D2.2: Helsinki Demonstrator

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Executive summary

The URBANE project aims to contribute to the EU's goal of creating safe and sustainable last-mile transport operations. By developing replicable and scalable innovative last-mile delivery solutions, based on a novel service collaboration model inspired by the Internet (the Physical Internet), URBANE will support the transition to a more efficient and environmentally friendly logistics sector. To facilitate the achievement of this goal the project deploys, monitors, and tests these innovative services in four Lighthouse Living Labs (LLs) including Helsinki, Bologna, Valladolid, and Thessaloniki.

This document outlines the set up and operation of Helsinki LL that consists of the three piloting sprints designed iteratively based on the previous lessons learned. The pilots were aiming at demonstrating the feasibility of autonomous delivery vehicles (ADVs) in urban logistics by implementing various service models for businesses and residents in Helsinki. Moreover, Helsinki LL was demonstrating the use of cargo bikes and consolidation between multiple logistics service providers to see whether it would be financially sustainable model for the companies to fasten their shift towards emission-free deliveries. These operations were supported by the carbon-neutral goals of Helsinki city.

The first part of the report provides an overview of the LL, including its background, context, and objectives aligned with the Physical Internet concept. It also identifies key stakeholders and analyzes relevant policies and regulations. The second part focuses on the implementation phase, detailing real-world actions, the underlying physical and digital infrastructure, and models and tools developed by URBANE partners according to Helsinki LL needs and specificities. The final chapter summarizes the identified KPIs for comparison with other LLs, along with lessons learned and recommendations for future adoption and scaling. The final KPIs measurements, sustainability triangulation and the transferability potential of Helsinki LL are reported in *D2.1 Validation Report*.

The key takeaway from the Helsinki operations highlighted the importance of securing the necessary authorizations and engaging the city in providing land for the microhub. This microhub is essential as the operational base for both ADVs and cargo bikes. Also, increasing the volume of parcels is crucial to leverage the benefit of scaling up the operations. More parcels would justify the usage of more ADVs, cargo bikes and bigger premises for consolidating the parcels between multiple stakeholders. In addition, Helsinki LL learned that marketing the solutions effectively has a huge impact on the way residents perceive the ADVs running in the urban environment and increase their curiosity to try the novel services.

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List of abbreviations

ACRONYM	DECRIPTION
ADV	Autonomous Delivery Vehicle
API	Application Programming Interface
B2B	Business to Business
B2C	Business to Consumer
BPMN	Business Process Model and Notation
CO2	Carbon Dioxide
DT	Digital Twin
EDI	Electronic Data Interchange
EV	Electric Vehicle

FVH	Forum Virium Helsinki
GA	Grant Agreement
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
HKI	Helsinki
HERO	Helsinki Robot
KPI	Key Performance Indicator
KM	Kilometre
LEV	Low Emission Vehicle
LEZ	Low Emission Zone
LL	Living Lab
LMAD	Last Mile Autonomous Delivery
LMD	Last Mile Delivery
LSP	Logistics Service Provider
MaaS	Mobility as a Service
NERO	No Emission Robot
PDA	Personal Digital Assistant
PI	Physical Internet
SDG	Sustainable Development Goals
SLAM	Simultaneous Localization and Mapping
SULP	Sustainable Urban Logistics Plan
SUMP	Sustainable Urban Mobility Plan
TMS	Transport Management System
UI	User Interface
3D	Three dimensional

1. Introduction

The purpose of this document is to provide a detailed analysis of the Helsinki Living Lab (LL) in work package 2 within the URBANE project. The report aims to describe the requirements for implementing the operations in Helsinki LL, which includes integration of autonomous delivery vehicles (ADVs), installation of a shared microhub and executing last-mile deliveries using sustainable electric vehicles. It defines the physical areas, digital and physical infrastructure used in the operations, fleet specifics, user stories involving all stakeholders, models, and optimization algorithms. Additionally, this report discusses the methodologies that have been utilised to measure progress and successfulness of the operations in Helsinki. Finally, the report outlines the lessons learned and recommendations for the future of PI-inspired urban logistics.

FIGURE 1 AUTONOMOUS DELIVERY VEHICLE HERO (HELSINKI ROBOT) DURING THE FIRST PILOTING SPRINT IN SUMMER 2023.

1.1 WP2 Tasks and Outcomes

1.2 URBANE Outputs Mapping to GA Commitments

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

URBANE GA ITEM	URBANE GA ITEM DESCRIPTION	DOCUMENT CHAPTER(S)	JUSTIFICATION
DELIVERABLE			
D2.2 Helsinki demonstrator	*Demonstrator and report on user acceptance/lessons learned. D2.2 will describe the results of collaboration with local authorities on the constraints and measures for the efficient introduction of ADVs in last mile delivery. It will include detailed requirements and user stories, the LL DT models, a detailed implementation plan including the operational zone definition and operational parameters, fleet details, measurements during execution in real life settings and lessons learned for future adoption and scale up.*	Chapters 3-10	This report consolidates the work done in Task 2.2 Helsinki Living Lab implementation. The demonstration consists of the three piloting sprints including autonomous last mile delivery vehicles, cargo bikes, and a microhub implementation. The key component is the strong collaboration between different logistics operators and the use of zero-emission vehicles. The report also details collaborative efforts with local authorities and businesses, identifying challenges and strategies for transitioning to PI-enabled last-mile deliveries. It provides in-depth specifications for piloting operations, digitalization needs, and infrastructure setup. Additionally, the report covers fleet characteristics, user experiences for all stakeholders, Living Lab Digital Twin models, and optimization algorithms. A comprehensive implementation plan, operational data, key performance indicators, and lessons learned, and results have been included to facilitate replication and expansion.
TASK			
Task 2.2 Helsinki Living Lab Implementation	*The goal of the Helsinki site is to demonstrate innovations and new services and assess how ADVs can be used for the last mile delivery. The LL stakeholders will collect requirements, design user stories, develop DT models and a roll out plan to manage the LL implementation in real life settings. Authorization of ADVs in collaboration with local authorities is a first key step. The implementation plan will detail the specific actions and will define the operational area and timeframe. LMAD will adapt the ADVs and their management platform for the scope of the operational use-case. HELS/FVH will elaborate delegation of rights between recipients and couriers. The LL will explore alternative delivery modes and use-cases: fixed route of robot with fixed schedule, on-demand delivery, secondary pickup option for missed delivery. LMAD will*	Chapters 3-10	Chapter 3 describes the operational zones, vision and challenges, the context and background of the operations. Chapter 4 dives deeper into the operations by describing the iteratively designed use cases thoroughly in line with the Physical Internet concept. It also describes the collaboration between URBANE and DISCO project. Chapters 5 and 6 map the involved stakeholders and the relevant policies and analysis at different levels. Chapter 7 includes the timeline and detailed steps taken to implement the piloting operations in Helsinki LL. Chapter 8 presents the infrastructure, developed tools and models, Digital Twin platform and the Impact Assessment Radar. The data for chosen KPIs are presented in chapter 9. After which, the lessons learned and recommendations for

adapt frequency and location of virtual pick-up points based on measured and predicted volumes to various parts of the operational area. The LL will also explore dynamic loading and un-loading between couriers and robots and develop DT-based simulations to evaluate first-mile (returns and reverse logistics), returns from recipients (C2B), new package sending from customers in collaboration with local businesses supporting shipment sending, pickups from local businesses (B2B). DT models will be developed to experiment with operational zone parameters (sidewalk properties like width, steepness, surface; bike path and car road crossings; pedestrian density; number of competing pick-up points and location;), residential building parameters (high-rise vs. mid-rise vs. sub-urban; main entrance access;), volumes of parcels going to the area, parcel types, number of safety operators needed per number of robots etc. For real world measurements data will be recorded by the robot (3D map of the operating zone, meteorological and air quality data, telemetry data on movements, speed, and other environmental measurements).

future development are described in chapter 10.

1.3 Deliverable overview and Report Structure

The deliverable is structured as follows:

- Chapter 2 focuses on data collection and analysis for Helsinki demonstrator.
- Chapter 3 is devoted to analyzing the Living Lab set up, including context, local plans and key initiatives and vision and challenges of the LL.
- Chapter 4 presents the specific use case implemented in the LL in line with Physical Internet concept and the collaboration with the DISCO project.
- Chapter 5 takes a closer look at stakeholders and their role.
- Chapter 6 focuses on the most relevant policies and regulations structured according to the competent authority.
- Chapter 7 analyzes the implementation activities of the pilot, including the timeline and LL trial set up and preparation.
- Chapter 8 presents the physical and digital infrastructure of the Living Lab and on the models and tools developed within URBANE according to Helsinki LL needs and specificities.
- Chapter 9 is on the evaluation/impact assessment including the identified KPIs for Helsinki LL use case. The final values and analysis have been reported in D2.1 Validation report
- Chapter 10 concludes with lessons learnt and results both at process and finalization stage level.

2. Data collection and analysis

Data collection is the process of gathering information for research or analysis. In URBANE WP2, the purposes are to I) perform a mapping of stakeholders in the different LLs, generating an overview of their perspectives on the LL innovations, ii) to assess the effectiveness and the sustainability impact of the URBANE LL innovations, iii) identify the potential or actual barriers/enablers to uptake, iii) assess the transferability potential of the last mile solutions. For these purposes, different methods of data collection were used in URBANE, depending on the resources available to each LL. They included desk research, qualitative governance analysis, and interest mapping through interviews, and survey-based public perception feedback data. These data were collected in each LL scoping document – demonstrator (*D2.2, D2.3, D2.4, D2.5*) and then assessed and validated in *D2.1 Validation Report*.

The adopted methods in this document are the following:

- **Stakeholder mapping:** the process of identifying and categorizing individuals or organizations that are impacted by or interested in a project. This involves creating an overview that lists relevant entities and groups them accordingly.
- **Desk research:** collecting information from existing sources such as the LL's own databases, books, articles, reports, and online resources, including SULPs. As most of these documents were in the LL's native language, each Living Lab contributed to this process by providing English translations of their findings.
- **Qualitative governance analysis:** examination of how decisions are made, and power is distributed within an organization or community.
- **Survey-based public perception feedback data:** gathering information about people's perceptions, attitudes, and opinions on a specific topic. While some LLs have incorporated regular surveys into their operations, others may choose to conduct surveys specifically for the URBANE project.
- **T3.2 Structured Datasheets** (xls. format): template and guidelines for selection and calculation of KPIs, accompanied by general guidelines on the use of sheets and by descriptions, units of measurement, target group, and calculation methodology for each KPI.
- **BPMN diagram of the AS-IS and TO-BE situation:** description of the process as it occurs before the implementation of the solution and during pilot execution.

Data collection was performed under the coordination of ITL with the assistance of NORCE and FIT Consulting (WP3 leader), who developed the methods and followed and guided LLs in the implementation. The same methodology will be transferred to the Wave 2 LLs.

3. Living Lab setup

3.1 Context – Local plans – Key initiatives

3.1.1 Location/City

The City of Helsinki (674 500 inhabitants) is the capital city located in the south of Finland. It serves as the central node for logistics purposes due to its great location combining motorways, harbors and airport facilities. Helsinki has 213.8 km^2, from which the city center covers only 2 km^2 area around the central railway station. The city center is dense and busy, which creates pressure to find sustainable and efficient solutions for urban logistics purposes.

The URBANE Helsinki piloting took place in 3 different locations in Helsinki. The pilot was divided into three sprints: the first sprint undertook its operations from May till August 2023 in the Kalasatama and Sörnäinen districts appr. 3,5 kilometres from the main railway station in Helsinki (ie. the city center). In Figure 2, the pilot sprint one area is marked with a circle in the upper right corner. The first sprint demonstrated how LMAD's ADV and DB Schenker's cargo bike were performing Business to Business (B2B) deliveries. The ADV and cargo bike were delivering tools from Würth Center Sörnäinen to nearby construction sites. During the said piloting sprint, Helsinki LL was collecting valuable insights on how the ADV's technical capabilities were meeting the requirements of construction site logistics and whether it would be a holistically sustainable use case in the future. Key findings were that construction workers might not be willing to order the tools using the ADV because they enjoy the break when picking up their tools themselves. However, increasing the service's visibility and accessibility might positively impact the volume over time.

