown at this stage



Data Accessibility		How is the data accessed? Include details on the system or API used to access data (e.g., REST API, data export, or real-time streaming). Indicate if data is read/write.	Description with Access Methods	The data is in .xls format and is readable with excel	Via API - specs unknown at this stage
Data Location/Documentation			URL or Location Description of Data	no	
Data Update Frequency		How often is the data updated? Provide specific times (e.g., real-time, every 15 minutes, hourly, daily, monthly).		Data was collected from May 24 - September 24	The data is updated in real-time, ensuring that logistics operators and city planners have access to the most current information about curbside availability and traffic conditions. (Source: D2.1 - Urban Logistics Transition Requirements2)
Data Interdependencies		Is the data dependent on external sources (e.g., city data, third-party APIs)? If so, describe the source and reliability.	Yes/No + Description	Yes - the data is owned by the LSPs and is not public	Yes, the data relies on external sources such as IoT sensors installed in curbside zones, city-provided data from traffic management systems, and third-party APIs for parking operations.



Data Standards Compliance		Does the solution comply with any data standards (e.g., for logistics, urban data spaces, GDPR)?	Yes/No + Description	Yes - the data is owned by the LSPs and is not public	Yes, the solution complies with GDPR by anonymizing and encrypting personal data collected from sensors and cameras. Data collection is restricted to non-identifiable information relevant to logistics.
Sensor Infrastructure		Are IoT sensors or real-time data sources (e.g., for occupancy) used? If so, describe their role in data collection and decision-making.	Yes/No + Description	Yes, IoT sensors monitor micro-hub traffic	Yes, IoT sensors and cameras are extensively used to monitor curbside occupancy, parking availability, and traffic flows. These sensors provide the real-time data that powers dynamic curbside management. (Source: D2.1 - Urban Logistics Transition Requirements2)
2. Operational Synergies					
Workflow Description	A person with in-depth knowledge of the project and the pilots themselves, or even domain experts such as transportation engineers, logistics scientists, or lawyers.	If applicable: Describe the core operational workflow (e.g., from data input to logistics routing). Include key steps and decision points.	Workflow Description or Chart	The DISCOPROXI workflow involves the collection and integration of data from urban spaces and LSPs. This data supports decision-making for micro-hub operations, demand-supply matching, and green last-mile logistics routing. (Source: D2.1 - Urban Logistics Transition Requirements2)	The DISCOCURB workflow involves dynamic curbside management by using data from sensors, cameras to monitor loading/unloading zones and parking spaces. Data is visualised through the Tietorahti platform to provide real-time information for



				logistics operators, enabling optimized space usage and traffic flow. In addition, floating car data will be utilised and analysed through selected service providers tool (tender process ongoing)
Workflow Dependencies	if applicable: Does the workflow rely on other systems (e.g., urban transport system, micro-hubs)? Specify key systems and describe how they interact.	Yes/No + Description	Yes - City Map Service (kartta.hel.fi)	Yes, floating car data will be utilised and analysed through selected service providers tool (tender process ongoing) in order to visualise and analyse commercial vehicle stops/times/behaviour in the city.
Shared Resource	if applicable: Can the solution share resources (e.g., vehicles, hubs) with other DISCO-X solutions? Which resources are shared and how?	Yes/No + Description	Yes - DISCOPROXI Mobile Micro Hubs can utilize DISCOCURB un/loading zone. DISCOPROXI Mobile Microhub concept utilises street space for consolidation between cargo bike fleets and van fleets. Hence, the information provided by Tietorahti through DISCOCURB monitoring solutions about the availability of un/loading zones can provide valuable information for the DISCOPROXI Microhub solutions where and when available un/loading zones are.	Yes, curbside zones are shared resources. They are dynamically allocated between logistics operators and other urban uses to optimize their use while minimizing congestion. (Source: D2.1 - Urban Logistics Transition Requirements2)



Workflow Redundancy Avoidance		If applicable: What mechanisms are in place to avoid redundancy (e.g., overuse of the same vehicle or storage space)?	Description	Not applicable	Redundancy is avoided by dynamically visualizing curbside spaces in real-time based on availability and demand. This prevents overlapping allocations and ensures efficient usage through data-driven decisions managed by the Tietorahti platform. (Source: D2.1 - Urban Logistics Transition Requirements2)
Real-time Coordination		if applicable: How are real-time changes (e.g., traffic conditions, vehicle breakdowns) handled in the solution? How does the solution coordinate these changes?	Description of real-time coordination	Real-time coordination can be achieved through the Tietorahti or national access point Fintraffic . They both provide traffic conditions, and other logistics related disruptions or limitations by providing real-time updates to logistics operators and dynamically rerouting deliveries as needed. Tietorahti utilises Fintraffic data to support it's service.	Real-time coordination is handled through sensors and the Tietorahti platform, which visualises data and updates operators on curbside availability, traffic conditions, and route planning. This allows logistics operators to adapt quickly to changing conditions, reducing delays and inefficiencies. (Source: D2.1 - Urban Logistics Transition Requirements2)
3. Technical Compatibility					
Platform Type	Technical experts like software engineers/architects	Which platforms or architectures does the solution run on (e.g., cloud-based,	Description of platform and architecture	Microhub traffic monitoring: https://telraam.net/en/location/9000007050	TBD (tender process ongoing)



