D1.1: URBANE framework for optimised green last mile operations

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Author: **Rod Franklin, KLU**

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Authoring, Revision & QA Information

Deliverable Contributors	
Contributor	Organisation (Acronym)
Rod Franklin	KLU
Gero Niemann	KLU
Malte Spanuth	KLU
Bart Vannieuwenhuyse	TRV
Xavier Brusset	SKEMA
Miguel Suarez	SKEMA
Karima Abidat	SKEMA
Kostas Zavitsas	VLTN
Yasanur Kayikci	VLTN
Efstathios Zavvos	VLTN
Albert Sole	EITUM
Javier Romo	CIDAUT
Simon Hayes	VAN
Merve Cebeci	TUD
Rodrigo Tapia	TUD
Lóri Tavasszy	TUD
Xenou Elpida	CERTH
Lara Prolingheuer	AENET
Gergely Horvath	LMAD
Samuli Salmela	DBSCH
Aristea Zafeiropoulou	KNT
Harris Niavis	INLECOM
Maria Kampa	INLECOM
Dimitris Rizopoulos	INLECOM
Ioanna Fergadiotou	INLECOM

Deliverable Contributors				
Version	Date	%	Changes	Author
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Executive Summary

The URBANE project provides support for the European Union's efforts to achieve safe and sustainable last mile delivery operations. The efforts conducted within the URBANE project to achieve safe and sustainable last mile delivery operations are driven by six key objectives:

1. Analyse the Physical, Digital, Social and Business dimensions of complex last mile logistics delivery systems to define target strategic innovations of significant potential impact and develop a new framework to facilitate the co-creation of innovative last mile delivery solutions, accounting for environmental and energy efficiency.
2. To setup, prototype, test and demonstrate last mile innovative solutions in four Lighthouse LLs [Wave 1], seen as commodities for all actors in an open, neutral and cooperation-based community.
3. Provide the infrastructural Enablers for Innovation Transferability including consensus protocols to support collaborative services in local logistics networks governed by smart contracts, Digital Twinning capabilities and data driven decision making tools to enable replicability of most performing practices.
4. Model, deploy and demonstrate smart solutions in two Twining Living Labs (Wave 2), clearly evidencing level of adaptation of models and efficient replicability of solutions demonstrated in Wave 1 LLs.
5. Develop Business Plans and design a Commercialization Path for key project outcomes.
6. Disseminate, promote scale-up, enable effective policymaking, and support relevant LL initiatives at EU level.

This report focuses on the first of these objectives and is the result of work done in completing Work Package 1 of the project, the URBANE innovation framework for optimized green last mile logistics. Deliverable 1.1 documents the work performed in three tasks of the work package and describes the principles and prerequisites of a Physical Internet inspired urban logistics operational model and establishes the strategic priorities and direction of the URBANE project.

The document defines how the Physical Internet (PI) operates, how this approach to conducting logistics operations can be applied to urban and last mile logistics operations, the challenges faced when attempting to implement the Physical Internet given existing commercial and regulatory constraints, and how cities can overcome these challenges to improve the environmental, social, and commercial aspects of last mile delivery operations. The document also identifies innovative approaches to the physical operation of last mile delivery services, documents successful collaborative models for these services and provides guidance for the other work packages in the project.

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List of Abbreviations

ACRONYM	DECRIPTION
ADV	Automated delivery vehicle
AGC	Automated guided cart
AGV	Automated guided vehicle
B2B	Business-to-business
B2C	Business-to-consumer
BEV	Battery-electric vehicles
BOT	Build operate transfer
BOO	Buy own operate
BOOT	Build own operate transfer
C-ITS	Cooperative Intelligent Transport Systems
CAAM	Cooperative, Connected and Automated Mobility
COOP MIL	Cooperative supply chain
EDV	Electric drive vehicle
E-LCV	Electric light commercial vehicle
E-Van	Electric delivery van
EFT	Electronic Fund Transfer
GeA	Gentlemen's Agreement
GHG	Greenhouse gas
GIS	Geographic information system
ICE	Internal combustion engine
IP	Internet Protocol
KPI	Key Performance Indicator
LaaS	Logistics as a Service
LDO	Lease develop operate
LEV	Light electric vehicle

LEZ	Low-emission zone
LMD	Last mile delivery
LOE	Letter of engagement
LOI	Letter of Intent
MaaS	Mobility as a Service
MLC	Multi-lateral contract
NDA	Non-Disclosure Agreement
OPHD	Off-peak hour delivery
PHEV	Plug-in hybrid electric vehicle
PI	Physical Internet
POD	Proof of delivery
PPP	Public private partnership
PUDO	Pick Up and Drop Off
T&L	Transport & Logistics
TCP	Transmission control protocol
TSP	Traveling salesman problem
UCC	Urban consolidation centre
ULEZ	Ultra-low-emission zone
WLAN	Wireless local area network
WOW	Warehouse on Wheels
VRP	Vehicle routing problem

Glossary of Terms and Acronyms

This table reflects the collaborative effort of project partners to harmonise the terminology used in last mile logistics in a PI context.

TERM	DEFINITION
Business Models	A business model describes the rationale for how an organisation creates, delivers, and captures value.

Cargo hitching	This delivery service refers to the combination of freight transport and public transport operations
City authorities	These are the de jure representatives of the residents. As such they are responsible for their well-being and echo their preoccupations
Click-and-collect delivery option	Click-and-collect links the online web shop to the physical shop. These points could be located in the store in which the purchase is made, or it could be at a different location.
End-customer	This terms not only covers individuals placing orders for goods, but also "legal persons," in other words, the businesses that operate within a city, governments, and visitors who may order goods while within a city's borders.
Incentive schemes	For a business model to be adopted by the actors, incentives schemes need to be examined. Incentive schemes refer to various aspects such as fiat, provision of infrastructure and market regulated private operations.
Logistics service providers	The term LSP is used as a collective term for main stakeholders that provide logistics services, e.g., carrier, warehouse operator, freight forwarder, etc.
Logistics Service provider (LSP LMD)	This term covers all actors that provide a logistics service (3PLs, warehouse operators, carriers, transport companies, etc.). This term is used throughout the document where the service provider's role can be understood from the context. In certain situations where a specific type of service provider is being discussed that type of logistics service provider's specific name is used (e.g., freight forwarder).
Microhub	A logistics facility for micro-consolidation, which is the bundling of goods at a location near the final delivery point. These facilities are also called as micro-consolidation centres and multicarrier consolidation centres.
Mobile microhub	These facilities are also as called moving warehouses, mobile warehouses, mobile microhubs and Warehouses on Wheels. These are trailers or containers fitted with a loading dock, warehousing facilities, and an office.
Mobile parcel lockers	Mobile parcel lockers, like mobile microhubs, allow the location of the parcel locker to be flexibly changed during the day.
Network structures	These are the models forming the channels of distribution that an organization's marketing group identifies as being important for reaching its customers.
Open access	This term refers to the seamless and open use of the PI-enabled services by any entity in the system.
Parcel lockers	These are logistics facilities providing self-serve characteristic for packages.
PI Access	This defines an easy and non-bureaucratic access to the PI is a crucial prerequisite for the effective and efficient implementation of the PI.
PI Adoption	This refers to understanding roles, access, governance, and operations as well as data exchange and performance requirements.

PI Governance	The goal of governance in the PI is to make the universal interconnection between logistics networks technically feasible and economically profitable which creates acceptance by society and industry.
PI Networks	PI networks connect various existing networks through nodes into a seamless interconnected logistics and transportation system to create a more interconnected and efficient network for the movement of goods.
PI nodes	PI nodes are physical locations for example terminals, depots, warehouses, distribution centres, parcel lockers or even cities.
PI System	This is defined as connectivity across logistic networks but also specific functionalities and integration of further entities, aside from the logistic networks itself.
Private systems	These include private-led initiatives, single carrier logistics facilities.
Public private partnerships	A shared infrastructure which uses the collaboration of city authorities and private investors to set up the microhubs either as Urban Consolidation Centres (UCC) or as parcel lockers where parcels are to be retrieved either by end-customers or by last mile delivery service providers.
Regional distribution centres	These facilities distribute and consolidate the packages to/from the UCCs. Also, they link areas in other words cities.
Urban Consolidation Centre	These are also called urban distribution centres, city logistics centres, city terminals, freight consolidation platforms, urban transhipment centres, and the more generic freight platforms can be shared logistics facilities or single owner facilities.
Value proposition	This concept refers to the products and/or services of a company that create value for a customer segment.

1. Introduction

1.1 WP1 tasks and outcomes

The URBANE project focuses on developing "efficient, replicable and socially acceptable innovative last mile delivery solutions." These solutions will be demonstrated in four Light House Living Laboratories, Helsinki, Bologna, Valladolid, and Thessaloniki. URBANE focuses on last mile delivery operations due to their rapid growth and resulting impact on a city's residents and environment. While freight transport emissions account for less than 10% of total global greenhouse gas emissions (Freight Transportation | MIT Climate Portal), emissions from freight operations, without a change in either demand or technology, are expected to double by 2050 (McKinsey Road Freight Global Pathways Report, ITF The Carbon Footprint of Global Trade). Growth in last mile delivery emissions is expected to be the fastest growing component of freight transport emissions. Estimates by Morgan Stanley (Global Ecommerce Growth Forecast 2022 | Morgan Stanley) indicate that ecommerce demand could grow between 17% and 20% over the next five years, with continuing double digit growth thereafter. Unless alternative approaches to the current van based operation of last mile delivery are adopted, cities can expect to see a continuing rise in negative environmental and social impacts from last mile deliveries for the foreseeable future.

This report is the final deliverable of Work Package 1 of the URBANE project. With this report, URBANE Framework for Optimized Green Last Mile Operations, the project provides a consolidated set of results from the tasks performed in the work package, describes the principles and prerequisites for a Physical Internet (PI) approach to urban logistics operations, and sets the strategic priorities and direction for the remainder of the URBANE project effort. Work Package 1 was composed of three primary tasks:

1. Define target strategic innovations of significant potential impact,
2. Last mile collaboration – incentives and white label schemes, and
3. PI-inspired urban logistics operations and data sharing governance across the value chain.

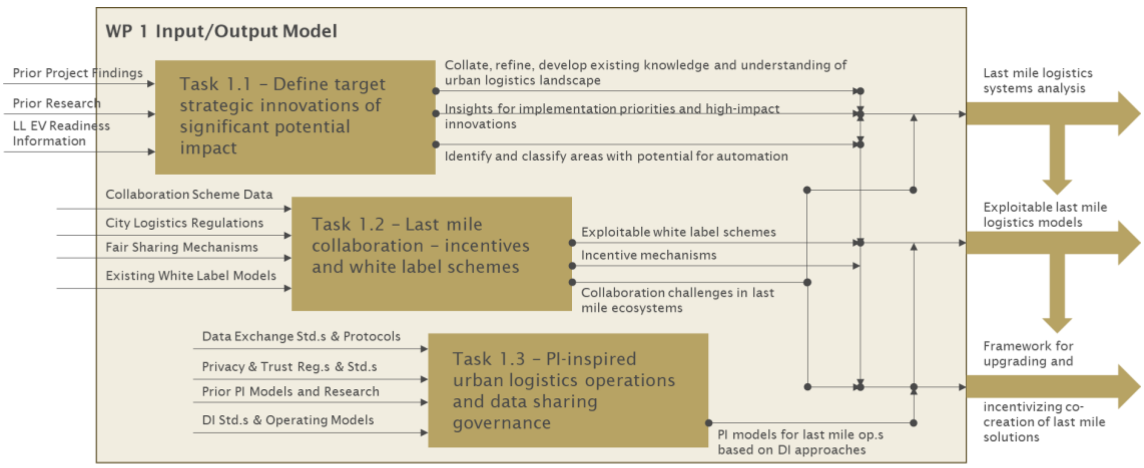


FIGURE 1 - WORK PACKAGE 1 INPUT/OUTPUT MODEL

This report is organized around a summary of the findings of each of these tasks, a description of the PI, and the development of a set of priorities for the URBANE project and its participants for developing innovative last mile solutions based on the PI (the requirements as specified per the project's grant agreement for this deliverable). The report also includes more detailed discussions on each of the tasks and their outputs for readers who wish to dig more deeply into the summarized findings and conclusions that appear in final deliverable itself.

As noted in the Introduction of this report, Work Package 1 of the URBANE project focuses on the development of a framework that provides guidance to project partners and other urban actors looking to implement sustainable last mile operations. To develop this framework, three tasks were defined for the work package. The tasks, their high-level outputs, and their relationship to one another are shown in the figure that follows.

The three tasks that compose the work package can be thought of as focusing on the development of a current state understanding of how last mile delivery is performed today, what innovative approaches have been tried and their outcomes, what is needed to move from the current state to a future state, and how one potential future state (a Physical Internet) might come about and what its benefits might be. As this work package's deliverable has been defined as a framework, its approach has been one of synthesis. Much work has been conducted in attempting to reconceptualize last mile delivery operations. These approaches, as will be discussed in the detailed task sections that follow the this section, have focused on eliminating traditional carbon based energy delivery vehicles from last mile operations, substituting local pick up and drop off (PUDO) systems for home, retail, or office delivery, moving delivery consolidation points closer to the neighbourhoods in which the deliveries are to be made, and utilizing emerging automated technologies (e.g., robots and drones) to substitute for human operated final delivery mechanisms. While many of these efforts have demonstrated both feasibility and benefit, there has been limited impact on the actual performance of last mile operations (e.g., see McKinsey, Infrastructure Technologies: Challenges and solutions for smart mobility in urban areas). Figure 2 maps the tasks with the outputs as addresses in this report.

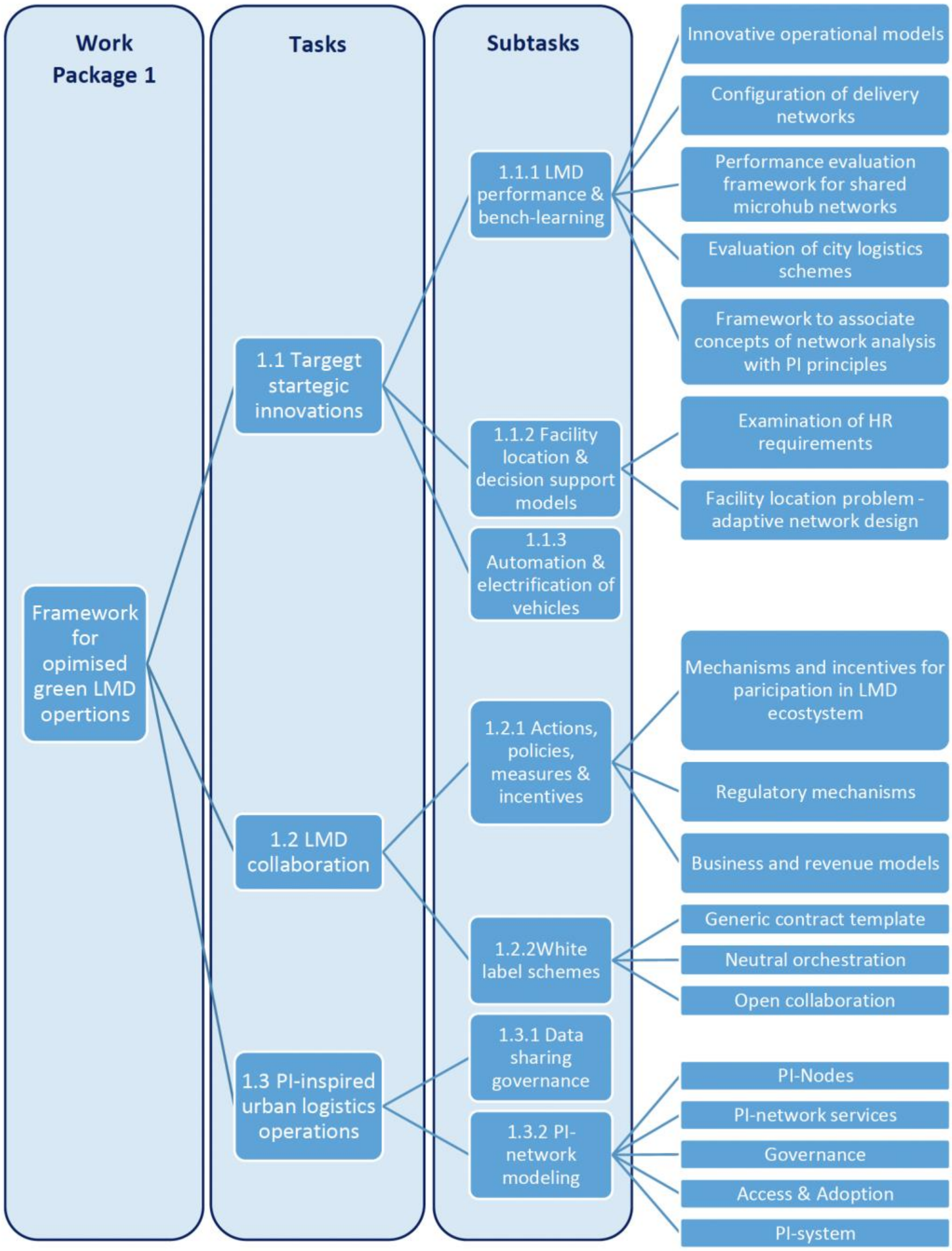


FIGURE 2 - MAPPING OF WP1 TASKS AND OUTCOMES

1.2 URBANE Outputs Mapping to GA Commitments

This report addresses the GA requirements as mapped in the following table.

TABLE 1 - DELIVERABLE ADHERENCE TO GRANT AGREEMENT DELIVERABLE AND WORK DESCRIPTION

URBANE GA Item	URBANE GA Item Description	Document Chapter(s)	Justification
		DELIVERABLE	
D.1.1 ***URBANE framework for optimised green last mile operations***	*Report on the assessment of solutions, user acceptance tests, KPI measurements across LLs, learning conclusions and reusable results (models). The report will consolidate stakeholder clustering in each Lighthouse LL city, based on agent-based scenario modelling, considering social, environmental and economic criteria.*	*Chapters 2-4*	*The report consolidates the outcomes of the work carried out in all WP1 tasks, starting from analysing the Physical, Digital, Social and Business dimensions of complex last mile logistics systems, drawing upon past projects and actual applications and introduces a PI framework aiming to accelerate the smart readiness transition of cities for greener last mile deliveries.*
		TASKS	
Task 1.1 ***Define target strategic innovations of significant potential impact***	*ST1.1.1: Last mile distribution performance and bench-learning activities.* *ST1.1.2: Demand based facility location and decision support models.* *ST1.1.3: Automation and electrification of vehicles and infrastructure smart readiness.*	*Chapter 3*	*This Chapter maps the landscape of prior work on innovations for last mile deliveries, identify improved decision-making approaches for the distribution of goods to urban neighbourhoods, and determine what infrastructure modifications/enhancements might be required to allow for the operation of innovative last mile delivery models and technologies.*
Task 1.2 ***Last mile collaboration - incentives and white label schemes***	*ST1.2.1: Proposal of actions, policies, measures and incentive schemes, that aim at the alignment of stakeholders' views (city authorities, logistic operators, warehouse owners) within the business ecosystem.*	*Chapter 4* *Annex 2*	*This Chapter focuses on determining potential mechanisms to encourage operators to collaborate. The first focus area looked at incentives that might encourage actors to collaborate. The second focus examined the potential of white label consolidation and delivery schemes*

	ST1.2.2 White-label collaboration scheme for city logistics ECO-systems, that can be adopted and adapted by collaborative communities of the LLs.		*as a potential collaborative means for last mile delivery. Annex 2 includes generic collaboration contracts that can be adapted and used in the URBANE Living Labs.*
Task 1.3 ***PI-inspired urban logistics operations and data sharing governance across the value cha***	*ST1.3.1 Data Sharing Governance.* *ST1.3.2 Modelling PI networks for last mile.*	*Chapter 2*	*Chapter 2 introduces the concept and functions of PI nodes in last mile deliveries, organised in a PI network. It sets the foundations for PI networks management, information exchange/sharing, the roles of stakeholders and governance imperatives including protocols to manage flows.*

1.3 Deliverable Overview and Report Structure

The report includes five main chapters:

- Chapter 1 - INTRODUCTION
- Chapter 2 - PHYSICAL INTERNET (PI) AND PI-ENABLED LAST MILE OPERATIONS, including barriers to PI adoption and guidelines for the URBANE Living Labs,
- Chapter 3 - MAPPING LANDSCAPE OF INNOVATION ON LAST MILE OPERATIONS
- Chapter 4 - LAST MILE COLLABORATION – INCENTIVES AND WHITE LABEL SCHEMES
- Chapter 5 includes the conclusions and next steps.

Further ANNEX 1 appends reference projects in Urban Logistics informing URBANE's activities and business models and last, ANNEX 2 includes generic collaboration contracts that can be adapted and used in the URBANE Living Labs, especially be leveraging blockchain technology and using them as the basis of Smart Contracts.

2. Physical Internet (PI) and PI-enabled Last Mile Operations

2.1 The Physical Internet (PI) – An overview

Online trade and the associated courier express parcel (CEP) sector have grown significantly in recent years (Esser & Kurte, 2020; Forbes, 2022; McKinsey, 2021). A study by A.T. Kearny estimates that the CEP market volume grew by 10% within Europe in 2016 (A.T. Kearny, 2017). In addition, a recently published study predicts a global compound annual growth rate for 2022 of 11.5%. By 2026, the market is expected to grow by 7.5% annually (The Business Research Company, 2022). These figures demonstrate the industry's rapid growth and increasing freight volume in the coming years.

The increase in parcel deliveries that is accompanying this growth in the CEP sector has had a negative impact on traffic in urban areas. This is a problem that needs to be addresses as, according to the European Court of Auditors, in 2019 70% of Europe's inhabitants were living in urban cities and this number is projected to increase to 80% by 2050 (ECA, 2019).

The combination of an increasing number of parcel shipments and a growing population in urban regions has led to increasing traffic and congestion in cities. Contributing to this problem are an increase in private automobiles, construction vehicle activities, public transport, and last mile delivery vehicles. The URBANE project is one of a number of European initiatives exploring innovative approaches to reducing the negative impacts of last mile deliveries. The focus of these initiatives is to identify workable solutions for cities that reduce traffic, lower negative environmental impacts due to delivery vehicles, and improve safety. One approach to potentially addressing the problems of increasing last mile delivery operations is a logistics approach based on ideas developed in moving digital packets over the Internet. This concept, called the Physical Internet (PI), is best understood if one understands how the digital Internet operates.

In the Internet, data packets are transmitted from a source host through different networks to a destination host (Figure 3). There are various devices and protocols (rules) that enable the smooth flow of data over these networks and between the hosts. Routers decide over which link (pathway) the data packet is sent to the next router closer to the destination. If the physical medium must be changed, for example from Ethernet cable to Wireless Local Area Network (WLAN), modems are used. To enable the flow of data packets over the networks, two protocols are particularly important: the Transmission Control Protocol (TCP) and the Internet Protocol (IP). The TCP how data and/or messages can be broken down into transmittable packets, manages the flow of these packets across the Internet, and ensures that the data that was transmitted reaches its destination. The IP provides routing and addressing rules for packets so that routers can send the packets to the appropriate destination host.

The Internet is not one single network, but a network-of-networks. Through the use of gateway protocols, the Internet ensures that each independent network (called Autonomous Systems in Internet terminology) can send messages across the many networks making up the Internet to destination hosts. The PI, in an analogous manner, aims to implement a network of independent physical distribution networks in which operations are performed by the existing network operators (logistics service providers

(LSPs)) or new players that emerge out of the PI. This physical network-of-networks is envisioned as enabling the efficient flow of goods between senders and end-customer through distribution, consolidation and intermodal centres/hubs (routers in the Internet) in a manner similar to that employed in the movement of data packets over the Internet (Dong & Franklin, 2021). Figure 3 illustrates the analogies between the Internet and PI.

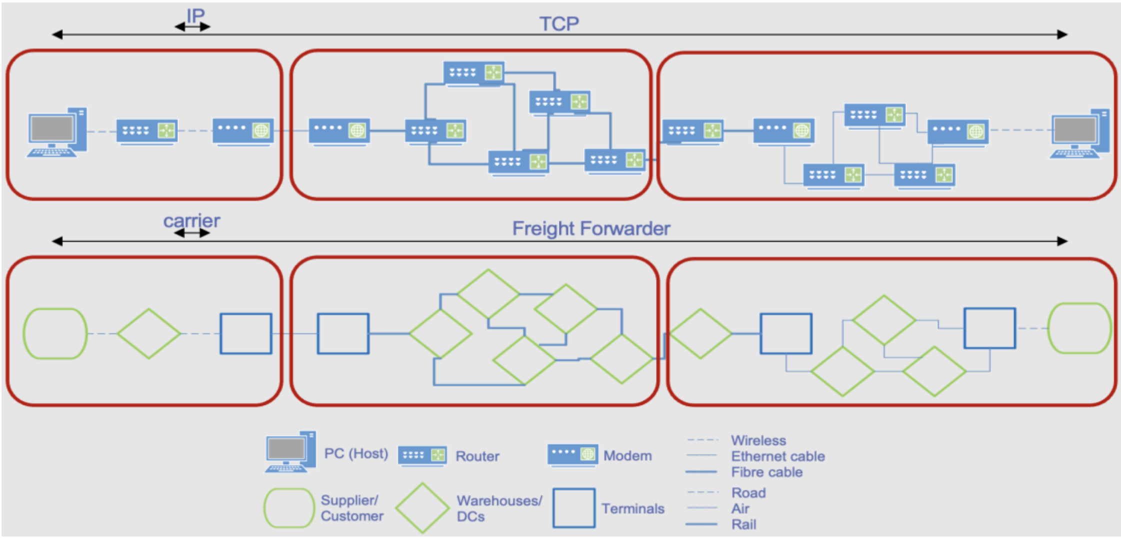


FIGURE 3 - COMPARISON INTERNET VS. PHYSICAL INTERNET

Figure 3 shows a simplified comparison of how a digital packet is sent over the Internet (top diagram) and how a physical package would flow over the PI. A translation between the steps shown in the two models can be found in Table 2. The physical shipment process starts with a supplier wanting to send parcels to an end-customer. Subsequently, the parcels are sent through various logistics networks until they reach the end-customer. Warehouses and distribution centres take on the role of routers, deconsolidating and consolidating packets and deciding which link to use for sending the package to the next "router." Terminals are involved when the mode of transport needs to be changed, for example from air to road. In PI, terminals are the equivalent of modems in the Internet. Freight forwarders, like the TCP protocol in the Internet, ensure that the packets reach the end-customer at the right time. Carriers take over the packet movement task of the IP and ensure secure transport of the parcels between the nodes (note that addressing standard that are used in the Internet, and which are defined by the IP, are defined for physical goods movements outside of the PI).

TABLE 2 - COMPONENTS INTERNET VS. PHYSICAL INTERNET

DI	Explanation	PI	Explanation
PC/Host	Sends/ receives data	**Supplier/ End-customer**	Sends/ receives parcels
Router	Divides data packets if they are too big for subsequent network.	**Warehouses/ Distribution centres**	Deconsolidates, consolidates, and redistributes parcels

	Decides which link is used next to transmit data packets		
Modem	Are used when the physical media is changed	**Terminals**	Are used when the mode of transport is changed
Wireless **Ethernet Cable** **Fiber Cable**	Infrastructure to transmit data Links PCs, Routers, and modems	**Road** **Air** **Rail**	Infrastructure for carrier to transport parcels Links supplier, warehouses, terminals, and end-customer
Transmission Control Protocol (TCP)	Ensures that the information reaches its destination in the correct order	**Freight Forwarder**	ensures that the packets reach their destination at the correct time
Internet Protocol (IP)	Ensures the transport of the data packets on the links between the routers	**Carrier**	ensures the transport of the packets on the links between warehouses
TCP/IP (together)	Orchestrate the transmission of data packets in a reliable, ordered manner between applications running on hosts communicating via an IP network.	**Freight Forwarders & Carriers** **(in collaboration)**	Organise the entire freight shipping process (including transport, documentation, warehousing etc.) from origin to destination in a logistics network.

The following sections of this report provide more detail concerning the components of PI. In these discussions the Internet will continue to be referenced to maintain the analogy started in this introductory section.

2.1.1 PI Nodes

2.1.1.1 What are PI nodes?

To develop a comprehensive overview of where PI nodes sit in the overall framework of the PI, the delivery process of a package is briefly described. To move goods from a starting point A to a destination B several stakeholders, physical vehicles and logistics facilities are involved. The following overview focuses on the distribution of a shipments within a single country and thus only includes a road based transport discussion. International or non-road modes of transport are not discussed in this simple model. As soon as the end-customer has placed an order, employees at fulfilment centres start to pick and pack the end-customer order, which is subsequently consolidated with other parcels and loaded into a line haul trailer to transport it to a sorting centre. At a sorting centre, loads are organized and consolidated into trucks for further middle haul transport. Once the goods end the middle haul at a delivery station, employees sort parcels for the last mile according to their delivery route into vans and end-customers are notified that their parcels are "out for delivery."

As noted, the delivery process incorporates several stations where parcels are deconsolidated, sorted, consolidated, and loaded again. These stations are defined as nodes in the PI framework. Once again, parallels can be drawn to the Internet where nodes such as routers also play a fundamental role in the deconsolidation, sorting, consolidation, and forwarding of data packets. The close resemblance between the flow of data packets and physical parcels makes it useful to understand the role of nodes in the Internet to be able to draw analogies for the nodes in the PI.

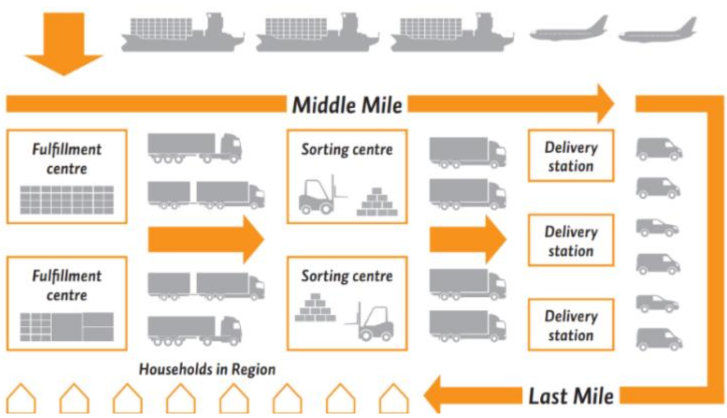


FIGURE 4 - DELIVERY PROCESS[1]

Various nodal technologies are employed for moving data packets over the Internet. These technologies are termed modems, switches, hubs, and routers. Modems are needed when the mode of transmission is changed (e.g., WLAN to ethernet cable). The task of a switch is to connect devices within a local network and to transfer data packets between them. Hubs distribute information to all devices within the local area network. Today's modern routers incorporate the functions of switches and hubs and this term (router) will be used in the remainder of this document to cover the functions of these other technologies. A router receives data packets that flow into its receiving queues. The router reads the header information on the incoming packet and determines where its final destination is. In determining where the packet is going, the router may determine that the packet's destination is outside the network to which the router belongs. If this determination is made, the router repackages for transmission across the gateway between its home network and the external network. Once the destination has been determined and any repackaging performed, the router moves the packet to an outbound queue for retransmission to the next stop in its journey (Dong & Franklin, 2021).

PI nodes are analogous to the various nodal technologies used in transmitting data packets over the Internet. However, PI nodes are physical locations such as terminals, depots, warehouses, distribution centres, parcel lockers, PUDO operations, etc. PI terminals, such as seaport, airport, inland waterway, and rail terminals, facilitate mode switch analogous to modems for Internet transmission mode switching. They also reroute shipments, so their operations, while a bit more complex than a standard router like node, can still be envisioned under the concept of a router. PI nodes, keeping in mind the prior discussion of terminals, act as routers handling deconsolidation, reconsolidation, and outbound lane determination for parcels that they handle. The workflows within the PI nodes are the responsibility of the node

[1] RLS_AMAZONS_LAST_MILE_DIN-A-4_20211006.INDD (ROSALUX.DE))

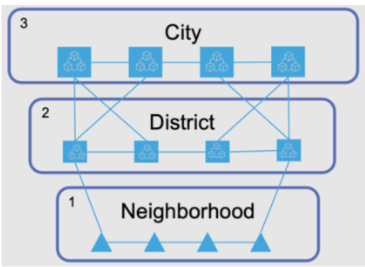
operators, just as the routing algorithms in each Internet router are determined by the router manufacturer. However, the inbound and outbound protocols, as well as the cross PI shipment management protocol all need to adhere to the PI's equivalent TCP/IP protocols to allow for the seamless transfer and flow of goods over the PI (note that these protocols are, at this point in time, still being discussed and defined).

Several different node hierarchies can be developed based on the perspective that one wishes to take concern the flow of goods over the PI. One might be interested in how goods flow through a geography where nodes are clustered depending on their geographical location. Another viewer might be interested in the function of the node and therefor cluster nodes based on the function each nodes serves. Nothing prevents someone from combining both of these views and this combined view, as described in Montreuil et. al (2018) is employed in the discussion of urban flows that follows.

The highest level node in the urban model acts as a gateway. It connects different cities with one another, receiving goods from outside its home city for distribution to locations within the city or retransmission onwards to other cities. It also receives goods from within its home city for distribution to other cities or for retransmission to other peer or lower level nodes within the city. The gateway node is responsible for receiving shipments, deconsolidation and reconsolidation of shipments, determination of best lane for their onward journey, and embarking them on that journey. The same functions are performed by the lower level local and microhubs, which are the next two hierarchy levels in the nodal hierarchy. The main difference between hierarchical level is that the volume of goods handled is reduced at each level due to the reduction in geographic coverage of the node (Montreuil et al., 2018).

To ensure better comprehensibility the hierarchy of the nodes with a short description of their main function is displayed below.

TABLE 3 - NODE HIERARCHY BASED ON MONTREUIL ET AL. (2018)

	**National**	**Primary autonomous system**
	Regional distribution centre • Distributes/ consolidates the parcels to/ from the UCCs • Links areas (cities)	Secondary autonomous system
	Urban consolidation centre • Distributes/ consolidates the parcels to/ from the microhubs • Links local cells (districts)	Local area network
	Microhub • Distributes/ consolidates the parcels to/ from the end-customer. • Links Unit zones (neighbourhoods)	Local area networks

2.1.1.2 The role of PI nodes

As explained in the previous section, PI nodes are entities that enable input and output flow in the logistics network. Specifically, in the last mile delivery setting, defining the roles and responsibilities of a node is of importance because it provides visibility and accessibility to the logistics operations for involved stakeholders when services and operations are shared in an integrated network. When multiple LSPs operate nodes independently, there is limited communication and visibility between node levels and hierarchies for stakeholders external to the LSP. Unlike the Internet where nodes share information on loads, congestion (through timing protocols), and connection status, LSPs operating their independent networks generally ignore other LSPs unless they have a contracted relationship with them. Even when under contract, only a small amount of information is shared between the LSPs. Sharing of resources and facilities is not an element of this competitive landscape.

In last mile delivery operations nodes of the system refer to distribution centres, urban consolidation centres, and microhubs. Even though these facilities fulfil the various roles for nodes in the defined hierarchy they are not open and shared among different LSPs. This leads to inefficiencies in the operation of the system of urban logistics (not necessarily in each LSP's operation of their nodes). PI nodes exhibit two critical differences. First, they provide an **open** physical infrastructure that enables the logistics services to be operated collaboratively, such as open regional distribution centres, UCCs, and microhubs. Secondly, these nodes are the main **enablers** of standard and accessible service operations. As open and collaborative transfer points, PI nodes are similar to the Internet nodes that perform inbound flow management, outbound lane selection, packet aggregation by lane, and outbound flow management without regard to whose packets they are handling.

2.1.1.3 Node operations in the PI

Nodes are one of the most complex parts of the PI vision as their roles determine the efficiency of the PI network. Open and shared nodes, operating in collaboration with one another, their logistics partners, and the communities in which they are situated increase efficiency and effectiveness of urban logistics operations. The operation of an integrated network of open and collaborative urban logistics nodes is something that will not occur overnight. An evolutionary process is envisioned for the development of this part of the PI vision. In this process the following generational steps are considered:

- *Generation 1:* Nodes standardise components for handling (equipment, sizes) and communication/ICT (RFID, APIs). In this stage, nodes start functioning in a common manner, and distribution centres, UCCs and microhubs become open and shared among the service users.
- *Generation 2:* Nodes standardise and automate their services and start interconnecting bilaterally.
- *Generation 3:* Nodes interact with the logistics network, meaning that instead of only having one UCC, nodes will be connected to a set of UCCs.
- *Generation 4:* Nodes collaborate to provide services to users and suppliers as a single network. This enables the use of pre-defined paths and routes as well as fully autonomous interaction between nodes at the physical and digital levels.

2.1.2 PI Networks

Current logistics networks consist of interconnected transportation and storage nodes, the links between them and the modes that are operated on the links as well as services that are provided within the network boundaries. The primary purpose of these networks is to enable the movement of goods from one point to another subject to specific objectives. These objectives may be cost efficiency, fastest delivery time or lowest environmental impact. PI networks propose a solution to optimize logistics under equal provision of several objectives.

2.1.2.1 What is a PI network?

Current logistics networks belong to LSPs like DHL, UPS, or FedEx that manage their networks in a highly optimized manner. In these networks the control is managed by a single company with limited visibility beyond the boundary of the network. These private networks include nodes that operate in a manner like routers on the Internet. DHL for example operates numerous warehouses, distribution centres, and consolidation hubs that represent nodes on the journey of a package from the sender to the end-customer. PI networks extend these private networks (Physical Intranets) by connecting them through gateways (Ballot et al., 2020). In the Internet these inter-network-connections are established through routers running Boundary Gateway Protocols. In the PI any node can act as an inter-network connection as long as it implements a standard set of PI interconnection protocols that enable goods being controlled by one LSP to be seamlessly handed over to another LSP for onward movement and control in the second LSP's network (Ballot et al., 2020).