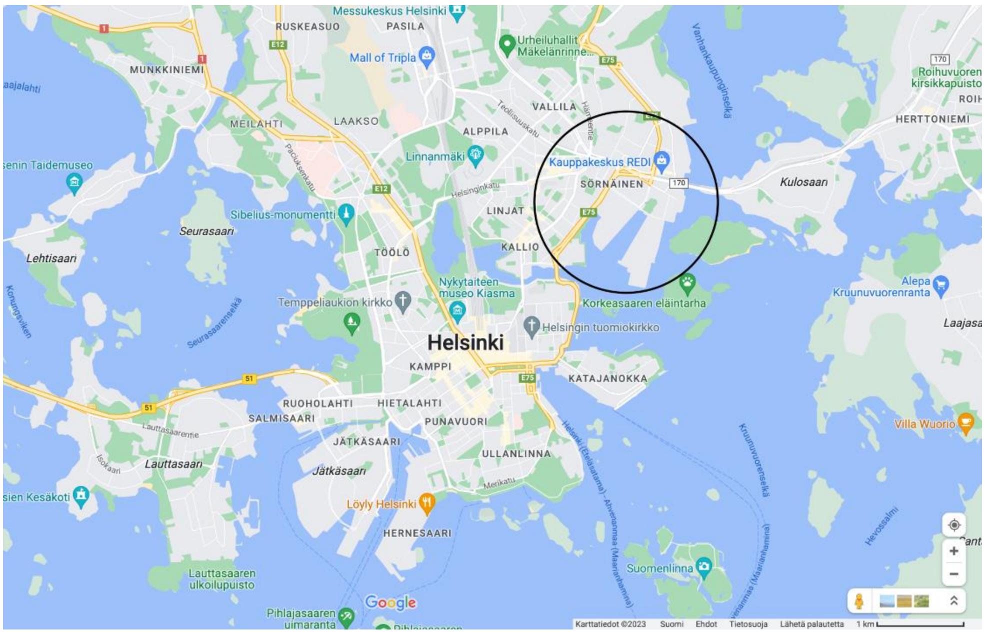

FIGURE 2 HELSINKI AND SÖRNÄINEN/KALASATAMA DISTRICTS

Based on the insights gathered from the sprint 1, Helsinki LL designed the next sprint. The sprint 2 of the Helsinki LL took place in the Q4 in 2023 in the Ruoholahti and Jätkäsaari region. The sprint 2 required the installation of a container. The container was utilised as a microhub for the ADV which executed last-mile deliveries for B2B and Business to Consumer (B2C) e-commerce parcels during the Christmas season. Getting permission to install a container in the city environment had numerous issues. Therefore, the ADV was placed into a heated parking hall where it could be recharged and stored securely before the installation of the container to Würth Center Jätkäsaari's private backyard. Enabling the ADV's B2C deliveries required the installation of a modular parcel locker system with an integrated PIN-code touchscreen and a client-facing SMS communication channel. Winter conditions added a layer of uncertainty due to cold weather affecting the motors and snow piles which made moving from one place to another more difficult. The volume was higher compared to the sprint 1 partly because of the Christmas season and partly caused by the successful marketing. Some issues during the sprint 2 were related to choosing the delivery option on the e-commerce website. The customer had to know the locations to which the ADV was delivering, which led to some cancelled deliveries.

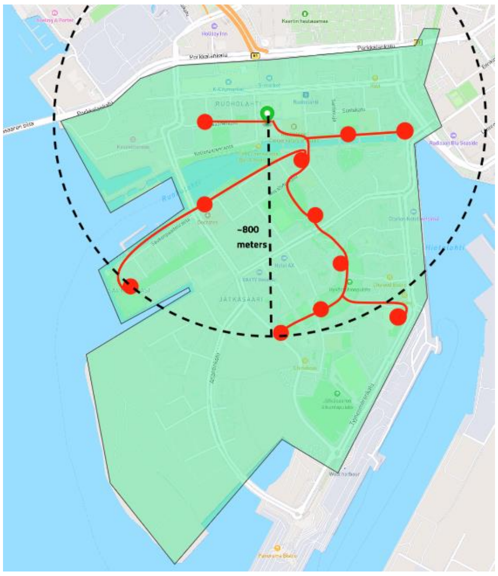

FIGURE 3 LMAD'S ADV'S RANGE FOR DELIVERIES

The last sprint 3 took place from May till July in 2024. URBANE joined forces with DISCO for the sprint 3 to utilize a pre-existing microhub as a homebase for the ADVs, cargo bikes and a service point for the residents in Helsinki. DISCO[1] (Data-driven, Integrated, Syncromodal, Collaborative and Optimised urban freight meta model for a new generation of urban logistics and planning with data sharing at European Living Labs) is a Horizon-funded project (GA 101103954) which demonstrates actions in low-utilized public spaces to bring them into use for city logistics and micro mobility purposes. Of all the DISCO partners, A2B is connected to URBANE activities and DB Schenker (DBS) acts as a stakeholder partner in DISCO. A2B is Finnish logistics service provider focusing on purely sustainable delivery vehicles like electric vans and

[1] https://discoprojecteu.com/

cargo bikes. Collaboration with DISCO project is defined in detail in chapter 4.5. The location for the sprint 3 is defined in Figure 4. Finding the suitable location for the sprint 3 required scouting underground premises like parking halls and service tunnels along with pop-up facilities on the ground level which could accommodate a service point, potential locker system, storage space for ADVs and cargo bikes as well as an electricity outlet. Some potential areas were found but the terrain wasn't suitable for the ADV. Also, the permit process to use land owned by the city of Helsinki turned out to be the biggest blocker during the Helsinki operations. Finally, a private real estate company Antilooppi rented their premises inside the shopping center in Ruoholahti for the DISCO project which led to a close collaboration between DISCO and URBANE partners enabling successful consolidation of the logistics operators. Also, the potential collaboration with a crowdshipping company Fiuge was terminated after the technical integration between Fiuge's crowdshipping platform and DB Schenker's operating systems failed. The involvement of the crowdshipping company brought privacy issues which the logistics service providers were unable to resolve. The parcels these companies were delivering should always be stored in a place which is accessible by only a few people who have been granted the right to access. The idea of crowdshipping is to provide the opportunity for every registered driver to deliver parcels via the crowdshipping platform which makes it impossible to limit access to the shared space. Therefore, the role of Fiuge and crowdshipping was examined only on a theoretical level.

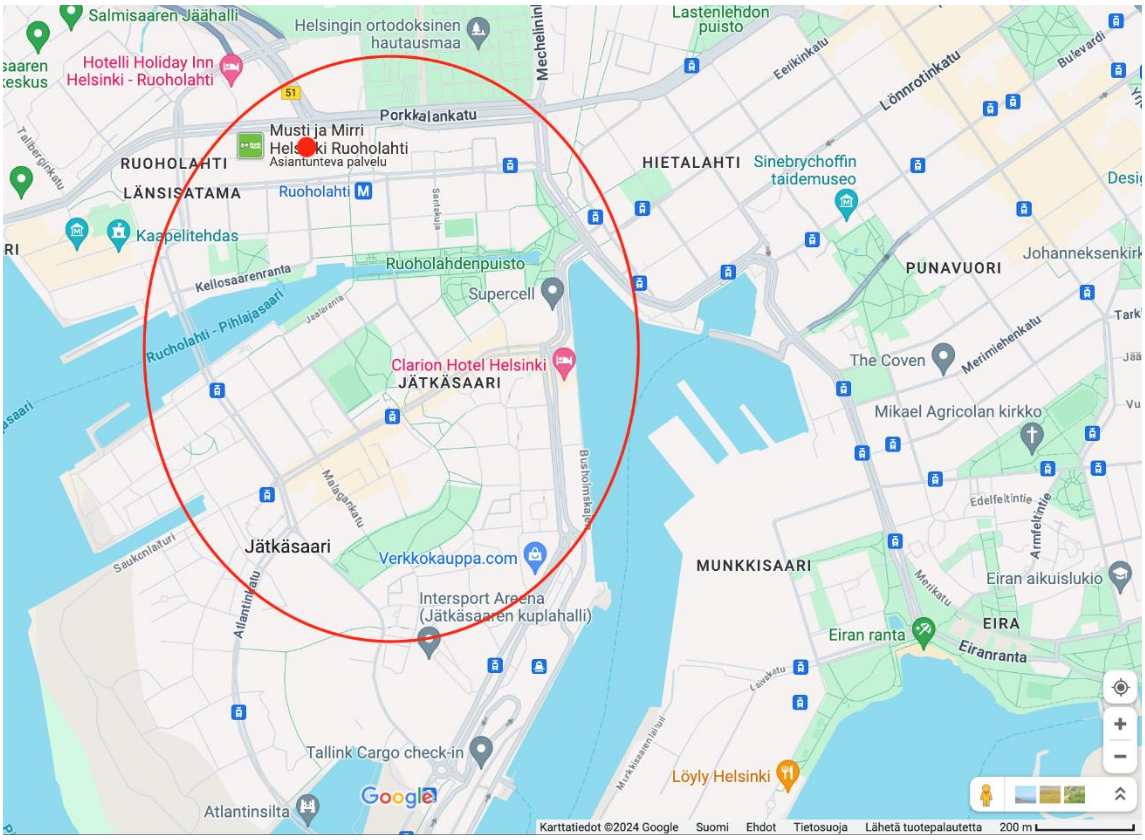

FIGURE 4 LMAD'S ADV'S RANGE FOR DELIVERIES DURING THE SPRINT 3 AND THE LOCATION OF THE MICROHUB

3.1.2 Context

The City of Helsinki aims to be carbon-neutral upon a city Carbon-Neutral 2030 Action Plan, towards low-emission deliveries. The inner-city areas delivery vehicles often stop inconveniently (e.g., driveways and sidewalks), increasing congestion, emissions and harming safety risks. The delivery vehicles (67% trucks, 20% combined vehicles, and 13% vans) are often too big to circulate in narrow streets. Unloading or drop-off spaces are often missing or occupied near the customers. Strategic goals promote walking and cycling over cars which lead to difficulties to get support for implementing logistic innovations, even though carbon neutrality targets could be achieved in logistics and transportation industry more easily than in many other fields. Therefore, URBANE Helsinki Living Lab aimed at promoting better quality logistics services for the residents, safer environment to move around the city, and less vans executing last-mile deliveries, simultaneously replacing conventional combustion engine vans with electric vehicles like autonomous delivery robots, cargo bikes and electric vans.

3.1.3 BPMN Diagram of the AS-IS situation

A unique aspect of Helsinki Living Lab operations was an iterative approach of the piloting activities. Helsinki LL divided the operation into three different piloting sprints from which the first sprint had different BPMN AS-IS situation compared to the second and third sprint. The biggest difference is the B2B and B2C deliveries meaning that the first pilot was intended to increase the service level for business deliveries while as the second and third were focusing on increasing the service level and quality for the residents and normal consumers. The differences are visually described as follows.

AS-IS scenario for the sprint 1

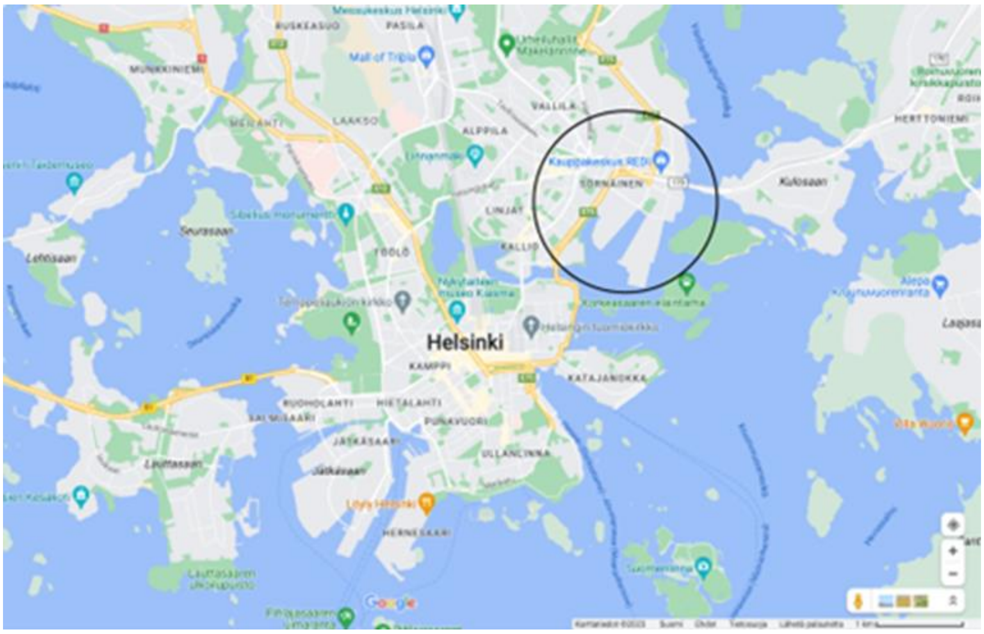

FIGURE 5 HELSINKI AND SÖRNÄINEN/KALASATAMA DISTRICTS

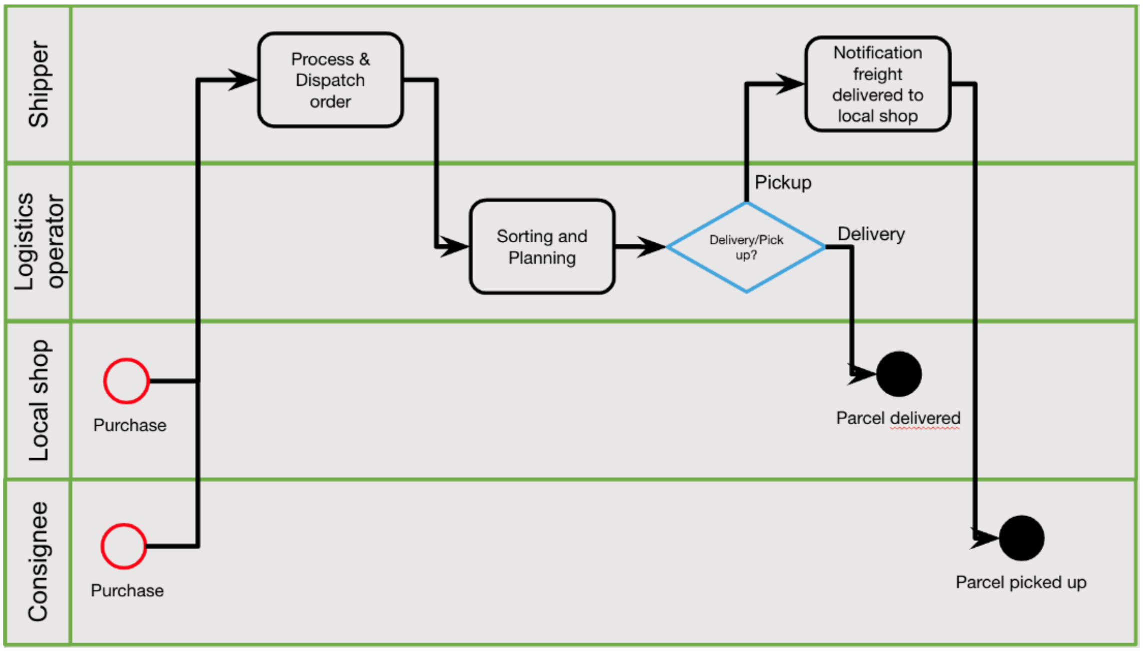

FIGURE 6 THE BPMN DIAGRAM OF THE "AS-IS" SITUATION FOR THE SPRINT 1 USE CASE.