		on-premises)? Provide details on the technology stack used (e.g., AWS, Azure, custom).			
Integration Methods		What methods are available to integrate the solution (e.g., APIs, webhooks)? Describe any technical requirements for integration.	List of integration methods + description	Not applicable	Sensor providers APIs
Standards Compliance	IT managers or/and system administrators	Which standards does your solution comply with (e.g., ISO standards, EU logistics standards, data exchange protocols)?	List of standards	Not applicable	TBD (tender process ongoing)
Scalability Challenges	Technical experts like software engineers/architects	Are there technical challenges in scaling the solution with increasing data, users, or geographic expansion? Describe potential performance bottlenecks.	Yes/No + Detailed explanation	From the point of view of scaling up geographically, the Micro Hubs need permissions which are extremely hard to get. Helsinki LL is working with the City to achieve more flexible permit process.	Yes, the sensors can be highly expensive hence limiting the scalability due to limited budgets of the Cities.
Digital Platforms Integration		Are Digital Twins, real-time analytics, or smart booking systems integrated into your operations? If so, which data points do they depend on?	Yes/No + Description	Not applicable - except the traffic monitoring in the Micro hub (https://telraam.net/en/location/9000007050)	Yes, the sensor data will be visualised in Tietorahti application in real-time for the drivers of LSPs.
Real-time Data Exchange		Can your system exchange real-time	Yes/No + Detailed description	Not applicable	Yes, the Mobile Micro Hubs can utilize the



		data with other DISCO-X solutions? Provide examples of the type of data shared (e.g., routing, vehicle status).			real-time visualised data of the Tietorahti app in order to select zones for consolidation.
4. Regulatory Framework					
Permitting and Licensing Details	Person with an in-depth knowledge of the project and the pilots themselves, or even domain experts like transportation engineers / logistics scientists / lawyers	Are there specific licenses or permits required for your solution?	Yes/No + Description	Yes, permits are required for the installation and use of micro-hubs and curbside management systems in public spaces, as both the DISCOPROXI and DISCOCURB solutions involve public infrastructure. The deployment of sensors, cameras, and logistic infrastructure in urban areas like Ruoholahti requires local authority approval. (Source: D2.1 - Urban Logistics Transition Requirements2)	Yes, Installing sensors and camera systems in public spaces requires permits from local authorities in Helsinki. (Source: D2.1 - Urban Logistics Transition Requirements2)
Policy Adaptability		How quickly can the solution adapt to new policies (e.g., changes in environmental laws)? Describe how the solution is designed to remain compliant.	Adaptation process description	The solutions in Helsinki, such as the DISCOPROXI micro-hubs and DISCOCURB curb management, are designed to quickly adapt to policy changes, particularly those related to environmental laws like Low-Emission Zones (LEZ). The Tietorahti platform used in Helsinki allows for real-time updates and adjustments to comply with new regulations.	The solution can quickly adapt to new policies, such as environmental laws, through software updates without needing major physical changes. (Source: D2.1 - Urban Logistics Transition Requirements2)
Local Regulation Compliance		Is the solution compliant with relevant local regulations (e.g., zoning, emissions)? Provide specific laws that have been considered in the development.	Yes/No + List of applicable laws	In Helsinki, the solutions are compliant with local zoning, environmental, and emissions regulations. This is critical given Helsinki's focus on reducing urban congestion and supporting sustainable logistics through shared infrastructure. (Source: D2.1 - Urban Logistics Transition Requirements2)	Yes, the solution complies with Helsinki's local regulations on public space usage (Source: D2.1 - Urban Logistics Transition Requirements2)



Data Privacy Compliance		Does the solution comply with GDPR or other privacy regulations? Include any specific data protection measures (e.g., encryption, anonymization).	Yes/No + Privacy compliance description	Yes, the solution complies with GDPR and other privacy regulations. Data collection is managed through anonymization and encryption techniques, ensuring that personal data is protected. This is especially relevant for data collected from micro-hub operations, real-time monitoring, and shared logistics services (Source: Grant Agreement)	Yes, the system complies with GDPR, using data anonymization and encryption to ensure privacy. (Source: D2.1 - Urban Logistics Transition Requirements2)
5. Infrastructure Requirements					
Shared Infrastructure	Technical experts like software engineers/architects	What infrastructure (physical or digital) is shared with other DISCO-X solutions? Provide details on shared hubs, cloud services, or sensors.	List + Detailed description	The Multifunctional Micro hub in Ruoholahti district is a shared facility between four companies.	un/loading zone sensors produce information about the availability of the zones directly to the drivers of LSPs through Tietorahti app. This information can be utilised by the LSPs utilising Mobile Micro Hub concept (DISCOPROXI)
Digital Infrastructure Requirements		What are the key digital infrastructure needs (e.g., bandwidth, cloud capacity, server specs)?	List + Detailed description	Not applicable	APIs for the transfer of data to relevant applications e.g. Tietorahti application.