2.1.2.2 PI network operations

PI networks connect various existing networks through nodes into a seamless interconnected logistics and transportation system. PI connection nodes may include warehouses, distribution centres, ports, transportation hubs, and other logistics facilities. The operations within the PI network provide seamless door-to-door service where users state their transport demand form origin to destination and leave the execution to the network and its actors. Effective and efficient collaboration and consolidation of loads within this network-of-networks maximizes the network performance and ensures service levels are met. Routing within the network is dynamically adjustable to absorb disturbances or demand fluctuations. Inventory can be stored within the shared nodes based on expected end-customer demand to reduce transport requirements and increase response times.

To ensure that all the operations in the PI are feasible, certain prerequisites on the physical, operational and digital levels have to be established (Crainic & Montreuil, 2016)

- **Physical level:** The PI network provides shippers with Infrastructure as a Service (IaaS) that is shared between different stakeholders. This infrastructure can be provided by cities (roads, curbs, parking spaces, sidewalks, open space, et al.) or private organizations (DHL, UPS, FedEx, et al.) that provide operational assets such as warehouses, distribution centres, or microhubs. Infrastructure and assets are, therefore, a service provided by the PI network.
- **Operational level:** On the operational level a smooth flow of goods across the network must be ensured. PI protocols and operating processes are employed to ensure goods reach their

destination on time and in the most efficient and effective way. Protocols ensure the dynamic consolidation and coordination of shipments based on real time routing, scheduling, pricing, and inventory deployment rules. Goods can also be stored in nodes to enable decentralized inventory management to increase service levels and reduce safety stocks.

- **Digital level:** To enable the operation of the PI network, information must be exchanged between LSPs and infrastructure systems. Smart logistics technologies, such as the Internet of Things (IoT), Artificial Intelligence (AI), and Big Data analytics, enable monitoring and real time tracking of goods allowing for upstream and downstream visibility across the supply chain. Blockchain and Smart Contracts technologies can help establish a secure and transparent system for information exchange and payments, by automating and enforcing agreements and facilitating efficient coordination and collaboration between all parties involved in the network (Bouchard et al, 2019; Hua & Zhang, 2020).

2.1.2.3 PI network management

Managing a network, whether it be the PI or the Internet, requires that participants adhere to standard protocols. In the Internet different Internet Service Providers (ISPs) provide different Internet services (Dong & Franklin, 2021). These ISPs are very similar to the LSPs that ensure the smooth flow of physical goods in the PI. To manage the flow of data packets, the Internet applies standards that are incorporated in protocols and are organized in layers. Such a protocol stack is also required for the PI to manage the operation of the PI network. The following table provides a mapping between the five layers in the Internet protocol stack used to manage the operations of the Internet to a similar protocol stack for the management of the PI network.

TABLE 4 - FIVE-LAYER INTERNET PROTOCOL MODEL APPLIED TO PI

	Internet	PI
Application Layer	Data (HTTP, POP3, SMTP) Communicates application data	Physical parcels equipped with all the relevant information that is needed to flow over the PI
Transport Layer	Segment (TCP, UDP) Provide error recovery service to application layer & end-to-end delivery of data	Shipment management by shipper or freight forwarder to ensure end-to-end delivery sender to end-customer mailing address (name, street, city, country) according to SLA (Flow & Error Control); Consolidation at the last node
Network Layer	Packet (IP, ICMP) addressing and routing	Address and handling requirements for shipment to ensure that shipment can be moved from origin to destination
Data Link Layer	Frame (Ethernet) Sending data over physical link governed by rules and conventions	Carrier selection process and carrier movement of goods per handling requirements and lane/region/country legal requirements
Physical layer	Frame (Cable) Transmits bits over physical link	Physical infrastructure (road, rail, air, sea, river, etc.) used to transport shipment along a path between origin and destination

2.1.3 PI System

The PI is a network-of-networks. This interconnected set of networks is necessary for the development of the PI, but it is not sufficient. In addition to the interconnected networks, interconnection of information and financial flows, regulatory requirements, and operating protocols are required to ensure that the PI operates as the envisioned open logistics system.

To establish such a PI system for last mile delivery operations requires the connection of several existing entities. Crainic & Montreuil (2016) identify eight interconnections that must exist for the urban PI system to operate.

1. Interconnection of cities as nodes: Cities represent a node in larger regional, national and international transport networks as they handle inbound and outbound flows that are processed by the logistics operations within the city. Connection between cities and regions is fundamental for the logistics flow and reachability within the city.
2. Interconnection of standardized systems: Encapsulation protocols and interfaces are fundamental for the operations of the PI. As most LSPs operate in many different cities, regions, and countries, they would have difficulty performing their services efficiently if every geographic entity established separate protocols for operating within their borders.
3. Interconnection of city logistics activities: The PI goes beyond the simple movement of goods to create an all-encompassing logistics system including the way goods are moved, stored, realized, supplied and used. Pooling, sharing, and collaboration between stakeholders provides for a more efficient and effective use of both the assets used for goods distribution within the city and the city's own infrastructure.
4. Interconnection of city networks into an urban web architecture: Through interconnecting the current city logistics architecture a shift to a distributed, multi-zone, multimodal, web-like approach enforces the PI's open logistics model. Dynamic, multimodal logistics flows and routing guided by policies and business decisions are the result of this integrated web architecture.
5. Interconnection of multiple urbane logistics centres: The PI sets the focus on exploiting the capabilities of a multiplicity of existing urban logistic centres rather than emphasizing one or a few new city distribution centres. These existing logistic facilities, spaces, public and private distribution centres, platforms, warehouses, parking spaces and facilities connected in the urban web provide the capacity for a highly connected and efficient urban PI.
6. Interconnection of stakeholders into an open system: The PI incorporates the engagement of multiple stakeholders that collaborate to achieve overall system performance. This collaboration requires supportive agreements on at least three levels: (1) On the operation level the city logistics web requires multiple multi-modal LSPs to collaborate, consolidate and synchronize. (2) On the business level, collaboration seeks for clear contractual arrangements between providers but also users to regulate pricing, service level, liability, insurance, risk, cost, revenue, and profit, that leads to interconnected business models. (3) On the public-service level, city authorities are asked to engage with LSPs to set up a proper environment with legislation, regulations and policies ensuring efficient and effective operations.
7. Interconnection of people mobility and freight: Existing infrastructure dedicated to people mobility should be interconnected to freight logistics for the sake of exploiting synergies through

movements that are taking place anyway, e.g., a tramway that is circulating the city can be used to transport goods between nodes.

8. Interconnection of (urban) infrastructure planning and logistics: Urban logistics are strongly dependent on other developments and activities within a city. For example, urban layout and land-use policies have a large impact on city logistics performance. Therefore, comprehensive and systematic urban planning through an interplay of freight and people transport providers as well as city authorities should be established.

2.1.3.1 Managing the interaction of networks within the PI

The interaction of networks within the PI requires security, privacy, and trust. As these prerequisites are established, interoperability and accessibility of resources further evolves towards the PI vision. Secure protocols and services are enablers for the PI vision. They also ensure operational efficiency of freight movement to increase the efficiency and effectiveness of the transport system regardless of freight characteristics, nodal operations or mode (Ballot et al., 2020). A further requirement is the extensibility of the system. New innovative protocols addressing new business models, services or further use cases may be interactively integrated into the system in an agile plug-and-play manner.

2.1.3.2 Information exchange between networks, nodes, etc.

Besides the operational aspects of the PI, it is also important to establish protocols and services for the flow of information and payments. Operations require visibility in terms of information across the PI system. Information concerning not only visibility to the supply chain is required, but also visibility to infrastructure availability and other factors that might impact the flow of goods is required. Payments must also be handled requiring that the PI system manage who does what and ensuring that when contracted activities are completed the contracting entity is paid for the services performed.

2.1.4 PI Access

Easy and non-bureaucratic access by shippers and LSPs to the PI is a crucial prerequisite for the effective and efficient implementation of the PI. Small LSPs, in a manner similar to their aggregation into groupage or pallet networks, can gain in reach and efficiency by being able to seamlessly access the PI. By integrating loads from a larger group of shippers and LSPs, the PI increases load and operational efficiencies reducing overall costs and environmental and social impacts (Briand et al., 2022). The PI will not establish itself over night. As with the Internet, small "experimental" operations are needed to demonstrate the benefits of the PI. The URBANE project is one such demonstration focusing on the urban portion of what the PI might look like. Access to a system always requires an initial induction point that connects to the larger system. Considering the Internet, the modern router represents this access point. The Internet is open and accessible to every individual wishing to connect. The PI is also envisioned as an open network-of-networks accessible to any shipper, LSP, or end-customer wishing to ship, manage, or receive physical goods.

2.1.4.1 Who can use the PI?

The PI is open to everyone, who complies with its protocols. Every shipper and end-customer that agrees to the procedures of the PI and every LSP that meets the requirements on load, network and system should be able to participate, collaborate, share assets and pool shipments in a fair and open manner. The LSP using the PI can be any LSP, a major international player such as a DHL, Kuehne + Nagle, Maersk, or UPS, a smaller regional or local player, or even an individual crowdshipper taking a single parcel over the "last mile" in an urban setting to an end-customer. All of these LSPs provide a logistics service enabled by the PI that moves their loads from an origination point to a destination point. To plan and oversee the whole journey of the load through the PI, LSPs such as freight forwarders, 4PLs, or major shipping companies using "control towers" would operate as they do today subject to ensuring that the protocols of the PI are followed (Figure 5).

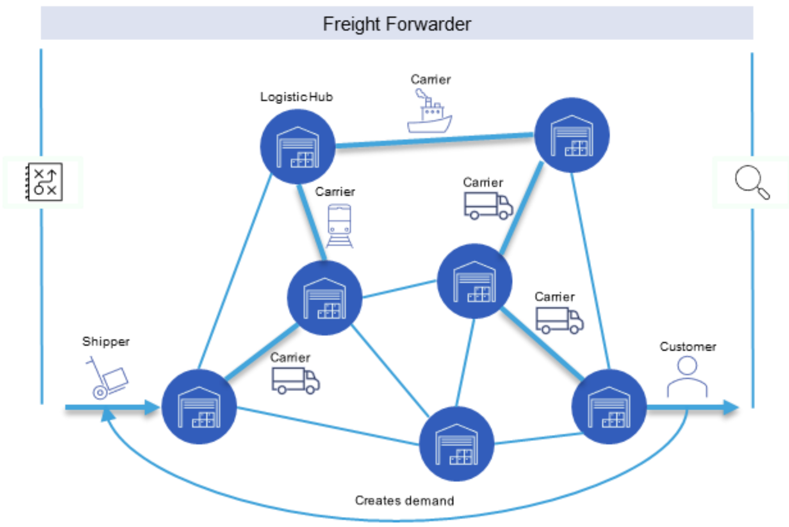


FIGURE 5 - SIMPLIFIED EXAMPLE OF FLOW OVER THE PI

2.1.4.2 The role of shippers, forwarders, carriers, hubs (nodes), end-customers in the PI

As mentioned in the previous section, there are several parties that participate in the shipment of goods over the PI. Shippers and end-customers are two crucial entities that initialize the PI process. The end-customer must create demand to start the PI process. As soon as there is demand, the shipper inserts the shipment into the system. The shipper and end-customer can be the same entity but generally are different actors. The roles of these entities can also change depending on the circumstance (e.g., an end-customer can become a shipper if they are returning an item). As with the Internet when it is used to send an email message, shippers (senders of the parcel) and end-customers (receivers of the parcel) need to trust that the PI will deliver their shipment as specified even though they do not know who will do the transportation or which route the parcel will take to get to its final destination.

Freight forwarders, carriers, hubs (nodes), and shippers that utilize their own internal "control tower" services are critical entities managing flows over the PI[2]. Freight forwarders and shipper control towers take over the management role of planning and monitoring the journey of the shipment. Freight forwarders and shipper control towers rely on the operations of carriers and hubs to execute the movement, transfer, and consolidation of shipments per service levels established with for the shipments. Through their oversite, the freight forwarders and shipper control towers act as the PI's TCP service ensuring that shipments arrive at their destinations on time and in full.

Hubs are the nodes in the network that deconsolidate and consolidate loads and move them out along connecting lanes to hubs closer to their final destination. In performing these services hubs act like routers in the Internet. Carriers are the entities that physically move the loads. Carriers can be large asset heavy companies such as Hapag Lloyd, Maersk, Lufthansa Cargo, Atlas Air, Deutsche Bahn, Burlington Northern, DB Schenker, or Schneider Trucking. They can also be small parcel carriers, last mile specialists, barge operators, city transit systems, etc. Their role is to move the freight physically from an origin point to a destination point over whichever infrastructure (road, air, sea, river, rail, etc.) they provide services over. In this function, these carriers combine part of the Internet's IP protocol covering the construction of messages and the physics of transporting electronic packets over wire, fibre, air, etc.

2.1.4.3 Management of a shipment in the PI

The management of the PI from a general perspective is facilitated through protocols, the rules, guidelines and conventions that define how goods and information should be handled as shipments traverse the PI. These protocols, as with the protocols originally developed for the Internet, are required primarily for the smooth transfer of shipments between connected logistics networks. These separate logistics networks interconnect through the gateway protocols of the PI ensuring that information concerning the contracted requirements for the shipments are seamlessly transferred downstream and information concerning the shipment's status is passed upstream. Adherence to this minimum set of gateway protocol standards allows LSPs that operate their own networks (Autonomous Systems as defined in the Internet) to continue to operate them as they have. However, their handling of shipments that they have received from external networks must be per the service requirements that they received through the gateway protocol connecting them to the external network and, should they transfer the shipment outside of their internal system to another LSP, they will need to transfer that shipment along with the information required by the gateway protocol (Gontara et al., 2018).

2.1.5 PI Governance

Governance of the PI should be analogous to how the Internet is governed, which assures that no government or commercial entities are allowed to decide who can or cannot use the network. The Internet has grown based on its decentralized structure and freedom from governmental oversight (van Eeten & Mueller, 2012). However, there are organizations, such as the Internet Engineering Task Force (IETF), that develop standards that are used by a majority of users. These standards ensure, among other things, the secure transfer of data between sender and receiver.

[2] Note that generally the term LSP (logistics service provider) is used elsewhere in this document to cover these entities as well as warehouse and distribution operators, last mile delivery specialists, etc. Here the specific types of LSP are broken out due to their special roles in managing the flows over the PI.

The goal of governance in the PI is to make the universal interconnection between logistics networks technically feasible and economically profitable, which creates acceptance by society and industry. The PI governance incorporates the rules, trust building processes and mechanisms that are defined by the stakeholders to evolve the PI. A bottom-up approach is favoured where nodes, networks, systems and their stakeholders collaboratively develop mechanisms that converge from PI islands to a global PI. Different layers for governance processes must be defined, e.g., systems and operations. Clear guidelines for integration and access of external stakeholders in vertically integrated networks, asset sharing, and competition have to be defined to provide an integrated governance approach.

2.1.5.1 Who "owns" the PI? – Coordination mechanisms

Whether an end state governance system for the PI can be designed before there is a true PI is an open question. Today's Internet has organically grown and its governance structure has changed over time. In its earliest years, the Internet was an academic and research project of the Defence Advanced Research Agency (DARPA) in the United States. DARPA's oversight was loose and one more focused on testing ideas, approaches, and theories of networking. This loose oversight allowed the academics and commercial organizations involved in developing the Internet to guide its development along the model of academic freedom assuming that open discussions and collaboration with colleagues would create a workable system benefiting their needs. During this informal and developmental period the voluntary governance mechanisms that are characteristic of today's Internet were established (Hoffman & Harris, 2006).

The Internet began when only a few small networks existed. Connecting them through the original Interface Message Processor (IMP), the precursor to the boundary gateways used today to connect Autonomous Systems, was a relatively straight forward and welcome process as these isolated networks could now communicate nationally and, soon, internationally. The PI, unfortunately, proposes to connect many already existing networks that span not only local areas, but regions, nations, and the globe. The operators of these networks have had many years to develop their particular approaches to moving freight and competing with other networks to generate revenue. Asking these independent and highly competitive networks to voluntarily collaborate and connect their networks is a daunting task.

The large conceptual barrier that collaboration brings to these independent network operators may not be as high as they and most others think. Today these large network operators already cooperate on a limited basis. Shipping companies carry containers managed by their competitors. Freight forwarders utilize the services of some of their competitors for operations in areas where their networks do not exist, or for the provision of services that they do not provide. In addition, they regularly have their loads consolidated with those of their competitors when employing third parties to move portions of their end-customer shipments. As an example, most freight forwarders do not own cargo ships or aircraft. They employ, therefore, the services of operators who do have these assets and who also provide similar services to their competitors, consolidating the loads provided and moving them in a controlled and successful manner.

However, hight the barriers might be, there is still a need for developing an open technical committee to help in developing the protocols to be used in the PI and to begin discussions between the various stakeholders that will utilize the PI. A task force similar to the Internet's IETF that is open to all interested stakeholders is needed (Figure 6). A group such as the non-profit European Alliance for Logistics Innovation through Collaboration in Europe (ALICE) could be considered for this function. This group could act in a role very similar to the IETF soliciting input on standards, establishing forums for discussion of new services and standards, and encouraging LSPs, shippers, end-customers, governments, manufacturers, etc. to work together to create an international logistics system that operates more efficiently and effectively.

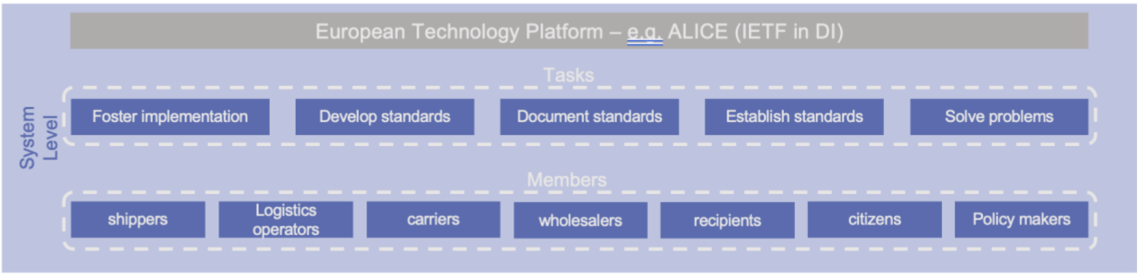


FIGURE 6 - GOVERNANCE TASK FORCE ON SYSTEM LEVEL, OWN ILLUSTRATION

2.1.5.2 Standardization - Using protocols to manage flows

The ICONET project, funded by the European Union's Horizon 2020 program, developed protocols for the PI that build heavily on the seven-layer OSI model adapted to the PI by Montreuil et al. (2012) as the OLI model (Open Logistics Interconnection model). The ICONET model utilizes a central orchestrator that oversees and manages the operations in the PI by applying the protocols that the project developed. The URBANE project does not exclude the idea of central orchestration but believes that however the governance model develops, it should be developed by the actors using and operating the PI. It should not be imposed as this will most likely lead to rejection and a failure of many actors to utilize the PI.

Nodes in the PI are key components in ensuring that goods are moved efficiently and effectively across the PI. To outline the protocols needed at the node level an explanation of how Internet routers, the analogue to PI nodes, operate is required. Gateways and routers represent connection points that apply certain protocols to forward and route data packets from origin to destination. The router incorporates a management architecture that uses a layering approach to categorize functions into three layers or "planes." More specifically, these layers are called the management plane, control plane, and data plane (Medhi & Ramasamy, 2018).

The Management Plane is responsible for the administrative configuration of the router and reporting and monitoring statistics of e.g., throughput on a link. The device itself is also monitored, e.g., fan speed, power supply failures or even the condition of components integrated in other layers. The configuration of the router is executed by assigning an IP address, identifying links to adjacent routers, invoking routing protocols and further functions. Also, manual configurations by humans can be implemented on the management plane.

The next level is the Control Plane that uses control information to manage a variety of functions through the execution of network protocols. One function is the establishment of a virtual link between the router and another router. The identification of the link and the connected router is termed routing and executed on the control plane through a routing table identifying adjacent routers and links.

Routing tables are set and updated by link state information that is exchanged between routers. This requires interactions between the Data Plane and Control Plane as link state information is sent via the Data Plane. the main function of the Data Plane, however, is the encapsulation of data packets and forwarding them to the appropriate output interface for transmission of the actual data packets that are sent via the Internet.

While the Internet uses routers to route and forward data packets through the network, the PI uses nodes that are similar in their function but routing physical parcels instead of data packets through the network (Dong & Franklin, 2021). Although there are significant differences between the operations in the Internet and the PI, the router architecture represents a good starting point for the protocol architecture of a PI-node.

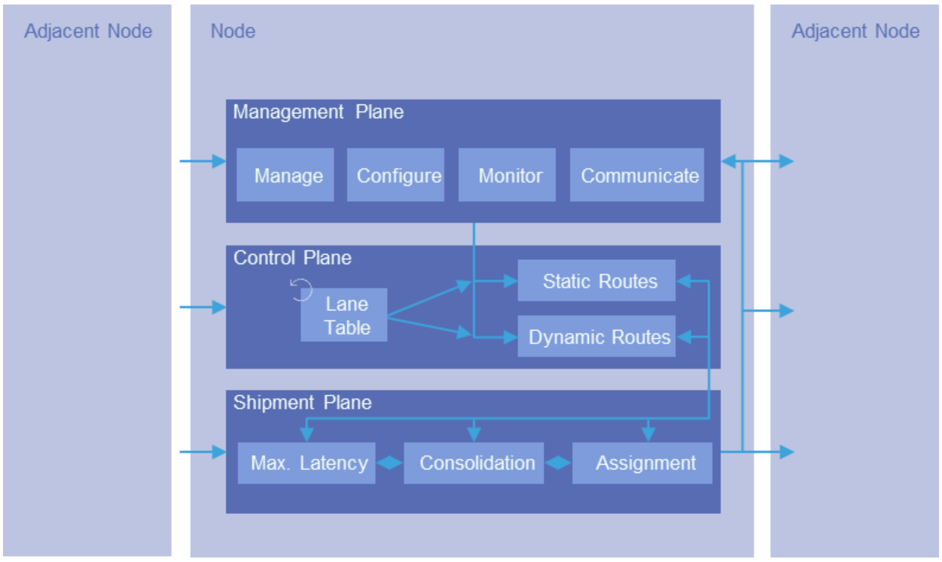


FIGURE 7 - EXAMPLE OF PI-NODE PROTOCOL STRUCTURE

Nodes in the PI can be intermodal terminals, distribution centres, packing stations or microhubs in an urban environment. We apply the planar approach used in routers to establish a layered architecture for nodes in the PI. Each layer executes its own functions and protocols.

The *Management Plane* is responsible for four key functions, (1) management of the operations within the node, (2) configuration of the operations, (3) quality monitoring of operations and (4) the communication of the node state to adjacent nodes. The node receives information concerning where the shipment is to go, when the shipment is supposed to arrive at its destination, special handling information, dimensions and weight of the shipment or parcels, and some sort of unique shipment identifier so that payments and notifications can be managed. This information is used to establish the operations within the node, to properly route the shipment onwards once these operations have been performed, and to notify payment systems or shipment "owners" as to events that they have subscribed to.

The *Control Plane* accesses information from the Management Plane such as service parameters or adjacent link-node information to execute the following three functions: (1) generate a lane table incorporating all adjacent lanes that is regularly updated regarding their state (2) perform static routing of parcels, (3) perform dynamic routing of parcels. The latter two functions require access to information from the lane table to perform routing. These functions are explained in more depth in the following section.

The *Shipment Plane* is responsible for two important functions: (1) consolidation of parcels based on destination and delivery time and (2) assignment of the loads to carriers based on an assignment mechanism defined by the node's management. If an auction or similar assignment mechanism is used by the node, it is important that the process be fast and efficient to avoid delays from excessive computational requirements.

All planes require some input, either from external sources or from previous protocols. Inputs may be minimum data requirements for a shipment, such as departure and destination locations, time windows for delivery, handling requirements, or even dimensions of the shipment. More specific information may include lane condition information, such as traffic conditions, or operational information about the capacity utilization of downstream nodes and carriers.

The node protocol example demonstrates how one could envision a set of operational protocols for an important element of the PI. The outline provided is only one of many ways that a set of protocols for a node could be established, although one that does use an Internet router's structure as a model. Other protocols analogous to the TCP/IP protocol, the newer MLPS protocols, etc. that control the movement of packets over the Internet are required for the efficient and seamless operation of the PI. Developing these protocols and gaining their acceptance by the various stakeholders that will use the PI is a challenge for the future.

2.1.5.3 Open standards

Development of operational protocols are only the beginning of realizing a functional PI. Users of the PI must be able to monitor whether service levels are being adhered to and regulatory requirements are being met. Examining how the PI should be overseen from a nation's perspective, there are three levels of oversight that arise (Figure 8). If the PI is viewed at the national level, it is overseen by the national government. National governmental agencies agree to employ the PI's protocols and ensure, among other things, that operators within the PI adhere to governmental regulations, laws, and national competitive requirements. Dropping down to the regional level, the regional authorities manage the PI and ensure compliance with regional regulations and laws. In doing so, the regulations of the higher level must be complied with. Moving down one level further to urban logistics operations, the PI is governed by the city authorities. Here too, the regulations of the higher-level structures must of course be considered.

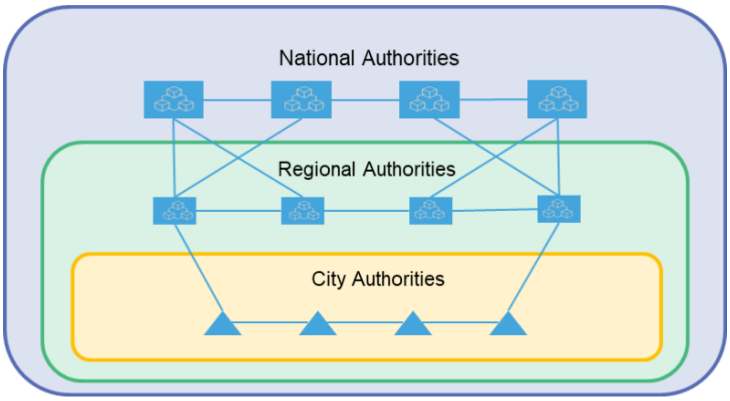


FIGURE 8 - ORGANIZATIONS INVOLVED IN OPERATIONS GOVERNANCE, OWN ILLUSTRATION

Governance also considers the following aspects:

- Regulation and policy, ensuring social and environmental responsibility
- Intellectual property considerations
- Liabilities
- Privacy and security
- Sustainability.

2.1.6 PI Adoption

The roles of the various stakeholders in the use of the PI have already been discussed in the sections above. In addition, it has been elaborated how access is enabled, how operations are performed, and how a governance structure permits creation of the PI. In order to achieve a high level of adoption by stakeholders, which in turn enables the smooth flow of parcels through the PI, underlying process enablers such as the data exchange requirements and payment processes must be examined in more detail. It is important to note that the adoption and widespread implementation of the PI will not be achieved in one dramatic switch of behaviours. Roles, access, governance, and operations will evolve over time. How this evolution will sort itself out remains to be seen. However, a little clarity on data exchange and payment processes may help allay certain adoption fears.

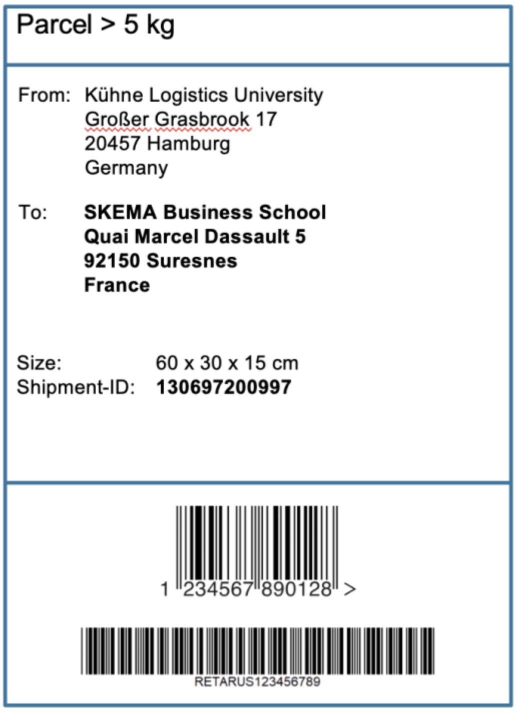
2.1.6.1 Data sharing - Data exchange requirements

It is important to point out that data that is required to tranship parcels through the PI is already available. Figure 9 illustrates an example of a shipping label that is currently used for shipping parcels. The information that is printed on it are weight, sender and end-customer address, size, shipment-id, and barcodes containing this information. It is also known which service the end-customer booked, and thus within what timeframe the parcels must be delivered. One further piece of information required concerns the nature of the goods, whether they are hazardous or not. Based on this information the parcels can be routed through existing networks, nodes can deconsolidate and consolidate the parcels as part of larger shipments, and the parcels can be assigned to an appropriate delivery mode.

This minimum information set is all that is needed to ship a parcel today, and it is all that is needed to ship a parcel across the PI. However, this information is insufficient to allow the various entities that handle the parcel to be paid, or for the entities that are managing the shipment to properly understand its status and to ensure that it reaches its destination on time, in full, and without damage.

In order to exploit the full potential of the PI, the sharing of additional data is essential. This includes information about the traffic situation on a lane, handling times at nodes, capacity constraints at nodes, or available space at the curb side. One could store this information in a multitude of different ways and aggregate it “on demand” so that decisions concerning deliveries and routes could be made and payments processed. However, because the PI is essentially a black box to the shipper and end-customer, should a dispute arise, simple database storage is insufficient. What is required is a formal non-repudiation system. One such system being employed today is the blockchain system. This approach to managing information about shipments requires that contractual information be instantiated in executable code and that the progress of the shipment be monitored so that contracted events can be logged and stored on the blockchain (something that will be explored in URBANE through Task 3.3). Disputes can now be addressed as the logging of events to the blockchain means that they cannot be denied (repudiated) and, therefore, are permissible as legal evidence of something having occurred.

Example of Shipping Label	Required Information



- Weight
- Size
- Sender Address
- End-customer Address
- Handling requirements (nature of good)
- Shipment-ID

FIGURE 9 - EXAMPLE PARCEL LABEL

Apart from the minimum data requirements for sending a parcel as can be found on a parcel label, the PI requires some further data exchange. This data exchange can be termed as “communication” between nodes. It is not competition-critical but it is crucial for smooth operations (Briand et al., 2022). “Operation” refers in this context to operations across the supply chain but not in the node. Operations in the node, e.g., loading, unloading or storing, are the responsibility of the node operator.

From a high-level-perspective, an urban node must communicate with its adjacent nodes. Adjacent nodes on the last mile are the end-customers receiving the parcel (downstream node) and a node that is further upstream the supply chain, such as UCCs. Figure 10 illustrates the communication between adjacent nodes. The communicated data is crucial for the node to make accurate decisions. As previously mentioned, data to be shared are the shipment information (address, timing of delivery and dimensions) and the handling requirements (refrigeration, fragile, glass). This information is communicated by the upstream node to enable the next node to properly process the parcel for delivery. When a node is becoming overloaded, this information must be communicated to avoid receiving further shipments that would be delayed by the node’s overloaded capacity. This information can be reffered to as node state. A node can alwayays accept or reject an inbound shipment that is announced to it. Rejections may occur if the node is facing congestion of parcel flows though the node or can not adhere to the handling requirements of the parcel (e.g., no freezer capacity for frozen items).

Shippers may want to stay up-to-date about the state of their shipement. This means that the PI must continually update its estimates on delivery times based on the current state of the PI. Shippers and end-customers can subscribe to this information for their shipments/orders to determine whether the parcels that have begun to flow through the PI will be delivered ontime or if they will be late. End-customers want to know the up-to-date time window of delivery and receive notice if a delay is going to occur. LSPs need to know when a parcel will be handed over to them so that they can plan their deliveries to comply with service levels. To end the delivery cycle, a notice about a successful delivery must be communicated to the urban node and the shipper to trigger the closure of delivery and payment of all participants in the delivery cycle.

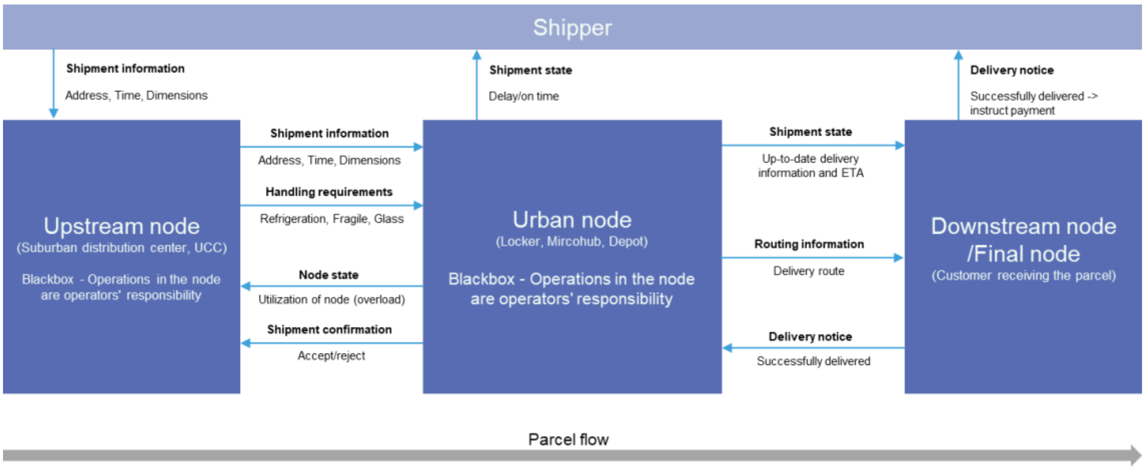


FIGURE 10 - DATA EXCHANGE DIAGRAM

2.1.6.2 Tracking activities, events, and ensuring delivery

Today, LSPs offer detailed tracking information to their end-customers. Starting with the notification that the parcel's delivery data has been transmitted by the shipper to the delivery LSP, through the arrival of the parcel in the end-customer's region, to the successful delivery. This service must also be available to the end-customer on the PI. But here the information is not only relevant for the end-customer, but also the events that occur as a result of the transmission of the shipment information.

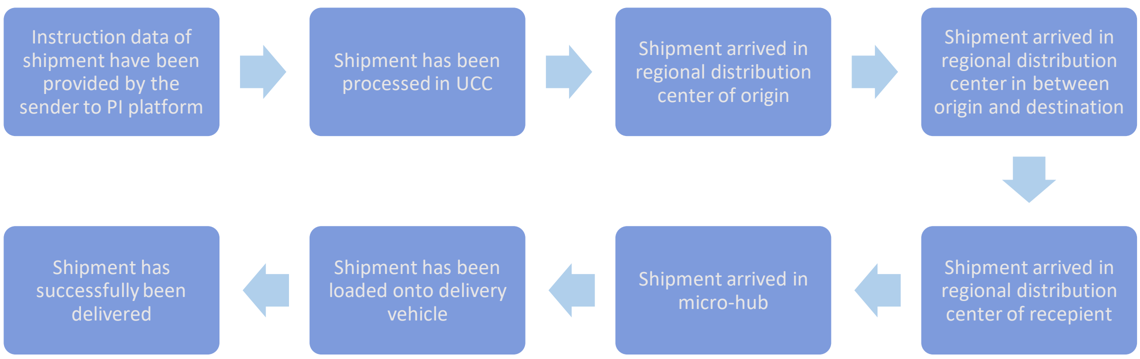


FIGURE 11 - TRACKING INFORMATION PROVIDED TO THE END-CUSTOMER

Each time the end-customer receives an update on the progress of the package, a stakeholder completes its service. For example, once the shipment has been processed in the UCC, the UCC operator has provided a service and must be compensated for it. For clarity, the following is an overview of each step (for an indicative scenario), including the information provided to the end-customer.

2.1.6.3 Payments

The previous section pointed out the different stakeholders participating in a delivery process. Each of these stakeholders requires payment for their services. A manually operated payment process would require significant resources and coordination when dealing with multiple stakeholders. In addition, manual processes are often prone to errors. This showcases the importance / need for an automated payment system for stakeholders to be compensated once they have completed their service according to the SLAs. One approach to addressing this requirement would be through the use of smart contracts (SCs). A SC is a contract translated into computer code that is automatically triggered and executed when a previously defined event occurs. Events can be generated by IoT devices, for example, when a package is detected by an RFID reader. Another possibility is to scan a barcode in the incoming goods department and thus confirm that the package arrived and been received at a UCC. A major benefit is that the events related to the SCs are stored on the blockchain and thus profit from transparency and immutability. For ease of understanding, the diagram below shows the simplified payment process for a stakeholder.

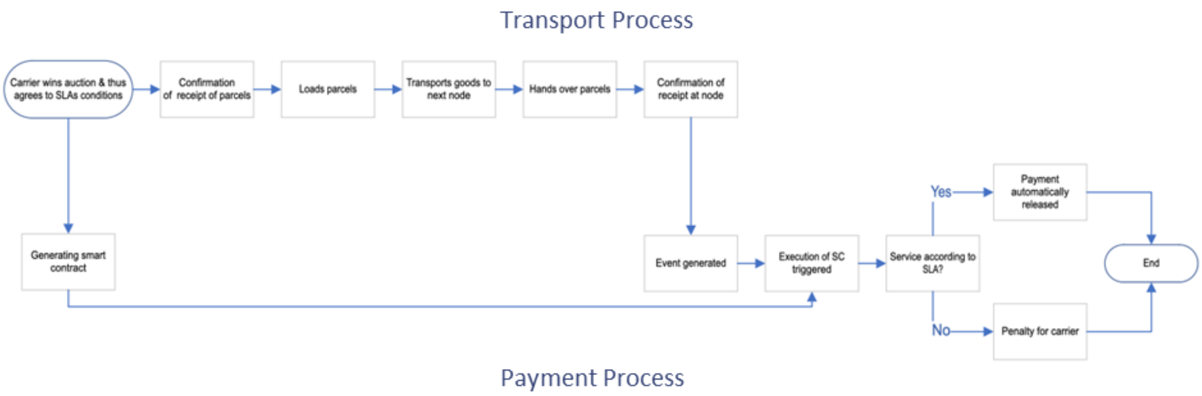


FIGURE 12 - PAYMENT PROCESS EXAMPLE

2.2 The PI and Last Mile Delivery

Looking at the supply chain of a parcel from the bird's eye view, there is a first mile, where the package is picked up and inserted into the system, a last mile, where package is delivered to its destination and the long haul in between. Protocols cannot simply adapt from one stage in the supply chain to another stage. The first and the last mile are different from what is in between.