Description of the AS-IS process:

- Customer makes the order through a webstore
- Order created and delivered to the Transport Management System (TMS) and assigned to a vehicle
- Pickup and transport to the local shop/terminal (optional consolidation)
- Pre-advisory notification call is made to the consignee before the delivery is done

AS-IS scenario for the sprint 2 and 3

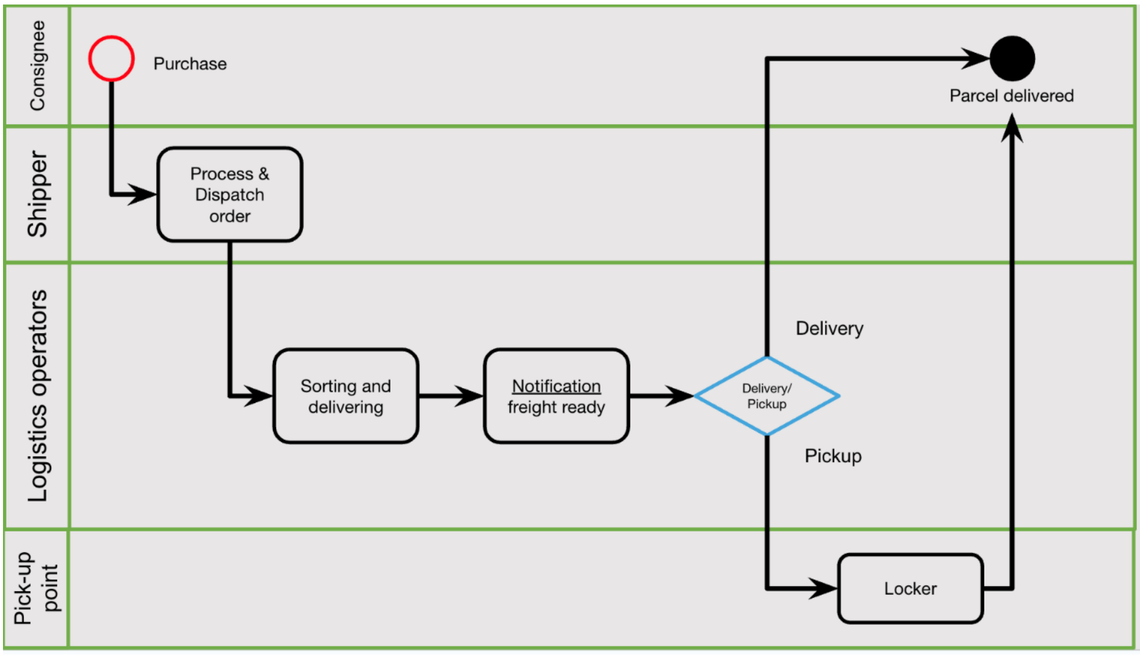

FIGURE 7 THE BPMN DIAGRAM OF THE "AS-IS" SITUATION FOR THE SPRINT 2 AND 3 USE CASES.

Description of the AS-IS process

- Customer makes the order through a webstore
- Order created and delivered to the TMS and assigned to a vehicle
- Transport to the locker for pickup or directly the end customer
- Pre-advisory notification call is made to the consignee before the delivery is done or when the parcel is ready to be picked up

3.1.4 Governance and Business models

Omnichannel logistics has become widely popular in the retail industry. Multiple companies such as IKEA have implemented their Click & Collect type of business model in which the customers can choose the products from the web store and collect them from the local pick-up point. This allows flexibility in the service and thus increases the customer experience. Logistics in Helsinki is widely relying on parcel locker systems that can be found in almost any shopping centers. Locker systems allow logistics operators to optimize the delivery routes and schedule conveniently because they are not dependent on the customer. A resident survey executed in Helsinki during the sprint 2024 for the URBANE operations and impact assessment showed that the vast majority of the residents have adopted the usage of the parcel locker systems and perceive them as the preferred way to get their parcels. This shows that the parcel locker systems are here to stay and will be a competitive and sustainable way for smaller parcels' last-mile logistics.

Crowd sourcing has been an increasing trend when a Finnish-based company Wolt started to distribute food using crowd shipping model. Crowd shipping enables faster on-demand deliveries. Initially, Helsinki LL aimed at onboarding a crowd shipping company to the consolidation microhub but during the process it became evident that crowd shipping creates privacy issues for other logistics companies acting under strict policies regarding the access to their customers' parcels. Honoring the participation of the actual partners in URBANE Helsinki LL operations it was clear that crowd shipping needed to be left out of the scope. Therefore, Helsinki LL was not able to pilot how leveraging the power of crowd shipping would increase the service level for residents or businesses in urban logistics. However, it would be interesting for future research.

3.1.5 Supporting market-based measures

Finland doesn't have road pricing or congestion charging even though there has been public discussion about them. The recent public discussion has been around low- and no-emission zones which could potentially be implemented in the city of Helsinki. However, this requires active participation and involvement of a variety of different stakeholders which means that it will be an extremely time-consuming decision-making process.

Some companies have been taking action towards sustainable logistics to be the forerunners when and if the potential low-emission zone will be eventually implemented in the city center. This will create a competitive advantage for them and potentially a new business when these operators can manage and deliver the last leg of the bigger logistics operators whose fleet is not yet fully sustainable.

3.2 Vision and challenge to be addressed in URBANE

3.2.1 LL Objectives

The objectives of the Helsinki Living Lab are as follows:

1) Piloting innovative and sustainable modes of multimodal last-mile deliveries;

2) Testing B2B and B2C deliveries with a range of goods and an ADV in different areas.

3) Testing the concept of consolidation microhub in the city with a range of innovative last-mile delivery (LMD) options for the B2B and B2C deliveries in densely populated areas while collecting valuable data for modelling activities

Main innovations are

a) safety and efficiency of remote supervision and operation of ADVs;

b) complex delivery models (from fixed route of the robot to on-demand and dynamic options);

c) ADV-based logistics;

d) micro-hubs as the storage place for robot(s), parcels, or other sustainable modes (cargo-bikes), but also possibly for customer service (pick-up and drop-off points and/or locker systems for parcel pick-up).

e) exploring the use of underused spaces like parking halls, service tunnels or mobile containers for last-mile logistics.

f) improving customer service by introducing novel methods of deliveries with on-demand functionalities.

g) testing the integration of multiple IT systems into one operational concept in city logistics.

The demonstration includes two autonomous vehicles in total from Twinswheel (figure 8) with two types of different modules: two robots using integrated parcel locker systems and one pilot using a storage box with a shelf. The demonstration also involves two cargo bikes.

FIGURE 8 TWINSWHEEL'S CITHY L DROID

3.2.2 Specific vision & ambition and the LL Problem/Challenge to be addressed by URBANE

Description of task 2.2. is as follows: "The goal of the Helsinki pilot site is to demonstrate innovations and new services and assess how ADVs can be used for the last mile delivery." Helsinki is contributing to global climate goals by finding novel low carbon solutions for urban logistics, especially last mile, which is usually the most polluting part of the traditional delivery chain. Helsinki is supporting open and transparent collaboration between various stakeholders which became one of the cornerstones in the Helsinki LL operations. While tackling the carbon neutrality goals, Helsinki is also aiming at constantly providing better services for its residents by collecting valuable insights regarding their needs and wishes. Based on these targets, Helsinki LL drafted a set of actions that our operations include:

- to test if the number of vans and trucks can be decreased in urban areas
- to test the use of ADVs in last-mile logistics
- to test the concept of microhubs in last-mile logistics
- to offer flexible and innovative delivery services for the citizens and companies

- to support the City of Helsinki's strategic objectives of emissions reductions and innovative logistics solutions
- to demonstrate collaboration between major logistics operator and start-ups

Environmental impact: Helsinki Living Lab piloted whether LEVs and cargo bikes can reduce the number of kilometers driven by combustion engine vehicles in the city. It also contributes to the high-level climate neutrality targets.

Social impact: the Helsinki pilot explores if the use of innovative delivery methods and microhubs can create better services for citizens and businesses. Also, how accessible the services are and how high is the user acceptance and satisfaction level. Simultaneously, it aims at making the city safer for its residents.

Economic impact: the Helsinki pilot explores if the use of innovative delivery methods and microhubs can create viable business models for future use in LMD. Cost sharing would potentially be an incentive to get most of the logistics operators on board when implementing sustainable solutions. Demonstration of a customer-centric business model tackling the fast-changing consumer buying patterns and obstacles in guaranteeing smooth business operations. The delivery model may further reduce carbon footprint, and this aspect of piloting will be explored further.

The demonstration also allowed for standardized and modular load units placing multiple parcels inside containers at the sorting terminal and then bringing them to city hubs, where last mile delivery vehicles pick them up. This model ensures quick and reliable transfer of goods from the feeder vehicle to the last mile delivery one. In addition, it allows mixing goods from several carriers in the same feeder vehicle and in the same city hub and ensures interoperability of different transportation systems and modes. This model also reduces the amount of packaging waste.

Contribution to the overall project: the Helsinki pilot contributed to the data collection and Innovation Transferability Platform and to the research on acceptability of innovative services in the logistics field. The objective was also to highlight aspects of urban logistics that would require future research.

FIGURE 9 CONCEPT OF MICROHUBS HAS BEEN TESTED IN HELSINKI IN EARLIER PROJECTS (SMUD AND LMAD)

3.2.3 Regulatory framework and regulations

To execute the operations in Helsinki LL, the ADVs must apply for special permits to run legally in the urban environment. The process of applying for these permits is described in detail in subchapter 7.2. The regulatory framework for running autonomous vehicles is still a work in progress [1] and currently there is plenty of research done in the field of autonomous mobility. The operations require a person in charge of traffic monitoring, so the ADV cannot run without supervision. However, the ADV can still use the fully autonomous mode.

Another regulatory aspect affecting the operations in Helsinki is the land usage. Charging and storing the ADVs requires physical infrastructure, a container or a space in a location which is easily accessible by vans, and which has electricity. This means that the location must be either owned by the private sector or then rented from the city of Helsinki. The process of renting the land from the city of Helsinki is hierarchical and requires long processing times which affected the decision to choose private properties. There are no supportive regulations directing the usage of land in favor of sustainable initiatives which should be considered in the future if the city of Helsinki will commit to neutralizing the carbon emissions in the field of urban logistics.

Further analysis of the regulatory framework can be found in chapter 6.

4. Use cases

4.1 Use case 1

Twinswheel ADVs operated by LMAD were used for the last-mile deliveries of tools, materials and supplies from a construction material and supply shop in the Kalasatama/Sörnäinen district to construction sites nearby. The objective was to explore whether an on-demand autonomous delivery can facilitate the delivery of construction materials. The BPMN diagram of the "as is" situation for the sprint 1 use case.

4.1.1 BPMN diagram TO-BE situation for sprint/use case 1

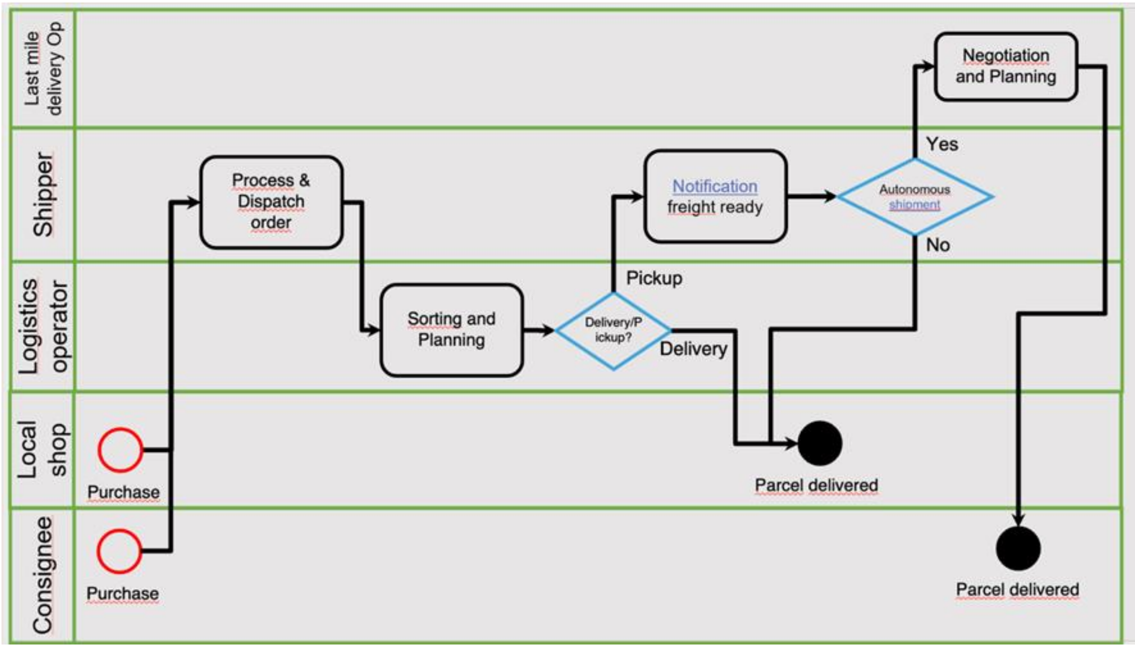

FIGURE 10 THE BPMN DIAGRAM OF THE "TO -BE" SITUATION FOR THE SPRINT 1 USE CASE

Description of the TO BE process:

- At the time of the purchase, the consignee or the local shop representative can optionally indicate whether the shipment is to be done by an autonomous vehicle
- The order data is translated into a shipment order for the logistics operator, then a driver picks up the shipment from the shipper and delivers it to local shop

- The data of the shipments that are to be delivered by an autonomous vehicle, are registered in the last mile operator system for consignee negotiation (time and place) and delivery planning
- Parcels are loaded to the autonomous vehicle ahead of a delivery mission, and finally parcels are delivered

Purchase

- The end customer (consignee) orders a product from the shipper's portal. Product(s) are sorted, packaged and labelled, ready for delivery. An automated shipment order is created and sent en masse to the logistics operator where the data (EDI) is transformed into a singular shipment.