Physical Infrastructure Bottlenecks		Are there known bottlenecks in physical infrastructure (e.g., limited loading docks, storage space)? Describe potential solutions.	Yes/No + Bottleneck details	The somewhat tight regulatory framework in Helsinki currently limits the dynamic expansion of Micro hub network in the City. However, the Helsinki LL is working with the City to establish a more dynamic regulatory framework in order to achieve more dynamic permit model to enable future Micro hub operations in the City.	Yes, electricity is not available in most of the loading zones due to the limitations of the infrastructure in the City.



Ghent Data Collection Sheet

Ghent Data Collection Sheet	Responsible expert who should fill out the information	Question / Description	Expected Data	DISCOPROXI	DISCOBAY	DISCOLLECTION
Measure in Short	/	Short description of the purpose of Disco-X measures in general	Summary	Introduces shared parcel lockers and proximity-based micro-hubs for last-mile deliveries. These hubs can reduce delivery fragmentation and increase efficiency by placing lockers or micro-hubs close to end users, such as at urban corners or residential areas.	Uses multimodal transport hubs (e.g., metro stations, railway stations, waterways) to consolidate last-mile deliveries, focusing on using green modes of transport such as electric vehicles and bicycles for final delivery stages.	Focuses on advanced data collection methods for optimizing urban logistics operations, such as real-time routing, access control, and dynamic demand management. It leverages dynamic data analytics to adjust to the evolving needs of the urban logistics network.
General Information						
Description of DISCO-X Solution	Everyone	Description of Disco-X solution as implemented in the LL	Summary/Description	Focuses on sustainable last-mile delivery by integrating green logistics options and real-time data for	Low-carbon logistics hub utilizing multimodal transport hubs for sustainable	Integrating dataspace technology for safe, secure and efficient data transferring within the UAC concept



				optimized planning and paths.	last-mile delivery.
Name of Solution				Urban Access Control (UAC) Integration	Low-carbon multimodal logistics
Description	Everyone	Short description of the specific Platform/Solution	Summary/Description	Sustainable last-mile delivery system using real-time data to calculate CO ² emissions and optimize delivery paths. (Source: D2.1 - Urban Logistics Transition Requirements)	Focuses on sustainable waterway transport, reducing emissions by combining water shuttles with cargo bikes for seamless logistics. (Source: D2.1 - Urban Logistics Transition Requirements)
Website		URL of the Solution	URL	-	MDS Broker - Data Offers
Progress/Updates		Recent progress of the solution. Updates to scope or functionalities that differ from deliverables	Text/Location of Progress Material	Integration and Testing: The Urban Access Control (UAC) system is currently being integrated with Dropon for testing. The testing starts in november, over time demonstrations will expand to include more companies and	A network of green last mile companies is being established, to propose multimodal delivery solutions for transport in and out of the city (with access points in the periphery of the city). Demonstration



			additional functionalities. The third phase of testing, set to begin in January, will incorporate all planned features.	s will look at construction logistics. Location of Progress Material: Lock construction between Ghent and Terneuzen, focusing on port infrastructure. (Source: D2.3 - DISCO Meta Model Suite architecture_final)	
Status	Current status of implementation	Text	Pilot Phase	Pilot Phase	In Development
Overlap/Integration	Is there overlap or integrations to other solutions	Text	Yes to DISCOBAY, DISCOLLECTION	Yes to DISCOPROXI, DISCOLLECTION : DISCOPROXI: Integrates with DISCOPROXI by using the port for goods that are distributed via DISCOPROXI's optimized last-mile logistics. DISCOLLECTION : integration of dataspace technology in UAC solution.	Yes to DISCOBAY, DISCOPROXY
1. Shared Data Types					



<p>Common Data Points</p>	<p>Technical experts like software engineers/architects</p>	<p>What types of data (e.g., warehouse capacity, traffic flows, space utilization) are generated or consumed?</p>	<p>List with detailed descriptions</p>	<p>Traffic flows: Real-time traffic data, including congestion levels and travel times, used to optimize delivery routes. Demand data: Insights into delivery volumes, vehicle loads, and delivery times. Sustainable operator data: Information on green logistics operators and their routes for eco-friendly deliveries. UVAR data: information on city access regulations - school environments - loading and unloading zones.</p>	<p>Demand data: Insights into delivery volumes, vehicle loads, and delivery times. Sustainable operator data: Information on green logistics operators and their routes for eco-friendly deliveries.</p>	<p>Parking spots: Available parking locations Parking occupancy (to an extend): real-time availability of parking spots Future plans - Access regulation data: specific access rules within city streets and zones</p>
<p>Public Data</p>		<p>Is this data publicly available?</p>	<p>Yes/No</p>	<p>partially yes</p>	<p>no</p>	<p>YES</p>
<p>Data Format Used</p>		<p>What is the exact format of the data generated/consumed (e.g., JSON, GeoJSON, CSV, etc.)? Include any formatting specifics, such as schema or API structure.</p>	<p>Data Format + Description</p>	<p>UAC usage logs are stored in JSON format</p>	<p>GLM information is collected in free text format</p>	<p>geojson</p>



