Data-Driven and Dynamic Land Use for Physical Internet-Led Urban Logistics and Planning

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Abstract. DISCO is an innovation action project co-funded by the European Commission, focused on upscaling urban logistics and smart planning, accelerating the transition to decarbonized and digital cities by changing the logistics paradigm using a Physical Internet (PI) led approach. DISCO leverages the PI and Urban Cloud concepts to demonstrate the value of dynamic allocation of city infrastructures. The 5 DISCO-X measures employ sensor enabled infrastructures using PI collaboration protocols and an Urban Cloud model to enable the efficient and effective allocation of city infrastructures to users. In order to guide the cities towards the digital transformation and thus allowing them to build an ecosystem of logistics players that are willing to stay interconnected, three actions are necessary: (i) Influential market players register last-mile delivery capacities in an Urban Freight (UF) Data Space and establish trusted data sharing with planners for smarter, effective, functional, and real-time planning; (ii) The Meta Model Suite delineates optimal paths to achieve concrete transformation in Living Labs acting as PI networks; (iii) all involved actors comply with certain IT standards and protocols. In UF Data Space, DISCO will know all freight transport capabilities and space available in the city, in real-time and in advance and will support operational efficiency, dynamic planning, optimal use of available infrastructures, network and asset and better user experience. DISCO will deploy a demonstration involving 4 Starring Living Labs + 4 Twinning Living Labs and a package of 23 innovation measures, along 5 DISCO-X innovations, layered as digital, physical and business.

Keywords: Urban Logistics · Physical Internet · Data Space

1 Introduction: The DISCO Vision

Priorities of the EU Green Deal [1] to reduce climate emissions by 55% by 2030 and for cities to become climate-neutral by 2050 cannot be met only by setting vehicles' decarbonisation targets. To achieve these goals, urban space, logistics services and transportation systems need to be re-designed, adopting a dynamic and optimal space allocation

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approach that integrates urban freight within an efficiently operated network-of-networks that exploits underused land based on throughput demands. Cities are complex entities composed of multiple interacting networks of actors, systems, technologies, and regulations [2]. As a structure built from the interaction of multiple networks, a city is not a planned construct, but an emergent concept reflecting the multitude of interactions between its underlying components (e.g., [3]). Historically, the approach cities have taken to managing this complexity has been to organize functionally and, within function, to focus on either technical or geographic components of the function [4]. Unfortunately, such a structure has encouraged the development of "silo" thinking, which ignores the interconnections of the various networks that operate within a city. As cities have grown, the services that they are expected to deliver to their citizens have also grown. These services, provided by numerous city functional departments and external commercial entities, intersect, facilitate, and constrain the various recipients of the services in an emergent manner that no individual city department or company can foresee or control. Given the city's inability to systemically control or understand what is happening at the operational level means that the efficient and effective use of city infrastructures is not possible resulting in user frustration, loss of good will, and fair allocation. Another approach to managing the operations of the city's infrastructure is required. One such approach uses the Internet as an example of how intelligent objects and resources might be managed. If every physical entity is instrumented with a real time sensing and communications device, why can't these physical entities be managed like resources on the Internet? A "Physical Internet" concept [5–8] is a particularly useful model for thinking of city infrastructures like computing resources that can be provisioned "on demand" through cloud like "Infrastructure as a Service" (IaaS) concepts [9]. It is also a useful approach to managing freight and mobility services, which resemble the flow of packets over the Internet [10]. By abstracting its infrastructure through an "Urban Cloud" model, the city would provide convenience to its citizens and businesses. These users would no longer have to seek out open areas for parking, dropping off, or picking up items. They could schedule the abstract space through applications built on top of the city's IaaS services and be assured that they could use the space for the duration that they have scheduled it.

DISCO leverages the PI and Urban Cloud concepts to demonstrate the value of dynamic allocation of city infrastructures. The DISCO-X (X = Curb, Proxi, Bay, Estate, and Collection) measures employ sensor enabled infrastructures using Physical Internet collaboration protocols and an Urban Cloud model (city infrastructure managed as a service and a digital twin platform connecting to the infrastructure, linking federated dataspaces, and providing modeling and analytic tools to predict behavior and build additional services as a Platform as a Service) to enable the efficient and effective allocation of city infrastructures to users.