Process and dispatching

- Transport order is assigned to a specific vehicle and sent to a PDA device that the driver uses to handle shipment information. The driver executes the pickup according to the order information from the shipper premises. The shipment is then delivered either to the sorting centre of the logistics operator or directly to the local shop.

Sorting and planning

- If the shipment is not delivered directly to the consignee, it is sorted in the logistics operator's terminal after the initial pickup by postal codes once, and then assigned to a specific delivery vehicle electronically. The driver of said vehicle receives notification in their PDA device of the delivery and loads the shipment.

Delivery / pick-up

- Based on the consignee's preference, if the consignee chooses to pick up the shipment from the local shop, it is delivered to the local shop. If the consignee chooses delivery, a pre-advice call is made to the consignee, and delivers straight to the consignee.

Notification freight ready

- After the shipment has been delivered to the local shop, a notification is sent to the shipper who then sends a notification to the consignee that the shipment is ready for pickup.
- If the shipment is delivered after being sorted in the logistics operator's terminal, a preadvisory call is made to the consignee before the delivery.

Autonomous shipment

- When receiving the parcels in the local shop, the local staff registers those parcels' data in the last mile operator's system that are to be delivered with an autonomous vehicle. The registration can happen manually or automated.
- Registering packages triggers an automated process of Negotiation and Planning.
- The parcels that are not considered for autonomous delivery follow the regular pickup process of the local shop.

Negotiation and planning

- Once delivery data is registered to the last mile operator platform, the consignee receives automated communication from the last mile operator, asking for their delivery preferences for delivery time and place.
- Based on the response information, the last mile operator platform plans the delivery, creates an autonomous delivery mission or adds the new parcel to an already existing one where the new delivery fits, and allocates the parcel to a vehicle's compartment where there is free capacity.
- The consignee also gets confirmation on when and where their parcel will be delivered. The delivery mission is re-optimized upon new parcels being added to it.

Parcel delivered

- The local shop's staff get a warning notification before an autonomous delivery mission is due to start, with the information about the parcels to be loaded. The vehicle waits at the local shop for loading.
- Upon successful loading of the parcels, the autonomous vehicle receives its optimized delivery mission from the last mile operator's platform and starts its delivery mission. The consignee(s) of the next delivery address get an automated Estimated Time of Arrival message, with pickup instructions.

- When the vehicle arrives, it waits for the consignee to pick up their parcel(s), then continues and delivers all parcels loaded, then returns to the local shop.

4.2 Use case 2

The Helsinki LL established a microhub in the city center in order to explore whether the number of vehicles can be reduced, and last-mile deliveries facilitated in city centers that are hard to reach and with limited access to parking. The microhub supported operations executed by an ADV which has an integrated modular parcel locker system.

4.2.1 BPMN diagram TO-BE situation for sprint/use case 2

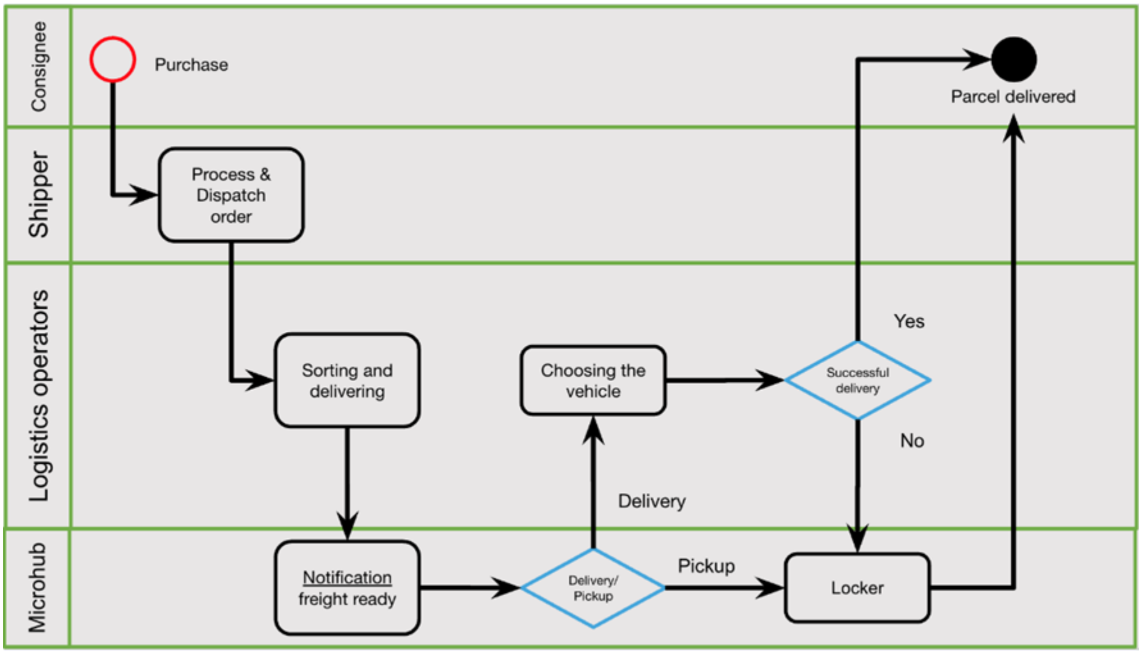

FIGURE 11 THE BPMN DIAGRAM OF THE "TO BE" SITUATION FOR THE SPRINT 2 USE CASE

Purchase

- The end customer (consignee) orders a product from the shipper's portal. Product(s) are sorted, packaged and labelled, ready for delivery. An automated shipment order is created and sent en masse to the logistics operator where the data (EDI) is transformed into a singular shipment.

Process and dispatching

- Transport order is assigned to a specific vehicle and sent to a PDA device that the driver uses to handle shipment information. The driver executes the pickup according to the order information from the shipper premises. The shipment is then delivered either to the sorting center of the logistics operator or directly to the locker located in the microhub.

Sorting and planning

- If the shipment is not delivered directly to the consignee, it is sorted in the logistics operator's terminal after the initial pickup by postal codes once, and then assigned to a specific delivery vehicle electronically. The driver of said vehicle receives notification in their PDA device of the delivery and loads the shipment.

Delivery / pick-up

- Based on the consignee's preference, if the consignee chooses to pick up the shipment from the locker, it is delivered to the microhub. If the consignee chooses delivery, a pre-advice call is made to the consignee and delivers straight to the consignee.

Choosing the vehicle

- Based on the optimized route planning, the vehicle will be chosen from the consolidation hub's fleet regardless of the company which is operating the vehicle. In other words, the parcels belong to a pool from which they are delivered using the optimized routes which decreases delivery time and unnecessary deliveries in general.

Successful delivery

- Successful delivery means that the parcel is delivered to the consignee's delivery address. Otherwise, the parcel will be delivered into the locker system located in the microhub.

4.3 Use case 3

The Helsinki LL established a microhub connecting an ecosystem of different stakeholders providing a variety of services ranging from first-mile customer service to last-mile deliveries. Detailed interventions of the use case were designed iteratively in collaboration with the DISCO project. The goal was to contribute to physical internet by enhancing the collaboration of the ecosystem using a data-driven microhub. This would ensure efficient enhancement of mobility services, especially last-mile deliveries. In addition, it would enable fusing and managing the physical, digital, virtual, emerging technologies, data, people, companies, ideas and business models in a novel way.

4.3.1 BPMN diagram TO-BE situation for sprint/use case 3

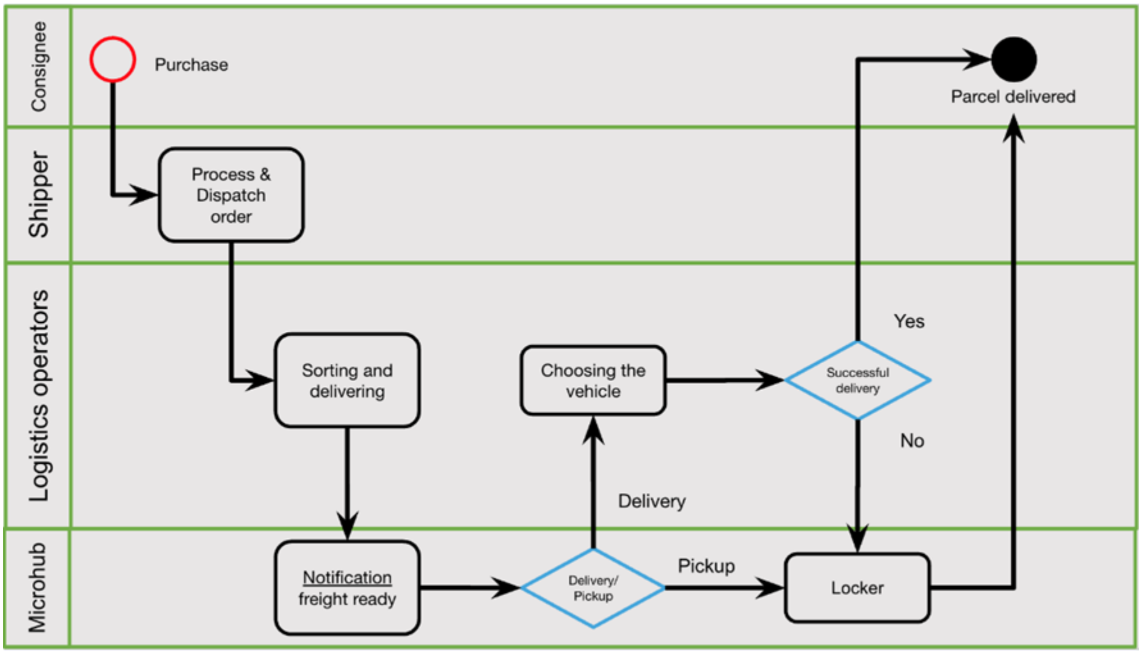

FIGURE 12 THE BPMN DIAGRAM OF THE "TO BE" SITUATION FOR THE SPRINT 3 USE CASE

Purchase

- The end customer (consignee) orders a product from the shipper's portal. Product(s) are sorted, packaged and labelled, ready for delivery. An automated shipment order is created and sent en masse to the logistics operator where the data (EDI) is transformed into a singular shipment.

Process and dispatching

- Transport order is assigned to a specific vehicle and sent to a PDA device that the driver uses to handle shipment information. The driver executes the pickup according to the order information from the shipper premises. The shipment is then delivered either to the sorting center of the logistics operator or directly to the locker located in the microhub.

Sorting and planning

- If the shipment is not delivered directly to the consignee, it is sorted in the logistics operator's terminal after the initial pickup by postal codes once, and then assigned to a specific delivery vehicle electronically. The driver of said vehicle receives notification in their PDA device of the delivery and loads the shipment.

Delivery / pick-up

- Based on the consignee's preference, if the consignee chooses to pick up the shipment from the locker, it is delivered to the microhub. If the consignee chooses delivery, a pre-advice call is made to the consignee, and delivers straight to the consignee.

Choosing the vehicle

- Based on the optimized route planning, the vehicle will be chosen from the consolidation hub's fleet regardless of the company which is operating the vehicle. In other words, the parcels belong to a pool from which they are delivered using the optimized routes which decreases delivery time and unnecessary deliveries in general.

Successful delivery

- Successful delivery means that the parcel is delivered to the consignee's delivery address. Otherwise, the parcel will be delivered to DB Schenker's official pick-up point in R-Kioski.

4.4 Interventions per use case done in the scope of URBANE

During sprint 1, the main use-case was delivery of construction tools and supplies using an ADV and a cargo-bike. The introduction of an on-demand delivery service with such innovative and no-emission modalities was the main intervention of this pilot sprint, offering an alternative to the original method of construction workers commuting back and forth between constructions sites in a crowded urban area, using heavy and polluting diesel vehicles.

Further interventions of the sprint 1 done in the scope of URBANE:

- Installing an electrified container for storing/charging the ADV
- Integrating a mono-compartment on the ADV serving larger shipments to construction sites
- Marketing the service sufficiently to provide guidance for the consumer
- Contributing to the physical internet by enabling timely and location-wise flexible, consumer-driven, delivery service of e-commerce parcels
- Trialing the impact of pre-determined pick-up locations and timeslots for the consumer satisfaction
- Also, URBANE operations followed Isaac Asimov's "Three laws of robotics" in the context of physical internet. The PI-inspired urban logistics operational models and strategic priorities are described in detail in D1.1. URBANE framework for optimised green last mile operations.

During pilot sprint 2, the main intervention was the introduction of a more flexible and personal delivery service for end consumers, using an ADV with a modular compartment solution. The LMAD platform was integrated with the parcel management system of DB Schenker, automating the parcel information exchange to enable a smooth B2C parcel delivery service, and personalization of communication to the end consumers. Also, during sprint 2, the ADV was tested in a very challenging environment, given the timing of the sprint which took place in November and December, during which months there was exceptionally large amount of snow in Helsinki. Valuable learnings were collected on the possible issues and challenges for future developments of ADVs in such operating domains.