Data Accessibility		How is the data accessed? Include details on the system or API used to access data (e.g., REST API, data export, or real-time streaming). Indicate if data is read/write.	Description with Access Methods	Logs are stored both on MongoDB and AWS S3 and can be accessed (with proper credentials) e.g. online or via API City access rules are stored in the Location Manager of Be-Mobile	GLM information is stored in an Excel sheet and transferred by e-mail	The Smart Data Platform does not have a public interface. It can only be accessed via dataspace contracts by identified participants on the data space. Only valid negotiated contracts can request the data via REST API. It is a read-only operation.
Data Location/Documentation			URL or Location Description of Data	Logs are stored both on MongoDB and AWS S3 and can be accessed (with proper credentials) e.g. online or via API call Location Manager can be accessed via API call	n/a	https://data.stad.gent/explore/?disjunctive.keyword&disjunctive.theme&sort=modified
Data Update Frequency		How often is the data updated? Provide specific times (e.g., real-time, every 15 minutes, hourly, daily, monthly).		A log file is generated with each call to the UAC API	manual one time input	Parking availability: hourly parkig locations; daily
Data Interdependencies		Is the data dependent on external sources (e.g., city data, third-party APIs)? If so, describe the	Yes/No + Description	Yes, the functioning of the UAC API depends on the input data of city	n/a	YES, the data is scraped from the Gent Open Data Portal. Parking spots are changed manually, but static so moderate reliability Parking availability are done through sensors in underground parkings, so high reliability



		source and reliability.		access rules and GLM information		
Data Standards Compliance		Does the solution comply with any data standards (e.g., for logistics, urban data spaces, GDPR)?	Yes/No + Description	No, however DatexII is an option	n/a	Parking locations follow the data standard of the EPA (European Parking Association), based on Datex2
Sensor Infrastructure		Are IoT sensors or real-time data sources (e.g., for occupancy) used? If so, describe their role in data collection and decision-making.	Yes/No + Description	No	n/a	Parking availability are done through sensors in underground parkings. These are connected directly to the Gent Open Data Portal
2. Operational Synergies						
Workflow Description	A person with in-depth knowledge of the project and the pilots themselves, or even domain experts such as transportation engineers, logistics scientists, or lawyers.	If applicable: Describe the core operational workflow (e.g., from data input to logistics routing). Include key steps and decision points.	Workflow Description or Chart	Step 1: preparation. Make sure all rules and regulations for access to the city are available digitally, as well GLM data. Step 2: integration of TMS-systems with UAC. Step 3: transport company will automatically use the UAC in its TMS system.	Data input of the client info, reception and deliver address, weight and size of the cargo - info to the planning system and invoicing - transport assignment to the drivers in the synchronomodal logistic chain	integration of datasources and UAC components with the dataspace. Further, it works the same as in Discoproxy (as it is the same solution, only a different architecture).



Workflow Dependencies		if applicable: Does the workflow rely on other systems (e.g., urban transport system, micro-hubs)? Specify key systems and describe how they interact.	Yes/No + Description	Yes: datasources made available by public partners, and TMS-integration by TMS-providers.	There is mainly an impact from the various restrictions to drive into the city, such as Low Emission Zone, neutral zones, timeslots,...	yes, the dataspace
Shared Resource		if applicable: Can the solution share resources (e.g., vehicles, hubs) with other DISCO-X solutions? Which resources are shared and how?	Yes/No + Description	n/a	Yes, there can be solutions shared between parcel deliveries per ship, cargo bike,..; and the use of cityhubs, pick-up shops,...	the dataspace
Workflow Redundancy Avoidance		If applicable: What mechanisms are in place to avoid redundancy (e.g., overuse of the same vehicle or storage space)?	Description	n/a	That is at the level of the planner of the different transportmodi	n/a
Real-time Coordination		if applicable: How are real-time changes (e.g., traffic conditions, vehicle breakdowns) handled in the solution? How does the solution coordinate these changes?	Description of real-time coordination	n/a	Interruptions in the logistic flow due to external causes of internal problems are solved at planning level by offering an alternative. If this is not possible (e.g. car is in the file,	n/a



						package has disappeared, ...) the customer is notified and an alternative is sought.
3. Technical Compatibility						
Platform Type	Technical experts like software engineers/architects	Which platforms or architectures does the solution run on (e.g., cloud-based, on-premises)? Provide details on the technology stack used (e.g., AWS, Azure, custom).	Description of platform and architecture	Cloud based, OpenStack	Cloud based	The Smart Data Platform runs on Dagster, an openly available tool to set up data pipelines
Integration Methods		What methods are available to integrate the solution (e.g., APIs, webhooks)? Describe any technical requirements for integration.	List of integration methods + description	API, see https://docs.be-mobile.biz/fleet-optimal-delivery-route-api	n/a	For integration, it is required to be a valid member of the dataspace, to have a valid certificate and have successfully negotiated with the provider connector for the use of the asset, which is a private REST API service endpoint. has context menu
Standards Compliance	IT managers or/and system administrators	Which standards does your solution comply with (e.g., ISO standards, EU logistics standards, data exchange protocols)?	List of standards	None, however DatexII is an option	n/a	