FIGURE 13 - PARCEL LOGISTIC CHAIN MODEL

In the urban environment, where parcel volumes are aggregated and density of flows get larger and larger, a solid mechanism for flow management is required. Today parcel flows are predominantly handled by large carriers delivering to end-customers by van. This is effective but not very efficient. Zooming in to the urban last mile, which can also be considered the first mile when considering return shipments, the parcel flow incorporates two stages, (1) from the UCC to urban microhubs and (2) from there to the destination considering different modes of transport as well as pick-up and drop-off options. Starting with the

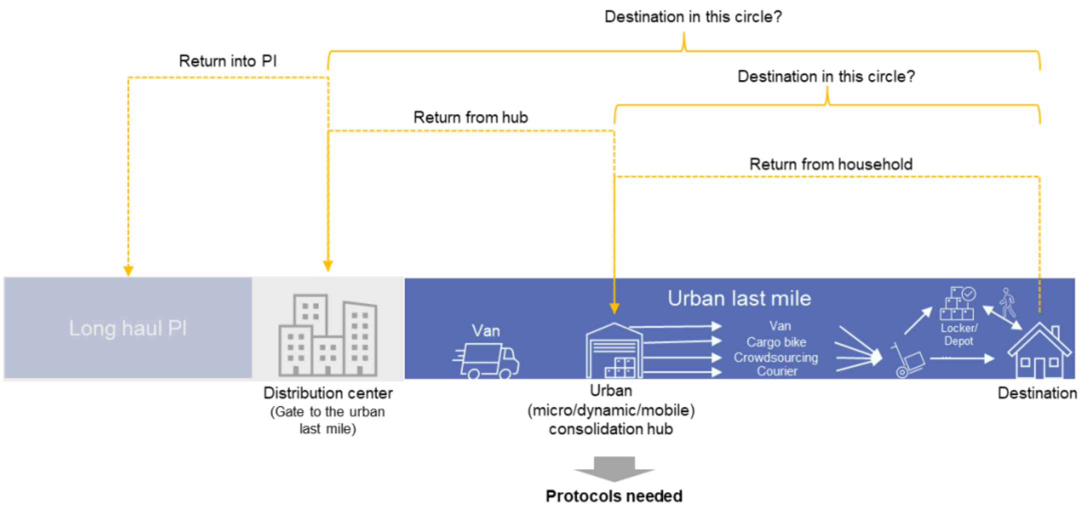


FIGURE 14 - STYLIZED LAST MILE DELIVERY

first stage at a UCC, which is located outside of the inner city, vehicles are equipped with parcels that need to be moved into city neighbourhoods. The UCC acts as a gate to the urban last mile as the transformation from long haul transport to urban city logistics takes place. Depending on regulations and conventions, e.g., zero emission zones, the right mode of transport has to be selected. The second stage starts with the microhub that serve as the local allocation and distribution facility. This microhub receives inflows that are subsequently deconsolidated and reconsolidated to several smaller outflows allocated to a mode that fits predefined criteria. The assigned last mile LSP delivers the parcel via one of the predefined modes, e.g., cargo bike, either directly to its destination or to a nearby pick-up point, e.g., parcel locker. On its round trip, the LSP also picks up return shipments that are returned to the UCC for movement up the supply chain to an appropriate returns centre.

2.2.1 Application of PI protocols – A hierarchy of flow management

As logistics flows cross the boundaries of a city, these streams become condensed and need proper management on the last mile to reach their final destinations. The flows can be carried by several different modes each having advantages and disadvantages. What modes should be selected depends heavily on the city's regulations. For example, low emission zones with narrow streets can exploit cargo bikes because of lower emissions, agility and less space utilization, while larger parcel volumes or large parcels can exploit the higher capacity of delivery vans. It is certain that relying on one mode will not solve the problems arising in the urban environment. There is a trade-off between the new innovative delivery solutions, e.g., cargo bikes, crowdsourcing, etc. and the conventional van. What is required is to balance the trade-offs between the different modes for effective and efficient delivery within the particular city neighbourhood. Flow management protocols can tackle the problems that arise.

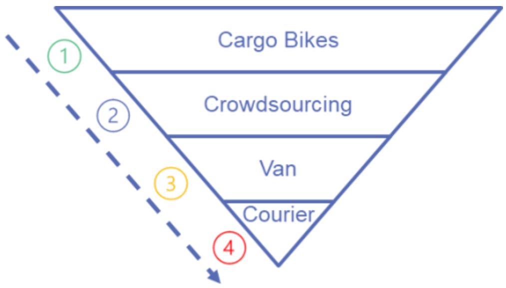


FIGURE 15 - HIERARCHY OF MODES

The funnel shown in Figure 15 is a stylised example of one model of a flow management protocol. It should be noted that the hierarchical model depicted is one of several conceptual models that might be utilized to determine how to allocate loads to different transport technologies. In the "real world" the process would most likely be messier and would sort itself out based on what was "best" for the city and distribution operations employed.

This example proposes the use of cargo bikes as a preferred mode of last mile delivery, followed by crowdsourcing. Certainly, crowdsourcing should be tied to restrictions as it is not the goal to artificially create traffic through individuals carrying parcels as their "mini-job". Crowdsourcing is meant to be an option for individual trips that will be performed anyway. As a third option, a van is considered as an option for bulky parcels, e.g., a flatscreen television. If none of previous options are available or workable, a van operator (courier in the figure) can be contracted to take over the delivery. The courier is a kind of back-up solution where the mode, used by the courier, is difficult to control.

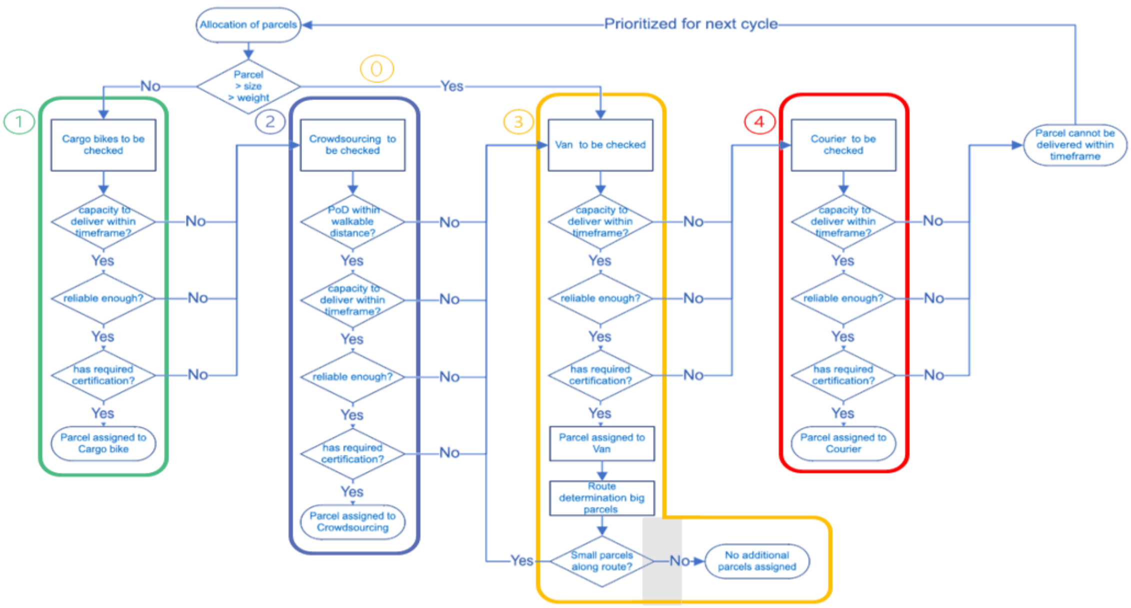


FIGURE 16 - ALLOCATION PROCEDURE

Figure 16 presents an example of an allocation procedure based on the hierarchy discussed previously. This flow chart represents the visualization of a protocol as a structured step-by-step recipe for flow allocation. Things that should be considered are as follows:

- Is the parcel eligible to be carried by cargo bike or is a van required (dimensions, weights)? A flatscreen, for example, may not be eligible for a cargo bike.
- Which parcels can a van additionally drop off along its route while delivering the bulky parcels?
- Does the selected mode have available capacity?
- Is the required reliability given by the selected mode?
- Has the selected carrier the right certification?
- Are further vans required to handle the high volume of parcels?
- Can a crowd shipper walk to the delivery point?

Apart from the outbound distribution flows, reverse flows need to be managed. End-customers need a reliable process for their return shipments. They can either drop the parcel at a nearby parcel locker, post office, microhub or preregister a pickup at home. For pickup at home, a preregistration is required as last mile LSPs need to know about the reverse flows and plan their routes and capacity accordingly.

2.2.2 Consolidation centres and efficient asset utilization – White label operations

Consolidation takes place at different stages within the supply chain. Consolidation provides efficiency benefits to long-haul operations as well as last mile operations. Several options have been proposed for handling consolidation for the last mile. These options were developed in a previous EU project called LEAD (Groothedde et al., 2021). The options are:

- Urban Consolidation Centres (UCC)
- Microhubs
- Mobile microhubs and small electric vehicles.

UCCs are usually located close to the area they supply. UCCs transform inbound flows arriving by truck or van into smaller and more efficient consolidated deliveries. The management and operations of these UCCs depend heavily on the participants using the UCC, the activities carried out and the funding method. For example, UCCs can be operated by a single company, a joint venture or the city itself to keep control over the logistic activities within its boundaries. Apart from the main purpose of the UCC, delivering goods, there are other functions that can be performed by a UCC. For example, a UCC can take over the storing of goods close to the end-customer as well as labelling and pricing activities. Another important extensional activity is the handling of return shipments.

Besides advantages like milage and trip reduction, increased vehicle utilization and lower environmental pollution, the consolidation for the last mile significantly promotes the use of green vehicles that are only useful for a limited range. On the other hand, UCCs come with high investment cost, organizational efforts to handle the wide variety of goods and land requirements, which is usually not easily available in crowded urban areas.

To overcome the problems associated with UCCs, microhubs are proposed. Microhubs are smaller UCCs with limited functions and a smaller delivery range. The main purpose of microhubs is the use of light vehicles (cargos bikes or walking). The use of light vehicles also promotes other concepts like off-hour and night-time delivery with non-noisy vehicles. City regulations such as low emission zones can be handled by microhubs. Logistic flows must be well planned as microhubs act as cross-docks that do not have very much space for storage and handling operations.

The use of microhubs requires the interplay between LSPs and city authorities as LSPs are required to collaborate and city authorities are responsible for providing adequate infrastructure. Microhubs can provide significant advantages over UCCs in terms of the space that is required, quicker processes and the limitation on light vehicles. Nevertheless, flexibility is lacking and additional operational effort is required for a further consolidation step in the supply chain between the distribution centre and the resident.

A mobile microhub can be a truck, bus, caravan or simply a container that can be dynamically positioned in the neighbourhood it supplies. From the depot goods are loaded into light vehicles, like cargo-bikes or electric tricycles. The loading of the mobile microhub takes place outside the city in the LSP's UCC or a shared UCC. From there the mobile microhub is moved into the neighbourhood it has been loaded to supply. Even if the depots are mobile, they require space to perform their distribution function. Potential areas to position a mobile microhub could be parking areas, underground car parks that are able to accommodate the size of the mobile microhub, or even unused areas in a neighbourhood (Mauch et al., 2021).

In general, each city must evaluate the optimal mix of these options based on their delivery data and determine the optimal operation and consolidation concept in close collaboration with all stakeholders. The central question that arises from these concepts is "Who is responsible for consolidation and executing the last mile?" On the one hand it could be a "White label" company operated by the city or on the other hand by a commercial LSP.

The KoMoDo project in Berlin is a good example of a shared microhub between different LSPs. Efficiency gains can be even larger if not only the facility is shared but transport vehicles in terms of load pooling. Sharing capacity on the last mile instead of everyone serving their own end-customers can further decrease traffic and increase efficiency.

A question that may come up as one discusses the use of consolidation centres in the urban environment is "How do the vast amounts of parcels get to the consolidation centre?" As several of the goals in using microhubs or UCCs are the reduction of traffic and CO2 emissions, one idea may be to utilize existing assets that are already circling around the city – the city's public transport system. The subway provides a good use case to exploit existing assets. Besides peak hours, e.g., when people are on their way to or from work, public transport is usually underutilized. If UCCs or microhubs are located close to subway or tram stations, their use during non-peak hours could decrease distance travelled by van or truck and, therefore, traffic and emissions.

2.3 Barriers to PI Adoption

The PI is an interesting concept and has captured the imagination of academics and industry as a potential solution to logistics related problems. Unfortunately, the uptake of the concept has been slowed by a number of actual and perceived barriers. It is not the intention of this document to list all barriers that have been discussed concerning the PI. Interested readers are encouraged to make use of the ALICE website to explore this topic and many more concerning the PI. To give the reader a short understanding of issues that have arisen that do act as barriers to the adoption of this model for logistics operations, the following list should suffice.

- Lack of Standardization – people, processes, and systems within and between LSPs, their end-customers, regulatory bodies, modes of transport, and many other interacting components in the logistics world have all developed independently from one another over the centuries. This has created a true "Tower of Babel" in which communications between parties in supply chain operations is extremely difficult. Achieving the "plug and play" connections that have become common for Internet access is still a long way off for the logistics industry.
- Infrastructure Constraints – modes of transport have evolved for centuries independently from one another. While the PI focuses on the best and most efficient use of assets to transport goods, the inability to synchronize and quickly transfer goods from one mode to another creates blockages for realizing environmental, asset utilization, and efficiency potentials postulated in PI models.
- Cultural Barriers / Lack of trust and collaboration – competitors in a market economy are extremely hesitant to collaborate with one another. Worries about revealing pricing, volumes, end-customer data, etc. based on real past experiences make collaboration are hard sell to these individuals.
- Regulatory / Legal Barriers – further delaying collaboration between competitors in the logistics space is the relatively recent set of competition penalties that were levied on the major actors by the EU for price fixing. The cease-and-desist requirements placed on these actors and the current interpretation of competition laws make most LSPs, and industry competitors in general, extremely hesitant to talk about anything with their competitors.
- Data Sharing and Privacy Concerns – layered on top of all the other legal issues, the recent GDPR rules developed to protect individual privacy act as another barrier to cooperation. Worries about what might happen if shared data is somehow stolen makes sharing data that much more difficult.

- Implementation costs – nothing is free in the world of business and when your margins are typically very low the issue of what something will cost takes a very high priority. Logistics service companies are not academic institutions where research is a key element of their reason for existence. Spending money on “research experiments” is not something that resonates in the executive suites of these companies.
- Complexity – as is noted throughout this report, the operation of supply chains is an extremely complex undertaking. Trying to sort out where a new model of operation fits in and where it might need to be modified to accommodate the infinite variety of ways that things are moved is not a simple task.

In the URBANE project PI work conducted in the previous EU projects STELIS, ICONET, and PLANET will be further advanced and tested in actual Living Lab situations. By testing and modifying the efforts of these predecessor projects it is hoped that improvements in the PI concept will be made and its readiness for actual deployment shown to a broader community of potential users.

2.4 Guidance to URBANE Living Labs

Much of the effort that will be conducted in the URBANE project focuses on collecting data on last mile delivery operations in the Living Labs, using this data to model and optimize last mile services for the Living Labs, and testing indirectly new concepts for achieving EU specified goals for reduction of greenhouse gases. In addition, URBANE project members will be working with the Living Labs to build models of their last mile system as PI systems to determine what improvements operations under PI principles might have on the efficiency, effectiveness, and city impacts of their last mile operations.

A key objective of the URBANE project is to ensure that the activities conducted within the project assist its partner cities, the initial Living Labs and follower cities, in building knowledge in support of their Sustainable Urban Logistics Plans (SULPs). The PI, as described in this document, provides a logical model for implementing sustainable urban logistics and LMD processes in compliance with the intent of the SULP planning process.

To help in implementing sustainable urban logistics and last mile delivery processes in line with the PI model and EU expectations, certain actions from the Living Labs are required. A short list of some of these actions appears below.

1. Define objectives for improving city congestion, emissions, and social impacts based on improvements in the operation of urban logistics and LMD activities;
2. Define the nodes and links in each use cases: Identify the physical locations and the routes connecting the nodes;
3. Define potential PI-inspired innovations (e.g., PI protocols) to be included in the nodes of the Living Labs;
4. Define the scope and boundaries of the Living Lab logistics model, considering the specific geographic area, the types of goods being transported, and the modes of transportation being used;

5. Identify the actors and define the roles as per the PI Framework: Determine the various stakeholders involved in the network, including shippers, LSPs, and end-customers;
6. Meet with the actors to discuss options, determine expectations, and refine plans for implementing the urban logistics and PI model;
7. Get engaged with city authorities to commonly discuss and define regulations that provide value socially, ecologically and economically.
8. Define infrastructure (physical and digital) for operating the network according to PI principles;
9. Identify the services that are offered such as transportation, warehousing, inventory management, order processing, and delivery. Define the requirements, relationships and interactions between the service providers and those requiring the use of the services (e.g., retailers, other LSPs, end-customers);
10. Develop an ongoing dialogue with LSPs, retailers, end-customers and city authorities concerning governance and commercial issues: Define how the elements within the urban network will operate, who will manage which of the elements, and how the operations will become self-supporting;
11. Map flows for the movement of goods through the network. Define type of products, indicative volumes of goods being transported, the capacity of the nodes, travel times associated with different modes: Develop processes and procedures to capture this data from ongoing operations to ensure that objectives are met, and improvements continue;
12. Incorporate WP3 technical assets in city transport management and planning: Consider how technology can be used to optimize the performance of urban logistics operations and its potential for building true PI functionality, including the use of sensors, digital twins, data analytics, blockchain, etc. to plan and manage in real time urban logistics operations;
13. Build on WP3 proposed performance metrics to evaluate the effectiveness of urban logistics operations and PI services, including e.g., delivery times, inventory accuracy, and order processing times;
14. Validate/ test models and operations: Models of operations and actual operations should be validated and tested using real-world data to ensure that they accurately represent the performance of the urban network and PI implementation;
15. Self-assess PI maturity at M12 and then M24; and
16. Use the models developed to make predictions/take decisions about network design, operations, and management.

The tasks outlined above map to the requirements for developing a SULP per the guidelines developed by the European Commission (see CIVITAS.eu website for more information on SULP requirements). Employing the principles of the PI to improve urban logistics operations and last mile delivery activities will help in achieving the improvement objectives envisioned for each LL and help deliver the net zero objectives that have been established for the European Union.

3. Mapping landscape of innovation on last mile operations

The sections of this report that follow discuss the findings of Task 1.1 conducted under Work Package 1 of the URBANE project. Task 1.1 of the URBANE project was undertaken to map the landscape of prior work on innovations for last mile deliveries, identify improved decision-making approaches for the distribution of goods to urban neighbourhoods, and determine what infrastructure modifications/enhancements might be required to allow for the operation of innovative last mile delivery models and technologies. Specifically, the three primary subtasks that were addressed in this task were:

1. Last mile distribution performance and bench-learning activities,
2. Demand based facility location and decision support models, and
3. Automation and electrification of vehicles and infrastructure smart readiness.

3.1 Last mile distribution performance and bench-learning activities

Research and piloting of innovative technologies and approaches to the last mile delivery problem are quite extensive. A quick Google Scholar search of the term "Last Mile Delivery Challenges" returns over 200,000 papers of which 500 have been published since the beginning of 2023 (as I write this note it is 1 April 2023 indicating an average publication rate of approximately 170 articles per month on the topic). The earliest article returned based on this search was from 1994 concerning the use of the analytical hierarchy process for decision making on environmental and social issues (Saaty, 1994). These research articles, along with the various demonstration projects that they have spawned cover numerous innovative approaches to addressing last mile deliveries. For ease of review and summarization, the most important of these concepts and topics have been organized under the headings of Technology, Facilities, Processes, and Regulations.

3.1.1 Last mile delivery technology innovation

The primary areas of focus for technical innovations in last mile delivery have been on the use of low emission delivery mechanisms, Internet of Things (IoT) enablement, blockchain based control, big data analytics, Artificial Intelligence (AI) support, and automation. Within the low emission delivery category, the key technology examined in both the academic literature and in pilot projects has been the use of delivery systems powered by electricity (de Mello Bandeira et al., 2019; Mirhedayatian & Yan, 2018; Moolenburgh et al., 2020). IoT or sensor technologies have been examined from the perspective of Intelligent Transport Systems for managing the flow of deliveries into neighbourhoods and for the operation of smart parcel lockers (Mangiaracina et al., 2019; Bosona, 2020; Brunner et al., 2018). Blockchain based control systems have been discussed as useful for ensuring delivery, reporting performance, and executing bonus/malus payments (Naclerio & Giovanni, 2022; Hribernik et al. 2020; Li et al., 2022). Big data discussions focus on both the capture of data through sensors and the analysis of this data to improve delivery planning and operational performance (Liu et al., 2020; Schwerdfeger & Boysen, 2020). Finally, AI and automation generally are discussed in an integrated manner for the robotic delivery of goods (Lemardele et al., 2021 and Sonneberg et al., 2019), although AI has more recently been broken out separately and examined from its ability to prescriptively take actions to optimize deliveries when certain data patterns are observed (Giuffrida et al., 2022; Iyer, 2021; Dogru & Keskin, 2020).

The European Union has been a leader in both examining the technical feasibility of technologies in last mile operations and in analysing their economic, social, and environmental impacts. The table that appears below lists only a few of the European Union funded projects where various approaches and technologies for sustainable last mile/urban logistics are or have been explored.

TABLE 5 - EU URBAN LOGISTICS PROJECTS

EU Project	Project Focus
CIVITAS	Smart city network focused on urban logistics solutions
LEAD	Smart city logistics using digital twins
ULaaDs	Demand driven collaborative urban logistics
SENATOR	Development of future oriented urban logistics governance approaches
URBANIZED	Adaptable and modular design of electric delivery vehicles
ONO	Electric cargo bikes for urban logistics
STORM	Exploration of novel green logistics transport concepts
SHOW	Urban automated vehicle operation demonstrator
SPROUT	Analysis and demonstration of current and novel sustainable urban mobility solutions
CARTRE	Compatibility of automated road transport systems
MOVE21	Smart multi-modal urban mobility and freight hubs
NOVELOG	Guidance and demonstration of sustainable urban freight operations for cities
DECARBOMILE	Interoperable multi-modal logistics solutions for last mile delivery
CityLab	Development of cost effective, zero emissions approaches to city logistics operations
SELIS	ICT infrastructure for logistics collaboration and federated exchange of information
ICONET	Development of tools, simulations, integration and management tools, and architecture for PI
PLANET	Development and demonstration of an EU integrated network operation system for global trade

The amount of work performed to date on examining potential technologies for improving last mile deliveries, managing logistics flows, and structuring systems to enable the linkage of logistics networks through the PI paradigm is significant. It is not the intent of this report to cover ground that has already been covered to a considerable extent by these prior efforts. However, it is the intent of the report to attempt to outline the highlights of this considerable body of work so that the interested reader can develop an understanding of the current state-of-the-art and how they might employ the technologies, platforms, services, and algorithms developed in this work to their particular circumstances.

3.1.2 Current approaches to last mile delivery

Before delving deeper into the current state-of-the-art in sustainable last mile delivery, it is appropriate to provide a brief discussion of how last mile delivery is performed today. The current approach to last mile delivery is an ad hoc combination of postal, large parcel, eCommerce company, mid-sized and small parcel companies, specialized delivery companies, couriers, startups, and private non-professional delivery services. These entities deliver goods directly to businesses, parcel lockers, and end-customers' homes or apartments. Because of the ad hoc nature of these delivery services, controlling the logistics service providers (LSPs) by city governments is difficult if not impossible. While the impact on communities of so many delivery entities is considerable and growing, it has been made somewhat acceptable by the fact that the great majority of deliveries are carried out by the large parcel and postal companies. It is estimated that between 60% and 80% of the volume of last mile deliveries are performed through these larger organizations and this volume mix will not change significantly in the future. (Heid et. Al.)

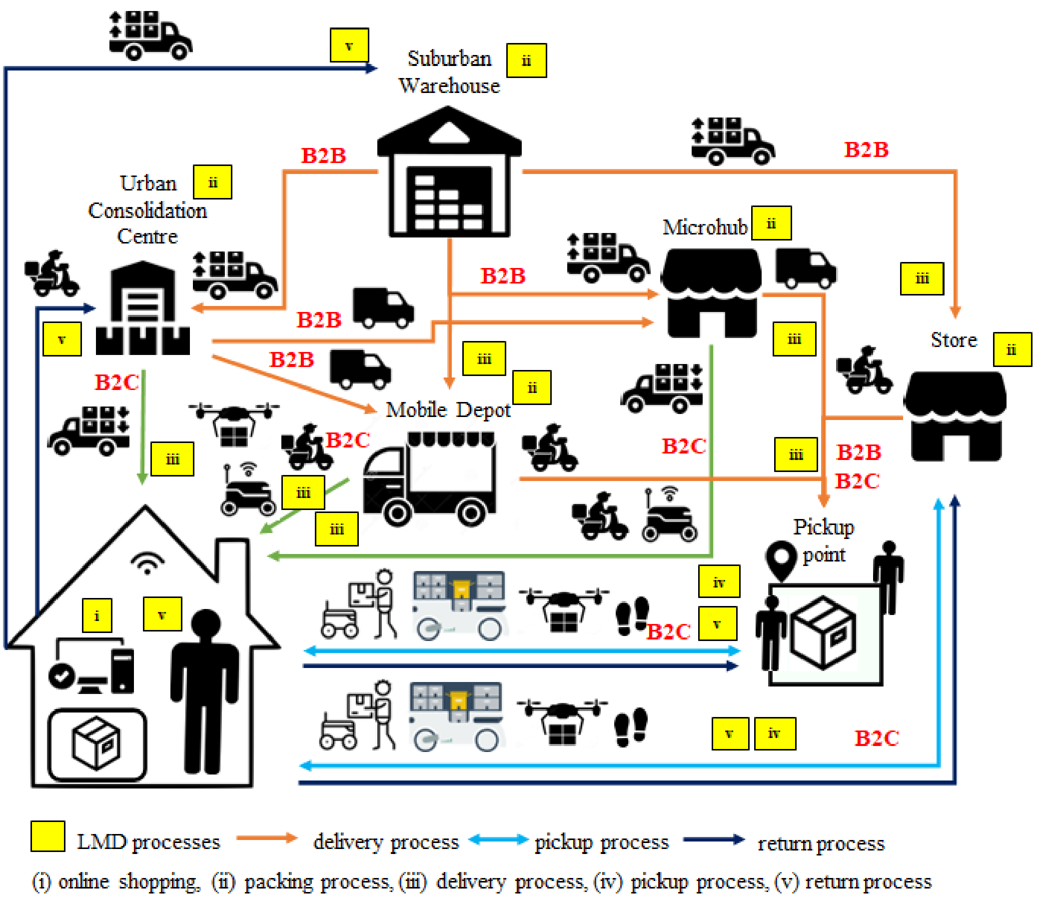


FIGURE 17 - B2C ECOMMERCE/OMNICHANNEL PROCESS

The consumer eCommerce last mile delivery process, while only one aspect of the total last mile delivery issue, demonstrates the complexity that cities have in addressing this issue.[3] A general overview of the eCommerce LMD processes can be seen in Figure 17.

The explanation of the LMD processes is provided below:

(i) Online shopping

The process of ordering products or services online – online purchase process. The related subprocesses are online order issued to warehouse; online order placed to the store; online order placed to pick up point. This process includes omnichannel services, where a variety of shopping channels can be considered for home shopping such as teleshopping, tv-shopping, digital shopping.

(ii) Packing process

The process of preparing products or materials for shipment/delivery. Packaging usually includes boxing up the products, labelling the boxes, and loading them onto a pallet or into a shipping container. The related subprocesses are packing in the warehouse; packing in the UCC; packing in the store.

(iii) Delivery process

The process of delivering ordered products to pick up points along the delivery network and to the end-customer's doorstep. The related subprocesses are delivery from the warehouse; delivery to consolidation centre; delivery from the consolidation centre; delivery to store; delivery from the store; delivery to pick up point; delivery to residential home.

(iv) Pick up process

The process of picking the ordered product from different pick up points, end-customer pick up. The related subprocesses are pick up from microhub; pick up from parcel lockers; pickup from collection point; pick up from store (instore pick up); pick up from post office; pick up from other transfer centre. This process is also termed as Pick-Up and Drop-Off (PUDO).

(v) Return process

The process of return would be an option for e-retailers and all products where a return can be foreseen/anticipated. The process of product return involves the end-customer taking a previously purchased product back to the retailer, and in turn receiving a refund in the original form of payment, exchange for another item (identical or different), or store credit. The related subprocesses are return taken from home; return to post office; return to store (branch office); return to pick up point. The return process includes also omnichannel returns where all physical or online return channels can be used to return the product.

Adding maintenance, landscaping, construction, public service (e.g., trash, road repair, etc.), healthcare, and other service vehicles to the mix of vehicles entering neighbourhoods and commercial districts, one quickly sees the challenges presented to both city governments and citizens in controlling last mile delivery operations.

[3] eCommerce deliveries are only one component of the last mile delivery issue. It is estimated that over 50% of vehicles classified as performing last mile services are associated with construction, maintenance, or land scape operations. It should also be noted that over 75% of city traffic is generated from personal autos or taxis (Australian, UK, Vienna traffic statistics).

3.1.3 Organizing the Last Mile Delivery Discussion

As has been noted previously, last mile delivery activities are complex. However, last mile delivery and freight operations are only one component (or subset) of the complex set of activities that fall under the umbrella term of "Urban Logistics." To separate the two domains, it is helpful to visualize where last mile activities fit into the overall complex of urban logistics activities. While such a separation is, by definition, somewhat arbitrary, it is useful for organizing and structuring the discussion of what the URBANE project's focus is.

Figure 18 provides a rough block framework for thinking about the various macro components involved in urban logistics. This figure, adapted from Janjevic & Winkenbach (2020) provides some structure for considering the various dimensions of urban and last mile delivery operations. Discussions of the primary elements and the current state-of-the-art in each element appear in the sections that follow.

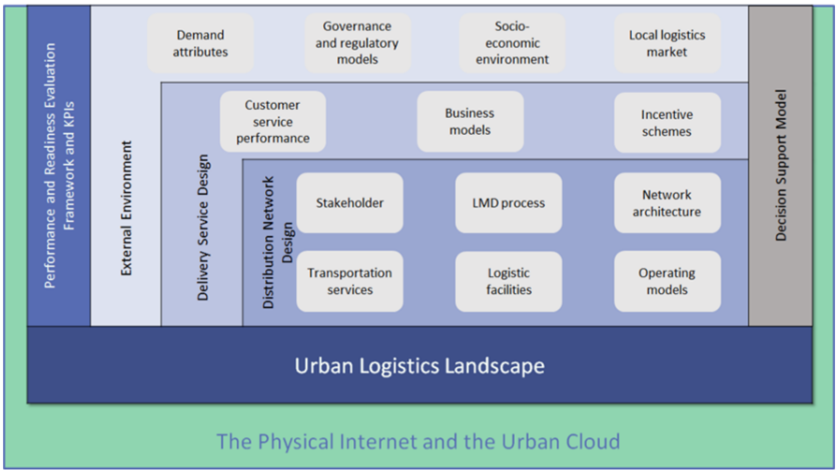


FIGURE 18 - URBAN LOGISTICS FRAMEWORK

3.1.3.1 Urban distribution network design

The success of last mile delivery operations depends on the appropriate design of the distribution network. This design, if carried out, focuses on designing and optimizing the network of facilities, routes, and transportation modes employed to ensure efficient and cost-effective delivery of goods and a seamless and satisfactory delivery experience to the end-customer. This is a process conducted by all large-scale parcel and logistics service companies. Unfortunately, the numerous small logistics companies, couriers, startups, and ad hoc private delivery organizations have limited resource capabilities and, therefore, generally are less adept at performing these optimization processes.

Designing an efficient and cost-effective last mile delivery network requires the LSP to develop a set of dynamic route optimization models based on both historical and real time delivery data. Constraints and/or considerations that the model must consider include:

- The number of layers or "echelons" that the network will have. This factor concerns the levels of consolidation and deconsolidation that occur as parcels are brought into a city, distributed to neighbourhoods, and then consolidated into a delivery vehicle for final delivery (Marujo et al., 2018; Lee et al., 2019; Janjevic & Winkenbach, 2020; Gunes, 2021).

- Number of times the vehicle parks to serve end-customers along the route. Dropping off parcels along a route consumes time and this fact needs to be incorporated into any route optimization procedure that an LSP employs. In urban areas where delivery personnel must search for parking spaces so that they can deliver parcels, this factor can create significant inefficiencies in the delivery process and the ability of an LSP to meet delivery window expectations. This fact also makes the delivery vehicle driver walk considerable distances in making their deliveries, which also adds to the total delivery time and reduces overall efficiencies (Allen et al., 2018).
- Network infrastructure. The type of roads, parking availability, general traffic patterns, available facility locations, charging infrastructure, public transport layout, geography, etc. all have significant impacts on how efficient a distribution network can be. In addition, the use of more novel delivery means, such as drones or robotic delivery systems, creates additional constraints as drop zones, landing pads, safe and secure pathways, etc. are all necessary for deploying these technologies in a last mile delivery model (Sindi & Woodman, 2020 and Bachofner et al., 2022).
- Average number of stops per day. This factor differs from the number of times a vehicle must park during a delivery route as it deals with the actual delivery addresses where parcels are delivered. The more stops per day that a driver makes the more time it takes to complete a delivery cycle. This figure is severely impacted when parking is unavailable and/or the network infrastructure is complex (Marujo et al., 2018 and Janjevic & Winkenbach, 2020).
- Number of EDV charging stations. With the increasing popularity of electric delivery vehicles in last mile delivery, the issue of available charging stations along a route has arisen. If an LSP expects to only charge their vehicles at their own depots, then sufficient power generation infrastructure to their depots is required. If the LSP expects to have their vehicles charged enroute throughout the day, then urban charging station infrastructure is required. The capability of this infrastructure, fast charging stations vs standard charging stations, location of stations, popularity of stations, etc. all can have a dramatic impact on the ability of the LSP to optimize their delivery service (Jochem et al., 2019; Burnham et al., 2017; Sun et al., 2016).
- Number of vehicle trips in the urban area. This factor depends on the volume of goods being handled at each level (echelon) of the network. As volumes increase the fill rates of vehicles and the density of deliveries increase. These changes in operating characteristics initially improve efficiencies in the network. However, after a certain volume level, new vehicles must be introduced in the system to meet delivery times. These new vehicles increase capacity and network efficiency drops. This cycle of activity operates on a continuous basis in networks experiencing continuous growth. For networks that are subject to high and low volume demand cycles (Christmas holiday demand vs January/February demand), dynamic scheduling and replanning of routes and vehicle use is required to maintain network efficiency (Özarik et al., 2021).

3.1.3.2 Stakeholders

Stakeholders are a key driver, consideration, constraint, and factor in any urban or last mile network. Stakeholders create demand, perform delivery services, facilitate delivery operations, regulate operations, initiate complaints, pay for services, and provide the products that are ultimately delivered. A study by Ballantyne et al. (2013) developed a useful framework for considering who the primary stakeholders are for urban freight operations[4]. Figure 19 reproduces this framework.