2 Methodology: The DISCO Approach

The DISCO relies on four subsequent methodological steps of a journey to scale up and accelerate to a climate-neutral data-driven value destination to 2030. This route is with the following methodological paths (Fig. 1):

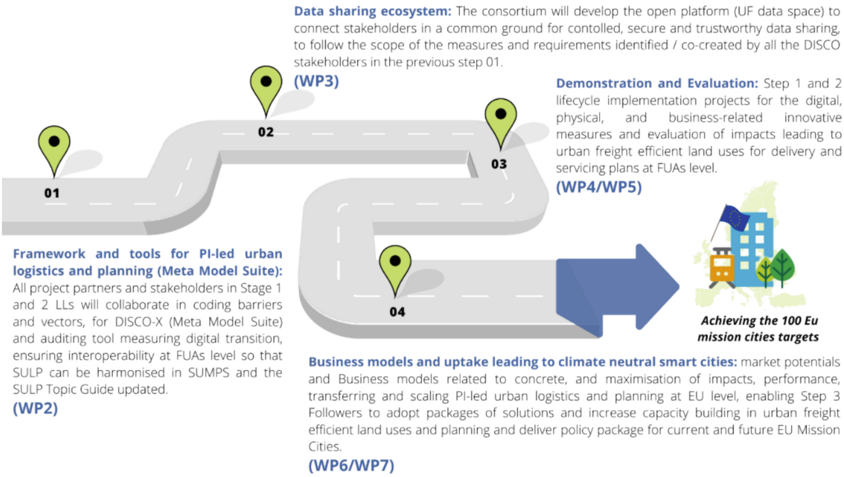

Fig. 1. Route to digital transformation in urban logistics and planning

In order to guide the cities towards the digital transformation and thus allowing them to build an ecosystem of logistics players that are willing to stay interconnected, three actions are necessary:

Action 1: Influential market players, from big carriers to cargo-bike couriers, register last-mile delivery capacities in an Urban Freight (UF) Data Space (IT platform) and establish trusted data sharing with planners for smarter, effective, functional, and real-time planning. Operators can benefit of dynamic (on-demand) and optimal use of (underexploited or strategically positioned) lands/space and adoption of zero-emission vehicles (e.g., e-bike to LEFV) and roll out of sustainable modes (waterborne / rail).

Action 2: The Meta Model Suite delineates optimal paths to achieve concrete transformation in Living Labs (LL) acting as PI networks, running packages of innovative digital, physical, and business measures, co-designed and enabled by multi-stakeholders' connectivity. Digital maturity is measured by Assessment Toolkit so that measures are widely accepted, scaled and to be considered in SULPs.

Action 3: All involved actors comply with certain IT standards and protocols, and ideally also on shipment sizes that are modular enough so that they can be flexibly and dynamically combined to allow a certain interconnection of the different parties to perform efficiently. In UF Data Space, DISCO will know (stream) all freight transport capabilities and space available in the city (e.g., freight hotels), in real-time and in advance and will support operational efficiency, dynamic planning, optimal use of available infrastructures, network and asset and better user experience. DISCO will be at the service of cities and operators, co-designing, simulating, monitoring, evaluating and scaling-up the DISCO innovative measures, belonging to different DISCO-X. These measures will be demonstrated by adopting the Meta Model Suite, enabled by the UF Data Space, empowering uptake, and replicability at different phases of design and implementation, and ensuring stakeholder's participation.

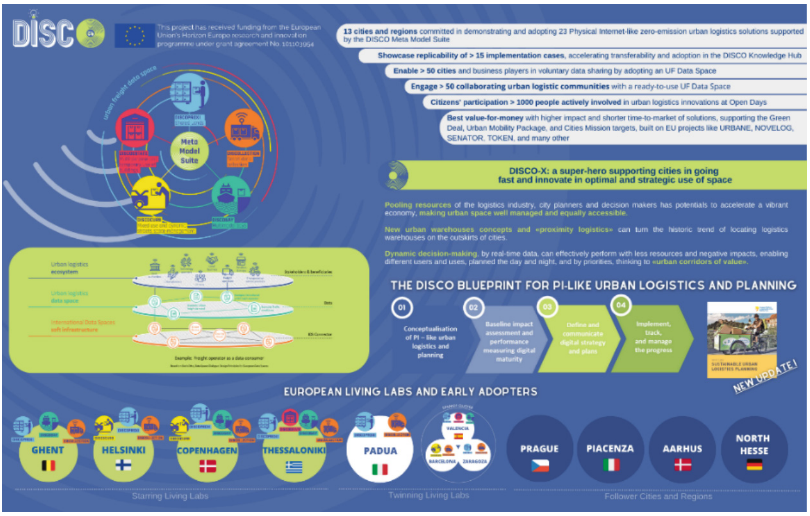

Fig. 2. DISCO overall approach

Meta Model Suite: The Meta Model Suite is a novel framework that supports the implementation and adoption of green last-mile delivery solutions in urban areas, based on the PI-led DISCO-X innovations listed below:

DISCOCURB - ***Mixed use and dynamic streets space management*** **-** Smart and flexible use of curb side, for parking slots, pick up points and network management.

DISCOPROXI - ***Shared Lands*** **-** Urban corners or lockers for nearby deliveries and omnichannel shipments, to optimise multiple collection and delivery solutions.

DISCOESTATE - ***Multi-purpose, flexible and temporary use of building space*** **-** Retrofitting building space for multi-tenant and temporary logistics use and enhance the reliability of last mile deliveries.