<p>Scalability Challenges</p>	<p>Technical experts like software engineers/architects</p>	<p>Are there technical challenges in scaling the solution with increasing data, users, or geographic expansion? Describe potential performance bottlenecks.</p>	<p>Yes/No + Detailed explanation</p>	<p>Upscaling can be done on a European level A large increase in users can lead to slower performances, in that case the server capacity needs to be increased</p>	<p>When scaling to an increasing number of users, there are limitations on the use of transport modes and the deployment of personnel. Between the realization that an increasing movement of requests for transport becomes a constant, the operational team needs to be reinforced with material and people. There is a considerable time lag between this realization and the investment decision, which can lead to a temporary disruption.</p>	<p>YES, - cities need to connect their open data portal to the Smart data platform - every new data set requires a defined data standards, which don't always exist - if cities want to convert data sets to the right standard, this requires some manual work</p>
<p>Digital Platforms Integration</p>		<p>Are Digital Twins, real-time analytics, or smart booking systems integrated into your operations? If so, which data</p>	<p>Yes/No + Description</p>	<p>No</p>	<p>No</p>	<p>NO</p>



		points do they depend on?				
Real-time Data Exchange		Can your system exchange real-time data with other DISCO-X solutions? Provide examples of the type of data shared (e.g., routing, vehicle status).	Yes/No + Detailed description	No	No	YES, although the other DISCO-X solutions also need to be connected to the data space. A future setup is investigated to connect the Urban Access Control (UAC) DISCO solution to the Data Space and share Access rule data from the Smart Data Platform directly to the UAC
4. Regulatory Framework						
Permitting and Licensing Details	Person with an in-depth knowledge of the project and the pilots themselves, or even domain experts like transportation engineers / logistics scientists / lawyers	Are there specific licenses or permits required for your solution?	Yes/No + Description	no: the UAC itself will use the available data.	Yes: Permits related to the use of waterways and low-emission logistics are required. This includes permissions for operating sustainable transport modes, such as electric barges and cargo bikes, within city limits and on public waterways.	n/a



<p>Policy Adaptability</p>		<p>How quickly can the solution adapt to new policies (e.g., changes in environmental laws)? Describe how the solution is designed to remain compliant.</p>	<p>Adaptation process description</p>	<p>Adaptation process description: DISCOPROXI is designed to quickly adapt to new environmental laws, such as emission reduction targets and urban traffic control updates. The real-time data integration allows for immediate adjustments in delivery routes and access permissions to comply with new regulations. Future updates can be implemented via software updates to the UAC system.</p>	<p>Adaptation process description: DISCOBAY can quickly adapt to changes in environmental regulations, such as stricter emission controls, loading and unloading regulations or waterway usage rules. The system is designed to incorporate real-time data on emissions and traffic, allowing it to modify operations to stay compliant with new laws. (Source: D2.1 - Urban Logistics Transition Requirements, p. 57)</p>	<p>n/a</p>
<p>Local Regulation Compliance</p>		<p>Is the solution compliant with relevant local regulations (e.g., zoning, emissions)? Provide specific laws that have</p>	<p>Yes/No + List of applicable laws</p>	<p>Yes: The solution complies with local zoning regulations, emission control laws, and urban access rules. Relevant laws</p>	<p>Yes: DISCOBAY complies with local zoning, waterway, and emission regulations. Relevant laws include local</p>	<p>n/a</p>



		<p>been considered in the development.</p>	<p>include the European Clean Air Policy and local emission standards for city traffic in Ghent.</p>	<p>water transport regulations, EU Clean Air policies, and emissions reduction targets for urban logistics. (Source: D2.1 - Urban Logistics Transition Requirements, p. 36)</p>		
<p>Data Privacy Compliance</p>		<p>Does the solution comply with GDPR or other privacy regulations? Include any specific data protection measures (e.g., encryption, anonymization).</p>	<p>Yes/No + Privacy compliance description</p>	<p>Yes: DISCOPROXI complies with GDPR and other privacy regulations. Data protection measures include encryption of real-time traffic and delivery data, as well as anonymization protocols to protect personal data during last-mile delivery operations.</p>	<p>Yes: DISCOBAY complies with GDPR and other privacy regulations. Data collected from transport operations, including real-time delivery tracking and environmental impact, is encrypted and anonymized to ensure privacy compliance. (Source: D2.2 - Digital Transition Assessment Tool, p. 27 and D2.3 - DISCO Meta Model Suite Architecture, p. 62)</p>	<p>Yes: DISCOPROXI complies with GDPR and other privacy regulations. Data protection measures include encryption of real-time traffic and delivery data, as well as anonymization protocols to protect personal data during last-mile delivery operations.</p>



5. Infrastructure Requirements						
Shared Infrastructure	Technical experts like software engineers/architects	What infrastructure (physical or digital) is shared with other DISCO-X solutions? Provide details on shared hubs, cloud services, or sensors.	List + Detailed description	The UAC components; as it is the same solution.	The UAC components; as it is the same solution.	The UAC components; as it is the same solution.
Digital Infrastructure Requirements		What are the key digital infrastructure needs (e.g., bandwidth, cloud capacity, server capacity, server specs)?	List + Detailed description	Cloud capacity, server capacity, storage space	Cloud capacity, server capacity, storage space	Already available data platform in-house with the city or partner (open) API connection to connect the data platform with the Smart Data Platform
Physical Infrastructure Bottlenecks		Are there known bottlenecks in physical infrastructure (e.g., limited loading docks, storage space)? Describe potential solutions.	Yes/No + Bottleneck details	no	To much regulation and restrictions from the city. Lack of quays for urban distribution via IW. Locks that does not work and are necessary for the transport via waterways.	no