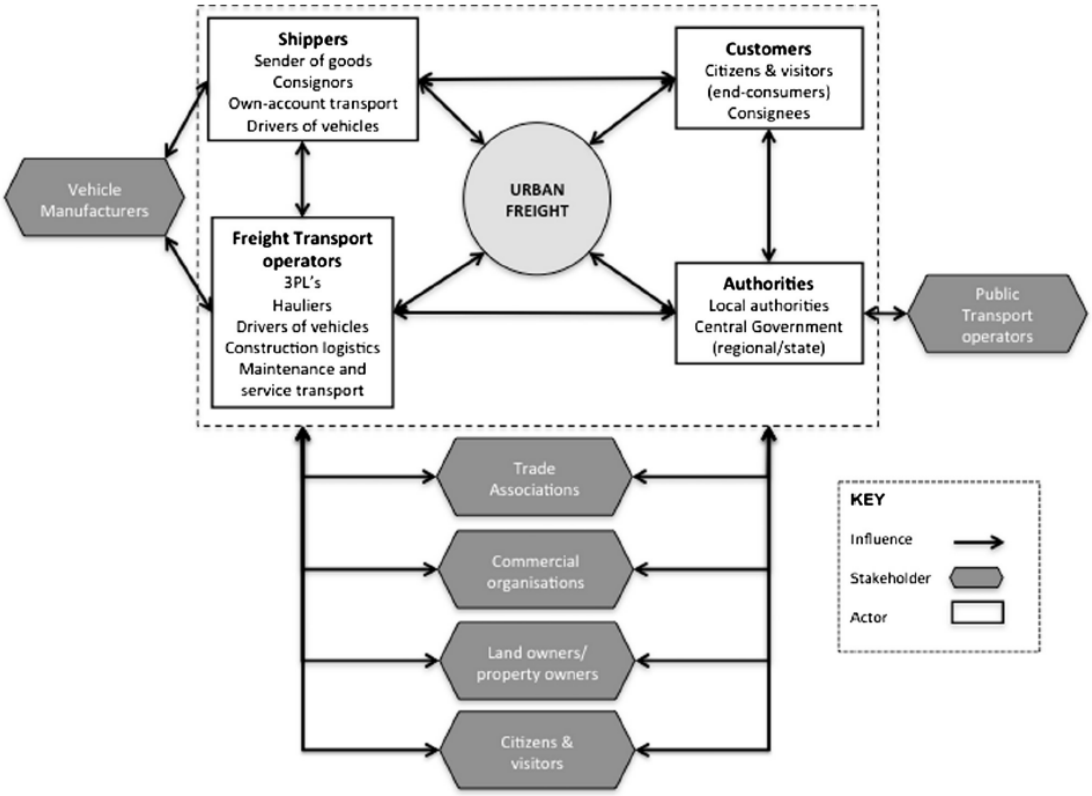


FIGURE 19 - BALLANTYNE ET AL. (2013) URBAN FREIGHT STAKEHOLDERS FRAMEWORK

The Ballantyne framework posits four primary stakeholders in urban freight:

1. Shippers – the individuals who send the goods, operate their own delivery vehicles, and the drivers of those vehicles;
2. Customers – citizens, retailers, manufacturers, governments, and other actors who are the receivers of the shipments;
3. Freight operators – third party logistics service providers, transport companies, transport company drivers, construction companies, and maintenance and service companies; and
4. Authorities – local, regional, and national governmental entities that oversee and regulate transportation, shipment of goods, and local operations.

[4] Note that the Ballantyne framework is an extension of a framework developed by Nemoto et al. (2001) and presented at an OECD conference in Paris.

Shippers

Shippers, those whose goods are being transported to customers, are interested in the efficiency of the transport operation as this drives costs. They are also interested in the effectiveness of the transport operation as this has an impact on the customer's perception of their product and organization. Shipper interest in how their goods are transported (the effectiveness issue) is leading to an increasing awareness of the environmental impacts of their delivery processes, packaging, and product design. In a recent report by McKinsey the consulting firm found that shippers are willing to pay a premium for sustainable logistics offering but are not doing so because there is a lack of clear demand requirements, industry standards (a worry about competitiveness), and the high cost of sustainable delivery services (van Gogh et al., 2022).

End - Customers

There is little need for a process called "urban logistics" without demand from customers. The term "customer" is used here not only to cover the common use of the term for individuals placing orders for goods, but also the legal definition which broadens the term to cover "legal persons," the businesses that operate within a city, governments, and visitors who may order goods while within a city's borders. Historically, providing last mile delivery services to citizens has not been viewed as major issue (Meyburg et al., 1974 and Ogden, 1984). Orders were placed and deliveries made by the postal service, specialized parcel carriers, or freight operators. City officials, citizens, and customers paid little attention to the freight operations except when they experienced some type of inconvenience due to a delivery being late or delivery vehicles blocking access to roadways or buildings.

Stakeholder interest in urban freight operations fundamentally changed with the advent of e-Commerce. The rising demand for home delivery of online ordered goods was already causing significant concern prior to the pandemic. With the forced isolation of individuals to their homes during the pandemic, last mile deliveries in urban neighbourhoods skyrocketed. This increase in home delivery was generally not a significant problem as work related traffic was limited. However, with the pandemic receding into history, home delivery of goods, food, meals, etc. has continued to increase. Coupled with the development of omnichannel retail operations, increased construction efforts, and ongoing maintenance and home services growth, the urban freight question has become the urban freight problem.

Customer interest in urban freight operations focuses on several factors. Primary customer concerns are timeliness of deliveries, cost of delivery, reliability of service, visual impacts of service provision, convenience, safety and security, and, more recently, environmental impacts (Ballantyne et al., 2013). A very recent large sample study by Engelhardt (2023) of German online shoppers found that approximately 40% of those interviewed would not be willing to pay for sustainable last mile deliveries. Of the 60% who would be willing to pay, the average sustainability charge for a delivery was approximately €2. Given that logistics service companies recover only about 80% of the cost of a last mile delivery and that sustainable last mile deliveries increase costs (Statista, 2023), a willingness to pay €2 additional for sustainable deliveries still results in a loss on last mile delivery operations[5]. The desire for instant gratification of demands coupled with no extra costs for such immediate delivery places an extreme burden on logistics service operators.

[5] Note that these figures apply to averages, not to the tails of the curve around the average values. In dense city deliveries, logistics companies actually realize a slight profit on last mile deliveries due to economies of scale in delivery. A similar positive outcome for sustainable deliveries, if paid for by an €2 fee would be expected.

Freight transport operators (logistics service providers)

The number of logistics service providers (LSPs) delivering goods in a city has historically been limited in number. With the advent of new direct-to-consumer, omnichannel operations, the new era of working from home (post COVID era), and non-traditional delivery means (cargo bicycles, drones, etc.) this number is growing. Controlling these delivery organizations is extremely difficult for city authorities as there is little information available on their day-to-day, hour-to-hour, and minute-to-minute activities. In addition, while traditional parcel delivery companies are generally the focus of city transportation personnel, these operators account for only about half of the total freight operator vehicles delivering freight within a city (Cherrett et al., 2012). The remaining LSPs deliver to construction sites, perform maintenance or landscaping services, work on utilities, or haul trash for the city.

City Authorities

City authorities are the *de jure* representatives of the residents. As such they are responsible for their well-being and echo their preoccupations. Over the years city authorities have developed and implemented several types of regulatory frameworks for the usage of public space and roads such as parking space areas, traffic management, access controls, time of day delivery control, etc.

In their capacities as representatives of their constituencies, city authorities are now trying various policies to reduce pollution within their boundaries. Efforts focused on noise pollution, fine particle emissions, NOx emissions, and CO_2 emissions are being explored or implemented. Policies include, among others, limiting the entry of vehicles to certain licence plate numbers when poor air quality is observed (Paris), others put up time windows for entry into certain commercial zones (Antwerp), others impose a certain type of fuel or engine for access to low emissions zones (Brussels).

City authorities are concerned about providing their citizenry with a pleasing environment in which to live, a place in which their quality of life can improve, where they can work and earn a living, and where the city is economically sound and attractive enough to entice people to visit. However, city authorities can only have an impact on the territory within the boundary of their city. Unfortunately, pollution, traffic, vehicle technologies, etc. extend beyond the city's boundary while impacting citizens quality of life and ability to enjoy an economically sound social environment. This fact means that regional and national authorities must also be involved in cooperative efforts to control the negative impacts of pollution.

Urban transport, as part of the services that a city oversees for its citizens, is thus an area where city authorities are beginning to become more directly involved. With increasing problems caused by eCommerce and omnichannel business models and the negative impacts of global warming from the emission of CO_{2e} pollutants, cities are facing the need to regulate how urban freight operations are conducted. In particular, city, regional, state, country, and EU authorities are focusing on the negative impacts of last mile deliveries and how they can be addressed. The URBANE project's existence is a result of this focus.

For the major LSPs such as DHL, FedEx, UPS, DPD, Chronopost, Die Post and other local post parcel delivery providers, the cost of delivering in a city centre with its high density of deliveries means that the cost per drop is low. It is reckoned that LSPs make a profit on deliveries inside cities with dense population, but a loss on deliveries to residential and rural addresses (Engelhardt, 2023). These large operators account for upwards of 80% of the total delivery volume for parcels within an urban area (VCO, 2019). In addition, these large LSPs tend to utilize sophisticated bin packing and route optimization planning systems making their internal delivery operations as efficient as possible[6].

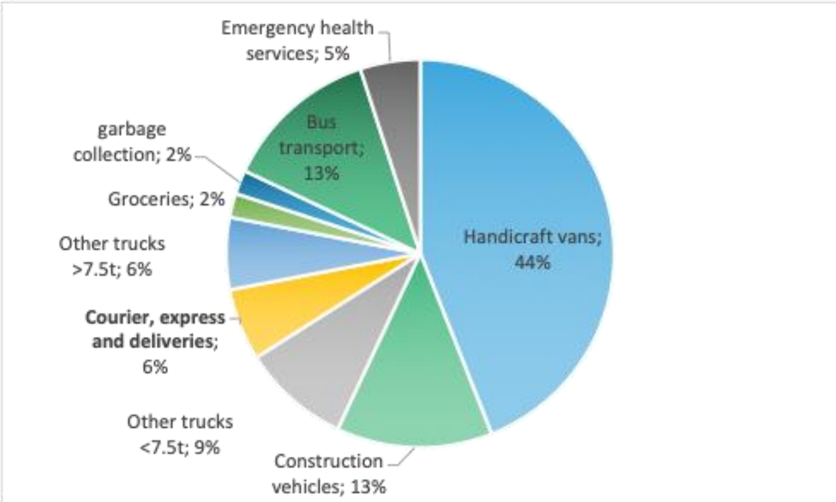


FIGURE 20 - URBAN LOGISTICS – DISTRIBUTION BY TYPE WHERE THE COURIER AND EXPRESS DELIVERIES ACCOUNT FOR 6% OF VEHICLES ENTERING THE CITY (MOBILITÄT MIT ZUKUNFT, VCO, VIENNA, 2019)

The URBANE project examines the impact of collaboration between LSPs to determine how consolidation of flows can improve asset utilization, reduce total kilometres travelled, reduce costs, and reduce environmental impacts. It is expected that, whether the LSP is large or small, they will benefit from the collaborative model (the PI concept) through lower overall costs.

Microhub operators

Microhubs are logistics facilities for micro-consolidation, which is the bundling of goods at a location near the final delivery point (e.g. within 1 to 5 km from the final destination) (Janjevic & Ndiaye, 2014). Microhub operations may use a permanent building or a mobile structure, operate on a permanent or temporary basis, and may be operated by one or more businesses in parallel. In general, though, microhub operations have five common characteristics (Janjevic & Ndiaye, 2014):

- Intend to reduce the number of vehicle trips in an urban area
- Focus on the delivery of smaller and lighter loads
- Allow goods to be transferred to a cleaner mode of transport, such as cycling or walking, for the last mile of delivery
- Are typically operated by privately owned LSPs
- Facilities are located within an urban area near the final delivery point.

[6] UPS To Enhance ORION With Continuous Delivery Route Optimization | About UPS

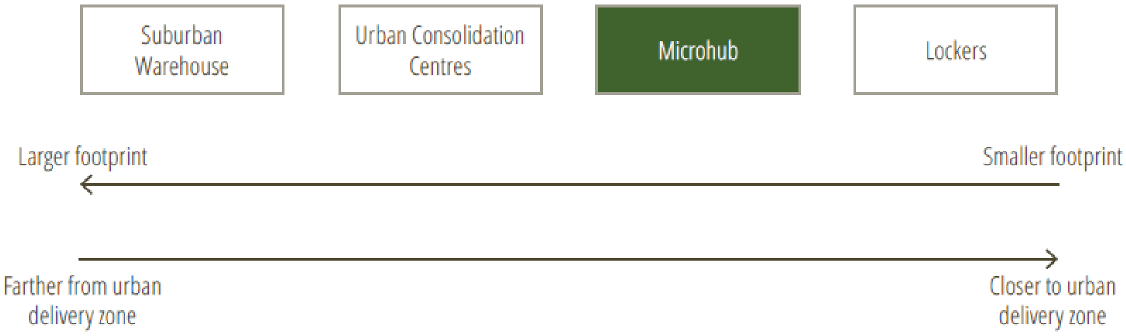


FIGURE 21 - TYPES OF URBAN LOGISTIC SPACES (JANJEVIC & NDIAYE, 2014)

City deliveries of e-commerce parcels require a number of locations where parcels can be deposited and retrieved either for final delivery or by local residents. These locations can be either owned by some public entity or privately owned and operated. In some instances, the microhub is positioned on a public space leased by the city authorities. Some of those locations are stores with specific agreements with LSPs to receive and deliver parcels to final customers given a specific information recording device such as a PDA or smartphone.

Although microhubs and parcel lockers are similar in some ways, we differentiate them in this report based on the self-serve characteristic of parcel lockers. Parcel lockers are very small storage units that are located close to the final delivery point in urban or rural areas, and which can be conveniently accessed by customers without the help of a staff person (Figure 21) (Janjevic & Ndiaye, 2014).

In the classification presented in Katsela et al., (2022) where three microhub typologies are identified: (1) the first is a last-mile collaboration between LSP and local stores located in city centres. We do not use such a category here as it would imply involving local retailers in the setup of microhubs, something which we think would not be economical. The illustration of this model (see xx) is based upon the case study of a startup in 2009 in London which now has folded for lack of economic interest from the London retailers. We argue that this model will not thrive.

(2) Shared infrastructure (government-supported initiatives) which have labelled here as public private partnerships (PPP). The shared infrastructure uses the collaboration of city authorities and private investors to set up the microhubs. We will name this form in the remainder of this document as PPP. The third, (3) private systems (private-led initiatives, single LSP logistics facility). LSPs can integrate microhubs into logistics operations using a private model (Lee et al., 2019). Single-LSP microhubs are typically private-led initiatives. LSPs can use these microhubs as additional transhipment platforms within their existing and exclusive delivery networks and build them to be either stationary or mobile (Katsela et al., 2022).

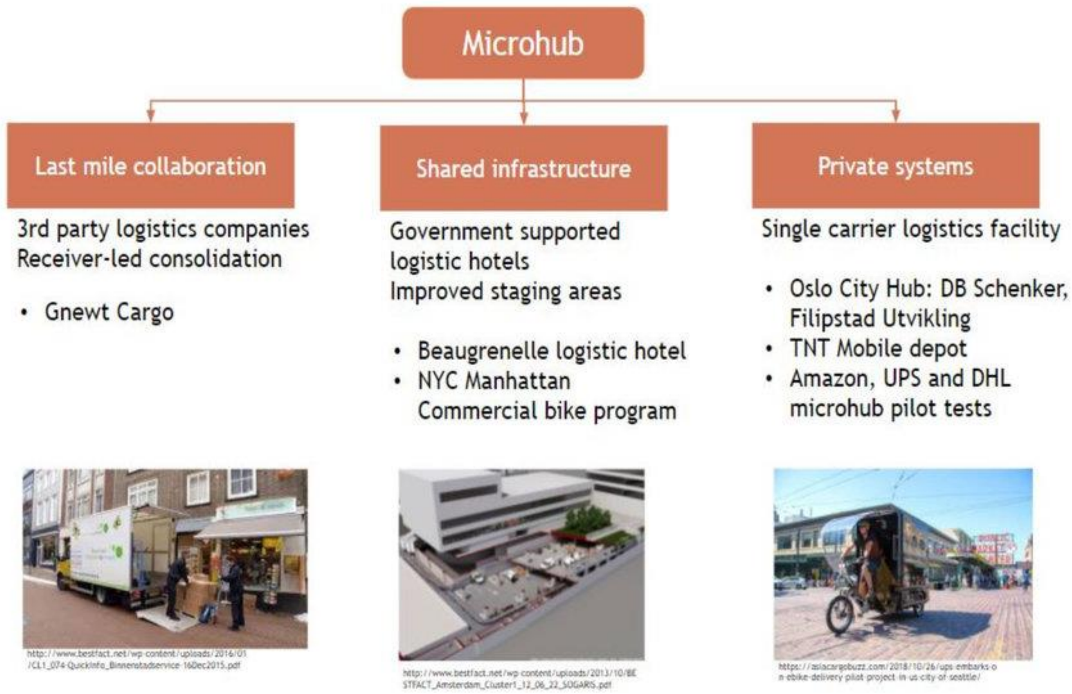


FIGURE 22 - MICROHUB OPERATIONAL TYPOLOGIES AND EXAMPLES (KATSELA, 2022)

The position and corresponding authorization by the city authorities must be related to delivery volumes and frequencies. As those change in time, so the parcel lockers and microhubs must be eventually repositioned to different locations. The process to do so must be sufficiently easy and quick to provide economic value to the owner-operators (Novotná et al., 2022).

Cargobike and other small electric vehicle operators

This category of stakeholders includes various types of firms: some large, others small, some privately owned or in partnership with a city. It is considered here that their preoccupation is to ensure commercial viability and acceptance by the other stakeholders. A later section is devoted to the description of all the last mile delivery technical solutions available.

Parcel exchange platform

This type of stakeholder is necessary in the proposed solutions which are to be contemplated in this report and in the upcoming work in the course of the URBANE project. There already exist a stream of literature on such platforms with some proposing white label ones (Pufahl et al., 2020).

This platform would be created jointly with city authorities and LSP participation so to ensure its success.

Such a platform will provide the following services to the LSP and to the city.

To the LSP:

- On a real-time basis evaluate and present each LSP with a set of routes combining the available parcels to be delivered or picked up inside the city in such a way as to optimize the number of stops, kilometres, and time of the appropriate delivery vehicle.

- Present updated quality metrics (on time delivery) for parcels delivered the preceding business day for all parcels offered in the platform. These metrics will be the basis for quality reports for each LSP about the deliveries performed by the assigned LSP of the parcels originally entrusted to them. For example, if DHL has 300 parcels to deliver or pick up daily and these are shared between DPD, UPS, FedEx as well as DHL, then DHL will be informed of the quality of the service provided by the others as well as its own vehicles.
- Define periodically the bonuses and penalties shared out between the LSP according to their quality of service over the considered period. This will ensure that all LSPs will strive to provide the highest possible service over time. Note that the city does not have here to intervene.

To the city:

- Periodic reports about the number of parcels delivered by period and neighbourhood.
- Periodic reports about the market share of the various LSPs active in the city. These will have to include all LSPs which participate in the parcel exchange platform.
- Periodic reports about the overall quality of delivery service provided by the LSP in the platform. These reports might help the city in vetting the LSP active in the delivery service provided to citizens.
- Periodic reports about the emissions generated by the traffic of delivery vehicles inside the city as well as an estimate of the traffic generated in terms of road and parking occupancy.

To be able to deliver those services a number of information systems are required. The type and form of those systems are detailed elsewhere in the project. We are interested here in describing which type of information and by which stakeholder is necessary so that the above services can be performed.

Information from the LSP:

- Parcels to be delivered or picked up in real-time by the LSP with the corresponding logistic information such as origin and destination, size and weight of the parcel, time widow in which the parcel must be delivered or picked up. This information will serve as the basis for the optimization of the pickup and drop off (PUDO) routes which will then be assigned to a particular vehicle.
- Geographic position in real time of the fleet of delivery vehicles operating. In this way the system will assign a PUDO route to the optimally available vehicle in real time.

Information from the microhub operators:

- Information about parcels received for each microhub so that they be assigned to a vehicle for delivery in real time.
- Information about parcels returned because of missed deliveries in real time. In this way, a new delivery may be planned in a new time window.

Information from the city:

- Planned works in the city such as road closures, restrictions, parking availabilities etc. This information will be used by the exchange to evaluate the optimal PUDO routes and needs to be updated frequently.
- City plan of roads, parking spaces by destination (commercial, private), traffic lights, etc.

Various economic models can be applied. In the following some of the most important by their expected consequences. Others could eventually be implemented.

Public venture operated by the city authorities

In this model, the city invests in the information systems infrastructure required for the provision of services to the LSP operating in the city. Given the cost and expertise that such investment requires, it is expected that only the most important cities with the necessary financial means will implement this type of economic model.

Private venture independent from cities and LSP

This model does require that the necessary intellectual property (IP), including the one assembled by the work performed in the URBANE project, be collectively made available to such a venture. Further financial backing will also be required to fund the initial period before the fees collected from the various users of the platform allow it to break even. The venture will be expected to pay for the IP that is provided by the relevant partners in the URBANE project.

Public Private Partnership (PPP) between city and LSP

In this model, the PPP set up will be responding to the LSP as well as to the city for the service provided and the expected added value in economical as well as ecological and social terms. In this model, both the city and the LSP will need to be involved both strategically as well as operationally in the success of the partnership. Given that their interests diverge, attention will have to be given to the governance mechanisms so that this partnership remains relevant and serves the interests of all parties as has been experienced in various cities in the world such as Bogotá, Santiago, or Sao Paulo (Willoughby, 2013). Such mechanisms will be explored in a later section.

3.1.3.3 Last Mile Delivery Processes

No single approach to last mile delivery of goods exists in any urban environment. As noted earlier for the eCommerce/omnichannel delivery model, multiple actors, are employed to perform pick up and drop off activities in a manner that best suits their approach to solving the delivery problem. While this approach to last mile delivery gets the job done, there can be no doubt that it is both inefficient and costly. The problem that exists with last mile deliveries has arisen due to the rapid increase in demand for this service, the disruptive impact of instant gratification requirements on traditional consolidation and delivery planning processes, the involvement of numerous opportunistic startups without deep logistics experience, and the involvement of new delivery demands on traditional retailers without experience in delivering to end-customers.

The Wild, Wild, West

In the current urban logistics era, "innovative" last mile delivery services contribute to market fragmentation as they serve different niches. Their collective impact to making logistics operations more sustainable is not obvious but probably weak or in some cases even negative (Simoni et al., 2020 and Ermagun et al., 2019). Small businesses and startups that provide delivery services are mostly unsuccessful due to a lack of scale and inefficiencies either in demand or in supply. Ultimately, they are unable to continue operations due to heavy operational costs. A recent example to this is Redjepakketje which made an 88 Eurocent loss on every parcel delivered (Witlox, 2022). Traditionally, governments exercise very little control over the development of the logistics service market. They have some experience with “free ranging” platforms in other markets (Airbnb, Uber, Booking.com) and this has been problematic due to a lack of appropriate regulation and an inability by governments to react in the clock cycles that these startups operate under.

The traditional process for last mile deliveries can be described rather simply. Parcels requiring delivery are brought to an urban consolidation centre. They are sorted by postal code and delivery time request, if available. The sorted parcels are then assigned to various vehicle routes based on either an optimization process conducted by the delivery company or to delivery vans that cover the postal code on fixed routes. The items are then distributed to the addresses in the postal code area. If a parcel cannot be delivered due to the absence of an authorized end-customer, it is loaded back onto the delivery van and taken back to the central distribution centre where it will either be rescheduled for deliver or a notice will be provided to the receiving entity that the parcel must be picked up at a local PuDo location.

While this “standard” process forms the backbone of all the major parcel delivery company approaches to last mile delivery (i.e., DHL, FedEx, UPS, all postal services, etc.) there are many variations that exist. In large cities there may be a double sorting and consolidation process because of the density of deliveries. In this type of system, a central or regional processing centre sorts parcels by district (a combination of postal codes) and sends the parcels for that district to a district sorting facility. This facility sorts the received parcels by delivery route within the district and the standard process described in the previous paragraph is applied. This process of consolidation, sorting, shipment, deconsolidation, sorting, shipment can be carried out for however many echelons or layers a city might need to ensure efficient operations. It should be noted, however, that the more echelons that a network employs, the more costly the delivery process.

What has been described is a one-way delivery process. This description is not meant to ignore the returns process or the induction of new shipments that are outbound from a pickup point to another destination. The returns process is handled in several ways in the traditional model. Items can be brought to a consolidation point and inducted into the reverse system, pickups can be scheduled and handled by the LSPs as they deliver goods, or pickups can be scheduled and dedicated pick up operations performed.

The standard process for delivering goods over the last mile worked well for many years. It still works very well for the greatest volume of parcels that are delivered today. This is because the process allows for the pre-planning of loads and routes, which allows the LSPs to realize low costs and high efficiency. Unfortunately, the steady state conditions that allowed those organizations that utilize this process in the past have been disrupted over the past twenty-five years by the development of demand for next day/same day eCommerce deliveries, omnichannel “pick it up anywhere” deliveries, and ad hoc local grocery and restaurant deliveries. Optimization processes that require planning one day in advance are too rigid to handle the dynamism of “instant gratification” models. This means that LSPs must employ continuous optimization processes for planning loads and routes, a task that is actually not possible the minute a load and route is planned it is obsolete as new delivery orders arrive. To be able to handle these “instant” orders, the LSPs must now anticipate what the volume of unplanned parcels will be on a route and leave sufficient open space in the vehicle to handle this volume. To the extent that the organization is good at data analytics and has good predictive algorithms, this process can work, but it does create issues when vehicles go out only partially loaded or too many parcels arrive to be handled by the space available.

Environmental concerns are causing further problems for those following the traditional approach to last mile delivery. Because margins are very thin in logistics operations, large LSPs have optimized their routes and vehicle loads to get maximum efficiency out of their delivery process. This has meant that larger vans with low-cost diesel engines have traditionally been employed for their last mile operations. Diesel engines are durable propulsion units and the vehicles that the major players utilize have been designed for durability, load, and operator efficiency. New zero-emission rules for urban operations are forcing these organizations to retire or redeploy these assets before the end of their useful life and buy expensive, smaller, and less optimized vehicles to comply with the new regulations. This increases cost in an environment where margins are already extremely thin.

Ad hoc delivery demand, which these more traditional companies do not handle, is growing and causing a number of additional process problems. Grocery delivery vans, pizza scooters, restaurant delivery bicycles and scooters, traditional courier services, maintenance vans, landscape and gardening vans and trailers, construction vehicles, road service vehicles, utility maintenance vehicles, garbage trucks, street sweepers, etc. are all moving along streets and sidewalks vying for space with personal automobiles, bicycles, pedestrians walking, and now car sharing, bike sharing, and scooter sharing vehicles that are left haphazardly around the community. The last mile delivery process is, as the heading to this section denotes, truly “the Wild, Wild, West.”

Some control

City authorities together with regional/national authorities set the legal framework and design policy measures in order to ensure efficient and sustainable transport in cities. Typical control measures include time windows, car free and low/zero emission zones, weight and size regulations, traffic management, land use and curb side space management. These control measurements have not generated the desired or expected outcomes yet. Clearly, the accessibility to cities for light duty trucks and vans remains important to ensure that citizens have access to goods and services, so the space for limiting truck movement has bounds. Demand management is a measure of self-control applied by receivers of goods (off-peak delivery, use of PuDo locations (including parcel lockers), order consolidation, etc.) which is not necessarily driven by governmental regulations but may need government support. Financial incentives for off-peak hour deliveries (Holguín-Veras et al., 2006), zero emission city logistics in Rotterdam (de Bok et al., 2021), and time-window restrictions for handling parcels in urban areas (Cossu, 2016) are some examples where demand management is being enforced by city authorities.

Some interesting innovations

During the past several decades numerous innovations have been suggested, tested, and demonstrated as potential solutions to the sustainability problem of urban freight (see discussion earlier in this report). These innovations include robot/drone deliveries, micro- consolidation centres, crowdsourcing, parcel lockers, click and collect and cargo bikes. Unfortunately, last mile delivery is a complex system requiring that it be addressed as a system, not as simply a collection of problematic elements. As long as the approach to developing innovations for the last mile problem are disjointed and fragmented and not focused on the last mile process as a system, freight flows will remain fragmented, and the innovations will fail to improve the system.

Layered into this interesting and evolving technological landscape is the development the omnichannel business models. Omnichannel retailing strategies fostered by online shopping lead to increasing fragmentation of the delivery process. While traditional retail shopping generally required end-customers to perform pickup and delivery operations themselves, omnichannel shopping provides end-customers with a variety of delivery options. If an end-customer wants to pick something up from a store, omnichannel approaches allow this. If they wish to pick something up from a drop off point close to their home, omnichannel strategies allow this. If they wish to have something delivered to their home, omnichannel operations allow this option as well. End-customers are tightly linked to the delivery channel and LSP decisions. With the boom of omnichannel and online retailing, end-customers have become an important part of the delivery process by initiating the online orders and potentially transporting the products for themselves as well as for others (Wang et al., 2022a and Wang et al., 2022b). This revolution in shopping places end-customers in the centre of the decision-making process for how last mile delivery operations are performed.

Readiness for the future?

There is an ongoing and fast movement towards individual, innovative delivery solutions such as crowdsourcing, drones, robots, and the use of parcel lockers to transfer parcels to end-customers. The omnichannel revolution is fragmenting flows much more than they have ever been. These trends are driving both the disaggregation of traditional last mile networks and creation of a multitude of new delivery networks. In this changing world of last mile operations, it is increasingly important to somehow facilitate the dynamic linking of these networks to ensure that the efficient and effective delivery of goods can be achieved. A physical concept modelled after the Internet, the PI), could act to achieve this integration. The PI provides a vision where all these small LSPs could be hyperconnected. However, to be able to obtain economic, societal, and environmental efficiency of the PI vision, a certain market adoption level is required.

3.1.3.4 Network Architecture

Distribution networks are extremely complex, multi-layered entities that involve the services of numerous LSPs, cross many regulatory boundaries, involve differing modes of transport, and require extensive communications between different information systems, technologies, and personnel to ensure that a shipment successfully completes its journey from production location to final consumption location[7]. Within the domain of urban logistics, we can see that goods can arrive at a regional distribution centre, be transferred to a UCC, and then transferred again to microhubs. This process, as described previously, is the standard process employed by traditional LSPs and retailers in distributing the goods they are responsible for.

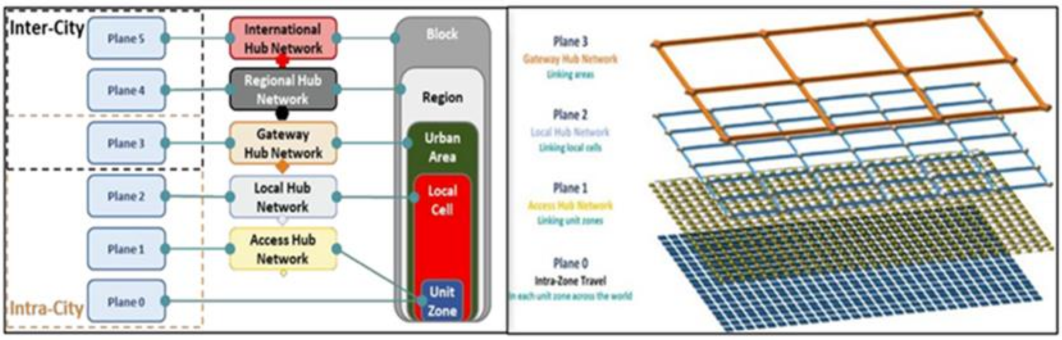


FIGURE 23 - HYPERCONNECTED – MULTILAYER DISTRIBUTION NETWORK (CAMPOS ET AL., 2021)

There are numerous variations on this standard theme for goods distribution. Wholesalers, distributors, third party online operators (e.g., Amazon), local retail, "big box" retailers (e.g., WalMart), and grocery stores (all acting as warehouses where the last mile delivery is handled by the end-customer picking up

[7] An interesting account of the many layers of movement from factory to end-customer is covered in Christopher Mims book Arriving Today: From factory to front door – Why everything has changed about how and what we buy, Harper Collins, 2021, ISBN 978006298752.

their goods themselves) can all be involved in the local distribution of goods adding to the complex web of relationships that facilitate the delivery of a producer's goods to the end-customer. The network models that producers employ for urban delivery of their products are as varied as the products themselves. These models form the channels of distribution that an organization's marketing group identifies as being important for reaching its customers.

Campos et al. (2021) have identified three network structures in urban logistics operations that group the models discussed above into three common architypes. These architypes are:

1. The traditional three tier hub and spoke network in which goods arrive at a regional distribution centre where they are stored and then reconsolidated for delivery to an UCC where they are further broken down and reconsolidated for last mile delivery. This process in shown in box (a) in Figure 24.
2. A three-tier hub and spoke network where the distribution centres at each tier in the network cross ship goods to one another as necessary. This type of network is common in Amazon's distribution model. This type of network in shown in box (b) in Figure 24.
3. A three-tier hub and spoke network that is hyperconnected, which means that a distribution centre can ship to any other centre and even end-customers depending on demands. This type of network is the theoretical basis for omnichannel retailing and the foundation of networks as envisioned in the PI. This network architype is shown in box (c) of Figure 24.

While Campos et al. (2021) restricts their diagrams to a three-tier structure, the architypes identified apply to any number of tiers as long as the rules noted above are followed. Network complexity increases as one goes from architype (a) to architype (c). This complexity is reflected in both the planning of network flows and the execution of operations. However, simulation of the hyperconnected network structure shown in architype (c) show that networks of this type yield the greatest benefits in speed, cost, and sustainability when implemented correctly (Kim et al., 2021).

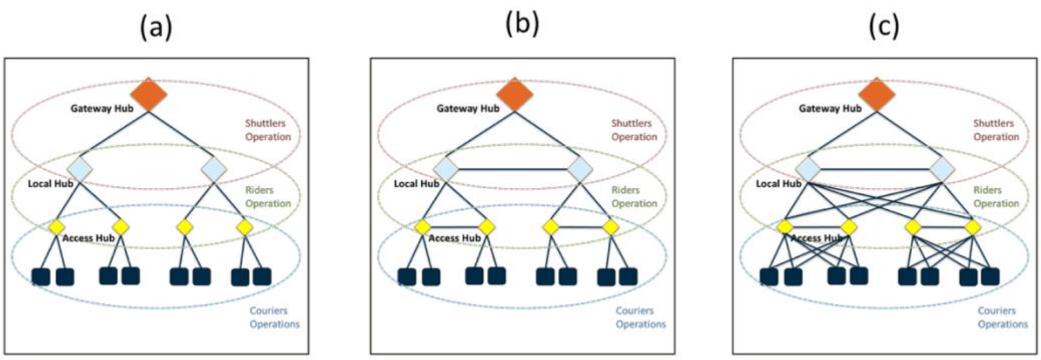


FIGURE 24 - NETWORK ARCHITYPES (CAMPOS ET AL., 2021)

While the above description covers the vast majority of network approaches used in Europe and other western countries, it should not be forgotten that even more complex delivery networks are used in cities such as Mumbai to deliver products to end-customers. The Dabbawala system of food delivery in Mumbai, as well as the many emerging food delivery services such as Colombia's Rappi or Uber Eats, demonstrate that the local pickup and delivery of items is an ever evolving and dynamic world where innovative last mile delivery processes are continuously being developed.

Network structures for urban logistics and last mile delivery continue to evolve. Innovative services such as Rappi and Uber Eats are continually being developed and tried out in various urban environments. While it is not clear how or when stability will again surface in the structure of urban networks, it is clear that the ability to master the challenges of planning and executing efficient operations in a hyperconnected network leads to greater flexibility, lower network costs, lower emissions, and greater execution reliability. All of these factors improve customer satisfaction and society's view of logistics operations in urban environments.

3.1.3.5 Transportation Services

FIGURE 25 - UPS TAYLOR SWIFT SPECIAL EDITION DELIVERY VAN

Efficient supply chain operations are focused on maintaining good flow. Stopping the flow of goods generates handling and delay costs. For this reason, efficient and effective delivery of transportation services is the key critical success factor in any urban logistics operation. Traditional large parcel distribution operations within urban environments have used specialized delivery vans for their operations (Figure 25). These vehicles were designed to handle the constant stop and start process that characterizes last mile delivery. The interiors of these vehicles, the diver entrance and exit design, and the instrumentation in the vehicle have all been optimized for efficiency in the delivery process.

Because most of these vehicles were designed prior to any considerations concerning greenhouse gas emissions, they were designed to use diesel engines. This design consideration was made based on the efficiency of the diesel's Otto cycle and the lower cost of diesel fuel. The decision was also driven by the fact that diesel engine propelled vehicles generally have better torque, which improves load carrying capacity.

With the realization in cities that one of the major generators of greenhouse gas emissions is the internal combustion engine, one of the major generators of NO_x and particulates is the diesel engine, cities have begun to pressure delivery companies to operate with "green" vehicles when performing deliveries within city boundaries. This has led traditional parcel delivery companies to begin migrating their delivery fleets, at least for urban operations, to more sustainable electric battery powered vehicles (Figure 26).

FIGURE 26 - NEW BATTERY ELECTRIC UPS URBAN DELIVERY VAN

As has been briefly noted in previous sections of this report, one of the most active areas of innovation in last mile delivery is in the choice of delivery technology. Technical solutions for last mile delivery cover an exploding diversity in approaches and technology types for delivering the parcels that customers and businesses order. The sections that follow provide a brief overview of some of these technologies. The reader should be aware that this overview is not meant to address every technology or technical approach currently being tested. Such a detailed approach would require a book length discussion, which is not the purpose of this report.

Innovative technologies for last mile delivery vehicles can be grouped into several classifications. The first logical classification is for vehicles that produce low or no emissions.

Low- or zero-emission vehicles

Electric vehicles, known as electric drive vehicles (EDVs) or battery-electric vehicles (BEVs), are driven solely by one or more electric motors powered by energy stored in batteries. The breakdown that appears below is based on material from the ULaaDS Horizon Europe study ULaaDS - Urban Logistics as an on-Demand Service and the Spanish CENIT project HALLO Hallo Project - Cenit | Science for Transport.