Further interventions of the sprint 2 done in the scope of URBANE:

- Renting and installing an electrified container for storing/charging the ADV
- Renting a lot from a parking hall for the ADV to start the operations before the container was installed.
- Integrating a modular parcel locker system into the ADV
- Marketing the service sufficiently to provide guidance for the consumer
- Contributing to the physical internet by enabling timely and location-wise flexible, consumer-driven, delivery service of e-commerce parcels
- Trialing the impact of pre-determined pick-up locations and timeslots for the consumer satisfaction
- Also, URBANE operations followed Isaac Asimov's "Three laws of robotics" in the context of physical internet

In sprint 3, the partners in the Helsinki Living Lab extended on the use-case of sprint 2. The main intervention was adding another ADV and a cargo bike to serve end consumers and business customers with an on-demand, flexible and personalized delivery service. The data exchange interfaces have been extended and improved, to allow better communication to customers, and further integration with the URBANE platform have been developed, allowing a transparent and real-time interface between pilot operations and relevant digital tools and models used by other Work Package partners.

Further interventions of the sprint 3 done in the scope of URBANE:

- Using a space rented by DISCO for storing/charging the ADVs, and to store and sort parcels for daily delivery operations for both the ADVs and the cargo bikes
- Integrating and deploying a second medium sized ADV to form a fleet of 2 ADVs
- Integrating a modular parcel locker system into a smaller ADV
- Marketing the service sufficiently to provide guidance for the consumer
- Evaluating the customer satisfaction of a service point for first-mile deliveries inside the microhub
- Contributing to the physical internet by enabling timely and location-wise flexible, consumer-driven, delivery service of e-commerce parcels
- Trialing the impact of pre-determined pick-up locations and timeslots for the consumer satisfaction
- Also, URBANE operations followed Isaac Asimov’s “Three laws of robotics” in the context of physical internet

4.5 DISCO AND URBANE projects collaboration and synergies

DISCO and URBANE built a joint pilot from May till July 2024. Joining our forces with DISCO brought in a wider range of services for the residents, higher volume of parcels to distribute, the possibility to consolidate the parcels, and enhances the image of urban logistics in the city center. Multiple stakeholders increase the leverage when negotiating potential locations for operations, because there are more parties involved in the discussions. Also, the City of Helsinki aims at providing an equal possibility for every company to execute their urban logistics services. Therefore, the wider range of parties, even competitors, could join the microhub, the easier it gets for the City to support the activities. The joint pilot was done based on the lessons we have learned during last pilots in an iterative manner.

Some of the decisions done in collaboration with DISCO are as follows:

- Choosing the most suitable locations for the microhub and applying permits for the land usage
- Choosing the structure of the microhub meaning that there is only one light weight microhub compared to a network of microhubs in different locations

- Onboarding DHL as a stakeholder partner and defining their responsibilities
- Choosing the number of last-mile vehicles and how they are operating
- Developing a concept of a microhub in a series of workshops
- Planning the operations, how to operate, and how to consolidate the parcels between different companies
- Installing the microhub
- Directing the parcels into the microhub
- Executing the last-mile deliveries from the microhub using multiple last-mile vehicles

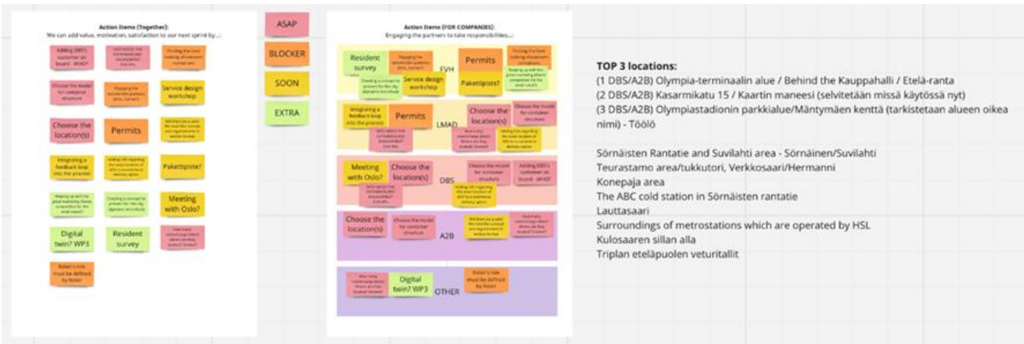

FIGURE 13 PICTURE OF THE SPRINT 3 PLANNING MEETING'S RESULTS.

Collaboration with DISCO was also crucial for Helsinki LL to be able to consolidate parcels between multiple logistics service providers because URBANE Helsinki LL has only one logistics service provider which can bring in volume. Therefore, important decisions were made together in workshops like presented in Figure 13. The goal was to design a piloting sprint which would satisfy the most important requirements each of the parties had. The division between the two project was done strictly according to the project plans meaning that URBANE partners were collecting data on multimodal last-mile deliveries while DISCO partners collected data on how the underutilized space could be harnessed for the logistics purposes. DISCO project rented the space for the operations and all costs related to the microhub as an infrastructure while URBANE partners covered their own costs of transporting the vehicles, implementing the software integrations to share deliveries, and executing the operations from the microhub to the end-customers. The location was chosen based on the volume and demand data of the participating logistics operators DB Schenker and A2B, keeping in mind the terrain which must be suitable for the ADVs. The volume was an important factor which we learned during the summer sprint 1 done in collaboration with Würth Center Sörnäinen. The volume from Würth was not sufficient for efficient LMD data collection. DHL and Forum Virium Helsinki were interested in a location that was visible for the residents in Helsinki to maximize the customers visiting the microhub. The Shopping center in Ruoholahti turned out to be a perfect location for the sprint 3 operations.

5. Stakeholders and their role

TABLE 2 LL STAKEHOLDERS AND ROLES

Stakeholder	Role	Internal(blank)/ External (X)	Objective
Users			
City authorities	Enabling the pilot activities in real urban environment and utilizing the results in future development of the city logistics		Enabling the utilization of new digital (and physical) solutions to better the service level and effectiveness of the city
Traficom	Licence (test plate) for driving the ADV in the urban environment	X	Results of the URBANE ADV pilots increases the level of practical knowledge on ADVs operating in real environment
Ministry of Transport	Utilizing the learnings of URBANE activities on strategical level	X	Results of the URBANE ADV pilots increases the level of practical knowledge on ADVs operating in real environment
Other cities	Utillizing the learnings of URBANE activities in developing local logistics services	X	Results of the URBANE ADV pilots increases the level of practical knowledge on ADVs operating in real environment
Last mile delivery providers			
Logistics operators: ex. DB Schenker	DB Schenker provides logistics knowledge and support in all phases to partners in Living Labs Helsinki. During the first pilot mainly logistics support (IT-infrastructure and planning) to LMAD in delivering last mile deliveries with its ADV's. During the following phases the role of DB Schenker grows as its logistics know- how is needed in planning and executing the microhub- concept in the city of Helsinki centre.		Objective of DB Schenker is to provide sufficient support to its LL-partners so that we as a collective are successful in the plans and objectives of the LL. .

Delivery companies	They will widen the number of different delivery modes. For example, adding crowdshipping as one of the delivery modes.	X	Piloting their solutions for last-mile deliveries.
Technical Providers			
LMAD	LMAD's role is to deploy its robot-agnostic platform during the pilot in public zones in Finland. LMAD will also interact with multiple relevant stakeholders to obtain the right to run longer pilots with autonomous robots on public sidewalks in Helsinki.		The goal of LMAD is to make robotic autonomous LMD more visible in urban environments. Generally speaking, the process involves repeated iterations to learn how the robots function, the social acceptance of various user groups, how the technology behaves in various environments, as well as to learn about different use cases while forging business partnerships.
TwinswHeel	Provides and maintains the robots for LMAD's operations.		Piloting their robots in different environment.
Others			
Citizens	Citizen participation is crucial for ensuring the positive attitude towards ADVs and faster deliveries. Also, it is important to make sure that citizens feel safe moving in the area around the microhub in case there are more vehicles in the chosen location.	X	Faster service, safe and pleasant environment.

6. Governance Analysis

6.1 Government dimensions

Local government policies and regulations are influencing the innovations rolled out in Helsinki. The urban environment has loading points which are marked with traffic signs and there should be an increase in these points based on feedback. Regarding the drop-off, parking restrictions especially in the inner city are aiding the logistics operations by providing easily accessible spaces for vans. Usage of sidewalks and bike lanes is restricted according to the Road Traffic Act (729/2018).

The Action Plan for City Logistics is guiding the process of designing new innovations in Helsinki LL due to its nature of advancing and supporting the development and testing of low-emission delivery alternatives and local delivery hubs. The leasing agreements are making the demonstration harder because the urban space which is meant for the residents is not easily given for logistics operations. For example, using underutilized marketplaces during November was impossible. Successful implementation of a microhub in the future requires a neutral private sector hub operator.

6.2 Policy context and motivation in Helsinki

Economic Policy Priorities 2022-2025

Carbon Neutral Helsinki Action Plan (2030) is steering the development of urban logistics towards sustainable and innovative solutions.

In addition, from the economic development point of view, the City of Helsinki Economic Policy Priorities (2022-2025) states that *"several external transformative powers influence the development of transport and logistics, the most significant being digitalisation and the need to reduce emissions. The city has an active role as an enabler of novel solutions and business innovations and as a promoter of the operating conditions of businesses, including accessibility."*

6.2.1 Regional government policies and regulations

Helsinki is planning to design low/no-emission zones in the city centre of Helsinki and if this would happen, we need to re-evaluate how it would affect the potential location of a microhub in the future.

6.2.2 National level government policies and regulations

The Road Traffic Act (729/2018). Enacted in Naantali on 10 August 2018. Ministry of Transport and Communications.

Using the ADV on a sidewalk required a special permit from Traficom (Finnish Transport and Communications Agency). Also, using the ADV in remote operation requires changes in the process.

Climate Act (423/2022). Enacted in Naantali and Helsinki on 10 June 2022. Ministry of the Environment. Relevant content: Finland should not be producing more than they are cutting the CO2-emissions till the year 2035. Also, the total emissions released into the atmosphere in the emissions trading and effort sharing sectors should be reduced by 60% compared to the baseline year 1990. These strict targets enable the green transition in logistics and last-mile deliveries. Replacing the traditional combustion engine vehicles with cargo bikes, electric vehicles and other sustainable modes of delivery will contribute positively to the overall goal of Climate Act.

In Finland, the regulation regarding piloting autonomous vehicles in real urban environment is enabling in nature. The organisation responsible for monitoring and developing regulation on autonomous vehicles in Finland is the Finnish Transport and Communications Agency Traficom. Traficom needs to be engaged in discussions regarding the current legal requirements and required official permits and certificates for the autonomous platform when planning any autonomous vehicles related testing or piloting activities in Finland.

Currently, the certificates needed (test plates, other permits) vary depending on the technical characteristics of the robot/vehicle in question. An autonomous delivery robot can, for example, be classified as a pedestrian-assistance vehicle that can operate on pedestrian/bicycle lanes with pedestrian rules if the max speed of the robot is limited to 15 km/h and the power of the robot is max. 1 kW.

However, If the vehicle is faster or it has an engine more powerful than 1 kW, it falls under the classification of L7e. In Finland, the vehicles classified as L7e are only allowed to be operated on car lanes. According to the current regulatory framework, vehicles classified as L7e are not legally allowed to be operated on pedestrian streets nor bicycling lanes. However, a temporary permit for operating on pedestrian and bicycle lanes (even with vehicles classified as L7e) is relatively easy to receive in Finland through negotiations with the municipality and the police administration (more information in chapter 3). In the Helsinki LL's sprint 1 the ADV runs on pedestrian lanes with a special permit.

Traficom has been collecting comments and opinions from the citizens and organizations in an online service Lausuntopalvelu which is maintained by the Ministry of Justice. Feedback is collected regarding the preparation of the new legislation for ADVs in Finland. The draft proposal suggests an additional vehicle category referred as light autonomous delivery vehicle

Testing autonomous robots in public spaces in the real urban environment needs permission from the City of Helsinki to utilize public street space for piloting purposes. In addition, as the authority in charge of monitoring traffic safety in Finland, the National Police Board of Finland needs to be informed on the upcoming pilot operations. In practice, the City grants permit for using the public space as a work area for different types of activities. When using a street or, e.g., a park as a testing area for the autonomous solution, a notification about the use of the area must be submitted to the City. In addition to the notification application, the City requires a temporary traffic arrangement plan if the testing affects other street users in any way.

6.2.3 EU-level policies and regulations

Helsinki LL has been developed in line with the UN's Sustainable Development Goals. No SULP and SUMP implementation is taking place in Helsinki.

7. URBANE LL implementation

7.1 Timeline

TABLE 3 TIMELINE FOR THE HELSINKI LL ACTIVITIES

Sprint 1	Preparation												
	Execution												
Sprint 2	Preparation												
2024		January	February	March	April	May	June	July	August	September	October	November	December
Sprint 3	Preparation												
	Execution												

Helsinki LL started to plan its operations at the beginning of URBANE project in September 2022. However, the timeline for actual preparation of the operations differs from the overall project planning. Autumn 2022 was mostly spent planning the overall execution of the operations, meaning it included the structure of sprint-based design. The actual preparation of the first sprint started in January 2023. The detailed timeline and structure of the sprints is as follows:

Pilot sprint 1: LMAD solution and Twinswheel ADV tested in Kalasatama from May till August in 2023.