Copenhagen Data Collection Sheet

Copenhagen Data Collection Sheet	Responsible expert who should fill out the information	Question / Description	Expected Data	DISCOPROXI	DISCOBAY	DISCURB	DISCOLLECTION
Measure in Short	/	Short description of the purpose of Disco-X measures in general	Summary	Introduces shared parcel lockers and proximity-based micro-hubs for last-mile deliveries. These hubs can reduce delivery fragmentation and increase efficiency by placing lockers or micro-hubs close to end users, such as at urban corners or residential areas. The measure demonstrates the facilitation of smart lockers in strategically positioned public space lockers in order to pave the way for them to be utilized by	Uses multimodal transport hubs (e.g., metro stations, railway stations, waterways) to consolidate last-mile deliveries, focusing on using green modes of transport such as electric vehicles and bicycles for final delivery stages.	Focuses on optimizing the use of city curbside space for logistics operations, such as loading and unloading zones. The measure aims to allocate curbside capacity dynamically, ensuring efficient use of public spaces for both logistics providers and other users like pedestrians and vehicles.	Focuses on advanced data collection methods for optimizing urban logistics operations, such as real-time routing, access control, and dynamic demand management. It leverages dynamic data analytics to adjust to the evolving needs of the urban logistics network.



		multiple last mile delivery companies.					
General Information							
Description of DISCO-X Solution	Everyone	Description of Disco-X solution as implemented in the LL	Summary/Description	Develop a new sustainable business model for an open consolidation hub in the city thanks to the use of shared transport facilities for goods through smart solutions e.g., to attract more couriers to the existing urban micro-hub Køleskabet.	Retrofit the Høje Taastrup terminal as a peri-urban and neighbourhood multimodal hub for reloading, adopting zero-emission vehicles	Demonstrate an innovative dynamic space management and urban planning tool as a small-scale use case for effective and flexible curb side use.	To develop dynamic and real time transport data collection model from private logistics and e-commerce companies involving the local industrial community in the formulation of the new Sulp
Name of Solution				Digital twin	Digital twin	Booking logistics parking lots	Digital twin



Description	Everyone	Short description of the specific Platform/Solution	Summary/Description	Processing of logistics data provided by local operators to elaborate consolidation hub scenario and populate KPI.	Simulations through the Digital Twin that measures on the effects (such as CO2 and noise pollution) of a given physical retrofit (charging infrastructure in the outbound flow) in the peri-urban of Copenhagen	Aims to optimise logistics in Copenhagen by implementing smart zones that utilise sensor technology and provide real-time data. These zones will improve parking and logistics efficiency, ensuring better use of urban space and reducing violations.	Processing of logistics data provided by local operators to elaborate various decarbonation scenarios and build a Sulp
Website		URL of the Solution	URL	N/A	N/A	N/A	N/A
Progress/Updates		Recent progress of the solution. Updates to scope or functionalities that differ from deliverables	Text/Location of Progress Material	Ongoing, first results available	Ongoing, local data under provision	Pilot implementation ongoing	Ongoing, first results available
Status		Current status of implementation	Text	Pilot Phase	In Development	Pilot Phase	In Development
Overlap/Integration		Is there overlap or integrations to other solutions	Text	Common approach with Discollection and Discobay	Common approach with Discollection and Discoproxi	N/A	Common approach with Discobay and Discoproxi
1. Shared Data Types				(Source: DISCO - 1st Periodic Report M01-M18 v1)	(Source: DISCO - 1st Periodic Report M01-M18 v1)	(Sources: DISCO - 1st Periodic Report M01-M18 and the CTC - Company Presentation	



October 2024 - Iskandar)

Common Data Points	Technical experts like software engineers/architects	What types of data (e.g., warehouse capacity, traffic flows, space utilization) are generated or consumed?	List with detailed descriptions	Impact results out of the scenario on aggregated traffic, number of vehicles, CO2 emissions.	Traffic flows and vehicle charging station usage.	Vehicle occupancy and parking violation.	Impact results out of the scenario such as aggregated traffic, number of vehicles, CO2 emissions.
Public Data		Is this data publicly available?	Yes/No	No, the data used in DISCOPROXI, such as logistics provider information and hub availability data, is not publicly available due to commercial and privacy constraints.	No, the data is not publicly available due to confidentiality agreements with logistics partners and compliance with privacy regulations.	No, data is not publicly available due to privacy and operational confidentiality requirements, especially in managing curbside logistics.	No, the data used in DISCOLLECTION, such as logistics provider information and hub availability data, is not publicly available due to commercial and privacy constraints.
Data Format Used		What is the exact format of the data generated/consumed (e.g., JSON, GeoJSON, CSV, etc.)? Include any formatting specifics, such as schema or API structure.	Data Format + Description	.csv	.csv	.csv	