- Light electric vehicle (LEV), small vehicle weighing less than 100kg that run on electricity
- Electric light commercial vehicle (e-LCV), used for commercial purposes, they have a gross vehicle weight of no more than 3.5 metric tonnes – defined by the EU as an N1 vehicle
- Electric delivery van (E-van) is one of the electric drive vehicles (EDVs), regular-sized van that runs on electricity instead of petrol and an internal combustion engine
- Low emission vehicle (CNG and EURO V Diesel Trucks)

- Plug-in Hybrid Electric Vehicle (PHEV), a hybrid vehicle with a battery pack that can be recharged both internally and externally by plugging a charging cable into an external electric power source, as well as by its onboard internal combustion engine (ICE)-powered generator.
- Cargo bikes (cargo cycles)
    - E-assist cargo bike
        - Small e-cargo bike (15 kg, 2 wheels) – e.g., Ebike4delivery
        - Medium e-cargo bike (100 kg, 2 wheels) – e.g., Urban arrow L
        - Medium e-cargo bike with trailer (360 kg, 4 wheels) – e.g., Larry vs Harry Bullitt + Carla Cargo
        - Large e-cargo bike (200 kg, 3 wheels) – e.g., Rytle Movr25
        - Large e-cargo bike with trailer (200 kg, 4 or more wheels) – e.g., Velove Armadillo, UPS eQuad, EAV 2cubed
    - Pedal-only cargo bike (Narayanan & Antoniou, 2022)

FIGURE 27 - UPS ELECTRIC CARGO TRICYCLE AND QUAD WHEEL EV

- Postal delivery bikes (50-75 kg, 2 wheels)
- Longtail bike (50-100 kg, 2 wheels)
- Frontloader/Long John bike (150-200 kg, 2-3 wheels)
- Backloader, heavy load (500 kg, 3-4 wheels)

FIGURE 28 - LONGTAIL AND FRONT LOAD BICYCLES

The URBANE project's Living Lab in Valladolid, Spain will be testing various electric vehicle technologies in its portion of the project to determine their impact on last mile delivery in a test neighbourhood. The bicycles to be used in this test are designed to utilize solar charging systems. The concept will test whether onboard solar charging extends the productive use and range of the bicycles used in test scenario.

Living Lab demonstration: Valladolid

Electric vehicles support Valladolids "Plan Integral de Apoyo al Comercio de Proximidad" plan, that aims amongst other things the electrification of last mile delivery vehicles. Based on the aforementioned different vehicles the Living Lab is able to assess which of them suits best for their use case.

Autonomous delivery vehicles (ADVs)

ADVs are gaining considerable interest as potential mechanisms to perform last mile delivery services. The interest in autonomous ground-based vehicles (droids) focuses on their ability to potentially eliminate the need for delivery personnel, a costly and increasingly difficult asset to find. Autonomous aerial vehicles (drones) have also captured the interest of delivery organizations based on their ability to avoid congestion and deliver parcels in the most direct path possible ("as the crow flies"). Electric battery drones are limited in the weight and size of the goods they can carry, so they are primarily being examined for rapid delivery of small parcels and critical goods such as medicines. A brief overview of some of the many different types of autonomous vehicles being tested today follows.

- Ground-based autonomous vehicles:
  - Sidewalk robots
    - Follower sidewalk robots – e.g., Starship[8], ALEES[9], LMAD[10] for on-site parcel deliveries (Figure 29),
    - (Semi-) autonomous sidewalk robots[11] – e.g., Amazon Scout[12], UrbANT[13], TeleRetail, Eliport, BoxBot, Kiwibot, Udelv, Nuro, Robby technologies etc.

ADVs, such as the ones shown following, are still in their early stage of deployment. Issues associated with vandalism, ability to operate over all terrains, ability to operate in bad weather, operational restrictions in winter conditions, theft, and other factors must be thoroughly analysed and addressed before significant commercial deployment of the technology can be made.

Road robots are self-driving vehicles that carry parcels. Most of the trials today are done with a safety driver on board to take control if needed, but in the future, fully autonomous vehicles without a safety driver are anticipated.

[8] Startship's autonomous package delivery robot - https://www.starship.xyz/

[9] ALEES, self-driving logistical electric units for urban environments https://vil.be/en/project/alees/

[10] LMAD https://www.lmad.eu/news/adr-industrial-site-nokia-france/

[11] 10 autonomous robots for last-mile deliveries, https://www.practicalecommerce.com/10-autonomous-robots-for-last-mile-deliveries

[12] Amazon Scout - fully-electric delivery system – https://www.aboutamazon.com/news/transportation/meet-scout

[13] UrbANT, development of an urban, automated, user-oriented (in German "nutzerorientiert") transport platform - https://urbant.de/en/

FIGURE 29 - LMAD AUTONOMOUS DELIVERY ROBOT, STARSHIP AND ALEES VEHICLEALEES VEHICLES

Living Lab demonstration: Helsinki

ADVs are not just theory but also piloted in practice. In their first sprint, Living Lab Helsinki will be utilizing Twinswheel ADVs operated by LMAD for last-mile delivery of tools, materials, and supplies from a construction material and supply shop located in the Kalasatama/Söörnäinen district to nearby construction sites. The aim is to investigate whether on-demand autonomous delivery can streamline the delivery of construction materials.

Light autonomous vehicles for urban deliveries are being explored by various LSPs. These vehicles have the advantage over droids in that they can carry considerably more cargo. This plays into the strategies of the large LSPs who worry about the inefficiencies introduced into their systems by having to break down larger loads into small delivery parcels increasing the number of delivery vehicles and personnel required to execute a delivery operation.

- Road robots (<3.5 tonnes)
  - Low speed vans
  - High speed vans

FIGURE 30 - A TWINSWHEEL ADV

FIGURE 31 - EXAMPLES OF LIGHT AUTONOMOUS VEHICLES FOR PARCEL DELIVERY

Heavy autonomous vehicles can be used to serve first or second tier distribution centres in a logistics network. These vehicles carry loads similar to today's large trucks and are being examined for use where environmental restrictions require sustainable vehicle operations and truck drivers are difficult to find.

- Road robots (>3.5 tonnes)
  - Autonomous trucks
  - Platooning (Truck Platooning)

Platooning vehicles move in a group or platoon with the trucks driven autonomously by smart technology and continuously communicating with one another. The platooning is a technology by which two or more trucks, called connected automated vehicles, exchange information to circulate on the road in a joint and coordinated manner, allowing very small spacings and still travelling safely at relatively high speeds (Martínez-Díaz et al. (2021)). This system incorporates vehicle detection, anti-collision and lateral control technologies to increase road safety.

Autonomous aerial vehicles, UAVs or drones, have captured the imagination of academics, LSPs, end-customers, and the press. Amazon's announcement over 10 years ago that it was experimenting with drone delivery is credited with making this concept a hot topic. The reality of drone delivery, at least for battery powered drones operating in dense urban environments, is not quite what the technology hype would want one to believe. Drones have limited weight carrying capacity, travel distance, have problems in heavy rain, wind, and fog, must be certified to travel in air corridors, and are not very good yet at finding drop points for people living in dense urban housing. These constraints have not dented the excitement in the technology as the concept is both rather "science fiction" like and it does have positive benefits (avoidance of traffic congestion, fast routing to drop zone, etc.). For these reasons, the technology will continue to be studied, hyped, and, hopefully, someday employed for last mile delivery.

- Aerial autonomous vehicle
  - Drones
    - Multirotor drones – e.g., Amazon prime air drone[14]
    - Hybrid drones

[14] Prime Air drone deliveries - https://www.aboutamazon.com/news/transportation/amazon-prime-air-prepares-for-drone-deliveries

FIGURE 32 - AMAZON PRIME AIR FLYING DRONE WAREHOUSE AND DRONE

“Ducktrain” systems combine one or more automated and light electrical four-wheel vehicles (Ducks) that can operate with a driver or driverless between a microhub and the final delivery district (Schomakers et al., 2022). Ducktrains can operate in platoons to gain efficiency while transiting to the delivery district where it can split up operations into single ducks. With the help of AI, a ducktrain can optimize its route while avoiding obstacles and manoeuvring safely during transit[15]. Each duck is equipped with multiple sensors to detect the leading object (main vehicle/person) and virtually couple to it. A Ducktrain can split up at any time and drive to a delivery person when they are ready to deliver more parcels.

The trailer duck is a version of the ducktrain concept in which the duck is connected to a leading object with a physical, force-free drawbar. The connected duck can be pulled by a pedestrian or connected to a bicycle or other LEVs (Schomakers et al., 2022).

FIGURE 33 - THE TRAILER DUCK[16]

The follow-me duck is another version of the ducktrain in which ducks automatically follow a leading object using a virtual digital connection based on sensor technology.

[15] https://www.innoenergy.com/discover-innovative-solutions/online-marketplace-for-energy-innovations/ducktrain/

[16] https://www.tuvie.com/ducktrain-electric-automated-logistic-vehicle-for-future-urban-last-mile-delivery/

FIGURE 34 - THE FOLLOW ME DUCK OF DUCKTRAIN[17]

Finally, the autonomous duck can operate autonomously, allowing ducktrains or single ducks to operate without human involvement. The auto duck has the ability to make its own driving decisions. However, as an intermediate step, it might be remotely operated to comply with legislation (Schomakers et al., 2022).

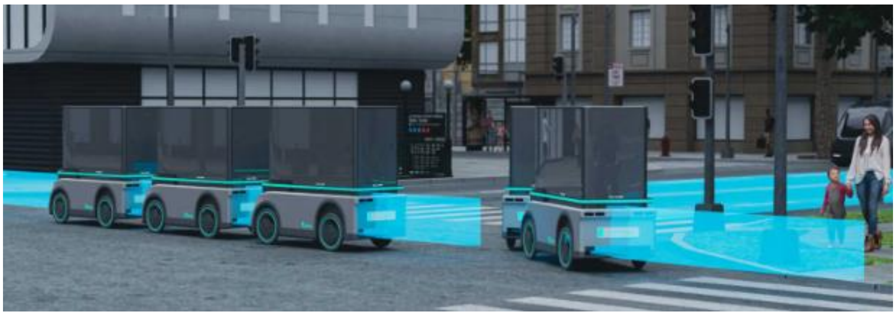


FIGURE 35 - THE AUTO DUCK OF DUCKTRAIN[18]

Different combinations of vehicles with autonomous robots, drones, etc. are being tested. These combination operations, generally called “sidekick” operations in the literature, exist because of constraints in the various delivery technologies. As an example, Murray and Raj (2020) examine the multiple flying sidekicks traveling salesman problem looking at how the use of trucks as both mobile inventory stores and hangers for the drones can best operate when using multiple drones to deliver parcels along a route. Examples of sidekick operations include the aerial drone/van combination, van/droid combinations, public transit/droid combinations, barge/droid combinations, barge/aerial drone combinations, etc.

In the van/droid model, which is typical of the sidekick process, specially adapted vans are integrated with autonomous delivery robots to allow efficient delivery of goods in neighbourhoods. Instead of completing door-to-door delivery, the vans drive to pre-agreed locations to load and unload goods and then dispatch the robots in the final step for on-demand delivery (Ostermeier et al., 2022). Upon making the customer delivery, the robots will autonomously find their way back to the van for re-loading. An example of this

[17] https://ducktrain.io/follow-me-duck/
[18] https://ducktrain.io/auto-duck/

type of sidekick operation is "Robovan,"[19] which was developed by a partnership between Starship Technologies sidewalk robots and Mercedes-Benz Vans.

FIGURE 36 - SPECIALIZED TRUCK LAUNCHING ROBOTS AT THE CURBSIDE.

Cargo hitching is the combination of freight transport and public transport operations. Public transport can be considered a transportation mode, therefore including cargo hitching as an option for LMD. This concept is generally classified as an extended form of crowdsourced delivery, as its main goal is to reduce freight flows by integrating them into existing passenger flows (Meyer et al., 2022). Cargo hitching, while not new, has gained interest as the crowdsourcing model has gained in popularity. It has been implemented in various modes of transport such as bus service and tram service. Cargo hitching aims at designing integrated (pax/freight) transport networks and related coordination policies - transport planners in this model of urban planning must design urban transport systems that accommodate both passenger and goods flows.

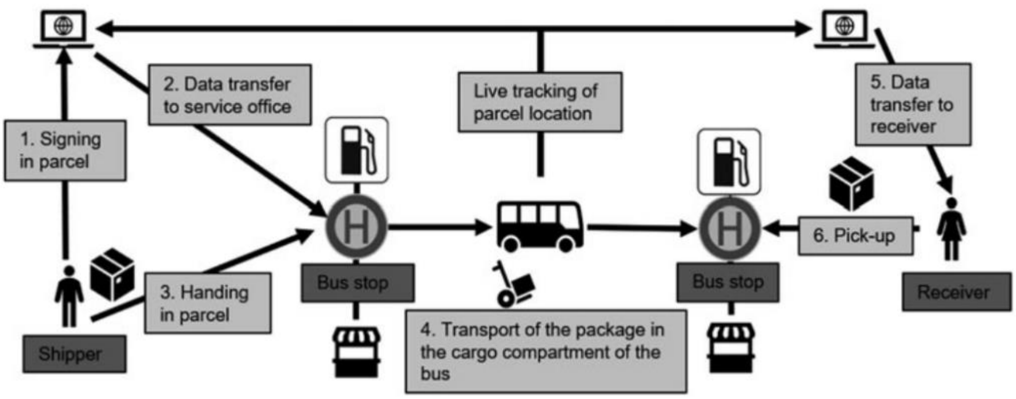


FIGURE 37 - AN EXAMPLE OF CARGO HITCHING

[19] https://www.starship.xyz/press_releases/robovan-by-starship-technologies-and-mercedes-benz-vans-future-proof-local-delivery/

3.1.3.6 Logistics Facilities

Logistics facilities can be divided into three types based on their location, size, and functionality (Lee et al., 2019). Regional distribution centres located close to access highways into and out of a city form the largest type of facility. Intermediary urban consolidation centres (UCCs) operate as receiving stations for goods for delivery into the neighbourhoods they are responsible for. They receive goods from the regional warehouse, break these shipments down into delivery zones, consolidate outbound deliveries by zone and move them down to the third tier of the network. The UCCs also receive inbound items from the third tier in the network and consolidate these flows for upward shipment to the regional distribution centre. The third tier in the urban freight network is composed of microhubs and mobile microhubs. These smaller facilities operate in a similar manner to the UCCs but cover a much smaller area. They are responsible for deconsolidating the goods received from the UCC, assigning goods for delivery to last mile delivery entities, receiving returned goods or goods destined for locations other than their territory, and reshipping these goods upstream to the UCC for further onward processing. More detailed discussion of these facilities appears in the sections that follow.

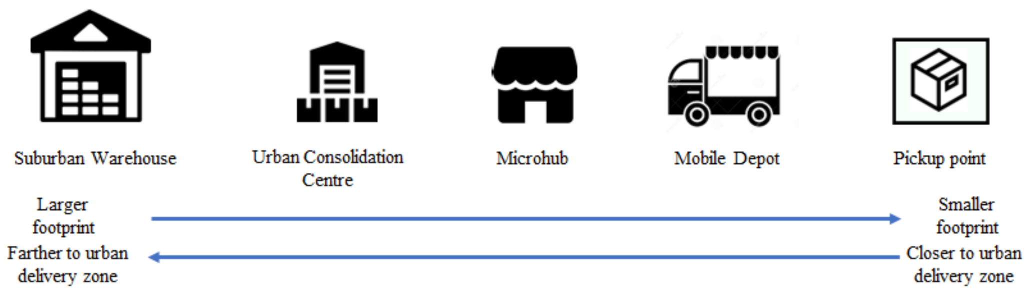


FIGURE 38 - TYPES OF URBAN LOGISTICS FACILITIES

Regional distribution centre

Regional distribution centre, also called an *urban warehouse*, *distribution centre* or *regular warehouse* is a large conveniently located warehouse responsible for the distribution of goods to a city. Large urban areas have multiple warehouses that perform this function. These warehouses receive goods from numerous external providers and locations, store the goods, and respond to orders from the customers they serve by picking, packing and shipping onwards the orders for further processing in the more local UCCs. These warehouses also receive outgoing goods from the UCCs and are responsible for sorting, consolidating, and shipping outbound these goods. Depending on the volume of goods handled, these warehouses can be quite large with headcounts approaching 5,000 or more individuals.

Urban Consolidation Centre (UCCs)

UCCs, also called urban distribution centres, city logistics centres, city terminals, freight consolidation platforms, urban transhipment centres, and the more generic freight platforms can be shared logistics facilities or single owner facilities. They enable the transhipment of goods directed to urban areas, aiming to consolidate deliveries and thus provide greater efficiency in the distribution process by increasing load factors and decreasing the number of trucks required to deliver goods into the city (Panero et al., 2011). Many studies propose shared UCCs as a promising solution for achieving sustainable urban growth and mitigating the negative effects of last mile deliveries (Björklund & Johansson, 2018). However, numerous challenges exist in operating shared UCCs.

LSPs, particularly larger players, feel that using a UCC operated by a third party compromises their ability to meet the cost and service levels they have promised their customers. In addition, LSPs are hesitant to allow their customer list to be "discovered" by competitors, which might happen if data on their delivery destinations becomes known. The dynamic nature of cost and service time commitments that these large LSPs face creates complications for their own internal operations. When using an UCC they often find that the LSP operating the UCC is not able to meet these customer driven promises and, therefore, the LSP is penalized for the performance of the UCC. Additional challenges to successfully implementing these facilities are the lack of operational, economic, and regulatory processes that facilitate the efficient and effective last mile delivery of goods (Simoni et al., 2018). Since UCCs fail to attract a sufficient number of LSPs, they lead to high operational costs, which causes a downward spiral in their attractiveness (Simoni et al. (2018) and Janjevic & Ndiaye, 2017). In general, it has been found that ongoing "incentives" are required to attract LSPs to use these facilities. These incentives are regulations, zero-emission zones, time windows for deliveries, and cost offsets.

Microhub

Microhubs, also called as *micro-consolidation centres* (Janjevic et al. ,2013) and *multicarrier consolidation centres* (Lee et al., 2019) are defined as a special case of UCCs with closer proximity to the delivery point and serving a smaller range of service areas. A microhub, operating as a small footprint UCC, is a logistics facility where goods are prepared for delivery, serves a limited spatial range, and facilitates a mode shift to low-emission vehicles (e.g., LEV) or soft transportation services (e.g., walking or cargo bikes).

Living Lab demonstration: Helsinki

The idea is to exploit the benefits of microhubs in the city center for efficiency gains in the last mile. Helsinki Living Lab aims for consolidating loads from several LSPs in standardized and modular load in sortation centers outside the city. Further, they are aiming to apply innovative last mile delivery vehicles, such as LEVs, ADVs, cargo bikes and crowdsourcing.

Mobile microhubs also called *moving warehouses*, *mobile warehouses*, *mobile depots,* and *Warehouses on Wheels* (WOW) (Verlinde et al. (2014) and Marujo et al., 2018), are trailers or containers fitted with a loading dock, warehousing facilities, and an office. Microhubs serve as a buffer that store goods received from regional distribution centres or UCCs and ship them directly to end-customer. According to Arvidsson and Pazirandeh (2017), this service might be more environmentally friendly and might improve the liveability of the city, however, as a business model, it has some drawbacks, such as cost competitiveness, coordination problems between LSPs and end-customers, and trust issues. More recent work by Oliveira et al. (2020) reviewing several actual mobile microhub implementations have found that the systems are effective and that commercial LSPs, particularly large LSPs, see them as both a socially responsible and economically viable approach to dealing with the last mile delivery problem.

Oliveira et al. (2020) classify mobile microhubs into single tier and two-tier systems. Single tier systems are systems in which the mobile microhub is set up at a fixed or static location throughout the day. The depot is loaded with items for delivery for the day at a central urban warehouse and then dropped at its static location. Last mile deliveries and collections are dispatched from this static location throughout the day and, at the end of the day, the mobile microhub is picked up and returned to the central urban warehouse. This approach to using mobile microhubs is beneficial as they do not require a fixed location for the depot and their siting can be changed from day-to-day based on demand.

The two-tier system identified by Oliveira et al. (2020) employs moving mobile microhubs that follow a path during the day dispatching parcels to last mile delivery vehicles as they move along their path. These types of delivery systems are similar to the sidekick systems described previously. The examples cited by Oliveira et al. were barges on the Seine River in Paris, public trams, "freight buses," light rail systems, and vans as the depot dispatching various last mile vehicles. The two-tier system defined by Oliveira et al. (2020) is shown in Figure 39.

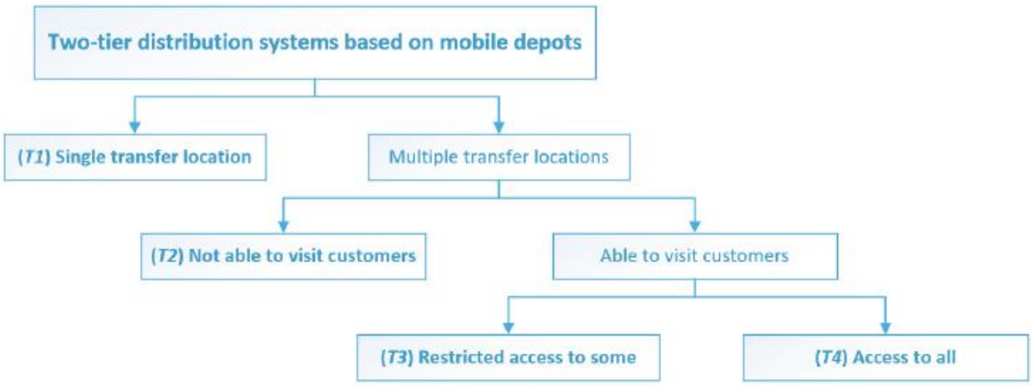


FIGURE 39 - TWO-TIER MOBILE MICROHUB SYSTEM, OLIVEIRA ET AL. (2020)

Click and collect in stores

An important option in omnichannel fulfilment is the "click-and-collect delivery option." Click-and-collect links the online web shop to the physical shop and is one of the dominant modes of delivery in last mile (Hübner et al., 2016). While the click-and-collect point could be located in the store in which the purchase is made, the parcel could be picked up at a different, but more convenient to the end-customer, store. There are several factors affecting the choice of click-and-collect option: accessibility and timeliness of the collection point (Milioti et al., 2020), perceived environmental contribution of the service (Milioti et. al., 2020), car use in the city (Milioti et al., 2020); and trip motivation (Miquel-Romero et al., 2018). A recent study compares the potential of click-and-collect, home delivery, and crowd logistics distribution channels (Melkonyan et al., 2020) and highlights the promising advantages of crowd logistics distribution channels in terms of costs and CO_2 emissions.

Parcel lockers

Another delivery model for pickup is parcel lockers (Buldeo Rai et al., 2019). This service enables end-customers to participate in the LMD operation by picking up their merchandise from a specific point. In the literature, parcel lockers are also referred to as delivery or pickup boxes, smart lockers, locker banks, and automated parcel lockers. Considering that the location of the parcel lockers is one of the most important aspects of their use (Deutsch & Golany, 2018), there is an increasing trend towards parcel lockers being located in dense urban areas, train stations, and other high traffic areas (Poulter, 2014). Smart and/or modular parcel lockers have been examined in the context of complex urban fulfilment flows and it has been determined that they that can diminish logistics flows through consolidation (Pan et al., 2021).

Parcel lockers can either be permanently situated at a location, or they can be movable and relocated based on demand. Stationary parcel lockers are situated at secure and unattended locations to which an LSP may deliver parcels for later independent pick-up by the customer (Schwerdfeger & Boysen, 2022). Delivery to parcel lockers as part of the last mile process provides LSPs with a convenient consolidated delivery point where customer presence is not required. As Pan et al. (2021) demonstrate, this type of delivery point can improve overall last mile delivery costs while lowering GHG emissions. Parcel lockers are currently deployed by parcel operators (e.g., DHL in Germany, Bpost in Belgium, Yamato Transport in Japan and UPS in the US) and online retailers (e.g., Amazon in the U.S. and Europe and Flipkart in India).

FIGURE 40 - STATIONARY PARCEL LOCKER OF DHL FROM GERMANY

Mobile parcel lockers, like mobile microhubs, allow the location of the parcel locker to be flexibly changed during the day. This capability improves accessibility for customers who also have changing delivery requirements and locations. Mobile parcel lockers can be moved with a driver (fix or swap) or autonomously by being mounted on or loaded into vehicles (Schwerdfeger & Boysen, 2022). Renault launched EZ-GO, an electric, connected and shared autonomous vehicle concept, where the self-service parcel lockers can be opened with a smartphone app. Carrefour introduced the “MobileDrive” service that uses autonomous delivery vehicles carrying a small parcel locker. Rinspeed introduced a modular vehicle “CitySnap” and a modular autonomous vehicle “MetroSnap” for mobile parcel stations (see figures that follow). Schwerdfeger and Boysen (2020) show that by using mobile as opposed to fixed parcel locker locations the number of parcel lockers, or parcel locker fleet size, can be greatly reduced while maintaining the same or better customer service.

FIGURE 41 - AUTONOMOUS DRIVING PLATFORM EZ-GO OF RENAULT[20]

FIGURE 42 - CARREFOUR'S MOBILEDRIVE SERVICE[21]

FIGURE 43 - RINSPEED'S MODULAR VEHICLE "CITYSNAP"[22]

[20] https://itchronicles.com/automation/the-last-mile-to-automation-how-autonomous-vehicles-could-solve-the-last-mile-delivery-problem/
[21] https://trans.info/en/carrefour-autonomous-shuttle-317362
[22] https://www.rinspeed.com/en/CitySnap_53_concept-car.html

FIGURE 44 - RINSPEED'S MODULAR AUTONOMOUS VEHICLE “METROSNAP”[23]

While parcel lockers act as a modern extension of the old post office boxes that have existed for decades, attended pickup and drop off locations extend the post office pickup and drop off function to separate commercial retail stores. Winkenbach and Janjevic (2018) note that company pickup and drop off points can be implemented as standalone convenience centres (e.g., Mailboxes Etc.) or as integrated points within high traffic retail centres (e.g., Amazon pickup/drop off centres on university campuses, Marks & Spencer’s pickup and drop off points, USPS pickup and drop off points in the U.S., Australia Post’s pickup and drop off points across Australia, etc.). Typically, retail partners for this type of deployment are selected based on criteria such as long opening hours and a dense network of conveniently located stores close to customer demand.

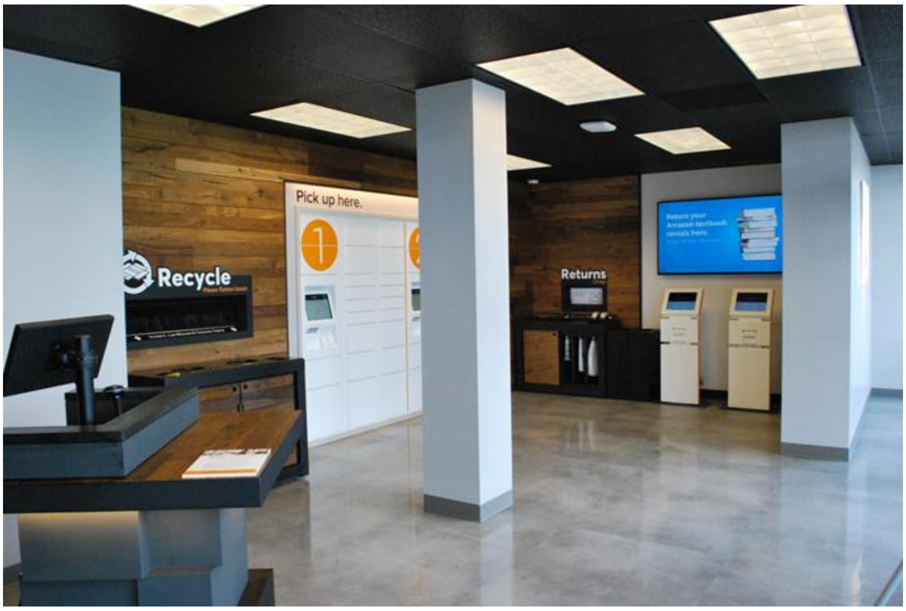


FIGURE 45 - AMAZON UNATTENDED PICKUP AND DROP-OFF CENTER – SEATTLE, WHASHINGTON

[23] https://www.rinspeed.eu/en/MetroSnap_51_concept-car.html

Unattended pick up and drop off units operate like normal parcel lockers, but have the added functionality of being able to receive end end-customer returns. These stations can be located in shopping centres, business parks, or near residential neighbourhoods (Lee et al., 2019). Such facilities allow couriers to consolidate trips and avoid missed deliveries. For omnichannel services retailers allow their stores to act as drop off points for returned items even if the item was not purchased at that store.

3.1.3.7 Last mile delivery operating models

In general, the term "operating model" refers to the people, processes, and management activities an organization performs to deliver its value proposition to customers. For a last mile delivery service, the operating model covers who will execute the logistics and transport service, what logistics and transport services will be performed, where the logistics and transport services will be performed, and how the logistics and transport services will be performed. Last mile operating models can focus only on the delivery/fulfilment of last mile delivery, or they can include the reverse flow of goods as well.

As the reader should have noted by now, there are many approaches to delivering last mile fulfilment services. These approaches vary based on network design, technologies employed, services offered, and regulatory requirements. Historically, last mile services were provided by the State (postal delivery) or large parcel companies (DHL, TNT, DPD, UPS, FedEx, etc.). Each of these LSPs managed their own networks, vehicles, facilities, and personnel with limited regulatory oversight. The commercial parcel companies sometimes contracted out last mile deliveries for markets in which the volumes were insufficient for them to invest in dedicated operations. However, the service was set up, the networks were independent and operated as if the other networks providing similar services did not exist.

Cities did not take exceptional notice of how last mile deliveries were being made during this time as there was little true negative impact to citizens because of the relatively low volume of parcel deliveries. Growth in the volume of parcel deliveries over the past 25 years has caused a shift in how cities think about these activities today. This growth initially benefited the commercial parcel companies as they profited from greater volumes, which drove greater efficiencies in their delivery operations. Unfortunately, as end-customers and retailers have begun asking for faster and faster delivery times, even the major LSPs have begun to change their minds concerning the last mile delivery operation.

Cities and parcel companies have attempted many different initiatives in the vain attempt to control the costs, social, environmental, and economic, that time driven last mile delivery has generated. Beginning in the early 1990s UCCs were thought to hold the key to solving the last mile problem. After all, the concept of economies of scale offered by integrating all logistics flows into and out of an urban environment on paper looks very interesting. Unfortunately, as already noted, the inability of such a single centre to accommodate all of the various contractual obligations of the LSPs, the suspicion of LSPs and retailers of their competitors, the additional costs associated with double handling of parcels, and the real lack of high-volume consolidation centre management expertise has made most attempt to operate such centres in a revenue positive manner fail. Some centres still operate, but through subsidies from the host city with few, if any, of the major delivery companies willingly participating (Logorio et al., 2016; Giampoldaki et al., 2021; Nordtomme et al.,2015).

While efforts are continuing to implement UCCs based on learning from past failures, much of the focus today on improving last mile delivery operations is being driven by the potential of new technologies and delivery approaches. Because many of these technologies are limited in their freight capacity (e.g., drones, droids, bicycles), travel distance (e.g., bicycles), and speed (e.g., droids, bicycles) the concept of using microhubs located close to delivery points is becoming an attractive component in network and operational models. The discussion that follows focuses on operational models employing microhubs as they are the focus of the URBANE project and its Living Lab demonstrations.

Microhub operating models

Microhubs are regarded as “enablers” of new city logistics solutions. In the course of their implementation, the role of the public sector is increasingly being discussed (Kaspi et al., 2022). The central question is whether an efficient supply of goods is the responsibility of a city government since it contributes to a high quality of life of its citizens.

Many operational models can be integrated into microhubs. Numerous European cities including Berlin, London, Paris, Brussels are piloting microhub operations. When choosing an operational model, it is important to consider whether microhubs are used for only one LSP and its end-customers or whether the microhubs support a mix of LSPs and the consolidation of their flows (Lee et al., 2019). Different operational processes can be considered for each microhub operation. For example, vehicle registration requirements within delivery zone (low-emission zone, congestion charge, restricting on peak large vehicle), delivery type (B2C, B2B), delivered cargo type (non-perishable, non-food parcels, mixed parcels including perishable food deliveries, etc.), delivery mode(s) employed (e-assisted cargo bikes, EVs, pedal only cargo bikes, customer pickup, etc.), time of resupply (off-peak, before morning peak), delivery zone density, multicarrier consolidation, and different government contributions (e.g., free logistics space in city centre, microhub operational fundings) to support the operations are all operational activities that should be considered. Some examples of microhub operational models are as follows: KoMoDo's operations in Berlin using independently operated microhub spaces, Gnewt Cargo's operations in Central London using a mixed multicarrier consolidation approach (HALLO, 2021); La Petite Reine's operations in Paris using a full multicarrier consolidation approach. The operational models for these examples are shown in the figures that follow.

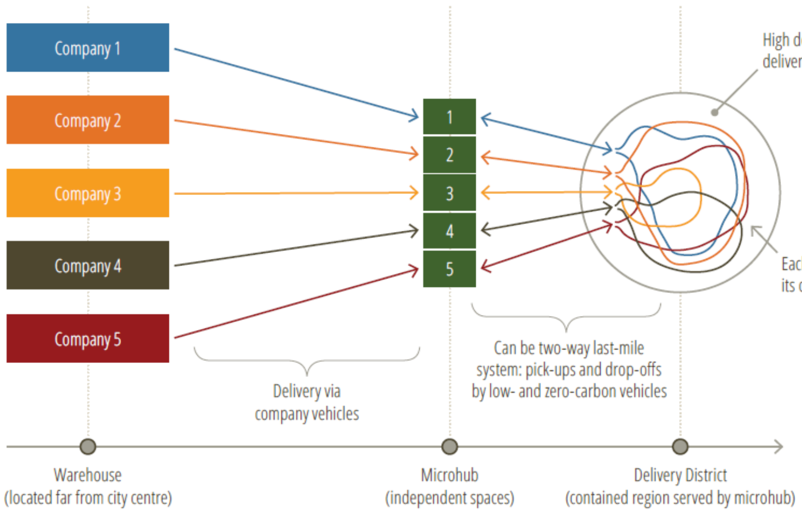


FIGURE 46- KOMODO'S MICROHUB OPERATION MODEL IN BERLIN

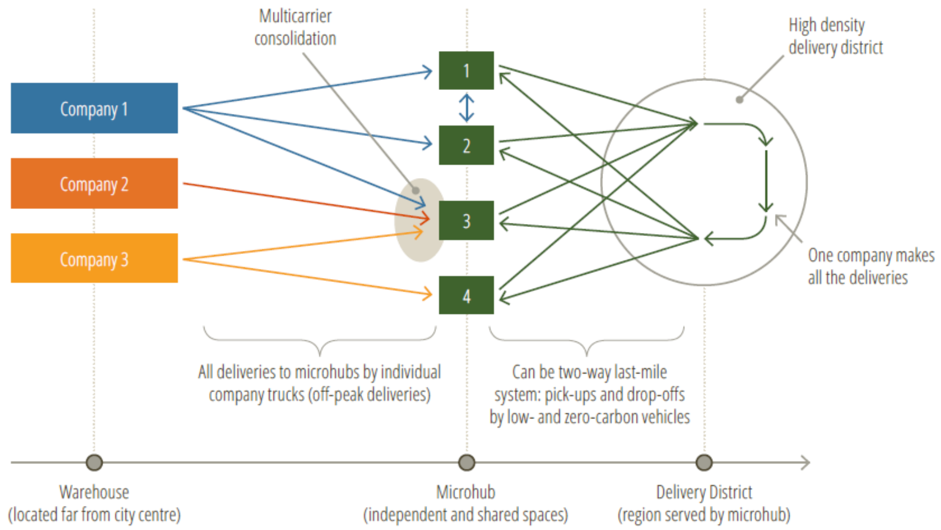


FIGURE 47 - GNEWT CARGO'S MICROHUB OPERATION MODEL IN LONDON

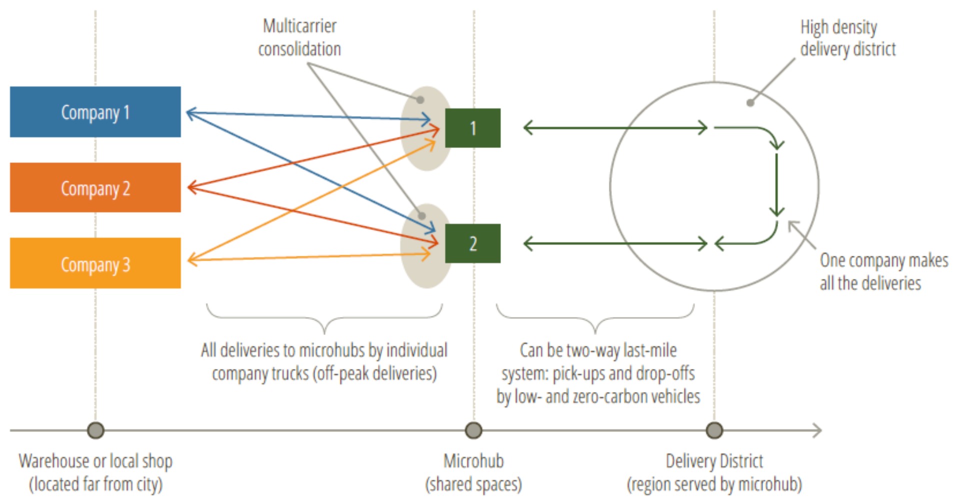


FIGURE 48 - LA PETITE REINE'S MICROHUB OPERATION MODEL IN PARIS

Operations management

Commercial LSPs, left to themselves, will attempt to operate their last mile and urban logistics service independent from other LSPs. From economic theory this may be acceptable if the volumes handled by the LSP are sufficiently large that they are operating their consolidation and delivery activities on what is called the efficient frontier for these types of services. Although the large LSPs argue that this is indeed the situation, it is extremely difficult to determine what the efficient frontier is for parcel delivery in a city and whether any individual LSP is operating close to this theoretical frontier.

In the absence of a clear definition of which optimal delivery services are set up, it is rational for cities to look at mechanisms that "encourage" commercial logistics companies to cooperate and combine logistics flows and thus reduce social and environmental impacts within their boundaries. Cities have a number of different ways to regulate the last mile operations within their boundaries. They can "rule by fiat," provide infrastructure as a service to encourage collaboration, or allow the market to try and sort things out while encouraging actors to "just be friends." The table below addresses each of these options for the three main last mile delivery concepts discussed so far in this paper: pickup and drop off exchanges, microhubs, and the actual last mile transport operation. A more detailed discussion of each approach follows.