DISCOBAY - ***Multimodal bays*** **-** Mutualised and multimodal (e.g., rail/waterborne) distribution centres pooling green last mile delivery.

DISCOLLECTION - ***Smart data collection methods*** **-** Advanced access control and real time routing for optimised and prioritized, incentivised and dynamic access permission enabling smart network management upon priorities and functional areas.

These innovations aim to promote the adoption of shared green last mile solutions by considering physical, digital, and operational aspects. The suite consists of four main functionalities: (1) guidance to cities on the different DISCO innovations and their requirements, (2) definition of the transition path for each DISCO city to achieve a smooth transition to PI-led innovations and incorporate them into their SULP, (3) planning and operational tools for designing and implementing the different DISCO-X solutions, and (4) guidance to cities on the data requirements of each DISCO-X and how to develop their own dataspaces.

Urban Freight Data Space: The DISCO UF Data Space is the underlying digital enabler for the deployment of data-driven collaborative planning services. It provides a trustworthy framework for sharing data related to transportation, delivery, space use, and supply chain operations in urban areas across decentralised networks, whilst introducing semantic interoperability. The latter is particularly critical for establishing a common understanding of data meaning and context across diverse sources and the DISCO-X applications. Through the DISCO UF Data Space data sovereignty, transparency and fairness are ensured, creating the ground for stakeholders' onboarding. Data connectors will facilitate seamless data exchange services while incorporating robust data security enforcement mechanisms. A catalogue of key reusable services will further support the development of sustainable urban logistics strategies.

The Adaptive Blueprint for PI-Like Urban Logistics and Planning: The Adaptive Blueprint process will run across 4-Phases that will help cities and communities in undertaking a successful digital transformation with a simple stepwise approach, as initially planned in the Fig. 2. It will intensify the dialogue on SULPs and will provide insight in relation to urban logistics system of the future, the main planning requirements for promoting the shift towards PI-led solutions.

3 Preliminary Results and Discussion

At the final submission stage of this paper, the project hasn't reached yet one year of life. However, preliminary results showed: (i) Cities are confronted with a vast array of data types, originating from various platforms and in different formats. This heterogeneity, stemming from the unique requirements of the five DISCO-X categories, underscores the need for a specialized data aggregation tool or add-on within the urban dataspace; (ii) A preliminary version of the Meta Model Suite was introduced. This tool is envisioned as a comprehensive resource for cities embarking on the journey towards PI-enabled infrastructure management, offering a unified framework for the effective implementation of PI principles in urban logistics and infrastructure planning.

The DISCO impact domain underpinning PI-led urban logistics land use and planning in which innovation must be placed at the service of cities are: ***Shared Solutions***: Ability to create asset-less solutions by crowdsourcing platforms bringing various stakeholders under a common platform and creating value in terms of the economy of scale expected to generate. They can collaborate around technology to provide on-demand deliveries when it comes to their last-mile logistics. ***Connected logistics***: Ability to leverage key trends towards a data-centric approach and use analytics to manage fleets and regroup deliveries to take critical decisions pertaining to key logistics functions. Incorporating analytics to optimise routes and fuel usage, control emissions and monitor operational efficiency and performance, as well as for predictive deliveries to understand where an order would be. ***Smart logistics***: Ability to offer authorities opportunities to improve dynamic traffic management and improve enforcement of local rules, e.g., in terms of accessibility of a city centre. Smart logistics offer business opportunities to logistics companies and customers, improve efficient transport and warehousing, and facilitate (inter)connectivity among logistics networks, e.g., exchange of transport orders between different parties and/or modalities. Equal sharing costs / benefits models remain a hot topic. The exchange of traffic and logistics trip data between companies / authorities enables parties to improve operations. Smart logistics solutions create new connections and enable LSP's to collaborate. ***Urban network management***: Ability to adopt flexible and smart use of networks, dynamic access regulation, low emission zones regulation and monitoring, parking space management, dynamic routing. ***Agile storage and last-mile distribution:*** Ability to improve the delivery process and manage loading and unloading areas (scarce space management, in a flexible and integrated way, and of the contested curb side); to improve consolidation of goods and management of flows; to introduce new technologies that can make the freight distribution process more efficient through automation and data analysis.

4 Future Research

DISCO project will run for a total of four years, being yet at the first year only the initial phase of DISCO-X innovation in urban areas has been delineated together with a PI-operational paradigm offering a guidance for cities in implementing DISCO-X strategies effectively. In the next months/years for each DISCO-X, specific tools will be developed to enable the operation of the DISCO-X solutions to each city. The Urban Freight Data Space will facilitate the tools deployment by providing the good organization of the data needed for the implementation of each DISCO-X in the cities and utilize the meta data flows of the Urban Freight Data Space to obtain information sufficiently covering their needs.

Disclaimer DISCO is funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. Neither the European Union nor the granting authority can be held responsible for them."

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