Data Accessibility		How is the data accessed? Include details on the system or API used to access data (e.g., REST API, data export, or real-time streaming). Indicate if data is read/write.	Description with Access Methods	N/A	N/A	The sensors integrate with a booking app to provide real-time availability on a map. Sensors are calibrated to detect the electromagnetic fields of vehicles, activating and deactivating based on the presence of cars.	N/A
Data Location/Documentation			URL or Location Description of Data	local	local		local
Data Update Frequency		How often is the data updated? Provide specific times (e.g., real-time, every 15 minutes, hourly, daily, monthly).		N/A	N/A	The sensors provide real-time availability	N/A
Data Interdependencies		Is the data dependent on external sources (e.g., city data, third-party APIs)? If so, describe the source and reliability.	Yes/No + Description	No	No	Yes. Additional datasets include booking details, user numbers, and sensor-generated occupancy data, all accessible through a GDPR-compliant dashboard.	no



Data Standards Compliance		Does the solution comply with any data standards (e.g., for logistics, urban data spaces, GDPR)?	Yes/No + Description	Yes, DISCOPROXI complies with GDPR and other logistics data standards, including anonymization and encryption measures to protect user data	Yes, the solution complies with GDPR, ISO standards, and EU logistics data exchange protocols, ensuring data security and privacy.	Yes, it complies with GDPR and other urban data standards, with encryption and anonymization for data protection.	Yes, it complies with GDPR and other urban data standards, with encryption and anonymization for data protection.
Sensor Infrastructure		Are IoT sensors or real-time data sources (e.g., for occupancy) used? If so, describe their role in data collection and decision-making.	Yes/No + Description	No	No	Data is collected via NB-IoT sensors embedded in the ground.	No
2. Operational Synergies				(Source: DISCO - 1st Periodic Report M01-M18 v1)	(Source: DISCO - 1st Periodic Report M01-M18 v1)	(Sources: DISCO - 1st Periodic Report M01-M18 and the CTC - Company Presentation October 2024 - Iskandar)	
Workflow Description	A person with in-depth knowledge of the project and the pilots themselves, or even domain experts such as transportation engineers, logistics scientists, or lawyers.	If applicable: Describe the core operational workflow (e.g., from data input to logistics routing). Include key steps and decision points.	Workflow Description or Chart	Data provided by logistics operators and processed into a modeling pipeline	Data provided by logistics operators, traffic count data from a one-off campaign and processed into a modeling pipeline	The workflow involves collecting data from sensors, processing it in real-time, and adjusting curbside space allocation to balance logistics needs with city space requirements.	Data provided by logistics operators and processed into a modeling pipeline



Workflow Dependencies		if applicable: Does the workflow rely on other systems (e.g., urban transport system, micro-hubs)? Specify key systems and describe how they interact.	Yes/No + Description	No	No	No	No
Shared Resource		if applicable: Can the solution share resources (e.g., vehicles, hubs) with other DISCO-X solutions? Which resources are shared and how?	Yes/No + Description	No	No	No	No
Workflow Redundancy Avoidance		If applicable: What mechanisms are in place to avoid redundancy (e.g., overuse of the same vehicle or storage space)?	Description	The modelling pipeline integrates optimisation processes to generate optimal results.	N/A	The solution utilizes data-driven decision-making to prevent overuse of curb space, ensuring balanced allocation based on demand.	The modelling pipeline integrates optimisation processes to generate optimal results.
Real-time Coordination		if applicable: How are real-time changes (e.g., traffic conditions, vehicle breakdowns) handled in the solution? How does the solution coordinate these changes?	Description of real-time coordination	N/A	N/A	N/A	N/A



3. Technical Compatibility				(Source: DISCO - 1st Periodic Report M01-M18 v1)		(Sources: DISCO - 1st Periodic Report M01-M18 and the CTC - Company Presentation October 2024 - Iskandar)	
Platform Type	Technical experts like software engineers/architects	Which platforms or architectures does the solution run on (e.g., cloud-based, on-premises)? Provide details on the technology stack used (e.g., AWS, Azure, custom).	Description of platform and architecture	Local resources	Local resources	Local resources	
Integration Methods		What methods are available to integrate the solution (e.g., APIs, webhooks)? Describe any technical requirements for integration.	List of integration methods + description	N/A	N/A	N/A	
Standards Compliance	IT managers or/and system administrators	Which standards does your solution comply with (e.g., ISO standards, EU logistics standards, data exchange protocols)?	List of standards	N/A	N/A	N/A	



Scalability Challenges	Technical experts like software engineers/architects	Are there technical challenges in scaling the solution with increasing data, users, or geographic expansion? Describe potential performance bottlenecks.	Yes/No + Detailed explanation	N/A	N/A	Yes, scaling may involve challenges such as increased bandwidth and server capacity demands due to higher data flow from more sensors and users.	N/A
Digital Platforms Integration		Are Digital Twins, real-time analytics, or smart booking systems integrated into your operations? If so, which data points do they depend on?	Yes/No + Description	Yes, Digital Twin is part of the process	Yes, Digital Twin is part of the process	Yes, Digital Twin technology is used to simulate curbside management scenarios, integrating data for real-time analysis.	Yes, Digital Twin is part of the process
Real-time Data Exchange		Can your system exchange real-time data with other DISCO-X solutions? Provide examples of the type of data shared (e.g., routing, vehicle status).	Yes/No + Detailed description	N/A	N/A		N/A
4. Regulatory Framework				(Source: DISCO - 1st Periodic Report M01-M18 v1)	(Source: DISCO - 1st Periodic Report M01-M18 v1)		