Pilot sprint 2: microhub concept in Ruoholahti from October till December in 2023.

Pilot sprint 3: larger microhub concept and collaboration in Ruoholahti from May till July in 2024.

7.2 LL trial set up and preparation

Helsinki LL operations included three separate piloting sprints which preparation and execution have been described here in detail. In addition to the pilot operations, Helsinki LL has conducted a public perception survey in collaboration with the university of Hanken which results can be found below.

Sprint 1 Pilot Summary:

- Delivery: The Twinswheel robot, named HeRo, arrived in Helsinki at the end of March 2023.
- Permissions: Necessary approvals were obtained from the Finnish Transport and Communication Agency (Traficom).
- Insurance: LMAD covered insurance for the robot itself and any potential third-party damage during the initial pilot phase.
- Pilot Launch: The pilot started off in early May.
- Risk Assessment: Potential risks were identified and addressed before deployment.

- Testing Phase: HeRo underwent testing in the Kalasatama district from May to the end of August.
- Delivery Frequency: HeRo averaged between 1 and 10 deliveries per day. The cargo bike had higher volume during the testing period.
- Volume: There was no significant increase in delivery volume from Würth during the pilot period.
- Feedback & Improvement: The team gathered feedback and explored potential improvements for parcel distribution processes in the second phase of the pilot.
- International Interest: HeRo attracted visitors interested in technology from various countries.
- Pilot Extension: Due to low delivery volume during the summer holidays, the pilot period was extended until the end of August.
- Wrap-up: A retrospective meeting in September provided valuable insights for future pilot design. HeRo departed the Würth Center on August 25th, followed by DB Schenker's container leaving the site before the end of August.

The sprint 2 pilot summary:

- The location of the sprint 2's microhub was in the backyard of Würth Center Jätkäsaari in Jätkäsaari. The location was decided with DISCO partners from four potential locations written down in a draft document. The initial plan to pilot in Itämerentori was changed due to an unexpected electricity issue. The ADV was stored and charged in the heated parking hall under Ruoholahdentori marketplace in Ruoholahti before the container was installed in Jätkäsaari. The container was rented for the purpose of storing the parcels and charging the ADV during the operations.
- TwinswHeel shipped a modular parcel locker system for the ADV operated by LMAD and it was already installed and tested during the end of pilot 1 in Kalasatama. This locker system provided an opportunity to use the ADV for B2C deliveries during the sprint 2.
- The ADV was running operations in Ruoholahti from November till the end of December. The ADV was in a warm parking hall under the initial planned location of the microhub and it was delivering DB Schenker's parcels. After the container was installed, the ADV was transferred to Würth Center Jätkäsaari.
- The sprint 2 got a massive amount of media visibility which ended up enhancing the image of the ADVs in general.

The sprint 3 pilot summary:

- Onboarding DHL as an external stakeholder of the sprint 3 went very well. They implemented their own manned service point for the residents at their own expense. The opening hours of DHL's service point were also the opening hours of the microhub for people to visit it and meet the robots.
- Negotiating with Helsinki city to provide us guidance concerning the suitable locations was more complicated than expected. After months of scouting for potential locations, Helsinki LL ended up using a private property which DISCO project rented from a real estate company called Antilooppi. Collaboration enabled the opportunity to demonstrate the power of consolidation between multiple LSPs.
- Planning the responsibilities and drafting an overall plan of the operations executed during the sprint 3 was mostly done in collaboration with both URBANE and DISCO partners in face-to-face workshops. This ensured transparency and clarity regarding the responsibilities.
- Designing the microhub's visual elements and marketing the operations was very successful, because it created a brand around sustainable last-mile logistics and promoted urban logistics as a fun and fresh thing compared to the conventional way of perceiving logistics.
- Sprint 3 provided plenty of data for the WP3 modelling activities and KPIs even though the overall volume of the ADVs was quite low. The cargo bike from DB Schenker delivered a lot more parcels.

Forum Virium Helsinki conducted a public perception survey for the residents in Helsinki in collaboration with NORCE and students from the University of Hanken. Hanken students interviewed people on the streets regarding how they perceive robots and would they be open to try out the service. The Hanken students conducted 48 interviews. From Hanken interviews, 60% of the respondents were women and 38% between 50-60 years old. The youngest respondent was over 50, because students' target was to measure how the elderly people perceived robots while the survey conducted by FVH was collecting data from all age groups. As found from the interviews, most of the interviewees (n=35) had not seen the robot, 11 had seen it with a few of them several times, and 2 had either maybe seen it or seen it online. Only one interviewee stated that they had heard about the pilot. However, robots in general were quite a familiar concept to the interviewees. Although the familiarity or encountering other robots were not asked, 16 respondents mentioned that they had heard or seen Starship robots or other robots. From each age group and gender, there was one or more interviewees who had encountered the robot. According to the results, the interviewees would react mostly positively if they encountered the robot. Most reactions were amusement, curiosity, and interest. Most people that were reserved towards the robot at first (n=7) had either neutral or positive reactions in case of encountering the robot (n=6). However, those who viewed the robot as scary, had still negative reactions, either being uncomfortable or stepping aside. What is noteworthy from the interview results is that although most people feel positive about ADVs, over half of the respondents (26 out of 48) didn't say they would trust the robot completely. The concerns of people who have not seen the robot shouldn't be overlooked, as this indicates that the safety perceptions are not completely optimal. Therefore, it is important to pay close attention to the safety aspects to increase trust and have positive social impact even in the future.

The survey conducted by Forum Virium Helsinki consisted of three different parts regarding the consumer's preferences on delivery means, attitude towards ADVs, and social demographic data for grouping and analysing the results. The responses were anonymous and handled according to the GDPR policies. The online survey was conducted for one month period and led to 48 responses. Measured on a scale from 1 to 10 (from least important or interesting aspect to the most important or interesting aspect), convenient location (average 9.13) and convenient pick-up time (8.64) were the most important factors when asked about the most important factors of home deliveries. Low environmental impact was the least interesting aspect (6.89) when choosing the delivery means. Most of the people had already adopted the use of parcel locker systems as their preferred means of LMD (8.96). Robots were quite an unfamiliar option, but still the majority would be open to trying it out if the service were available in their area (7.49). When asked about the feeling of safety near the ADV, only two answers were below 3, giving the average of 7.85. This means that the safety concerns cannot be overlooked but mainly people feel positively towards robots.

Production of Droids (ADV)

FIGURE 14 PERSON INTERACTIVNG WITH NERO

The TwinswHeel droids (ADV) are designed and produced in Cahors, Occitanie (France). Soben, the company that designs and manufactures the TwinswHeel droids, is an SME with 40 employees. The TwinswHeel ciTHy droids come in three main families: 1. The ciTHy S can carry up to 50 kg, costing around 25-30 k€, the ciTHy M can carry up to 150 kg, costing around 45-55 k€, and the ciTHy L can carry up to 300 kg, costing around 65-80 k€. As part of the Urbane project, we experimented with a ciTHy M and a ciTHy L. These droids can be customized at two levels: the first, the simplest, involves painting the bodies, and the second involves the rear box, which can be 100% custom-made. As part of Urbane, several boxes were tested, and TwinswHeel developed locker boxes for the M and L. For the LMAD partner, TwinswHeel provided a ciTHy L droid in 2023 and 2024 and a ciTHy M droid in 2024. The production and validation of each of these droids takes approximately 6 months.

FIGURE 15 HERO AND NERO IN THE MICROHUB

Customization

As part of Urbane, the ciTHy M and L droids are standard droids on which TwinswHeel has implemented new features and new boxes to meet the specific needs of Helsinki and LMAD's uses:

- Added new GNSS (GPS) systems to locate the robots in space. Indeed, TwinswHeel's classic SLAM navigation in very open environments like those in Helsinki did not cover 100% of LMAD's missions.
- Strengthened electronics and mechanics to withstand the Finnish climate.
- Designed and manufactured a 25-locker box for the ciTHy L with the electronics and software to manage them.
- Designed and manufactured a 6-locker box for the ciTHy M with the electronics and software to manage them.

Thanks to the URBANE project, TwinswHeel has reinforced droids for Nordic countries and boxes with lockers for B2C delivery.

Setting Up a Robot in an Area

FIGURE 16 MAP OF THE NERO'S MOVEMENT

TwinswHeel droids are small autonomous vehicles that require significant preparation before they can operate reliably and safely. Three steps that were followed can be defined as follows:

- Creating the SLAM map of the future operating area for the droids.
- Creating the virtual routes and virtual stations that the droid will follow.
- Validating the virtual routes and making adjustments if necessary.

For this, it takes (for an area of 20 hectares = a square with 500 m sides):

- 1 day to record the data and create the map.
- ½ day to create the virtual routes/stations.
- 2 days to validate all the routes.
- 1 day to test the service in dry runs.

Setting up an ADR fleet in a 20-hectare area took about a week. Doing this for one or multiple robots is the same, as they will share the maps and virtual route graphs (even between different-sized robots like ciTHy L and ciTHy M).

More specifically the steps taken for the ADV to run in a new environment are as follows:

- Mapping a new area:

During the mapping process, a TwinsWheels and LMAD representative, as well as the ADV, were present in the pilot location. They concentrated their efforts on mapping the pre-defined zone and routes that the robot would take during the deliveries. During the mapping process, multiple sensors of the ADV recorded data simultaneously, which was then fused into a digital map of the area. This digital map was later used for the ADV to localize itself with a high level of precision, which is the base for autonomous operations. Within the digital map, routes or trajectories were set up by defining waypoints, which then resulted in a fully connected graph; such a route network could then be used by the LMAD platform to control and manage the ADV on its delivery operations.

- Getting permission process:

1. Make a short summary of the planned use case

2. Define the location where the solution is to be tested

3. Define general information (e.g. what, where, when, how many vehicles, what time period and times of day, who's the operator),

4. Contact Mobility Lab Helsinki: The Mobility Lab helps companies test and develop their solutions in the real urban environment (including the permits needed).

5. Contact Traficom for the processing of the official certificate application, and iterate through possible vehicle categorization

6. Apply for vehicle liability insurance at a Finnish insurance provider based on the vehicle category of the ADV or the one agreed with Traficom

7. A notification about the use of a public area (area lease) must be submitted to the city at least seven working days before the planned starting date.

8. Fill out the notification about work in a public area and mark "Aluevuokraus" as the type of notification.

9. Compile a temporary traffic arrangement plan as an attachment to the notification

10. Submit the notification and its attachment(s) and a signed letter of credentials (if needed) by e-mail (luvat(at)hel.fi) at least seven days before the planned start date.

11. Inform the National Police Board of Finland of the upcoming pilot operations by sending detailed information about the pilot by email to the police administration.

8. Infrastructure

8.1 Existing physical infrastructure

TABLE 4 INFRASTRUCTURE

Asset	Description
Consolidation & Network Infrastructure	Underground service tunnel network available in the city center but it wasn't easily accessible for our operations because we needed the charging infrastructure and any solid infrastructure to be installed inside the service tunnel wasn't acceptable.
Vehicle Fleet	Number of ADVs in pilot phase one: 1 Number of cargo bikes in phase one: 1 Number of ADVs in pilot phase two: 1 Number of ADVs in pilot phase three: 2 Number of cargo bikes in phase two: 2
Delivery Schemes & smart logistics solutions	
Parcel Lockers	Several parcel lockers in all parts of the city, in active use by logistics operators and customers. Also, R-kioski shop which is the official drop-off point for DB Schenker's parcels
Vehicle Technologies	
ADVs, cargo bikes and microhub	In the pilot: **ADV #1:** Vehicle type: Autonomous robot (TwinswHeel ciTHy L robot) Maximum allowed mass [kg]: 578 Fuel: Fully electric Fuel consumption per Km [l/km or kWh/km]: 0,18 kWh / km Integrated module with a shelf was used in pilot 1 Integrated locker capacity: 25 Number of Vehicles: 1 **ADV #2:** Vehicle type: Autonomous robot (Twinswheel ciTHy M robot) Maximum allowed mass [kg]: 250kg Fuel: Fully electric Fuel consumption per Km [l/km or kWh/km]: 0,18 kWh / km Integrated locker capacity: 6 Number of Vehicles: 1

	Cargo bike: Vehicle type: Electrically assisted cargo bike Fuel: Fully electric Number of vehicles: 2 In the city: EVs and EV charging sites available **Microhub #1** A 10'' sized warm rental container located in the backyard of Würth Center Jätkäsaari Electricity from the shop **Microhub #2** Over 200 square meters large space inside the shopping center Ruoholahti Private property rented by DISCO project Includes charging infrastructure for the ADVs and cargo bikes and a manned service point facilitated by DHL Locked storage for parcels

8.2 Existing digital infrastructure

8.2.1 Existing ICT Solutions and Operational information systems

Existing ICT Solutions and Operational information systems:

- LMAD and GIM[2] Robotics sensor/IoT technology has been used in previous projects
- LMAD Parcel tracking system
- LMAD ADV fleet & mission management system
- TwinswHeel teleoperations system
- LMAD and DB Schenker data integration, LMAD platform

8.2.2 Available datasets related to LL scope

Available datasets related to LL scope:

- Open data of existing mobility data in the city of Helsinki: https://www.hsl.fi/en/hsl/open-data
- Helsinki Region Infoshare (www.hri.fi) hosts thousands of open data sets
- Forum Virium/Mobility Lab Helsinki's Mobility Data Catalogue: https://mobilitylab.hel.fi/data/
- Statistical data about electricity mix and households: https://stat.fi/index_en.html
- Spatial data in several different databases: https://kartta.hel.fi/

[2] https://gimrobotics.fi/

The data sets collected from the Helsinki Living Lab pilots have been listed as follows:

- ID 1_DELIVERY DEMAND DATA: DB Schenker's demand data including the volume of parcels in the sprint 2 pilot area used for microhub location optimization algorithm.
- ID 2_TRANSPORT DATA: DB Schenker's and LMAD's data including the details, like delivery times and locations, of deliveries done during the second sprint. The data was used for nonrepudiation in last mile consolidation meaning the blockchain and smart contract implementation.
- ID 3_POPULATION DATA: Data collected by FVH for measuring the residents' behavior and attitudes towards the ADVs and choosing the delivery mode.
- ID 4_DELIVERIES: LMAD's, Würth's and DB Schenker's data of deliveries to measure SDG impact of the Helsinki operations.
- ID 5_CUSTOMER SATISFACTION: FVH's and LMAD's data collected regarding customer satisfaction to improve the last mile services for the residents.