TABLE 6 - OPERTIONS MANAGEMENT MODELS

Operating Model		**Administrative fiat**	**Provision of Infrastructure**	**Market regulated**
Owner		Public Sector	Public / Private Sectors	Private Sector
Operator	Package Exchange	City	City	Neutral Third Party
	Microhub	City	City	LSP
	Last Mile	City	LSP	LSP
White Label		Yes	Yes/No	No

- Operating Model 1: Administrative fiat

In this model, the city assumes the operation of the package exchange, microhubs and the last mile. It owns the microhub infrastructure. It is important to note that the activity of LSPs regarding parcel delivery within city limits is restricted due to environmental or transport regulation. Thus, LSPs are required to make their parcels available to the microhubs following the instructions of the package exchange. The last mile is characterized by a white-label approach, where the delivery vehicles (including cargo bikes and others) are provided, operated, and maintained by the city. In this model, the white label LMD operator would still have to satisfy a quality-of-service level equal to that previously offered by the LSP. This quality metric would be monitored closely both by the city authority as well as the LSP for which that white label operator is delivering the parcels.

- Operating Model 2: Provision of Infrastructure

This model describes a variant in which the city assumes the operation of the package exchange and the microhubs. It also owns the microhub infrastructure. Similarly, as in the first Operating Model, the activity of LSPs regarding parcel delivery within city limits is restricted due to environmental or transport regulation. However, the last mile is carried out by LSPs, who either closely cooperate within a white label framework or do not cooperate with each other, parcels are sorted on the basis of the respective LSP and fed into their respective routes. Here the delivery vehicles (incl. cargo bikes and others) are provided, operated and maintained by the respective LSP.

- Operating Model 3: Market regulated

This model describes a variant in which a neutral third party assumes the operation of the package exchange, while LSPs operate microhubs and last mile deliveries. Ownership of the microhub real estate is in private hands and rented to the LSPs or owned by the LSPs. There is no city environmental or transport regulation that requires the LSPs to collaborate. The operation of the microhubs and the delivery of parcels within their respective zones of influence are allocated to individual LSPs. Since this model is not a white label approach, there is only limited cooperation between the LSPs. The delivery vehicles (including cargo bikes and others) are provided, operated, and maintained by the respective LSP.

Operating Model 4: White label urban logistics. An LSP is selected based on a 'public' tender set up by the community of urban logistics actors, both public and private. A neutral trustee is monitoring the operations executed by the appointed LSP on behalf of the community of urban logistics actors.

Crowdshipping

As the PI vision is considered an opportunity to interconnect people's mobility and freight logistics (Crainic & Montreuil, 2016), multiple last mile delivery services have been introduced recently aiming to improve the mobility of physical entities (Montreuil et al., 2013). While these services aim to connect passengers with freight movements in last mile delivery, they also lead to changes in consumers' decision-making processes. Rougès and Montreuil (2014) highlight several possibilities for making use of crowdsourced LMD and its advantages in the context of hyperconnected last mile delivery. Studies are showing a promising link between PI and interconnected crowdshipping (Rougès & Montreuil, 2014; Raviv & Tenzer, 2018; Di Febbraro et. al., 2018). As an innovative business model, this service is defined as a platform that links customers to a crowd of travellers who are willing to pick up and deliver parcels to them (Rougès & Montreuil, 2014). Through the platform, the sender and occasional LMD LSP can be easily matched, which is the promise of this business model. The package can potentially be delivered at less cost and quicker to the end-customer. Most importantly, the number of freight trips can potentially be reduced, as the service uses travellers who are already making trips for their own purposes. In a PI context, optimisation models have been proposed to evaluate the efficiency impact of crowdshipping (Di Febbraro et al., 2018 and Raviv & Tenzer, 2018). According to Di Febbraro et al. (2018), crowdshipping can support the concept of PI by splitting freight into smaller standardised parcels and routing them through alternative paths. Similarly, Raviv and Tenzer (2018) propose a stochastic dynamic model to demonstrate the economic viability of crowdshipping under the assumption of an open PI infrastructure. A few research avenues are found in the literature on connecting parcel lockers and crowdshipping operations by using public transport infrastructure (Gatta et al., 2018 and Kızıl & Yıldız, 2023). However, in some cases, it can occur that new routes are generated, and existing trips are not reduced. The service can then lead to an increase in travel times and cause congestion (Tapia et al., 2023). Hence, it is important to link crowdsourcing services with the existing infrastructure to ensure that the benefits of the service are realized. Another important factor for crowdshipping services to be used are the capacity constraints of the crowd. To be effective a large number of willing informal shippers must be available to pick up and deliver the parcels tendered or the system becomes constrained in a manner similar to car sharing operation on busy holiday evenings. Tapia et al. (2023) note that crowdshipping is most likely to be a service executed for Local-to-Local deliveries and for small parcels since it is not possible to deliver large items with the crowd.

Omnichannel Systems

The advent of online shopping, social media marketing, and paid influencers has fundamentally changed the marketing strategies of major retailers. Historically, retailers worked hard to develop separate sales channels through which they marketed and sold their products. These channels were managed as if they were separate business and cross channel selling was discouraged. Because of the Internet and its ability to break down barriers, retailers have had to rethink their approach to marketing and sales. The new approach adopted by the retail world is called omnichannel sales and marketing (Taylor et al., 2019).

Omnichannel fulfilment is defined by Taylor et al. (2019) as:

> *Processes that enable a firm to meet customer demand through the flexible sharing of fulfilment link(s) across any combination of channels with respect to purchase origination and purchase receipt.*

This definition indicates that all upstream delivery and fulfilment points available to the retailer are potential sources of fulfilment for the end-customer's order. End-customers can pick up orders at the retail store, have them delivered to a parcel locker or pickup point convenient to them, or have them delivered directly to their home. All delivery options are available as are all fulfilment sources (i.e., regional distribution centre, any store in the chain, suppliers, or even a competitor's store).

3.1.4 Performance and readiness evaluation framework and KPIs

This section of the document will be kept short as Task 3.2 in Work Package 3 is focused on developing a detailed list of key performance indicators for cities. When a city wishes to understand how well it is performing concerning its logistics operations/activities it first needs to measure what those activities are. As a first level of performance indicators, a city should ask itself:

- How many parcel delivery vehicles enter each of my neighbourhoods on a daily basis?
- At what time do they enter?
- What are the sizes of these vehicles?
- What types of vehicles are they?
- How many other delivery vehicles are entering these neighbourhoods (maintenance, construction, landscaping, large items, service, etc.)?
- How many parcels are being delivered on a daily basis?

If a city does not collect this information, then it is not possible to understand in an exact manner what the impact on the community is from parcel deliveries. Collection of this information can be performed through basic traffic counting systems that register vehicle weights moving along roads into neighbourhoods, traffic cameras, and regulatory requirements for delivery vehicle, construction vehicle, etc. operators to report this information on a periodic basis to the city's transportation management department.

Once a community has captured a basic set of data concerning input and output volumes moving into its neighbourhoods, it can begin capturing more granular data that focuses on performance. These data require additional reporting from the LSP, which will take additional negotiations and some arm twisting. However, these data provide the city with an understanding of how efficient the current last mile delivery operations and where to focus as it attempts to increase efficiency and effectiveness while lowering impacts. These data are:

- Vehicle load factors (inbound and outbound)
- Transit time (dwell time in neighbourhood)
- Carbon footprint (based on engine type, load, and dwell time of kilometres travelled in city)

Based on these data a city can begin to determine the efficiency of the last mile operations and start work on determining what might be actions to take to improve this efficiency.

From a readiness perspective the city should consider how advanced it is internally to handle the digitalization needed to continuously monitor logistics operations within its borders, how advanced are the logistics companies servicing its community in digital technologies, how automated are these companies and how far is the city in exploring ITS technologies, and finally how good is the city's Internet infrastructure for supporting the increasing bandwidth and speed required for operating highly automated logistics and mobility services. The city might also consider its plans for regular and fast battery charging stations as these are essential to converting both diesel- and gas-powered mobility and logistics services to electrical power sources.

Thinking of novel operating paradigms, the city should also examine where it, as well as its LSP, real-estate developers, and retailers, are in their willingness to collaborate for the betterment of the community. Collaboration and digitalization are at the heart of new operating models for mobility in the future. They should be key elements in understanding whether the stakeholders are ready for the future.

3.2 State-of-the-Art demand driven network modelling

3.2.1 Modelling of transportation networks

The modelling of transportation networks has a long history. Most approaches to modelling transportation networks are based on graph theory with the famous solution to the "Seven Bridges of Königsberg" problem by Leonhard Euler in 1736 generally considered to be the beginning of a new field of science called topology (Newman, 1953 and Euler, 1741). More recent modelling efforts have focused on the use of linear, non-linear, integer, mixed integer, agent based, and heuristic models to find optimal or near optimal solutions to transport network problems. These modelling approaches generally break down into focus areas where the analyses attempt to determine the best route, route with time windows, route based on capacity or other constraints, distribution of vehicles and routes, shortest paths, best distribution/location of facilities, best coverage of regions, etc.

While the modelling of transportation networks has become quite mature with numerous software tools now available to help the analyst, recent changes in how transportation is performed, network configurations, and in the importance of certain performance criteria have made it imperative that new models be developed to ensure that the best possible urban freight networks are being employed (Kaspi et al. 2022).

Further pushing the state-of-the art in transportation modelling, the rising interest in the PI model as a potential solution to city logistics problems has opened another avenue for the development of new transportation models. The PI assumes that distribution networks are hyperconnected constructs rather than hierarchical networks as is usually assumed in standard network models. Hyperconnected networks are dense networks where hierarchies may exist between nodes, but connections are assumed to be omni-directional essentially eliminating hierarchies from the analysis. The omni-directional nature of PI networks allows flows to originate or terminate at any of the nodes in the network, which creates new demands on how the network is modelled. Additionally, since nodes can now be most sources and sinks for flows, the optimization and design of the network must now include a focus on the actual items flowing in the network, something that traditional network models were able to ignore (Orenstein & Raviv, 2022; Kim et al., 2021; Montreuil, 2016).

The sections that follow cover the major factors and approaches currently in use when developing network models. It is not the intention of this report to develop new models to address the changed circumstances affecting urban logistics networks today, and tomorrow. Such an effort, however, is part of the URBANE project and will be addressed through the work being performed in Work Package 3 of the project.

3.2.2 Current modelling approaches

Demand based facility location.

Facility location plays a crucial role in LMD. Choosing the right location for LMD facilities is important because it can have a significant impact on the efficiency and effectiveness of the entire delivery process. The location of the facility affects delivery times, transportation costs, and the quality of service provided to customers. Factors that need to be considered while choosing a location for LMD facilities include the proximity to the delivery area, access to transportation infrastructure, availability of parking and loading/unloading facilities, local regulations and restrictions, and the local labour market. Additionally, companies may also consider environmental factors, such as the carbon footprint of the delivery process and the availability of sustainable transportation options.

Demand-based facility location for LMD involves strategically placing facilities including regional distribution centre, UCCs (Savall-Manyó & Ribas, 2022), microhubs (Oliveira et al., 2020) or mini-depots (Nieto-Isaza et al., 2022), parcel lockers (Kahr, 2022), mobile parcel lockers (Schwerdfeger and Boysen, 2020) or other pickup points (Dragomir et al., 2022) based on the specific demand patterns of customers in a particular area. This approach helps to optimize the delivery process by reducing transportation costs, increasing delivery efficiency, and improving customer satisfaction. Traditional optimization and modelling methods such as mixed integer linear programming, heuristics, branch and bound, and Lagrangian relaxation (Baghalian et al., 2013) are used widely for calculating where to place facilities in LMD.

Several other techniques have also been employed to determine the best locations for LMD facilities based on demand patterns while reducing delivery times, optimizing routes, and increasing delivery capacity. One approach is to use data analytics and machine learning algorithms (Xu et al., 2021) to analyse customer behaviour and identify the areas with the highest demand for deliveries. This can include factors such as population density, demographics, shopping patterns, and delivery frequency. Another technique is to use geographic information systems (GIS) (Guerlain et al., 2016) and spatial analysis tools (Aljohani and Thompson, 2020) to map the delivery area and identify the most optimal locations for facilities based on factors such as proximity to customer locations, transportation networks, and traffic patterns.

Development of adaptive network design

An adaptive network design in LMD refers to a flexible and dynamic system that can adjust to changing customer demand, traffic patterns, and other related factors that impact the delivery process (Snoeck, 2020). This type of network design can help companies optimize their LMD operations by improving delivery times, reducing transportation costs, and enhancing customer satisfaction. To develop an adaptive network design in LMD, companies can use different methods and techniques to analyse customer behaviour and identify the areas with the highest demand for deliveries. This can help companies to adjust their network design in real-time, based on changes in demand patterns and other factors. For example, changing demand patterns can affect the locations of mobile parcel lockers in an area. The network of the mobile parcel lockers can be redesigned in real-time and the lockers repositioned to best serve the current demand situation (Schwerdfeger and Boysen, 2020, 2022)). Additionally, utilising technologies such as GPS tracking and mobile apps can provide real-time updates to monitor and optimize and adjust delivery routes as needed (Laranjeiro et al., 2019). This can help to reduce delivery times and transportation costs by optimizing the use of available delivery resources.

Another key component of an adaptive network design is the use of multiple delivery channels, including traditional delivery methods, such as trucks and vans, as well as alternative delivery methods, such as drones, droids, delivery robots and autonomous vehicles (Arishi et al., 2022 and Yuan & Herve, 2022). By diversifying delivery channels, companies can improve their flexibility and responsiveness to changing customer needs, traffic patterns, and other factors that impact the delivery process.

Vehicle Routing

The most common network planning model is the Vehicle Routing Problem (VRP) and its variants, which offers a mathematical solution to the routing of delivery routes for LMD vehicles. The VRP has wide applicability and has been extensively researched and documented in the literature (Dantzig & Ramser, 1959). The VRP is a well-known NP-hard problem because it includes the Traveling Salesman Problem (TSP) as a special case (Garey & Johnson, 1979). To solve the VRP for real-world delivery route instances that involve thousands of delivery locations on a daily basis, heuristics and approximate methods are used that identify near optimal solutions in a reasonably fast computational time. The mathematically optimized solution is frequently found to lack the implicit knowledge of the urban environment that seasoned delivery drivers have, which means that the route actually followed by the driver may not be the one planned by the system (Alvarez et al., 2017). Recent advances in improving the accuracy of the VRP utilizing historical data and Machine Learning attempt to address this issue (Merchán et al., 2022).

Assignment in e-commerce fulfilment – the ICONET model

In eCommerce orders, users typically order one or more items online and a delivery is arranged to their home or a nearby pickup point. Operators typically associate specific delivery postcodes to distribution facilities from where the order is to be fulfilled. This approach has given rise to the issue of stockouts, which is particularly intense in supermarket orders, where users create a shopping cart that contains multiple items. The issue of stockouts was investigated for a supermarket chain as one of the ICONET EU research project Living Labs in Porto, Portugal. As an alternative to the postcode-based system a dynamic algorithmic system was proposed for identifying the optimal store to fulfil each order (ICONET, 2021).

At the instant an order is placed, the system retrieves stock information for each available supermarket from a centralized database. Then an optimisation algorithm is deployed that identifies the optimal store for fulfilling all orders with respect to the stock level available at each store and the operational costs and constraints of delivering from that store. The aim of the tool is to associate orders with specific delivery locations but unknown fulfilment locations to fulfilment stores in an optimal manner. This problem, while being demonstrated for food delivery, is the same problem faced by retailers as they try to fulfil customer demand using an omnichannel approach (Arslan et al., 2021).

Assignment models such as the one developed in the ICONET project can be expanded to account for employee and asset availability, and deal with scheduling issues and constraints. To deal with these additional variables, a planning horizon is defined that may range from a single day to multiple months and the optimization model decision variables are adjusted to account for specific timestamps within the planning horizon. The solutions obtained include information on when a decision should be implemented, what staffing is requires, and what other resources are required so that the planned demand can be met. In cases where multiple optimal solutions are available, it is possible to further optimize the problem by adding an additional optimization layer.

FIGURE 49 - DISTRIBUTION NETWORK FOR NO ADDITIONAL PICKUP LOCATIONS (LEFT), 3 ADDITIONAL PICKUP LOCATIONS (MIDDLE), 5 ADDITIONAL PICKUP LOCATIONS (RIGHT)

In the context of the ICONET Living Lab in Porto, Portugal, an additional functionality was considered that aimed to assist decision makers in expanding the network. In the context of eCommerce for a supermarket, expanding the network can be achieved by setting up "Dark Stores," or by enabling of eCommerce order preparation from existing stores that currently do not fulfil eCommerce orders.

A facility location model was set up considering the stock level available at each store, the operational costs and constraints of delivering from that store, as well as the cost of enabling a store to fulfil orders (either setting up a Dark Store or enabling an existing store). The optimization model identified five stores, illustrated in Figure 49, as the optimal stores to enable eCommerce order preparation with ranking indicating the first identified (most significant addition) to second and third identified, (the next most important/ or second, third, etc.).

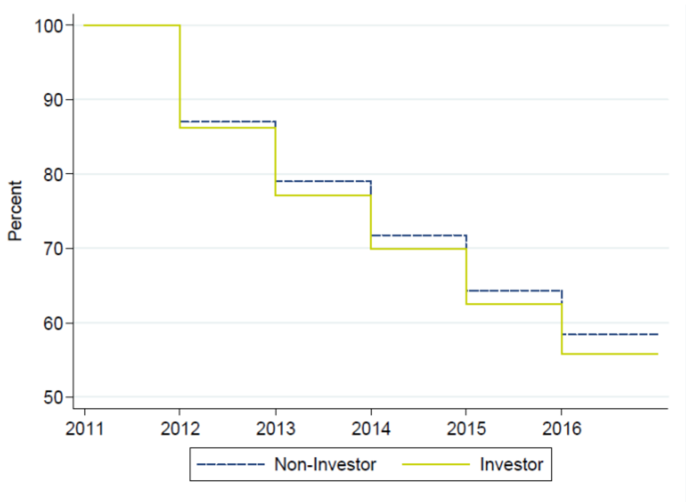
3.2.2.1 Human Resources Requirements

Operating logistics centres in a last mile delivery network requires a diverse and skilled workforce that can manage the complex operations of the centre efficiently. It is essential to ensure that the workforce is adequately trained, equipped with the necessary tools and resources, and motivated to provide the highest level of service to customers (Janjevic & Winkenbach, 2020). The human resources requirements for operating logistics centres may vary depending on the size of the centre and the volume of deliveries being handled. However, there are some key roles that are required for each facility such as centre manager, dispatchers, warehouse workers, IT personnel, and drivers. The key to success for any of the operations in a future urban logistics environment that these individuals address is their ability to handle the dynamic nature of last mile delivery operations, their focus on customer service, and their ability to operate in a highly digitalized environment.

Digital technologies are invading all aspects of the logistics chain. As has been noted earlier in this document, new AI enabled robotic delivery systems, AI and big data optimization and planning systems, the Internet of Things for enabling Intelligent Transport Systems (ITSs), automated storage and retrieval systems, etc., etc., etc. are all potential elements of a future based urban logistics system. The individuals who operate in these systems will no longer be hired because of their ability to handle the manual tasks of unloading, putting away, picking, and loading boxes. These tasks will be performed in an automated manner using robots or similar automated mechanisms. The individuals working in these highly automated systems will need to be capable of handling and controlling their automated partners and performing maintenance functions to ensure that the automation is able to provide the on demand services that customers will require (O'Kane et al., 2019; Walwei, 2016; Konle-Seidl & Danesi, 2022).

A recent study by the European Parliament's Committee on Employment and Social Affairs found (Konle-Seidl and Danesi, 2022):

An important lesson from recent empirical studies is that with the adoption of digital technologies at the establishment level, existing jobs will not be lost on a large scale. Study findings, however, agree in that the impact of workplace digitalisation is uneven among workers with different skills levels. Increased investment in digitalisation is generally associated with increased employment of high-skilled workers and reduced employment of low-skilled workers. Re- and upskilling might, however, not always be the silver bullet for individual workers with physical or mental limitations.



Notes: The figure displays the share of workers in investing and non-investing establishments who are still employed at their original employer on June 30 of each year, without any employment interruption. Unobserved periods of up to 30 days count as continuous employment.
Source: IAB-ZEW Labor Market 4.0 Establishment Survey, IEB; own calculations.

FIGURE 50 - CONTINUOUS EMPLOYMENT AFTER DIGITALIZATION (GENZ AND SCHANBEL, 2021)

While the European study starts out on a positive note, its implications for individuals who are not highly skilled, those that currently operate as warehousing or transport personnel, are likely to find that the digital future is not beneficial, at least without significant reskilling. A study by Genz and Schnabel (2021) of the impact of company investments in digital technologies shows that over time companies investing in digital technologies tend to reduce their long-term employees in a statistically meaningful manner.

The answer to this challenging "digital divide" issue is clearly education and retraining. Unfortunately, projections do not indicate that adequate reskilling services or new foundational education models are being developed at a pace that will ensure that appropriate skills will be available when the time comes to implement the highly automated urban logistics systems necessary to meet consumer, social, and environmental demands over the next ten years. A recent study by McKinsey (2020) found that most organizations they spoke with were either currently experiencing a skills gap due to digitalization or expected to see such a gap within the next five years.

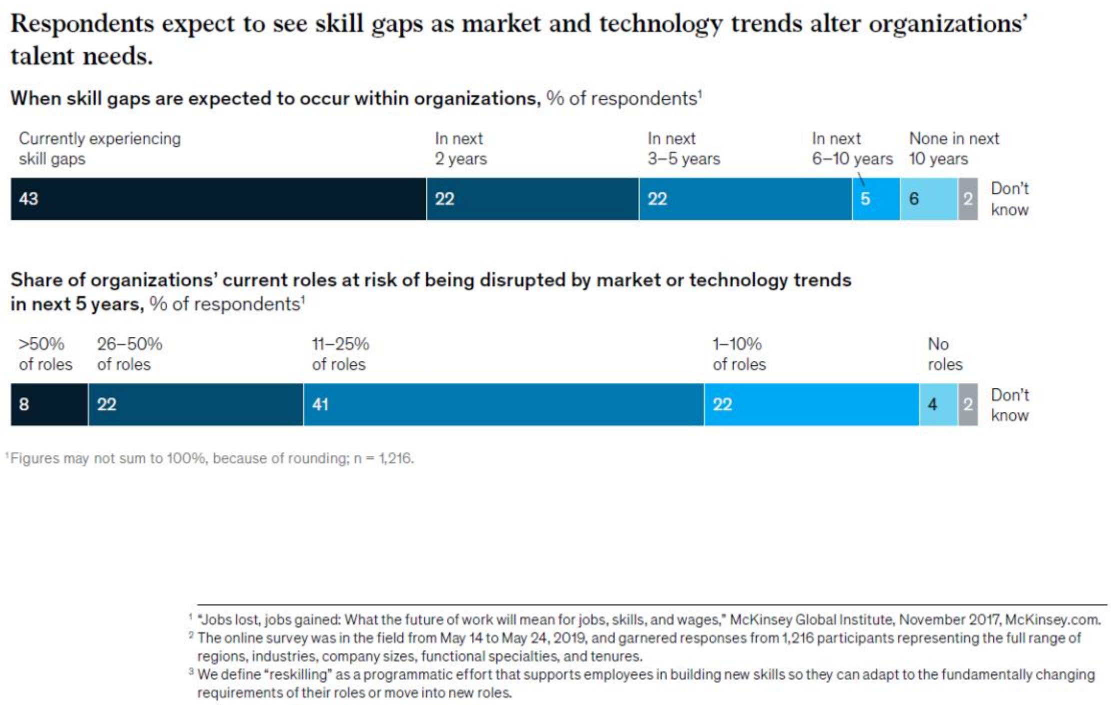


FIGURE 51 - MCKINSEY "BEYOND HIRING", 2020

How digitalization will actually play out in the urban logistics arena remains to be seen. However, one can expect that as digital technologies are introduced into urban operations both benefits to end-customers and workers, at least those that remain, will be substantial. Digital technologies promise to increase reliability, lower costs, and improve the efficiency of urban freight operations (Dong and Franklin, 2021). Once organizations and individuals become familiar with the automated intra-logistics technologies and the automated delivery technologies it is expected that overall safety of both workers and citizens will improve as digital automation is thought to be safer than human activities (Kern, 2021). Health and safety improvements occur because automation of heavy lifting, repetitive movement tasks, automation of delivery vehicles, and more integrated control of all automated systems means that there are fewer opportunities for workers to injure themselves and for delivery vehicles to cause injuries or safety related failures while operating in the external environment (Paulikova et al., 2021). [24]

3.3 Automation and Electrification of Vehicles – Smart readiness

The use of new technologies such as electric, zero-emission vehicles could be a relevant element in reducing the negative impacts of last-mile delivery (LMD) transportation of goods. Currently, one of the most promising technologies is BEVs, which produce zero tailpipe emissions, and depending on the way in which the electricity is produced, has significant potential in reducing overall CO_2 emissions. Besides, they provide lower operating noise compared to ICE-powered vehicles and regenerative braking technology for further efficiency.

3.3.1 Barriers and limitations to the adoption of EDVs/ADVs for LMD operations

While in the short term EVs can provide some benefits at local level, their widespread penetration is mostly dependent on overcoming the barriers and challenges to their adoption. Three perspectives can be identified for this task (1):

- Considerations coming from the academic community,
- Considerations coming from LSPs that have not adopted EVs in their operations yet,
- Considerations coming from specialized LSPs with actual experience in parcel deliveries using EVs.

In general, five groups of barriers and limitations to the adoption of EVs can be found:

1. **General barriers:** User acceptance of EVs is crucial to enable the massive introduction of EVs in LMD operations, be it the final recipient of the parcel or the LSP. There is still a certain lack of confidence in the technology amongst fleet managers, as well as ineffective training on issues such as range management and repair capabilities of EVs that could compromise their effective deployment for LMD purposes.
2. **Operational barriers:**The three main sub-topics here are limited range, fleet decisions, and drivers training. It is known that range can be influenced by a number of externalities such as driving behaviour, external temperature, use of auxiliary loads, topography and the weight being transported. In practice, this translates into actual ranges significantly lower than promised ones. In relation to range, a positive attitude change is being experienced: when companies conduct trials of the technology, they find that they do not need such a long range for daily operations, or they are able to adapt their routines to the available range without losing efficiency. It can be concluded that while the short-term introduction of EVs in most urban areas could be made without significant difficulties, operators in less urban areas need to define carefully which infrastructure they would require (e.g., battery swapping, charging stations).

[24] An interesting article by O'Brien et al. (2022) examines the increased mortality of workers replaced by automation in U.S. manufacturing jobs. Their results indicate that there is a statistically significant increase in the premature death of individuals who have been replaced by digital technologies. This is a sobering and unintended consequence of the race to automate away "menial" jobs.

3. **Infrastructure barriers:** One critical barrier to address is the availability of adequate and flexible EV charging infrastructure. Two main options arise in relation with charging infrastructure: public charging stations, and depot-based charging stations. The former might present some issues related to cargo security risks due to long charging times in open spaces, and also related to the inefficient use of the driver's time whilst charging the vehicle during deliveries. The latter, on its side, requires a certain investment in the charging stations themselves (potentially fast-charging stations), but in many cases upgrades to the existing grid are required to cope with the power requirements for charging a vehicle fleet.
4. **Battery technology-related barriers:** It is known that the battery health and lifespan can be strongly influenced by the type of charging utilized, frequent overcharging, or frequent discharging operations. An alternative to avoid placing excessive stress in the vehicle's batteries might be battery swapping, although this solution would require an increased battery inventory, therefore increasing costs.
5. **Cost barriers:** currently EVs for LMD operations are still niche products, with only a few manufacturers offering products at (generally) expensive prices. Even though purchase prices are expected to lower in the following years, in any case the higher purchase cost would be relatively easier for LSPs to overcome, considering that the higher annual mileage translates into lower operating and maintenance costs when compared against conventional vehicles. At a higher level, total cost of ownership of EV fleets is influenced by two cost drivers: technological and regional factors. Technological factors refer to the durability of EVs and their batteries. The regional factors include energy prices, taxes, incentives and regional market features.

3.3.2 Assessing the cities smart readiness for massive EDV/ADV implementation

According to a report released by the World Economic Forum (WEF)(2), if no interventions are put in place, the number of delivery vehicles in the top 100 cities globally will increase by 36% by 2030. This implies that emissions from delivery traffic will increase by 32% and traffic congestion will rise by over 21%, in part due to the increase of double-parking and line blockages. According to forecasts, by 2030 a 14%-35% of the freight vehicles will be xEVs.

A key aspect for the massive adoption of EDVs/ADVs is the push of the city regulators, for example in the form of EV/AV target shares and inner-city traffic regulation. Although it seems like logistics players will gradually transforms their fleet even if no heavy regulations are put in force, obviously the impact will be greater if regulators push for that.

It is quite clear the highest benefits for both private and public stakeholders require collaborative efforts from both sides. For example, massive EV penetration will become effective through both regulatory efforts and automotive OEMs working to bring down battery costs and enabling positive Total Costs of Ownership (TCO). Besides, connectivity solutions must be a priority to optimize delivery routes and monitor the effective enforcement of traffic regulations.

Another important point is to set a regulatory landscape as homogeneous as possible, therefore allowing the private sector to plan for the medium term and develop technologies and innovative solutions to optimize operations and make them more sustainable. Unfortunately, nowadays the regulatory landscape is greatly heterogeneous, and in some cases, there are no regulations at all (e.g drone usage regulations).

In this sense, the establishment of consistent and globally binding regulations for disruptive technologies such as autonomous delivery or zero emission fleets would be beneficial in terms of predictability, strategic investment planning and also road safety.

There are several actions that can be implemented by both cities and LSPs in order to increase the share of EDVs and ADVs for last-mile operations, such as the ones described below (3)(4):

- Purchasing small electric vehicles instead of ICE of bigger EVs: compared to delivery motorbikes, small electric cars have a lower TCO, and their larger capacity makes it possible to deliver more in a single trip. On the other hand, electrified cargo bikes, if properly used, can be as efficient as LDVs in areas with small distances between delivery points. Besides, small electric vehicles have other advantages when driving inside city centres. These vehicles are, in general, more resilient to congestion, and they also use less curb space than conventional delivery vehicles and allow navigating faster when in traffic.
- Use of available tools for supporting the transition to EDVs/ADVs: there are several tools available online that allow LSPs to calculate potential savings of EDVs according to specific vehicle types, fleet sized, driving profiles, charging infrastructure and charging strategies. Two examples of them are the TCO calculator of Californian utility Pacific Gas and Electric, and also the eCost calculator tool developed by Mercedes-Benz.
- Deploy charging infrastructure to promote electrification of LCVs: ensuring that deport charging is available for large fleets requires grid upgrades in the proximity of the depots. To avoid delays in depot charging deployment, cities should streamline regulatory requirements for grid upgrades, also explaining which stakeholders should take responsibility to cover the costs of grid reinforcements. Also, the allocation of public funding to support the deployment of a core network of publicly accessible chargers shared with passenger cars can be explored. The justification for this action at a city level lies in the higher investment risks faced for purely public charging deployment, in comparison with private chargers, due to the higher installation costs and contextual requirement of high frequency of use, which is not the most frequent scenario nowadays.
- Prioritizing low- and zero-emission vehicles in public procurement programs tailored for commercial vehicles, for instance postal service.
- Giving preferential access to EDVs for freight deliveries in portions of urban areas. There are frequently implemented through Urban Access Regulations, Low Emission Zones, Ultra-Low Emission Zones, or even Zero-Emission Zones.
- Introducing economic incentives, such as differentiated registration or circulation taxes based on the environmental performance of the vehicles.
- Green procurement policies for vehicle fleets: public procurement of large EDV fleets can enable the demonstration of the technology usefulness at large scale, as well as enable fleet managers to build experience and to optimize vehicle use. These kinds of initiatives are considered crucial for large scale market adoption. If scaled up and applied as minimum thresholds for publicly owned low- and zero-emission vehicles, these programs allow the industry realize economies of scale.

4. Last Mile Collaboration – Incentives and White Label Schemes

This chapter consolidates the work carried out under Task 1.2 of the URBANE project, which focuses on processes that encourage LSPs operating last mile delivery services to collaborate in their deliveries. Collaboration in these last mile activities has been shown to increase delivery efficiency, reduce congestion and social impacts, and reduce environmental damage. Two primary areas were focused on in determining potential mechanisms to encourage operators to collaborate. The first focus area looked at incentives that might encourage actors to collaborate. The second focus examined the potential of white label consolidation and delivery schemes as a potential collaborative means for last mile delivery. The sections that follow discuss the findings of this task concerning these two focus areas.

4.1.1 Incentive schemes

The purpose of the project is to help cities in Europe in increasing social welfare for their residents and reduce the environmental impact of urban logistics operations. This task will describe in a general way how the proposed framework, business models, policies, and Incentive schemes can provide some of the necessary impetus to improve logistics performance and succeed in achieving the targets set by cities for their citizens. In urban regions, freight transportation is crucial for replenishing stores and market inventories as well as for transporting parcels to citizens' homes. However, urban freight transportation generates negative effects, such as increased air and noise pollution, disturbance of traffic flow, and traffic congestion.

The URBANE project focuses on a particular aspect of today's cities: the commercial traffic that enters cities daily and occupies the public space. The aim of the project is to provide tools and examples that will help cities reduce several of the nuisance sources of this activity. By reducing the traffic, cities would realize a lower carbon footprint from the commercial vehicles that come into cities to deliver eCommerce parcels to residents as well as reduced traffic and noise.

It should be noted here that the task covered by this report includes the traffic generated by the delivery of orders placed by residents or commercial entities through phone, online purchases, or other contracting processes. This means that the project does not consider traffic due to public services such as waste collection, ambulance or other health services, police, firefighting services. The project also does not consider the traffic due to construction and other building services that must enter the city to deliver building materials or take out rubble or other building waste. Finally, the project does not focus on general mobility services such as buses, private cars, scooters, bicycles, etc.

In the prior section of this report discussed the various stakeholders involved in a city's last mile delivery operations. These stakeholders, particularly the commercial stakeholders, but also the city and its citizens, provide last mile services based on their expectations of receiving value for the services performed. To realize this value requires that the entities operate with a defined business model that both serves their interests and is structured so that it creates and delivers value to the consumers of the entity's services.

The section that follows discusses the structure of such business models for the providers of last mile delivery services.

4.1.1.1 Business Models

A business model describes the rationale for how an organization creates, delivers, and captures value (Osterwalder & Pigneur, 2010). Osterwalder's business model canvas (Figure 52) shows the primary components that need to be addressed in any business model. In this work, the focus will be on five of the key elements of the canvas. These five focus areas are highlighted in blue.

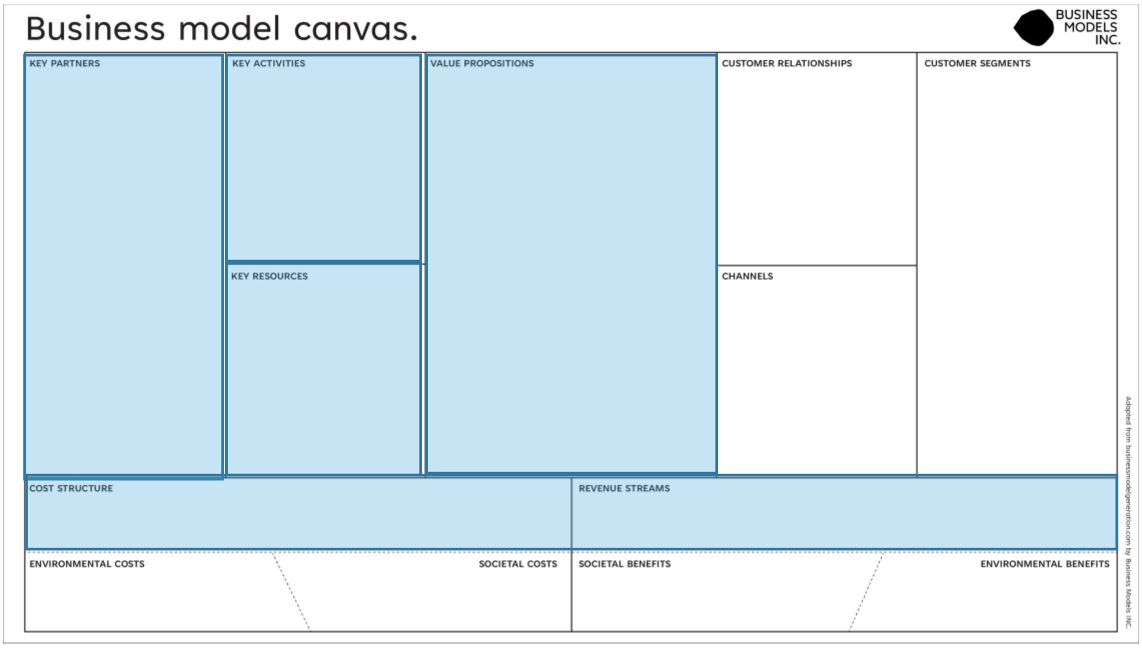


FIGURE 52 - BUSINESS MODEL CANVAS (SOURCE BUSINESS PROCESS INC.)

Value proposition

The value proposition refers to the products and/or services of a company that create value for a customer segment. It also includes the strategy of differentiation that a company pursues to distinguish itself from its competition (Abdelkafi et al., 2013).