Permitting and Licensing Details	Person with an in-depth knowledge of the project and the pilots themselves, or even domain experts like transportation engineers / logistics scientists / lawyers	Are there specific licenses or permits required for your solution?	Yes/No + Description	N/A	N/A	Yes. The DISCOCURB solution requires specific permits and licenses related to urban logistics and public space management, particularly in connection with parking management and the installation of sensors for real-time data collection. Local traffic and municipal regulations need to be adhered to in order to enable the dynamic use of curbside spaces . (Source: D2.1 - Urban Logistics Transition Requirements2, D2.3 - DISCO Meta Model Suite architecture_final and DISCO Project summary)	N/A
---	---	--	----------------------	-----	-----	--	-----



Policy Adaptability		How quickly can the solution adapt to new policies (e.g., changes in environmental laws)? Describe how the solution is designed to remain compliant.	Adaptation process description	The solution could adapt to new traffic regulation policies	The solution could adapt to new traffic regulation policies	The solution is flexible and designed to adjust quickly to changes in policies such as new zoning regulations, emissions-related laws, or environmental policies.	The solution could adapt to new traffic regulation policies
Local Regulation Compliance		Is the solution compliant with relevant local regulations (e.g., zoning, emissions)? Provide specific laws that have been considered in the development.	Yes/No + List of applicable laws	Yes. The solution complies with local regulations, including zoning laws, emissions targets, and environmental sustainability goals. Relevant laws in Copenhagen include Sustainable Urban Logistics Plans (SULPs), which aim to reduce traffic congestion and emissions through more efficient urban freight management. (Source: D2.1 - Urban Logistics Transition Requirements2 and D2.3 - DISCO Meta Model Suite architecture_final)	es. The solution complies with local regulations, particularly regarding zoning, emissions reduction laws, and logistics operations in urban areas. Relevant regulations include Danish laws on zero-emission vehicles and urban freight planning, as well as Copenhagen's local Sustainable Urban Mobility Plans (SULPs). (Source: D2.1 - Urban Logistics Transition Requirements2 and D2.3 - DISCO Meta Model Suite architecture_final)	Yes. The solution complies with local regulations in Copenhagen, including those related to emissions control, zoning laws, and urban logistics. The project is closely aligned with Copenhagen's Sustainable Urban Logistics Plans (SULPs), which aim to reduce congestion and emissions through smart logistics management. (Source: D2.1 - Urban Logistics Transition Requirements2 and D2.3 - DISCO Meta Model Suite architecture_final)	Yes. The solution complies with local regulations, including zoning laws, emissions targets, and environmental sustainability goals. Relevant laws in Copenhagen include Sustainable Urban Logistics Plans (SULPs), which aim to reduce traffic congestion and emissions through more efficient urban freight management. (Source: D2.1 - Urban Logistics Transition Requirements2 and D2.3 - DISCO Meta Model Suite architecture_final)



Data Privacy Compliance		Does the solution comply with GDPR or other privacy regulations? Include any specific data protection measures (e.g., encryption, anonymization).	Yes/No + Privacy compliance description	Yes. DISCOPROXI complies with GDPR and other applicable privacy regulations. Data collected from logistics operations is anonymized to protect users' privacy. (Source: D2.1 - Urban Logistics Transition Requirements2, D2.2_Digital Transition Assessment Tool and D2.3 - DISCO Meta Model Suite architecture_final)	Yes. The Høje-Taastrup Transport Center complies with GDPR and other privacy regulations. All data collected from logistics operations, such as routing and warehouse utilization data, is anonymized.	Yes, it ensures data protection through encryption and anonymization of personal data collected from parking apps and sensors monitoring curbside availability. This ensures that no personally identifiable information is misused during the dynamic management of curbside spaces. (Source: D2.1 - Urban Logistics Transition Requirements2, D2.2_Digital Transition Assessment Tool and D2.3 - DISCO Meta Model Suite architecture_final)	Yes. DISCOLLECTION complies with GDPR and other applicable privacy regulations. Data collected from logistics operations is anonymized to protect users' privacy. (Source: D2.1 - Urban Logistics Transition Requirements2, D2.2_Digital Transition Assessment Tool and D2.3 - DISCO Meta Model Suite architecture_final)
5. Infrastructure Requirements						(Sources: DISCO - 1st Periodic Report M01-M18 and the CTC - Company Presentation October 2024 - Iskandar)	



Shared Infrastructure	Technical experts like software engineers/architects	What infrastructure (physical or digital) is shared with other DISCO-X solutions? Provide details on shared hubs, cloud services, or sensors.	List + Detailed description		N/A
Digital Infrastructure Requirements		What are the key digital infrastructure needs (e.g., bandwidth, cloud capacity, server specs)?	List + Detailed description		Cloud servers and IoT data storage capacity are needed to support the extensive data flow and real-time analytics requirements.
Physical Infrastructure Bottlenecks		Are there known bottlenecks in physical infrastructure (e.g., limited loading docks, storage space)? Describe potential solutions.	Yes/No + Bottleneck details		Potential bottlenecks include limited loading docks and curbside space, managed through dynamic allocation and sensor data.