8.2.3 Existing Digital Twin

The City of Helsinki has been developing the digital twin for a long time and was one of the first cities in the world to do so. Right now, the work is at the stage of collecting and searching for different types of data and opening them up in a digital format.

The Helsinki digital twin is a virtual representation of the city, and an entity made up of several data sources or "a system of systems". It is a compilation of open data sources and information updated at regular intervals. It is a digital system in development that can be used for several purposes by different parties who also produce and maintain its data sources. With the help of various tools, the data from different sources can be examined, used, refined and combined while significant added value is gained.

The digital twin of mobility can be used, for instance, to simulate traffic flows in the city and for the purpose of traffic planning or maintenance of infrastructure. The situational picture of traffic is based on real-time information of traffic flows. By sharing data, new services and business models can be supported.

Helsinki's digital twin provides a virtual overview of the city environment. 3D City models are an integral part of the current Helsinki DT and provide a starting point for data integration. Currently, the city maintains two 3D city models, both covering the entire city administrative area: a semantic city information model following the CityGML specification, and a textured mesh model based on oblique aerial photographs.

The semantic city information model (Figure 17) is based on several information sources: maps of Helsinki and spatial data, registers and point clouds from laser scanning, aerial photographs and information from various buildings. The current model includes buildings, streets and the shape of terrains. Objects like bridges and trees will be added later. The model is continuously updated. (City of Helsinki, 2022).

FIGURE 17 HELSINKI SEMANTIC CITY INFORMATION MODEL.

The reality mesh models (Figure 18), on the other hand, are based on aerial photographs taken of the city in the summer of 2017. The model is a conversion of aerial photographs into a textured reality mesh. A mesh model for cities is nowadays a cost-effective solution and based on highly automated computing. The accuracy of the model is dependent on the accuracy of the data; reflective, mirrored and moving surfaces are not presented correctly in the model since these types of surfaces are not depicted accurately in the aerial photographs.

FIGURE 18 HELSINKI TEXTURED MESH MODEL.

8.3 Models & tools developed/used/extended in URBANE

8.3.1 New services in the URBANE

The Helsinki LL demonstrates novel services contributing to the overall goals of the URBANE project.

New services in the URBANE are as follows:

- use of ADVs in last-mile deliveries
- use of cargo bikes in last-mile deliveries
- Use of consolidation hub in last-mile deliveries
- On-demand deliveries and flexible pre-determined pick-up service for the residents

Using ADVs in LMDs allows the consumer to choose the pick-up location of their parcel from multiple pre-determined pick-up locations. In addition, the one-hour time slot when the parcel is delivered to the pick-up point can be chosen from a list of available delivery times. This allows the consumers to plan their daily activities without having to wait for their parcel to arrive at an inconvenient time. The use of ADV in B2B deliveries enabled on-demand deliveries, because the robot can be dedicated to a specific route serving only a handful of customers, which makes the on-demand deliveries much more efficient compared to conventional mean of delivery where drivers have full schedules and might not be available for fast-paced on-demand deliveries.

8.3.2 Decision Support Digital models

The Helsinki LL has multiple piloting locations in the city of Helsinki, in Finland. Helsinki LL proposed testing the concept of microhubs in the city, specifically focusing on innovative LMD options such as robot deliveries using ADVs, cargo bikes and teleoperation.

To explore the acceptability of ADVs by consumers (i.e. how consumers choose a delivery method, and whether they tend to choose ADV delivery or not), an integrated agent-based simulation model is designed and developed. In this model, the HUMAT modules (NORCE) simulate consumer choices between the ADV service and home delivery options over time, MASS-GT (TUD) is used to generate household demand and the VRP module (SKEMA) is used for simulating the routing of the ADVs. If the ADV is chosen, the VRP module computes the delivery times, percentage of total parcels delivered, average waiting time and the average queue length at each delivery point. It also computes the total distance travelled and the total emissions produced by the ADV during the delivery round.

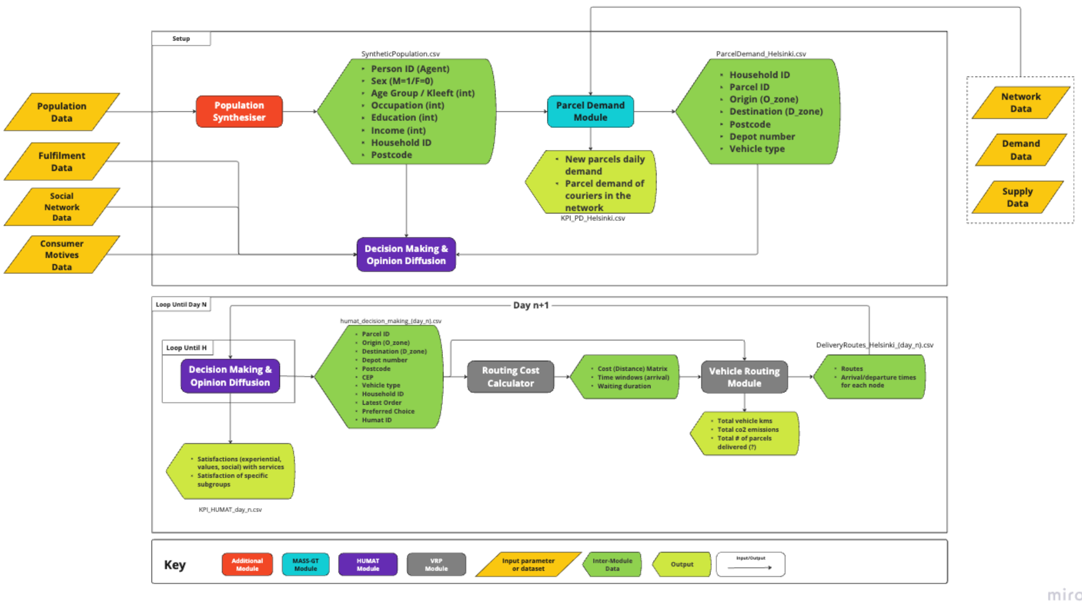

FIGURE 19 AGENT-BASED SIMULATION MODEL FOR ADV DELIVERY SERVICE

The integrated model is conceptualized as depicted in Figure 19. In summary, during the setup phase firstly an artificial Helsinki population is synthesized, then the parcel demand is initialized and after the decision-making of consumers is initialized. The simulation runs through multiple days, with iterative decision-making and routing optimization. Outputs are tracked in terms of satisfactions of consumers, parcel delivery efficiency and environmental impact, with continuous feedback loops to refine the model.

These models give a basic understanding on how the ADV service model could provide better services for the residents in Helsinki. The LL partners can use the insights to validate whether investing in ADV service could be socially, environmentally, and financially sustainable solution for LMDs. Where digital tools can support the initial negotiations whether to invest or not, they cannot change the consumer behavior or provide deeper insights on how to convert the consumers into users of the ADV service. For that purpose, we will need to use qualitative research and market analysis to understand the consumer needs even better. If these insights could be added to the models, then we might end up creating a tool which could also suggest steps for creating a strategy for implementing the ADV service.

8.3.3 DT Decision support capabilities, services and requirements to facilitate the vision

The URBANE Digital Twin Platform (DT) simulates different delivery scenarios aspiring to answer different "what-if" questions. This empowers its users to experiment with different strategies, such as placing new microhubs in different locations in a city or changing LMD vehicles, and see how they impact efficiency, costs, and the environment before implementing them in the real world. The Digital Twin makes use of a series of models developed in the project and presented in section 8.3.2. that seek to explore the Living Lab's operational performance. All models have been integrated into the DT following a meticulous integration process and are available for exploration and testing through the Portal of the DT, as shown in Figure 20. Through the Portal users can use the models to define *scenarios* (i.e., a sequence of models) and test these scenarios using different inputs, which in turn allows them to explore different "what-if" questions.

The URBANE Digital Twin Platform was made available for access to project partners in 2023. The feedback received from users suggested that a more user-friendly version of the platform could help users navigate through the models in a more intuitive manner. Taking all this into consideration, a domain-specific application on top of the URBANE Digital Twin was designed and developed that would offer a user-friendly and intuitive experience to the LL users. The application, called CitIQore, focused initially on the models and use case of the Bologna LL, but was later extended to address the use case of Helsinki with a special focus on the LMD by ADVs.

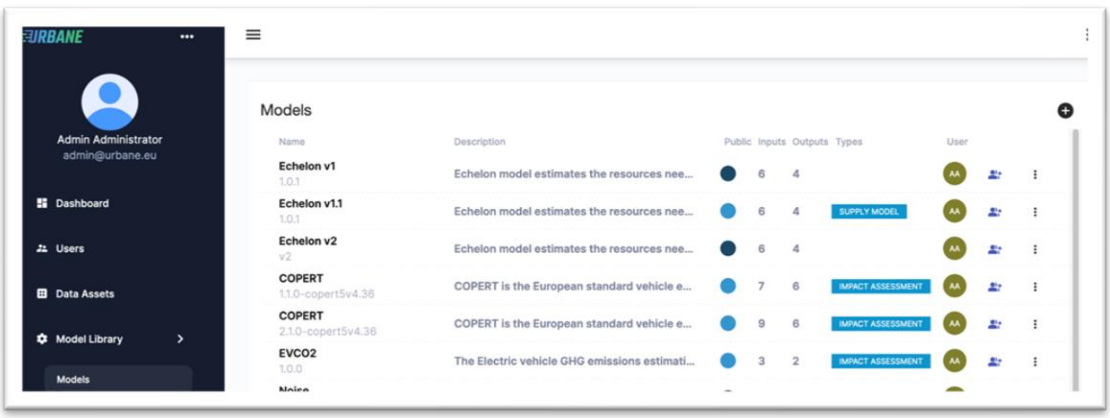

FIGURE 20 PORTAL OF THE URBANE DIGITAL TWIN PLATFORM

CitIQore is a web-based application that allows authenticated users to explore different interventions (i.e., LL use cases) developed in the context of the URBANE LLs. As a first step, users are called to choose between the developed interventions, as depicted in Figure 21.

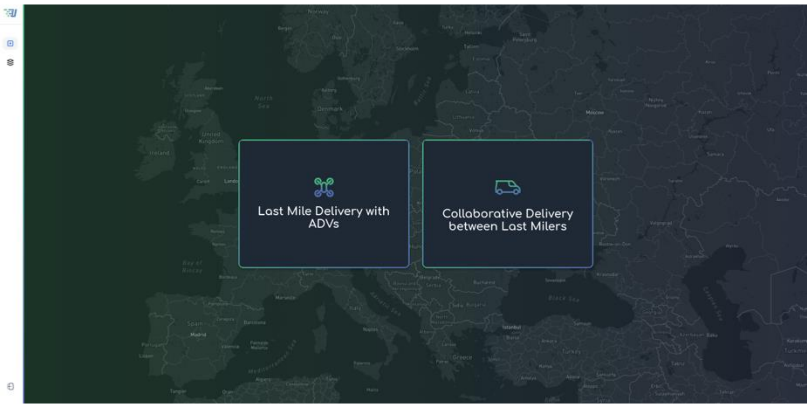

FIGURE 21 CITIQORE INTERVENTIONS

After choosing the *Last Mile Delivery with ADVs* option, the users are called to select the specific area on the map that they want to explore using this intervention.

The CitIQore application together with the URBANE Digital Twin are the central components of the WP3 Innovation &Transferability Platform. Therefore, reusability and transferability are key features of the developed solution. With that in mind, even though the selected intervention was developed for the Helsinki LL, it can be applied to any other location or city, by allowing the users to select different locations on the map (Figure 22). In this case, the sequence of models will be executed for the user-selected location (Figure 23).

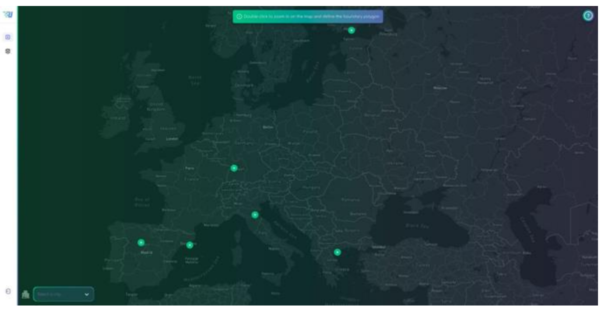

FIGURE 23 CITIQORE MAP

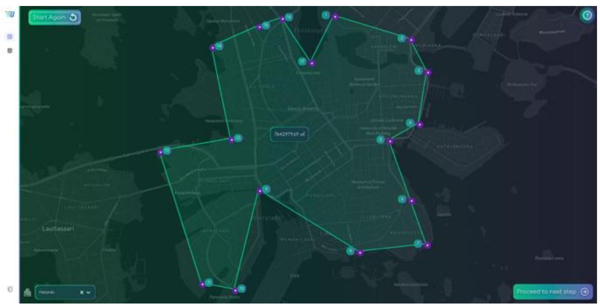

FIGURE 22 CITIQORE USER SELECTED POLYGON

Once the user has selected the area of focus on the map, they are called to define their “what-if” scenario further by selecting from a range of inputs regarding the first mile and last mile delivery of the parcels.