The operating models discussed in the prior section of this report aim to improve the efficiency and effectiveness of parcel deliveries in the city, while keeping current performance in terms of service level and cost for the customer. The business models also incorporate reliability, timeliness, courtesy, and convenience as these are key value requirements imposed by customers of the last mile delivery service. It should be noted that compliance with legal requirements imposed by a city, region, state, or the European Union, while part of what a last mile delivery service must address in its operations, are not formally considered part of its value proposition. Customers of the service assume that all the LSPs comply with the laws for operating within the city. Whether this is a good assumption or not is not part of the analysis presented in the document.

Key resources

The most significant assets required to create the value proposition are called key resources. They can be physical, financial or intellectual in nature, but do not have to be directly owned by the organization (Delmond et al., 2016).

All operating models introduced previously require logistics and delivery competence as key resources. In addition to the optimization algorithms and data transfer technologies used by the LSPs, physical resources such as cargo bikes, transport carts, electric vehicles, and other equipment used in the last mile play a crucial role. The real estate related to the microhubs also represents a critical resource, since suitable properties are of limited availability in the inner-city area.

Key partners

Key partners participate in the conception, implementation, and operation of the business model (Osterwalder & Pigneur, 2010). Key partners in all operating models are the city, third-party logistics providers, neutral third-party operators, delivery means operators, and real estate developers. To ensure consistent terminology across the project, we subsume third-party logistics providers under LSPs and delivery means operators under LMD LSPs.

Key activities

Key activities are also required to successfully place value propositions on the market (Johnson et al., 2008). Key activities among key partners differ depending on which operating model is chosen.

TABLE 7 - KEY ACTIVITIES OF KEY PARTNERS

Key Partner	Administrative fiat	Provision of Infrastructure	Market regulated
City	Regulate parcel deliveries in the inner-city Operate the package exchange Buy / build and operate microhubs Buy and operate last mile equipment Debit LSP for parcel deliveries in the inner city	Regulate parcel deliveries in the inner-city Operate the package exchange Buy / build and operate microhubs Debit LSP for parcel deliveries in the inner city	Ensure Neutral Operator and LSP performances through service contracts
LSP	Transfer parcel data to package exchange Deliver parcels to microhubs	Transfer parcel data to package exchange Deliver parcels to microhubs Buy and operate last mile equipment	Transfer parcel data to package exchange Deliver parcels to microhubs Rent and operate microhubs Buy and operate last mile equipment
Neutral Operator	None	None	Operate the package exchange
Real Estate Developer	None	None	Buy / build microhubs
LMP LSP	Deliver parcels	Deliver parcels	Deliver parcels

Cost structure and Revenue sources

In the context of implementing a business model, investments and marginal operational costs as well as additional sources of revenue must be considered. These are relatively easy to determine after defining the key activities, key partners and key resources. However, different operating models have different cost structures and revenue sources (Osterwalder and Pigneur, 2010).

TABLE 8 - COST AND REVENUE STRUCTURES OF KEY PARTNERS

Key Partner		Administrative fiat	Provision of Infrastructure	Market regulated
City	**Cost structure**	Investments in microhubs and last mile equipment Costs of operation of microhubs and last mile delivery Costs of operation of package exchange	Investments in microhubs Costs of operation of microhubs Costs of operation of package exchange	Service invoice from the Neutral Operator
	Revenue sources	Service invoice to LSPs	Service invoice to LSPs	Service invoice to LSPs
LSP	**Cost structure**	Reduction of last mile delivery costs Service invoice from the city	Investments in last mile equipment Last mile delivery marginal cost Service invoice from the city	Costs of rental of microhubs Last mile delivery marginal cost Service invoice from the city
	Revenue sources	Shipper contract	Shipper contract	Shipper contract
Neutral Operator	**Cost structure**	None	None	Costs of operation of package exchange
	Revenue sources	None	None	Service invoice to the city
Real Estate Developer	**Cost structure**	Investment in microhubs	Investment in microhubs	Investment in microhubs
	Revenue sources	Rental fee from city	Rental fee from city	Rental fee from LSPs
LMD LSP	**Cost structure**	Delivery operations	Delivery operations	Delivery operations
	Revenue sources	Invoice to LSP	Invoice to LSP	Invoice to LSP

4.1.1.2 Incentive schemes

After having presented the possible business models we must examine what would be required for the actors to adopt one or the other model. It should be clear that commercial entities expect to gain from their adoption of a business model. The gain they expect is not social. To paraphrase Adam Smith, “it is not from the goodness of his heart that the LSP delivers parcels, but from his self-interest.” For each business model the key actors involved are identified and a discussion of how they might be encouraged to adopt the necessary steps for the business model to function is developed. The propositions are by construction theoretical and do not reflect the idiosyncratic situations of each city in which they can or should be implemented.

The adaptation of each business model to the special case of each city and Living Lab will be further developed in WP5, task 5.3.

Incentives for administrative fiat

In the case of the city taking the lead in the delivery of parcels in the city centre, the options for the LSP, the real-estate developers or the end-customers are limited. In effect, the last mile deliveries are organized in a monopolistic way by a city mandated operator (neutral operator) with exclusive rights and the corresponding responsibility of final delivery to the end-customer. In this model the LSP is required to deliver any parcels bound for delivery to the regulated sector of the city to the city’s designated operator. The LSP is “encouraged” to do this by the promise of deliveries according to stated performance measures, which the LSP can communicate to the shippers using its service so that it is not held accountable for missed deliveries. It should be noted that pressure would be placed on the city and its neutral operator to perform to its stated delivery objectives as failure to do so would potentially create legal responses from the shipper of goods, the LSP, and the receiver of the goods. In addition, failures to deliver against the performance promised could also result in political pressures to rethink the business model.

To ensure the success of this model, the city must make participation compulsory. If, as has happened in some cities, the LSP can withdraw from this operating model, they will do so and that will lead to the failure of the model and a return to the previous delivery approach of the LSPs. For this business model to operate properly, city authorities need to establish a very strong and clear regulatory and governance framework clearly defining the roles, expected performance metrics and regulatory regimes for all of the actors involved: the LSP, parcel exchange platform, physical delivery entities, and real estate developers of the microhubs.

The LSP delivers directly to the microhubs in this model and no longer has the commercial contact with the end-customer. Given the importance of controlling the final delivery of the parcels entrusted to them by the shipper, LSPs are expected to refuse to participate in such a business model. Only if participation is compulsory under the threat of exclusion from operations in the covered zone can the LSP be expected to participate.

The city or its designated operator should report their quality indicators to the LSP. These should include the respect of delivery time windows and of failed deliveries. The contract between the city and the LSP should include penalties and bonuses for meeting the expected quality targets so as to avoid legal problems should shipper or end-customer delivery promises not being met.

- Small last mile delivery providers

The neutral operator of the last mile delivery service inside the city centre limits is a de facto monopolist. As such, they should be required to report quality of service metrics such as percentage of parcels delivered within the time slot which the end-customer booked. To ensure that the neutral operator does not engage in opportunistic behaviour, proof of delivery (POD) data about the final delivery should be collected and made available to the LSP and shipper whose parcels are being delivered. When the data become unavailable or the quality metric is not met, the corresponding LSP who originally placed the parcels in the microhub should be entitled to compensation from the neutral operator. Should the neutral operator not meet their obligations, the city authorities would have to arbitrate the case between the neutral operator and the wronged LSP.

A specialised LSP (cargobike, EV, etc.) may be contracted to perform the last mile delivery from the microhubs to the end-customer or to parcel lockers. These LSPs would contract either with the city or the neutral facility operator. Contracts would specify performance metrics as well as compensation and bonus/malus terms. This quality of service would be measured by KPIs such as percentage of deliveries performed within the time window set by the end-customer, greenhouse gases emitted during deliveries, and other metrics depending on the city's requirements.

- Microhub and parcel locker operators

The city may be the owner and operator of the real estate where parcel lockers and microhubs are located. In this case, the city may decide to forgo hiring a neutral operator to manage the last mile distribution service. However, in most cases the city will hire a third party to operate the service. As with any outsourcing contract, the city will need to negotiate appropriate terms and conditions, set performance expectations, define complaint handling processes, and establish appropriate bonus/malus and compensation components for the contract. Should a third party be hired to perform the last mile service, the city will most likely need to assist the LSP in finding a suitable site to establish their microhubs and parcel lockers if these are part of the required service.

Incentives for provision of infrastructure

The business model where the city will provide some infrastructure has very different effects on the interested stakeholders. In this model, the LSP has to invest in ecologically friendly transport equipment to deliver the parcels retrieved from the microhubs or contract with an LSP with these types of vehicles. In this case the LSP maintains their commercial contact with the end-customers. Investments in the microhubs and the package exchange platform is borne by the city or an equivalent city sponsored entity. The cost of using such infrastructure is paid for by the LSP. The necessary incentive to ensure adoption of this model by all LSPs is the assurance that there will be no cost penalty for employing this approach. If this is not the case, as is likely, then the city will need to develop regulations requiring all LSPs to use the specified system.

This business model is only successful when all stakeholders work closely together and the system is efficiently run and monitored. The main benefit for the city administration from introducing this service is the minimization of the negative environmental and economic externalities of last mile deliveries and avoiding the responsibility of directly managing a network for last mile deliveries. The crucial role of the public administration is to design and introduce the appropriate policies for strengthening cooperation among the service's users using cooperative and connected mobility systems. Some appropriate policies for supporting the use of such a service would be:

- Offering financial incentives to the LSPs for using this service (i.e., free parking for a specific time-period, monthly parking coupons etc.).
- Adapted regulations for shared smart parking bays, for both passenger and freight transportation during dedicated hours and/or days (like at weekends).
- Urban space re-allocation and provision of priority lanes to urban freight transportation.

- Parcel exchange platform

To ensure that the parcel exchange platform is efficiently managed and provides the expected value-added services to the city and the LSPs, it is likely that it will need to be set up as a for-profit commercial venture. The exchange receives revenues from a subscription/membership fee and a fee per parcel from the LSPs. The city should not have to be involved in subsidizing the exchange platform as it is already placed in a monopolistic situation and should be responsible for the performance of the services it has been set up to deliver.

The platform delivers services to the LSPs in the form of optimized routing and consolidation of parcels that are handled by it for its LSP members. The platform acts as a neutral exchange of both information on where parcels are to be delivered and parcels to be picked up. This neutrality is essential as LSPs would not want to deliver this information to a competing LSP. The platform's objective is to consolidate the delivery requirements from its members and propose optimized routes to the LSPs managing the last mile services. The exchange must run smoothly and be connected to the LSP information systems, which requires upfront investment in connectivity as well as ongoing maintenance and upgrades as these systems evolve.

The initial investment cost may need to be supported by the city and once set up revenues should come from the LSPs as they will have to provide the data about parcels and subsequently execute the vehicle assigned optimal routes as provided by the exchange. Similar collaboration between airlines for passenger traffic already exists (Amadeus) where flight information is exchanged and passengers can then combine the various legs of their journeys using the available flight information in a standard fashion.

For such a system to work, information system performance and operational trust is required. Incentives to ensure quality of service must be agreed upon by the parcel exchange platform and its LSP partners under the supervision of the city. Performance failures should be addressed through contractual bonus/malus provisions and remediation requirements. A dispute resolution process involving the city as arbitrator will also likely need to be included in any contracts between the platform and LSPs providing LMD services.

- City authorities

In this business model, the role of city authorities remains important. As in the operation of a port, the city operates as the landowner and can build the required microhubs and parcel lockers themselves or contract out this construction to third part real estate companies (e.g., CBRE or Prologis). Facilities constructed by the city or rented from a city contracted real estate entity will be operated and maintained by the city or a neutral party. Revenue for the operation of the microhubs and parcel lockers comes from the LSP who pays a fee to the operator based on the volume of parcels handled.

As the city's regulations require the LSPs to use the city provided infrastructure, contracting between the city and LSPs should define the parameters of service, bonus/malus and payment requirements, dispute resolution processes, and any other requirement that similar commercial relationships involve.

Incentives for market regulated private operations

In this last business model, the city establishes a regulatory framework in which the private operators will exercise their activity and allows the commercial parties to operate independently as long as they perform within the boundaries of the regulations.

- City authorities

The cities have an important role in setting the stage for private operator activities. The current situation in Europe, and generally around the world, is for each city to impose unique restrictions on LSPs based on the particular needs of the city, its businesses, and its citizens. While these restrictions make the job of LSPs more difficult as they cannot create a "one size fits all" service model that is transferrable between cities, it serves the basic function of the city, which is to provide a social and economic environment that is compatible with the unique needs and character of its citizens. Examples of the differences in how cities are attempting to manage last mile delivery issues can be seen in:

- Barcelona's recent imposition of a tax on LSPs based on the volume of parcels delivered[25].
- The imposition of time windows for entry into certain Dutch city centres.
- The requirement that only zero emission vehicles be used for city centre deliveries[26].

The incentive for cities to employ a market-based approach to last mile delivery, subject to regulatory constraints that fit the city's unique circumstances, is the expectation that competition will lower costs, drive innovation, and improve delivery services for its citizens and businesses. The key for cities to realize these incentives is to closely monitor the impacts of the free market operations on their communities and, where appropriate, utilize regulations, as in Barcelona, London, and many other cities, to address any negative impacts of last mile delivery.

- LSP inbound from sortation centres and outbound from microhubs

UCCs that sit outside densely populated inner-city neighbourhoods have traditionally operated as city hubs for the dispatch of last mile deliveries. These centres receive and store goods for city delivery, consolidate shipments, load vehicles, and dispatch the vehicles on either standard routes or dynamically planned routes based on delivery requirements. Such facilities, operated by large LSPs and retailers, generally have not employed a second tier of smaller microhubs for city deliveries believing that the extra handling added cost without improving service.

[25] See "Barcelona to become first city in Spain to levy 'Amazon tax'": https://www.theolivepress.es/spain-news/2022/12/02/barcelona-to-become-first-city-in-spain-to-levy-amazon-tax-in-bid-to-empty-streets-of-delivery-vans/amp/

[26] "These Dutch cities will allow only zero-emission deliveries by 2025": https://climatechampions.unfccc.int/these-dutch-cities-will-allow-only-zero-emission-deliveries-by-2025/

FIGURE 53 - POST NL ELECTRIC DELIVERY VANS

Postal companies, on the other hand, have always employed a two-tiered approach with regional consolidation centres dispatching loads to local neighbourhood post offices for final sorting, consolidation and delivery. The microhub model of city logistics, in which a second-tier operation is placed between the UCC and the final mile delivery is modelled after this postal service approach.

Depending on the regulatory requirements for a city, the LSPs and retailers providing last mile delivery services may develop their own microhub networks or contract for this service. The incentive for these organizations to utilize such a network design must be that by not doing so they are precluded from operating in certain zones of the city, or the entire city proper. As noted previously, absent such regulations, it is not in the interest of these large players to increase the costs of their delivery operations while their competitors stick with the lower cost single tier delivery system.[27]

If large LSPs and retailers are required to employ a microhub service network for last mile deliveries, they have two options available, they can build their own microhub network or they can outsource this operation to a third party. Given the competitive state of the LSP market in parcel services, it is highly unlikely that the major LSPs will outsource microhub operations to a third party. One only has to look at UPS' UPS Stores, FedEx's operation of FedEx Office centres, and DHL's still tight integration with the German post system. While these companies do use third parties for PUDO operations (e.g., Postal Annex and Mail Boxes Etc.), they do not use these facilities as microconsolidation and last mile delivery depots.

[27] It should be noted here that if the customers of these large LSPs were to organize together and demand that they use more environmentally and socially sound processes, then the companies would be forced "by the market" to implement different last mile approaches. In the absence of this organized push back by customers, regulation is the only approach to address the "tragedy of the commons" problem exemplified by their current approach.

These types of facilities are used mainly for the convenience of their customers. Consolidation and delivery services are still conducted through the urban consolidation facilities that they have set up.

FIGURE 54 - UPS, FEDEX, DHL LOCAL PUDO FACILITIES

- Last mile delivery companies

The second type of LSPs is the owner and operator of the fleet of inner city delivery vehicles (e.g., cargobikes, electric delivery vans). These inner city delivery specialists usually have fleets that carry smaller loads and have less range than the dedicated fleets of the large LSPs and retailers. These third party delivery specialists can perform PUDO operations along optimized tours provided by the LSPs, large retailers, or, if a city mandates through regulation the use of shared microhubs, a parcel exchange platform.

Their incentive is the payments they receive for delivering parcels per their contractual arrangements with the microhub operators. This means that they must follow the dispatch processes and procedures provided by the microhub operator or exchange platform and execute their delivery routes per the plans dispatched to them. When the parcel has been delivered (or picked up) the POD must be transferred to the dispatching entity so that the delivery (collection) fee can be attributed to the right delivery service. Missed deliveries, rescheduled deliveries must be updated in real time and the relevant parties informed (including the end-customer). For this to happen smoothly, the delivery dispatching platform plays an important role.

- Parcel exchange platform

The implementation of efficient and effective cooperation is quite challenging as the last mile delivery process is complex relying on numerous processes and the interaction of multiple actors with conflicting needs and interests. Should city regulations require the merging of LSP and retail flows in the microhubs, then a parcel exchange platform may be employed to provide the consolidation and route planning necessary for last mile deliveries. The incentive for the exchange platform to operate efficiently and effectively is the revenue it generates by properly consolidating and routing parcels for delivery. It may charge users of the service based on volume, as well as require them to pay an annual “membership” fee. These payments will be moderated by contractual performance and subject to bonus/malus adjustments based on that performance.

- Real estate developers for microhub and parcel locker operators

Real estate developers and microhub and parcel locker operations generate revenue from the rental of space for the microhubs and parcel lockers and the operation of the microhubs and parcel lockers. As demonstrated in (Katsela et al2022 by studying 17 case studies, a necessary framework for the efficient use and investment in microhubs depends upon two sets of factors: (a) relevance in terms of market demand and location with regard to the end-customers; (b) the right conditions in terms of road access, space for loading and unloading, security, Internet access. To incentivize these developers/operators, city authorities must work with them and the LSPs to identify the most efficient locations for the microhubs and parcel lockers so that they function efficiently both for the residents and the LSP. City authorities will also need to consult with the residents about the proposed locations to ensure the maximum acceptance.

4.1.1.3 Cooperative, Connected, and Automated Mobility (CCAM)

The rapid development of technology and innovation make it possible for cities to equip themselves with smart tools, infrastructure, and services to improve their citizens' quality of life and support their achievement of environmental targets. These technologies can boost Mobility as a Service (MaaS) and Logistics as a Service (LaaS), operational models that not only have large social impact (user satisfaction, user perception, user safety etc.) but also lead to a more sustainable and viable urban mobility ecosystem.

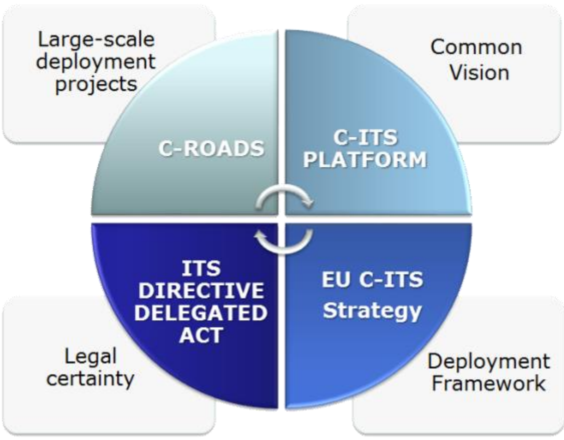


FIGURE 55 - THE CCAM SCHEME

The CCAM concept has different benefits for the various pillars of the urban mobility ecosystem. The current literature shows that the CCAM technology can have a beneficial impact on four main performance indicators:

1. Increase road safety (Fagnant & Kockelman, 2014; Kockelman et al., 2016 and Litman, 2020),
2. Achieve optimal operation of the smart urban mobility system together with the MaaS and LaaS concept (Bösch et al., 2018),
3. Improve the sustainability of the whole system (Anderson et al., 2014; Brown et al., 2014; Fagnant & Kockelman, 2014, Kockelman et al., 2016 and Wadud et al., 2016),
4. Reduce both the total vehicle fleet and the empty trips (Bösch et al., 2018; Burns, 2013; Chen et al., 2016; Fagnant & Kockelman 2014; Martinez & Crist, 2015; Zachariah et al., 2014; Zhang et al., 2015).

In the Marotta et al. (2018) study, based on the results of a cost benefit analysis (CBA), the economic benefits of using C-ITS were estimated both in social, environment and other categories while the study of Edwards et al. (2018) showed the positive impact on time using simulation results. A very important factor to achieve Cooperative, Connected and Automated Mobility is the vehicle-to-vehicle communication of the system vehicles. This is a technology that is at an early stage of development. However, especially in the logistics and urban freight transportation sector, implementation of efficient and effective cooperation is quite challenging as the sector is characterized by a complexity that relies on a large number of processes together with the interaction of multiple actors, each with conflicting needs and interests.

4.1.2 Stepwise process towards a white-label collaboration scheme

In this section a stepwise process towards a white-label collaboration scheme for city logistics ecosystems is described in the form of a manual. This manual can be considered as a guide through the process to set up a collaborative community for urban logistics and it explains the ideas and vision that URBANE offers. Various steps are elaborated to set up such a program. In particular, the role of the impartial orchestrator or trustee in this process is explained, supporting or coaching the parties involved. The orchestrator acts as an architect of the collaboration and the manager of the urban logistics community or ecosystem (see previous section concerning neutral LSPs) and is non-asset based.

The process is classified in 7 steps. These steps are consecutively:

1. Step 1: Matchmaking
2. Step 2: Common needs assessment & Scoping
3. Step 3: Alignment on expectations
4. Step 4: Requirements & Conditions & Critical Success Factors
5. Step 5: Joint Business Case - Collaborative Urban Logistics
6. Step 6: Preparation
7. Step 7: Implementation

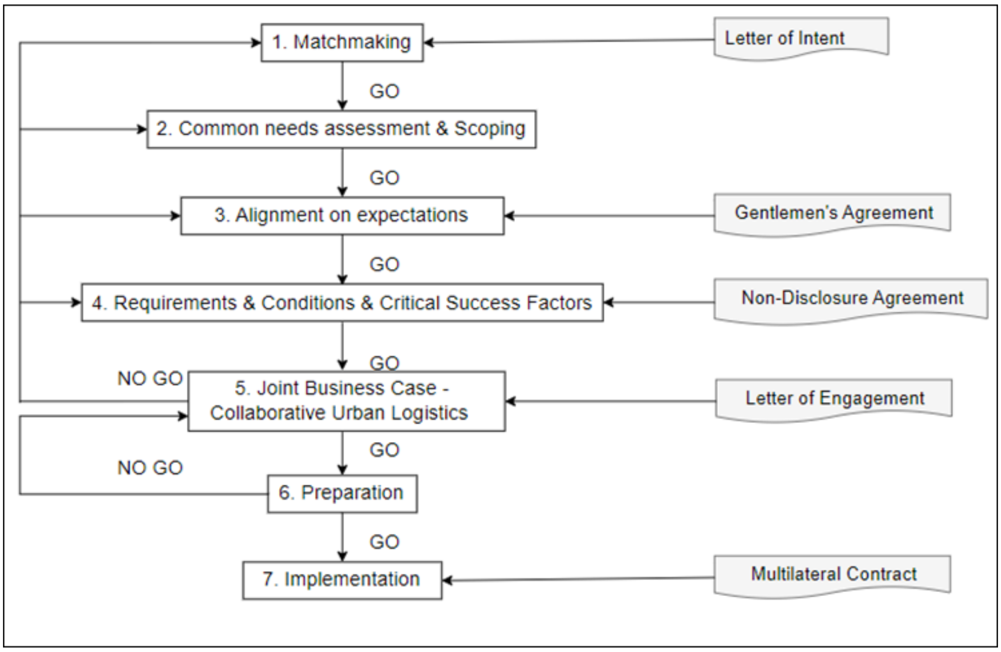


FIGURE 56 - STEPWISE PROCESS FOR SETTING UP A "WHITE LABEL" SERVICE

The process is conceived sequentially. After every step, one should have a "GO" – "NO-GO" decision moment. In case of a "GO" the next step can be started. In case of a "NO-GO" one might redo a former step. In some cases, a successful outcome is the result of various iterations or different attempts.

Step 1: Matchmaking

The first step might be the most challenging one. One should bring together stakeholders prepared to participate and to elaborate a common vision of urban logistics. If several parties have a common interest in a particular (type of) solution or have a common problem or need (i.e. the mobility problem or decreasing liveability), then a joint opportunity is identified. In this phase it is important to bring as many different stakeholders around the table as possible. If this is not yet the case, then that party or company needs to be asked to confirm its interest in such a collaboration. This confirmation of that party's intentions can be made formal in a letter of intent. If several parties are interested in a joint process for collaborative urban logistics the process can be proceeded. It might be an option for stakeholders to stay in this phase and to delay the next steps. This first phase can already be useful or fruitful especially in **experience sharing**. The various stakeholders are on speaking terms and learn from each other on different occasions or events.

In this phase one can set up **a platform** on which the various stakeholders can communicate and share all kinds of experiences with each other in a virtual way. Events on which the people can meet each other in person are considered mostly as generating extra value and are perceived as comfortable and pleasant. Ideally in this phase also public actors, together with other stakeholders, like shop owners, citizens, etc., are involved and become part of the collaborative urban logistics community.

An impartial actor without any assets and particular interests should be appointed to manage the further process and to guide the various actors through the different steps. This neutral party should neither be the representative of the public side (city council), nor a representative of the private side, market players, companies with logistics operations. This neutral party, also called the **orchestrator**, acts as an architect of the future proof collaborative urban logistics transport system. The latter is non-asset based.

✏ A letter of Intent (LoI) can make the mutual intentions of the various stakeholders formal. This LoI might also be called a covenant

Step 2: Common Needs Assessment & Scoping

With the involved and interested parties a collaborative urban logistics community is formed. Within this community one should elaborate a thorough needs assessment. Guided by the architect (trustee or orchestrator), parties start by assessing their own individual needs. Based on these individual needs the scope of the collaboration on urban logistics is made explicit.

Once there is **a clear scope**, one can look for common needs. This is always a crucial exercise. If this assessment does not result in unambiguous common needs among the parties, the basis for a solid cooperation is missing. It might be that the scoping is not evident. In that case a growth path can be defined: starting small (narrow scope), locally and focused on a particular logistics niche and extending step wise towards a larger zone, more actors and a broader logistics perspective.

Step 3: Alignment on Expectations and Objectives

Based on the common needs and a clear scope, alignment needs to be found on the expectations and objectives of the parties. Expectation management appears to be important in any collaboration set up. For a collaborative urban logistics initiative this alignment is also key. Every party involved needs to be a winner in a certain way. Based on common or at least aligned expectations one can define the requirements and develop the joint "business case".

! A Gentlemen's Agreement (GeA) is the formal outcome of this alignment exercise.

Step 4: Requirements & Conditions & Critical Success Factors

In step 4 the development of a joint logistics solution or service is started. The requirements are elaborated (What do we need?), the conditions are stipulated (Under which conditions or how do we expect the services?) and the critical success factors are defined (What is crucial or decisive for the success of the joint urban logistics service?).

It is the role of the orchestrator to guide the various stakeholders through this process. The different stakeholders can have totally different operational requirements, conditions or critical success factors. It is the task of the orchestrator to find a balance between all these inputs. In this phase the parties start to share (crucial, confidential) data with each other.

! Before gathering data for the joint business case, a Non-Disclosure Agreement (NDA) between each party and the neutral trustee must be signed.

Step 5: Joint Business Case – Collaborative Urban Logistics

Step 5 of the collaborative urban logistics process is the most creative one. A joint "business case" needs to be developed. Every business case needs to be positive on several objectives (cost-efficiency, effectiveness and/or sustainability). Being positive is always relative. One compares with a reference, which is most often the current situation or solution, the so-called AS IS. The new solution, through the collaboration, the so-called TO BE, needs to be better.

For this step detailed data is needed to feed the business case model. Because the actors involved have already gone through a whole process (the steps mentioned above) and the scope and expectations are clear and in balance, data gathering and sharing is much more evident and easier to organize. Nevertheless, the neutral architect plays a crucial role in this data gathering process. Some stakeholders might be competitors and could or should not share confidential or commercially sensitive data.

In this step there might be a **public infrastructure or spatial planning** dimension, e.g., for the allocation of Urban Consolidation Centre(s) (UCC) at the edge of city centres, microhubs in the inner city, white label (public, open access) parcel lockers in the various districts, etc. It is evident that in those cases the city or other authorities are involved and should be committed. Normally these public actors, together with other stakeholders, like shop owners, citizens, etc., are at that moment already part of the collaborative urban logistics community (step 1).

On top of a general improvement resulting from the collaboration and the joint initiative, a balanced and fair gain sharing is essential. All parties involved should get a fair share of the gains generated by the urban logistics collaboration.

! Once there is a mutual agreement on the business case and one is prepared to set up the purchase aggregation a Letter of Engagement (LoE) can complete this step.

Step 6: Preparation

In step 6, the roll out of the collaborative urban logistics solution is prepared. A timeline is defined for the implementation. If one needs to appoint an LSP -for the execution, often a two-steps process is provided, starting with a common request for information, followed by a request for proposal or quotation. This **tender process** is set up on behalf of the urban logistics community. This is the best guarantee that this is perceived as neutral and widely supported.

In some cities a distinct LSP is appointed for the different zones or districts. It is evident that the zoning or districting of a city is a crucial exercise that needs to be aligned with mobility strategies and other relevant policy choices or preferences.

A balance needs to be found between ambition and realism. Here again it is better to have a solid fundament, than a fast, unstable, unbalanced or unsustainable solution. The orchestrator can help to set realistic milestones in the **implementation plan**.

Step 7: Implementation

In step 7 the collaborative urban logistics initiative is implemented. The implementation plan is executed. An agreement is made and formalized in a multi-lateral contract (MLC). This document sets the legal frame for multilateral contracts containing clauses and articles to guide the entry and exit of community members, the gain and cost sharing mechanisms, the rights and obligations of members and stakeholders, data-sharing mechanisms, and the anti-trust compliance. The articles and clauses are the building blocks for a further customization of the multilateral collaboration to the unicity of each city.

After the launch of the collaborative urban logistics solution an effective process **monitoring** is necessary in order to adjust or to refine. At the end of the implementation a thorough evaluation is very helpful, especially towards future similar joint initiatives or towards next steps in collaborative urban logistics. One should learn from those experiences. Both positive and negative experiences help to improve further processes and initiatives in this field.

For the monitoring and evaluation some key performance indicators can be used:

- Efficiency: average number of kilometres per drop or cost per drop;
- Effectiveness: on-time in-full (OTIF) rate;
- Sustainability: CO_2 emission per drop.

Testimonials can be recorded and be put on the collaborative urban logistics platform (see step 1) in order to convince other companies or parties to go for similar initiatives or to join the community and to step into existing initiatives. This peer-to-peer communication and promotion seems to work. One can formalize this by appointing 'ambassadors'.

! An agreement is made and formalized in a multi-lateral contract (MLC).

The multi-lateral contract (MLC) must be open-access. That means open to any (other) candidate. Entrance procedures should be fair and proportionate. Any "exclusivity" is excluded. In this way the urban logistics community operates in an anti-trust compliant way.

Annex 2 appends indicative agreement templates that can be adopted and adapted in the Living Labs.

5. Conclusions and Next Steps

The PI is a holistic system that involves various building blocks, including, physical and digital networks, standardization, automation, integrated systems, multiple modes of transport, and numerous other building blocks. Above all, however, the PI is a system of collaboration. A system in which sharing is believed to offer greater opportunities for all players, increased efficiency of operations, lower emissions, lower costs, and lower congestion, but only if assets are shared. The goal of the PI is to realize more with less. It is a concept that looks at the efficiency of the entire system, not simply at individual LSPs, as the key to improved logistics in the future.

The LMD process is a critical component of logistics operations, and the use of innovative solutions such as drones, autonomous vehicles, and smart parcel lockers can enhance the efficiency of last mile deliveries. However, the LMD process is far too complex to be addressed by any one technical "silver bullet." It will take numerous improvements to ensure that the continued growth in LMD does not negatively impact the city's ability to deliver a positive experience to its citizens. The PI is a concept or frame in which a city can try different collaboration approaches to address the particular LMD issues it faces on its journey to improved urban logistics operations.

The URBANE project has been established to help document how various changes in LMD operations impact the system and whether PI like operations can improve this component of the logistics chain. It is with this in mind that the URBANE PI focused Framework has been developed.

The URBANE PI Framework ensures:

- Increased efficiency and flexibility;
- Improved sustainability;
- Increased collaboration;
- Improved visibility and reliability;
- Reduced operational costs;
- Enhanced customer service;
- Increased innovation, agility and responsiveness;
- Improved fairness;
- Improved competitiveness.

Much work remains and it is not planned that the URBANE project will solve all the ills arising from increased LMD. However, as the ancient Chinese proverb states, long journeys begin with small steps. URBANE is one such step on a long journey of improvement.

The URBANE project integrates multiple approaches to addressing the complex issue of urban logistics and, in particular, the last mile delivery problem. Work Package 3 of the project focuses on developing technical tools to help cities plan, operate, and improve their logistics activities. Through the development of a service platform, the work package provides city planners with tools to model logistics operations, simulate their last mile activities, and forecast potential outcomes if changes are made. These capabilities are made possible through the development of a digital twin service that can be connected to city data feeds and customized to model the city's actual logistics networks. The platform also provides optimization tools to help in deciding where to locate microhubs, how best to route delivery LSPs, and how to select the best transport means for delivery. Additional modelling capabilities are provided through the platform to determine how end-customers respond to various sustainable logistics initiatives, helping cities determine the best sustainability approach to take given their particular mix of neighbourhoods and citizens.

Work Package 5 of the project focuses on the development of business plans and commercial application of the findings of the project. This is an essential focus area for the project as the commercial application and uptake of new technologies and approaches to urban logistics and last mile delivery must occur if any lasting benefit from the work of the URBANE project is to be realized.

Scaling up the use cases and efforts performed by the city partners in the project is the focus of Work Package 6. This work package examines barriers to expanding the use case examples be they regulatory or commercial. It also focuses on promoting the various technologies and demonstration projects, so that a larger potential market for them can be developed.

Work Packages 2 and 4 focus on the cities themselves and their use cases. Work Package 2 is composed for four lead Living Lab cities. These cities will be early adopters of the technologies, models, and frameworks developed in the project. Based on the experiences of these cities, a second group of follower cities will pick up the application of the tools and techniques developed by the project to further test their usefulness, advance their designs, and expand on their application. The cities involved in these two work packages are the key "proof of concept" mechanisms for the concepts, technologies, and approaches being developed in URBANE, and the success they have is the ultimate test of the ideas that drive the project.

The URBANE project will run from September 2022 through January 2026. Its objectives are focused on achieving a significant reduction in greenhouse gas emissions from urban logistics operations while reducing the intensity of these operations in the urban environment. Its focus on the PI as a means to achieve these reductions provides clear support for the concept that better logistics operations can be achieved through open networks and collaborative sharing of assets.

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Annex 1 Urban Logistics Projects

This appendix summarises the key elements and conclusions from EIT Urban Mobility supported projects in the field of urban logistics. A total of 6 projects are presented, including a general description of the projects' objectives and stakeholders' involvement and an elaborate description of resulting logistics solutions and business models.

The projects are presented chronologically and are included into EIT Urban Mobility Business Plans for 2020, 2021 and 2022. Projects included in the Business Plan 2022 were in implementation as this report was being written for which some results could not be included.

FlexCurb

Project description and objectives

FlexCurb: Implementation of dynamic curb side management solutions to improve sustainable city logistics operations.

The FlexCURB project (2022) developed a digital solution for the dynamic management of curb space to improve street safety and better use of public realm while optimising delivery operations. The solution contributes to **integrate parking management, urban vehicle access regulations and freight management**.

Stakeholders' involvement

The stakeholders involved in the implementation of the project were a combination of research institutes and universities responsible for the technology support and big data analytics and operational research, a SME responsible for the commercialisation, a consulting company providing transversal support, a network association to ensure the upscaling and replication of the approaches, and the cities where pilots were implemented.

Business model description

The **product** developed in the project is the FlexCurb Planning platform, a web-based platform that provides cities with a comprehensive, consolidated, and accessible curb zones and regulations inventory to inform changes to public space (B2G product). The planning platform also reveals patterns of curb allocation and usage by different users, with a special focus on loading zones. As a result, city users have a better understanding of the effectiveness of both the current supply of parking spaces and the dynamic uses of the curb. The insights provided by the platform inform city managers on where and how to make interventions to better allocate the needs of curb users. Additionally, the planning platform is a scalable solution for cities thanks to the adoption of the Curb Data Specification (CDS), which enables the use of standardized data structures for curb regulations, curb usage, and curb metrics. This approach unlocks comparison between cities to provide a better context for decision making. The platform is commercialized through a yearly licensing selling mode.

Three categories of potential **customers** were identified:

- City authorities of urban areas (mid-sized municipalities, cities, metropolis, departments, regions) with digitalized curb regulations data and need for a curb inventory for non-technical decision makers.
- Design offices and semi-public urban planning agencies that produce studies to inform local urban planning.
- Logistics service providers operating in urban areas.

Potential **value propositions** considered:

- City authorities: understanding of curb space allocation and occupation to inform strategic plans and public space interventions. Support to geographic information system (GIS) outputs.
- Design offices and semi-public urban planning agencies: tools for data capture, visualization, and the creation of key indicators for decision-making.
- Logistics service providers: data access and understanding of urban areas where they operate.

The product has been successfully deployed in 4 European cities in operational environments and used by the targeted end-users. The deployment of the FlexCurb Planning platform in the four Living abs revealed product improvement opportunities including improvements to the usability, flexibility, and overall value offered.

HALLO

Project description and objectives

HALLO: Hubs for Last Mile Delivery Solutions

The HALLO project (2021-2022) focused on alleviating local environmental and traffic problems in urban areas by preventing deliveries by highly contaminating freight vehicles to reduce city pollution and congestion. The main innovation solution developed in HALLO was a detachable parcel box for cargo-bikes.

Stakeholders' involvement

The stakeholders involved in the implementation of the project were a combination of research institutes and universities (responsible for the layout of the facility location and the evaluation of the pilots), a design agency responsible for the design of the microhubs, a SME cargo-bike operator responsible for the commercialisation of parcel box and the public administrations involved in the testbeds.

Business model description[28]

The **product** developed in HALLO was a parcel box mainly commercialised in Spain and available as an "Add-on" in the rest of the EU. Cargo bikes can be fitted with the detachable Parcel Box and these can be loaded with parcel stacked on a Euro pallet; transhipment is done in one minute.

Potential **customers** include:

- Local distributors/last mile operators using cargo bikes.

Based on the following **value proposition**:

- Local distributors/last mile operators: parcel boxes have a higher capacity, are lightweight and less expensive than existing alternatives in the market. Compatibility with Euro pallet reduces transhipment time. Gains in efficiency due to lightweight of boxes and possibility to organise deliveries inside the bicycle parcel boxes.

[28] Success and failures of business models in 15 last mile delivery EU-funded projects study from HALLO is included in the Annex.

S+LOADZ

Project description and objectives

S+LOADZ: Multi-Sustainable Digital Loading and Delivery Zones for City Logistics.

The S+LOADZ project (2022) focused on accelerating the shift to sustainable and smart city logistics based on the digital transformation of parking spaces for urban freight and deliveries. It demonstrated state-of-the-art innovation by evaluating digital loading and delivery zones to assess the best legal, operational, and technical approach. A cost-effective platform was developed to control, regulate, and monitor multi sustainable digital loading and delivery zones for city logistics.

Stakeholders' involvement[29]

The stakeholders involved in the implementation of the project were a combination of research institutes and universities (responsible for the evaluation and analysis of data in the pilots), industrial partners (responsible for the exploitation activities), and public administrations (where the pilots were implemented).

Business model description

The **product** developed in the framework of the S+LOADZ project is a new add-on package of multi-sustainable features for a platform that controls, regulates and monitors digital loading and delivery zones, including:

• Big Data Analytics: Web-based platform to analyse Big Data collected from smart loading and delivery zones and anonymised parking data.

• Multi-sustainability features for digital loading and delivery zones: parking rules, response to pollution episodes, etc.

The two products are fit to be commercialised as a Software as a Service (SaaS).

The main potential **customers** are mid-sized cities with LEZ regulations/programmes based on the following **value proposition:**

i) regulate and control parking rules of smart loading and delivering zones, and

ii) analysis of big data from digital loading and delivery zones

Pilots have shown that the solution can support different configurations of use-cases – extending the range of users who can be managed at kerbsides and even controlling parking spaces at wholesales markets. Success factors in the implementation were political will, strong support from traffic officers and

[29] An analysis of the potential of micro-incentives for sustainable logistics is included in Annex 2.

a comprehensive communication campaign. Main challenges in the implementation were the administrative procedures and regulations from public administrations.

SMUD

Project description and objectives

SMUD: Shared micro depots for urban pickup and delivery.

The SMUD project (2020) focused on providing a publicly acceptable solution to share last mile delivery services between stakeholders, thus optimising the routes and space within the cities as well as leading to a reduction of emissions and traffic congestion.

Stakeholders' involvement

The stakeholders involved in the implementation of the project included research institutes and universities (providing scientific support and being responsible for the knowledge base and development of business models), an architecture agency (responsible for the design of the microhubs) and the public administrations (where pilots are implemented).

Business model description[30]

Two containers were deployed and used as facilities for micro urban consolidation centres (mUCC); these were placed next to a cycle lane allowing to reach the neuralgic city centre in 5 min by bike.

Six categories of potential **customers** were identified: end-customers, shippers, carriers, manufacturers, cities and property owners. Location and the characteristics of the facility (eg capacity, unloading area, space for docking) were considered the top key aspects to attract potential customers.

Shared microhub networks are considered to provide the following **value propositions**:

- Possibility of sharing a van/truck to serve multiple microhubs. Moreover, deliveries are carried out the day after the pick-up.
- Optimisation is performed whenever possible, although there is the possibility of unexpected events.
- When possible, the trucks make only one stop to the micro depot. However, the number of trucks can be minimised if they can make multiple stops at different micro depots.

[30] An analysis of trends and barriers for micro urban consolidation centres from the project is included in the Annex.

- The delivery planning is carried out considering different micro depots. After scheduling the full loads of one truck on one micro depot, the truck delivers to the micro depot and then proceeds to the next. The process continues until all deliveries are carried out.

RAPTOR

Project description and objectives

RAPTOR: Reverse Logistics in Toulouse

Rapid Applications for Transport (RAPTOR) is an EIT UM – funded competition that swiftly creates and tests solutions to niche urban mobility challenges. Participants compete to provide the most innovative, feasible, and impactful solutions.

RAPTOR uses AGILE innovation to solve urban mobility challenges that have been defined by the cities. The RAPTOR works in three steps:

- Cities define a unique mobility challenge they face (e.g., downtown pollution, unsafe e-scooter/e-bike use, safety in public space, etc.)
- EIT Urban Mobility and cities hold an open competition for start-ups and SMEs to propose solutions that address these challenges.
- The winners of the competition are awarded funding and have 4 months to develop a tailored solution to be tested in the city.

Toulouse Metropole RAPTOR challenge was centred around reverse logistics and more specifically the holistic collection of returnable containers and bio-waste. A cooperative supply chain (COOP MIL) involving local agri-food players: farmers, refillable container solutions, cargo bikes carriers and waste managers was implemented to respond to this challenge.

Stakeholders' involvement

The stakeholders involved in the implementation of the project included the Toulouse Metropole (where the pilot is implemented) and a SME responsible for the setting up of the cooperative supply chain.

Business model description

The **product** launched by COOP MIL was an online shop (digital marketplace) that allows farmers to offer their products to shopkeepers in Toulouse. COOP MIL receives all the products at the warehouse, and they prepare the orders so that can be delivered by cargo bikes or natural gas vehicles. They also set up a returnable container system to replace non-reusable crates, and they work with returnable bottles with a local partner. This allows them to optimise the reverse logistics, which means that when they deliver products they leave with empty containers and also with bio-waste to reduce the number of lorries in the city and therefore enhance this logistical solution. This allows them to have a very high level of transparency for all stakeholders, since COOP MIL belongs to the entire sector, both farmers and shopkeepers. Reusable containers are stored at the COOP MIL warehouse to be distributed to processing points (cleaning stations and compost sites).

Regarding the economic model, farmers choose the price of their products. A commission on sales is paid by the buyers to the COOP MIL. Farmers and stores save time and money on delivery and invoicing. Commissions are transparent for all members and profits are mostly dedicated to the COOP MIL development.

LOGISMILE

Project description and objectives

LOGISMILE: Last mile delivery for autonomous goods delivery

The LOGISMILE project (2022) is focused on developing an autonomous hub vehicle (AHV) that works with smaller autonomous delivery devices (ADD robots) and a remote back-end control centre managing the communication between the main vehicle and other devices, collecting data, optimising fleet operations and providing a fail-safe solution should a complex situation arise. The solution is piloted in 3 cities.

Stakeholders' involvement

The stakeholders involved in the implementation of the project included research centres and universities (responsible for the research in all aspects in robotics and AI), engineering and consulting companies (responsible for the mobility design and software development), industry companies (providers of the navigation system and mobility modelling and simulation) and public administrations involved in the implementation of the pilots (mainly municipalities but also public transport companies and authorities responsible for road safety and sustainable mobility policies).

Business model description

The ADD and AHV can be operated separately, depending on the needs of future end users. Clear business models and commercialisation plans are currently being explored and not available to be included in this document.

Annex 2 Generic contract templates

This section appends generic contract templates for white-label collaboration that can be adopted and adapted in the context of the URBANE Living Labs.

Letter of Intent (LOI)

Letter of Intent (LoI)

for Future Proof Urban Logistics – URBANE

1. Parties	**A.**	**ORGANISATION X**, having its main office in _______, at the address ______ hereinafter referred to as "**Stakeholder**"
	B.	**ORGANISATION A**, having its main office in _______, at the address ______ hereinafter referred to as "**Neutral Trustee**". *The neutral trustee is responsible for the orchestration of a future proof urban logistics system. Neutral Orchestration sets the terms for consolidation and collaboration among stakeholders at different levels. The neutral orchestrator will guarantee an anti-trust compliant environment for couriers and last mile delivery companies to operate into. Moreover, the orchestrator is needed to synchronize the last mile distribution of freight (alignment of cut-off times, alignment of deliveries to common customers etc.) in order to realize the potential savings in cost and emissions. Objective criteria and mechanisms to assign deliveries to the different parcel distributors have to be defined and implemented in an anti-trust compliant way, under the supervision of the neutral orchestrator. As community manager, the neutral orchestrator develops and manages the city logistics ECO-system to embed the involvement of each relevant stakeholder. Besides the alignment of couriers and last mile delivery companies, the involvement of the other stakeholders, including the city authorities, the shop owners, citizens etc. is key.*
2. Recitals	**A.**	URBANE stands for "UPSCALING INNOVATIVE GREEN URBAN LOGISTICS SOLUTIONS THROUGH MULTI-ACTOR COLLABORATION AND PI-INSPIRED LAST MILE DELIVERIES". The URBANE project focuses on developing "efficient, replicable and socially acceptable innovative last mile delivery solutions. URBANE focuses on last mile delivery operations due to their rapid growth and resulting impact on a city's residents and environment.
	B.	Solutions will be demonstrated in four *light house living laboratories*, living labs: Helsinki, Bologna, Valladolid, and Thessaloniki. Other cities are involved as followers.
	C.	Inspired by the Physical Internet idea, URBANE explores last mile collaboration among the various stakeholders and incentives and white label schemes.

	D.	This Letter of Intent (LOI) for a Future Proof Urban Logistics system within URBANE is aimed at formalizing the intention of the Stakeholder to participate to the multiple step process of a joint future proof urban logistics initiative within the scope of the URBANE project. This stepwise process is guided by the Neutral Trustee.
3. Subject or Scope	A.	The Stakeholder confirms its interest in the URBANE Future Proof Urban Logistics approach and in the particular subject or scope defined in the involved city, zone or district.
	B.	*Description of the Subject or Scope*
4. Process steps	A.	The process leading to a Future Proof Urban Logistics system (within URBANE) contains 7 steps: Step 1: Matchmaking Step 2: Common needs assessment Step 3: Alignment on expectations Step 4: Requirements & Conditions & Critical Success Factors Step 5: Joint Business Case Step 6: Preparation Step 7: Implementation
	B.	Step 1 - matchmaking is the first phase of a joint process. This step is often considered as the most crucial and time intensive. If the Subject or Scope of article 3.B is identified and the Stakeholder is interested, URBANE asks each individual stakeholder to enter this LoI and thus to participate to the process leading to a Future Proof Urban Logistics system (within URBANE). A signed LoI formalizes the matchmaking among the stakeholders (Step 1). This stepwise process is further guided by the Neutral Trustee.
	C.	The setup of a Future Proof Urban Logistics system (within URBANE) will be free of charge for the Stakeholder, as long as it is performed under the URBANE project. This project has received funding from the European Union's Horizon Europe research and innovation program under Grant Agreement N° 101069782.
5. Intent	A.	The Stakeholder declares to have the intention to participate to a joint Future Proof Urban Logistics process (within URBANE) by first aligning its expectations with those of the other Stakeholder(s) and to prepare a Gentlemen's Agreement (GeA) with other Stakeholders on the Subject or Scope (cfr. of article 3.B), as described in article 4 as a next step in the Future Proof Urban Logistics process (within URBANE). The process will be guided by the Neutral Trustee.

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On behalf of the Stakeholder:
Represented by:
Capacity: Date: Place: Signature:

On behalf of Neutral Trustee:
Represented by:
Capacity: Date: Place: Signature:

Gentlemen's Agreement (GeA)

Task T1.2.2 | URBANE Project | Grant Agreement no. 101069782

Gentlemen's Agreement (GeA)

for Future Proof Urban Logistics – URBANE

1. Parties	**A.**	1. **ORGANISATION X**, having its main office in _______, at the address ______ 2. **ORGANISATION Y**, having its main office in _______, at the address ______ 3. **ORGANISATION Z**, having its main office in _______, at the address ______ 4. … Hereinafter individually referred to as "Stakeholder" and the **"Urban Logistics Community"**.
	B.	**ORGANISATION A**, having its main office in _______, at the address ______ hereinafter referred to as **"Neutral Trustee"**. *The neutral trustee is responsible for the orchestration of a future proof urban logistics system. Neutral Orchestration sets the terms for consolidation and collaboration among stakeholders at different levels. The neutral orchestrator will guarantee an anti-trust compliant environment for couriers and last mile delivery companies to operate into. Moreover, the orchestrator is needed to synchronize the last mile distribution of freight (alignment of cut-off times, alignment of deliveries to common customers etc.) in order to realize the potential savings in cost and emissions. Objective criteria and mechanisms to assign deliveries to the different parcel distributors have to be defined and implemented in an anti-trust compliant way, under the supervision of the neutral orchestrator. As community manager, the neutral orchestrator develops and manages the city logistics ECO-system to embed the involvement of each relevant stakeholder. Besides the alignment of couriers and last mile delivery companies, the involvement of the other stakeholders, including the city authorities, the shop owners, citizens etc. is key.*
2. Recitals	**A.**	URBANE stands for "UPSCALING INNOVATIVE GREEN URBAN LOGISTICS SOLUTIONS THROUGH MULTI-ACTOR COLLABORATION AND PI-INSPIRED LAST MILE DELIVERIES". The URBANE project focuses on developing "efficient, replicable and socially acceptable innovative last mile delivery solutions. URBANE focuses on last mile delivery operations due to their rapid growth and resulting impact on a city's residents and environment.
	B.	Solutions will be demonstrated in four *light house living laboratories*, living labs: Helsinki, Bologna, Valladolid, and Thessaloniki. Other cities are involved as followers.

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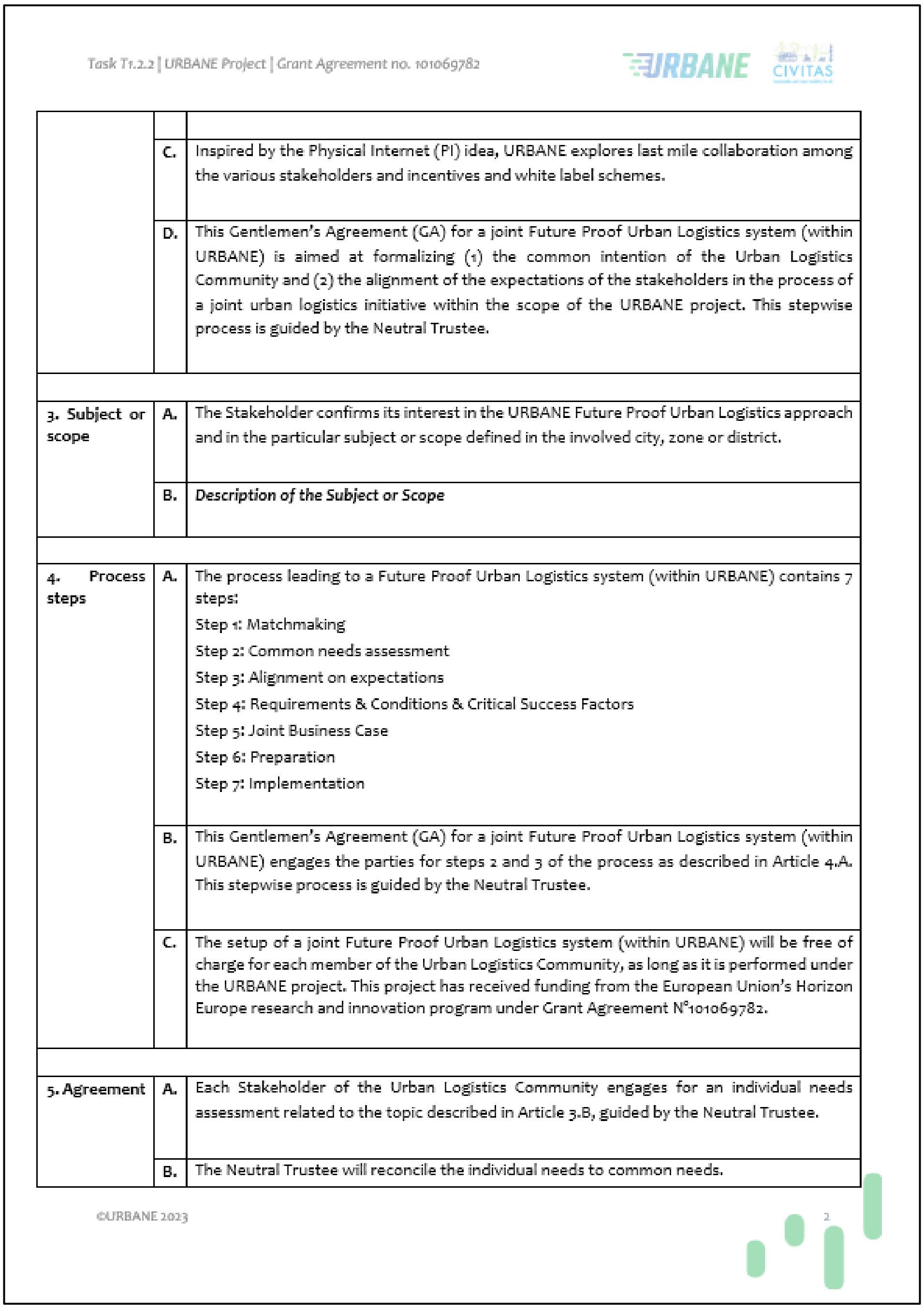
	C.	Inspired by the Physical Internet (PI) idea, URBANE explores last mile collaboration among the various stakeholders and incentives and white label schemes.
	D.	This Gentlemen's Agreement (GA) for a joint Future Proof Urban Logistics system (within URBANE) is aimed at formalizing (1) the common intention of the Urban Logistics Community and (2) the alignment of the expectations of the stakeholders in the process of a joint urban logistics initiative within the scope of the URBANE project. This stepwise process is guided by the Neutral Trustee.
3. Subject or scope	**A.**	The Stakeholder confirms its interest in the URBANE Future Proof Urban Logistics approach and in the particular subject or scope defined in the involved city, zone or district.
	B.	***Description of the Subject or Scope***
4. Process steps	**A.**	The process leading to a Future Proof Urban Logistics system (within URBANE) contains 7 steps: Step 1: Matchmaking Step 2: Common needs assessment Step 3: Alignment on expectations Step 4: Requirements & Conditions & Critical Success Factors Step 5: Joint Business Case Step 6: Preparation Step 7: Implementation
	B.	This Gentlemen's Agreement (GA) for a joint Future Proof Urban Logistics system (within URBANE) engages the parties for steps 2 and 3 of the process as described in Article 4.A. This stepwise process is guided by the Neutral Trustee.
	C.	The setup of a joint Future Proof Urban Logistics system (within URBANE) will be free of charge for each member of the Urban Logistics Community, as long as it is performed under the URBANE project. This project has received funding from the European Union's Horizon Europe research and innovation program under Grant Agreement N°101069782.
5. Agreement	**A.**	Each Stakeholder of the Urban Logistics Community engages for an individual needs assessment related to the topic described in Article 3.B, guided by the Neutral Trustee.
	B.	The Neutral Trustee will reconcile the individual needs to common needs.



	C.	Inspired by the Physical Internet (PI) idea, URBANE explores last mile collaboration among the various stakeholders and incentives and white label schemes.
	D.	This Gentlemen's Agreement (GA) for a joint Future Proof Urban Logistics system (within URBANE) is aimed at formalizing (1) the common intention of the Urban Logistics Community and (2) the alignment of the expectations of the stakeholders in the process of a joint urban logistics initiative within the scope of the URBANE project. This stepwise process is guided by the Neutral Trustee.
3. Subject or scope	A.	The Stakeholder confirms its interest in the URBANE Future Proof Urban Logistics approach and in the particular subject or scope defined in the involved city, zone or district.
	B.	***Description of the Subject or Scope***
4. Process steps	A.	The process leading to a Future Proof Urban Logistics system (within URBANE) contains 7 steps: Step 1: Matchmaking Step 2: Common needs assessment Step 3: Alignment on expectations Step 4: Requirements & Conditions & Critical Success Factors Step 5: Joint Business Case Step 6: Preparation Step 7: Implementation
	B.	This Gentlemen's Agreement (GA) for a joint Future Proof Urban Logistics system (within URBANE) engages the parties for steps 2 and 3 of the process as described in Article 4.A. This stepwise process is guided by the Neutral Trustee.
	C.	The setup of a joint Future Proof Urban Logistics system (within URBANE) will be free of charge for each member of the Urban Logistics Community, as long as it is performed under the URBANE project. This project has received funding from the European Union's Horizon Europe research and innovation program under Grant Agreement N°101069782.
5. Agreement	A.	Each Stakeholder of the Urban Logistics Community engages for an individual needs assessment related to the topic described in Article 3.B, guided by the Neutral Trustee.
	B.	The Neutral Trustee will reconcile the individual needs to common needs.

Non-Disclosure Agreement (NDA)

Task T1.2.2 | URBANE Project | Grant Agreement no. 101069782

Non-Disclosure Agreement (NDA)

for Future Proof Urban Logistics – URBANE

1. Parties	**A.**	**ORGANISATION X,** having its main office in ______, at the address ______ hereinafter referred to as "**Stakeholder**"
	B.	**ORGANISATION A,** having its main office in ______, at the address ______ hereinafter referred to as "**Neutral Trustee**". *The neutral trustee is responsible for the orchestration of a future proof urban logistics system. Neutral Orchestration sets the terms for consolidation and collaboration among stakeholders at different levels. The neutral orchestrator will guarantee an anti-trust compliant environment for couriers and last mile delivery companies to operate into. Moreover, the orchestrator is needed to synchronize the last mile distribution of freight (alignment of cut-off times, alignment of deliveries to common customers etc.) in order to realize the potential savings in cost and emissions. Objective criteria and mechanisms to assign deliveries to the different parcel distributors have to be defined and implemented in an anti-trust compliant way, under the supervision of the neutral orchestrator. As community manager, the neutral orchestrator develops and manages the city logistics ECO-system to embed the involvement of each relevant stakeholder. Besides the alignment of couriers and last mile delivery companies, the involvement of the other stakeholders, including the city authorities, the shop owners, citizens etc. is key.*
	C.	Hereinafter jointly referred to as "the Parties" or separately (also) as "a Party"
	D.	"**Disclosing party**" means the party furnishing Confidential Information and "**Receiving party**" means the party receiving it in the particular case.
2. Recitals	**A.**	URBANE stands for "UPSCALING INNOVATIVE GREEN URBAN LOGISTICS SOLUTIONS THROUGH MULTI-ACTOR COLLABORATION AND PI-INSPIRED LAST MILE DELIVERIES". The URBANE project focuses on developing "efficient, replicable and socially acceptable innovative last mile delivery solutions. URBANE focuses on last mile delivery operations due to their rapid growth and resulting impact on a city's residents and environment.
	B.	Solutions will be demonstrated in four *light house living laboratories*, living labs: Helsinki, Bologna, Valladolid, and Thessaloniki. Other cities are involved as followers.

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	C.	Inspired by the Physical Internet (PI) idea, URBANE explores last mile collaboration among the various stakeholders and incentives and white label schemes.
	D.	This Non-Disclosure Agreement (NDA) is aimed at formalizing the terms and conditions that are applicable to all confidential Information directly or indirectly exchanged by the Parties in relation to the Subject or Scope, as described in Article 3.B within the scope of the URBANE Project.
3. Subject	**A.**	The Stakeholder confirms its interest in the URBANE Future Proof Urban Logistics approach and in the particular subject or scope defined in the involved city, zone or district.
	B.	*Description of the Subject or Scope*
4. Confidential Information	**A.**	"Confidential Information" shall mean all information of the disclosing party, whether commercial, financial, technical or otherwise, disclosed to the recipient in connection with the Subject (cfr. Article 3) (whether disclosed orally, in documentary form, by demonstration or otherwise) which is contained in any form whatsoever (including without limitation data, drawings, films, documents and computer readable media) and which is marked or otherwise designated to show expressly or by necessary implication that it is confidential or proprietary to the disclosing party.
	B.	Each party shall maintain Information obtained in confidence from the other and use such Information only for the Subject, as described in Article 3.B. Each party agrees to treat Information disclosed to it by the other with the same degree of care as it uses in protecting its own confidential and proprietary information, and the Information shall be disclosed within the recipient company only on a need-to-know basis.
	C.	Disclosures of Confidential Information shall be made only to employees, officers, directors and legal advisors of the receiving party, who have a need to know such information, who have been advised of this agreement and who agree to abide by its terms.
	D.	The obligations of confidentiality and non-use shall not apply to Information which the receiving party can prove: 1. at the time of disclosure was generally known to the public or, after such disclosure, became generally known to the public other than by a breach of this Agreement by the receiving party; its employees or agents; or 2. was already in the possession of the receiving party at the time of such disclosure without an obligation of confidentiality; or 3. was later received on a non-confidential basis by the receiving party from a third party having the right to impart such Information; or

		4. was independently developed by the receiving party or lawfully received by the receiving party from another source without breach of this Agreement or similar agreement covering that other source. Information shall not be deemed to be within one or more of the foregoing exceptions merely because any part of such Information is embodied in general disclosures or because individual features, components or combinations are now or hereafter become publicly known.
	E.	The receiving party shall use all reasonable endeavours to effect and maintain adequate security measures to safeguard such Confidential Information from unauthorised access, use and misappropriation;
5. Duration	A.	The parties' obligations under this Agreement shall extend for the duration of the URBANE project. This project has received funding from the European Union's Horizon 2020 research and innovation program under Grant Agreement N°101069782.
	B.	Upon the completion or termination of the URBANE project, each receiving party shall promptly deliver up to the disclosing party all Confidential Information supplied by the disclosing party and all copies thereof and destroy or erase any Confidential Information contained in any materials and documentation prepared by or on behalf of the recipient or recorded in any memory device.
6. Jurisdiction	A.	In the event of a dispute, Belgian law shall apply and the courts of Brussels shall have jurisdiction.

On behalf of the Stakeholder:
Represented by:
Capacity: **Date:** **Place:** **Signature:**

On behalf of Neutral Trustee:

Represented by:
Capacity: **Date:** **Place:** **Signature:**

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Letter of Engagement (LoE)

Letter of Engagement (LoE)

for Future Proof Urban Logistics – URBANE

1. Parties	**A.**	1. **ORGANISATION X**, having its main office in _______, at the address ______ 2. **ORGANISATION Y**, having its main office in _______, at the address ______ 3. **ORGANISATION Z**, having its main office in _______, at the address ______ 4. … Hereinafter individually referred to as "Stakeholder" and the "**Urban Logistics Community**" or the "**Urban Logistics ECO-system**"
	B.	**ORGANISATION A**, having its main office in _______, at the address ______ hereinafter referred to as "**Neutral Trustee**". *The neutral trustee is responsible for the orchestration of a future proof urban logistics system. Neutral Orchestration sets the terms for consolidation and collaboration among stakeholders at different levels. The neutral orchestrator will guarantee an anti-trust compliant environment for couriers and last mile delivery companies to operate into. Moreover, the orchestrator is needed to synchronize the last mile distribution of freight (alignment of cut-off times, alignment of deliveries to common customers etc.) in order to realize the potential savings in cost and emissions. Objective criteria and mechanisms to assign deliveries to the different parcel distributors have to be defined and implemented in an anti-trust compliant way, under the supervision of the neutral orchestrator. As community manager, the neutral orchestrator develops and manages the city logistics ECO-system to embed the involvement of each relevant stakeholder. Besides the alignment of couriers and last mile delivery companies, the involvement of the other stakeholders, including the city authorities, the shop owners, citizens etc. is key.*
2. Recitals	**A.**	URBANE stands for "UPSCALING INNOVATIVE GREEN URBAN LOGISTICS SOLUTIONS THROUGH MULTI-ACTOR COLLABORATION AND PI-INSPIRED LAST MILE DELIVERIES". The URBANE project focuses on developing "efficient, replicable and socially acceptable innovative last mile delivery solutions. URBANE focuses on last mile delivery operations due to their rapid growth and resulting impact on a city's residents and environment.
	B.	Solutions will be demonstrated in four *light house living laboratories*, living labs: Helsinki, Bologna, Valladolid, and Thessaloniki. Other cities are involved as followers.

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	C.	Inspired by the Physical Internet (PI) idea, URBANE explores last mile collaboration among the various stakeholders and incentives and white label schemes.
	D.	Each Stakeholder of the Urban Logistics Community or the Urban Logistics ECO-system has confirmed its interest in the topic as described in article 3.B by having signed a Letter of Intent (LoI).
	E.	The Urban Logistics Community entered a Gentlemen's Agreement (GA) on *[Date]* aimed at formalizing (1) the common intention of the Urban Logistics Community and (2) the alignment of the expectations of the stakeholders in the process of a joint urban logistics initiative within the scope of the URBANE project. This stepwise process is guided by the Neutral Trustee.
	F.	Each Stakeholder of the Urban Logistics Community has signed a separate Non-Disclosure Agreement (NDA) with the Neutral Trustee before entering this LoE.
	G.	This Letter of Engagement (LoE) for a joint Future Proof Urban Logistics system (within URBANE) is aimed at formalizing the intention of the Stakeholder to participate in an active and collaborative way to the multiple step process of a joint urban logistics initiative within the scope of the URBANE project. This stepwise process is guided by the Neutral Trustee.
3. Subject or Scope	A.	The Stakeholder confirms its interest in the URBANE Future Proof Urban Logistics approach and in the particular subject or scope defined in the involved city, zone or district.
	B.	***Description of the Subject or Scope***
4. Process steps	A.	The process leading to a Future Proof Urban Logistics system (within URBANE) contains 7 steps: Step 1: Matchmaking Step 2: Common needs assessment Step 3: Alignment on expectations Step 4: Requirements & Conditions & Critical Success Factors Step 5: Joint Business Case Step 6: Preparation Step 7: Implementation

	B.	This Letter of Engagement (LoE) for a joint Future Proof Urban Logistics system (within URBANE) engages the parties for steps 4 and 5 of the process as described in Article 4.A. This stepwise process is guided by the Neutral Trustee.
	C.	The setup of a joint Future Proof Urban Logistics system (within URBANE) will be free of charge for each member of the Urban Logistics Community, as long as it is performed under the URBANE project. This project has received funding from the European Union's Horizon Europe research and innovation program under Grant Agreement N°101069782.
5. Engagement	**A.**	The Neutral Trustee will prepare and send a Request for Proposal (RFP) on the Subject described in Article 3.B. This RFP contains the requirements, conditions and the critical success factors to setup a joint urban logistics process. The Neutral Trustee leads the entire tendering process aiming at selecting one or more suppliers for the joint urban logistics solution.
	B.	Each Stakeholder of the Urban Logistics Community engages to share data and information with the Neutral Trustee enabling him to write an appropriate RFP.
	C.	The Neutral Trustee will elaborate the joint business case, based on the proposal of the selected supplier(s). The business case compares the TO-BE joint urban logistics solution with the AS-IS company's individual urban logistics solution on several objectives (cost-efficiency, effectiveness and/or sustainability).
	D.	Each Stakeholder of the Urban Logistics Community engages to share the required data and information with the Neutral Trustee enabling him to calculate the joint urban logistics solution and the Stakeholder's company specific urban logistics solution.
	E.	If the business case turns out to be positive, overall as well as for each Stakeholder individually, then each Stakeholder will engage to enter the Multilateral Contract (MLC) to formalize the Future Proof Urban Logistics solution.
6. Jurisdiction	**A.**	In the event of a dispute, Belgian law shall apply and the courts of Brussels shall have jurisdiction.

On behalf of the Stakeholder:	**On behalf of the Stakeholder:**	**On behalf of the Stakeholder:**
Represented by:	**Represented by:**	**Represented by:**

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Capacity: Date: Place: Signature:	Capacity: Date: Place: Signature:	Capacity: Date: Place: Signature:

On behalf of Neutral Trustee:
Represented by:
Capacity: Date: Place: Signature:

Multilateral Contract (MLC)

MULTILATERAL CONTRACT (MLC)

for Future Proof Urban Logistics – URBANE

1. Parties	**A.**	1. **ORGANISATION X,** having its main office in _______, at the address ______ 2. **ORGANISATION Y,** having its main office in _______, at the address ______ 3. **ORGANISATION Z,** having its main office in _______, at the address ______ 4. … Hereinafter individually referred to as "Stakeholder" and the "**Urban Logistics Community**" or the "**Urban Logistics ECO-system**".
	B.	**ORGANISATION A,** having its main office in _______, at the address ______ hereinafter referred to as "**Impartial Orchestrator**" or "**Trustee**". *The neutral trustee is responsible for the orchestration of a future proof urban logistics system. Neutral Orchestration sets the terms for consolidation and collaboration among stakeholders at different levels. The neutral orchestrator will guarantee an anti-trust compliant environment for couriers and last mile delivery companies to operate into. Moreover, the orchestrator is needed to synchronize the last mile distribution of freight (alignment of cut-off times, alignment of deliveries to common customers etc.) in order to realize the potential savings in cost and emissions. Objective criteria and mechanisms to assign deliveries to the different parcel distributors have to be defined and implemented in an anti-trust compliant way, under the supervision of the neutral orchestrator. As community manager, the neutral orchestrator develops and manages the city logistics ECO-system to embed the involvement of each relevant stakeholder. Besides the alignment of couriers and last mile delivery companies, the involvement of the other stakeholders, including the city authorities, the shop owners, citizens etc. is key.*
2. Recitals	**A.**	URBANE stands for "UPSCALING INNOVATIVE GREEN URBAN LOGISTICS SOLUTIONS THROUGH MULTI-ACTOR COLLABORATION AND PI-INSPIRED LAST MILE DELIVERIES". The URBANE project focuses on developing "efficient, replicable and socially acceptable innovative last mile delivery solutions. URBANE focuses on last mile delivery operations due to their rapid growth and resulting impact on a city's residents and environment.
	B.	Solutions will be demonstrated in four *light house living laboratories*, living labs: Helsinki, Bologna, Valladolid, and Thessaloniki. Other cities are involved as followers.

	C.	Inspired by the Physical Internet (PI) idea, URBANE explores last mile collaboration among the various stakeholders and incentives and white label schemes.
	D.	Each Stakeholder of the Urban Logistics Community or the Urban Logistics ECO-system has confirmed its interest in the topic as described in article 3.B by having signed a Letter of Intent (LoI) and/or a Letter of Engagement (LoE).
	E.	This Multilateral Contract for a joint Future Proof Urban Logistics system (within URBANE) is aimed at formalizing (1) the collaboration among the various Stakeholders. This collaboration is based on the common intention of the Urban Logistics Community and (2) the alignment of the expectations of the Stakeholders in the process of a joint urban logistics initiative within the scope of the URBANE project. This stepwise process is guided by the Impartial Orchestrator.
3. Subject or Scope	**A.**	The Stakeholder confirms its interest in the URBANE Future Proof Urban Logistics approach and in the particular subject or scope defined in the involved city, zone or district.
	B.	***Description of the Subject or Scope***
4. Process steps	**A.**	The process leading to a Future Proof Urban Logistics system (within URBANE) contains 7 steps: Step 1: Matchmaking Step 2: Common needs assessment Step 3: Alignment on expectations Step 4: Requirements & Conditions & Critical Success Factors Step 5: Joint Business Case Step 6: Preparation Step 7: Implementation
	B.	This Multilateral Contract for a joint Future Proof Urban Logistics (within the frame of the URBANE project) engages the parties for steps 7 - implementation of the process as described in Article 4.A. This stepwise process is guided by the Impartial Orchestrator.
	C.	The setup of a joint Future Proof Urban Logistics system (within the frame of the URBANE project) will be free of charge for each member of the Urban Logistics Community, as long as it is performed under the URBANE project. This project has received funding from the European Union's Horizon Europe research and innovation program under Grant Agreement N°101069782.

5. Agreement	**A.**	Each Stakeholder of the Urban Logistics Community or the "Urban Logistics ECO-system" engages for an individual needs assessment related to the topic described in Article 3.B, guided by the Impartial Orchestrator.
	B.	Each Stakeholder agrees on a collaboration which is **open and inclusive.** To achieve a highly efficient and coordinated last mile distribution, the collaboration of many companies is required. Therefore, it's mandatory that the city logistics ECO-system is open and accessible for any interested company. The openness of the collaborative communities is an absolute requirement to operate in an anti-trust compliant way.
	C.	**Entry and exit** The framework of the ECO-system will facilitate fast onboarding of new companies. Therefore, efficient processes are provided at legal, IT-connectivity and management level of the framework. Stakeholders have also the possibility to quit the collaboration in a easy and transparent way.
	D.	**Connectivity** IT-platforms connect the members of the ECO-system to support the collaboration. The technology will guarantee that data is shared in a safe and anti-trust compliant way.
	E.	The Impartial Orchestrator will do its utmost to achieve the necessary alignment and community building among the Stakeholders of the Urban Logistics Community or ECO-system. As the Impartial Orchestrator engages in an obligation of means and not in an obligation of results, achieving alignment among all actors is not guaranteed.

On behalf of the Stakeholder:	On behalf of the Stakeholder:	On behalf of the Stakeholder:
Represented by:	Represented by:	Represented by:
Capacity: Date: Place: Signature:	Capacity: Date: Place: Signature:	Capacity: Date: Place: Signature:

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On behalf of Impartial Orchestrator:
Represented by:
Capacity: **Date:** **Place:** **Signature:**

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

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

Communication, Dissemination, and Upscaling Manager: **Antonios Tsiligiannis, POLIS**
atsiligiannis@polisnetwork.eu

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