In this manner, with regards to the first mile they define the following (Figure 24):

- The number of deliveries (parcels) they wish to send out. This will provide input to the Random Delivery Generation Model, which will return random delivery points within the selected polygon for experimentation.
- The location of the warehouse will be the starting point for the first-mile delivery.
- The types of vehicles they wish to employ for the first mile, e.g., a Diesel or an electric truck.

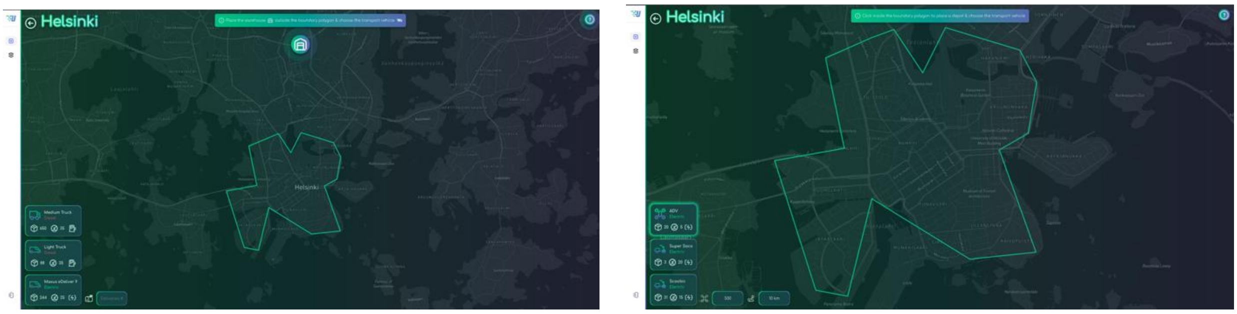

FIGURE 24 CITIQORE MAP ANDAND CITIQORE USER SELECTED POLYGON

Upon making these selections, users are called to define the parameters for the LMD, mainly the following:

- The placement of the microhub on the map.
- The LMD vehicles (mainly ADVs and electric bikes).
- Finally, they are called to design the ADV routes on the map for 1 or more ADVs (Figure 25). In the presented example, 4 ADVs are used for the last mile delivery.

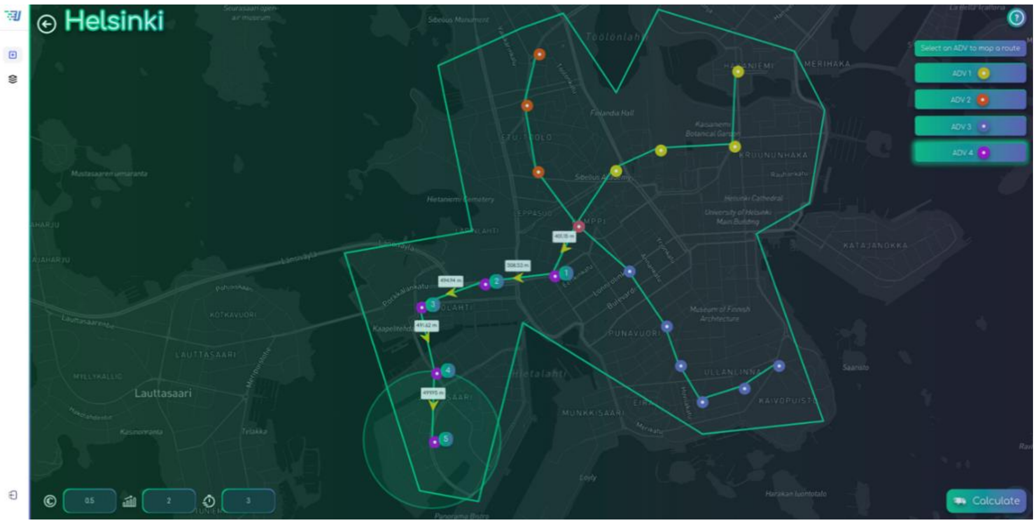

FIGURE 25 CITIQORE INPUTS - LAST-MILE

Apart from the beforementioned, the details regarding a potential financial investment are entered by the user, such as the duration and capital of the investment.

In this manner, they choose the input parameters for the models that will be triggered in the background. Following that, the CitIQore application calls the DT models with the selected user inputs, using the DT as the backend. A sequence of models is called and executed in this scenario:

1. The Random Delivery Generation Model, which returns random delivery points on a map for a given number of deliveries.
    - The 2-echelon model that calculates the distances covered in the 1st leg. The EVCO2 and copert models, which are models developed and used in a previous Horizon project (i.e., LEAD project [3]). These calculate the emissions for electric and non-electric vehicles respectively.
2. The ADV assignment model that is responsible for the assignment of parcels to the respective ADVs in accordance with the ADV's catchment area.
3. The Cost Benefit Analysis (CBA) model that addresses the economic aspects of a potential investment in the given scenario.

The outputs of the executed scenario are presented in a dedicated Dashboard, following the successful execution of the above-mentioned sequence of models. Screenshots of the Dashboard are presented in Figure 26 and Figure 27. An application walkthrough in the form of a video was sent to project partners, which can be found using the following link.

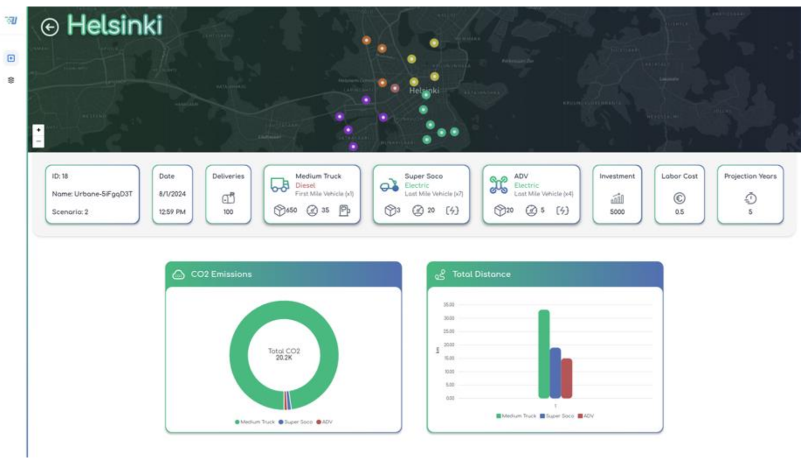

FIGURE 26 CITIQORE DASHBOARD (I)

[3] https://www.leadproject.eu/

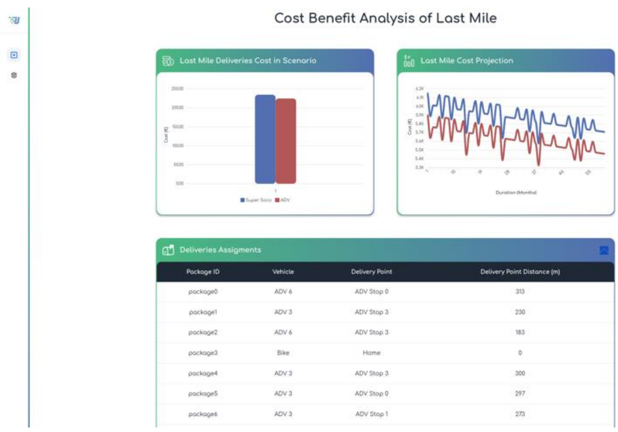

FIGURE 27 CITIQORE DASHBOARD (II)

After the implementation, the Helsinki LL partners were able to review the potential value the DT could bring in the future. Using the DT can provide extra support for LSPs when deciding to invest in LEVs. Especially the location-related insights can be important, because finding a suitable location for a microhub is a resource consuming process when done manually. DT can combine complex variables together and optimize the best location reliably. Even though the DT itself can be a valuable tool to support decision-making, the final step is to rent the land on which we might be running into issues. Therefore, the future development of the tool could integrate a layer from Helsinki city's open-source map to automatically detect whether the location is on the city's land or private property. This could be used as one of the variables when optimizing the location. Also, adding different types of vehicles and an ability to change some factors like parcel locker modules and capacity, service type, or other factors would refine the tool even further and provide more valuable insights.

8.3.4 Blockchain technology in LLs

The objective of the blockchain system is to guarantee non-repudiation throughout the shipment process when multiple parties are involved. The first step was to identify the events at which the package is transferred, and tracking is required. For purposes of clarity, the list of events for this use case is presented in Table 5.

1. Order in compartment (64B)	3. Order not delivered (23)
2. Order delivered (21)	4. Order delivered to secondary location (82)

TABLE 5 EVENTS INCL TSN CODES

The second key objective of the system is to assess performance to guarantee that the service has been delivered in line with the previously agreed service level agreements. To achieve this, a range of rules can be selected by the user including missed events, damaged shipments, and delayed shipments. The living labs send the event data through an Application Programming Interface (API) to the platform where it is processed and stored on the blockchain. The information is then displayed in the URBANE dashboard.

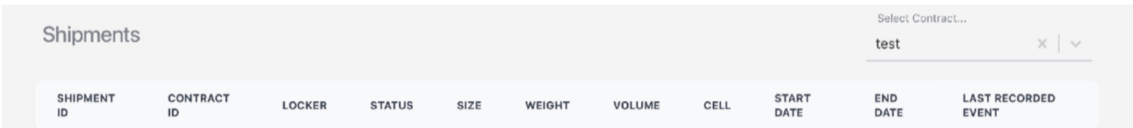

FIGURE 28 AGENT-BASED SIMULATION MODEL FOR ADV DELIVERY SERVICE

Prior to monitoring the events a smart contract must be created using the contract generator (Figure 28). The user may select the events to be monitored and the rules to be checked at this stage. Once the contract is in place and data from new events is sent to the platform via the API, these events will be visible in the Shipments Dashboard (Figure 29).

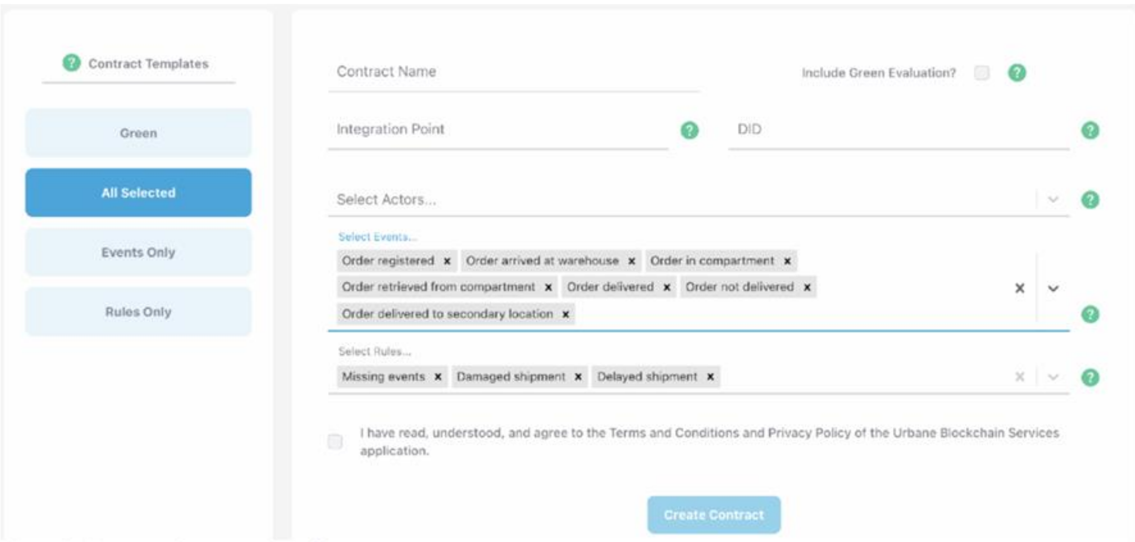

FIGURE 29 CONTRACT GENERATOR INTERFACE

To gain a more detailed overview of the events, one can select the Last Mile Events tab to view all events that have already been registered under a shipment. Additionally, alerts will appear when the rules have been executed with the corresponding result. Further information on the URBANE blockchain infrastructure is available in D3.1. and by the demonstration of the tool prepared using link.

The blockchain technology and smart contracts will provide an extra layer of security between different stakeholders who are willing to collaborate by consolidating their parcels to share the cost of microhub and the last mile operations. Blockchain's ability to provide nonrepudiation is a fascinating aspect especially for big international companies whose policies might not accept collaboration with competitors in the first place. However, standardizing the contracts and using strongly secure technology as the neutral layer between these players would ensure their interest towards collaboration thus consolidation in the future. The next step is to provide guidance for all different LSPs to find, gather and refine the data that should be used as an input to the platform. Sometimes the issue is that the companies might not know what data is required or they might find sharing the data as a security risk for the company. To ensure the future usage of blockchain, Helsinki LL suggests educating companies about the benefit of these technologies.

8.3.5 Impact Assessment Radar

The initial stage of the Impact Assessment Radar conducted a thorough evaluation of Helsinki's readiness to integrate innovative urban logistics solutions and use the outcomes to analyse city's capacity to integrating ADVs for LMD. This assessment focused on uncovering any potential challenges within the city's ecosystem, such as issues related to regulations, urban planning, infrastructure, data accessibility, stakeholder engagement, and public acceptance. This strategic tool was crucial in mapping out Helsinki's existing capabilities and pinpointing areas that need strengthening to facilitate the deployment of these logistics' innovations.

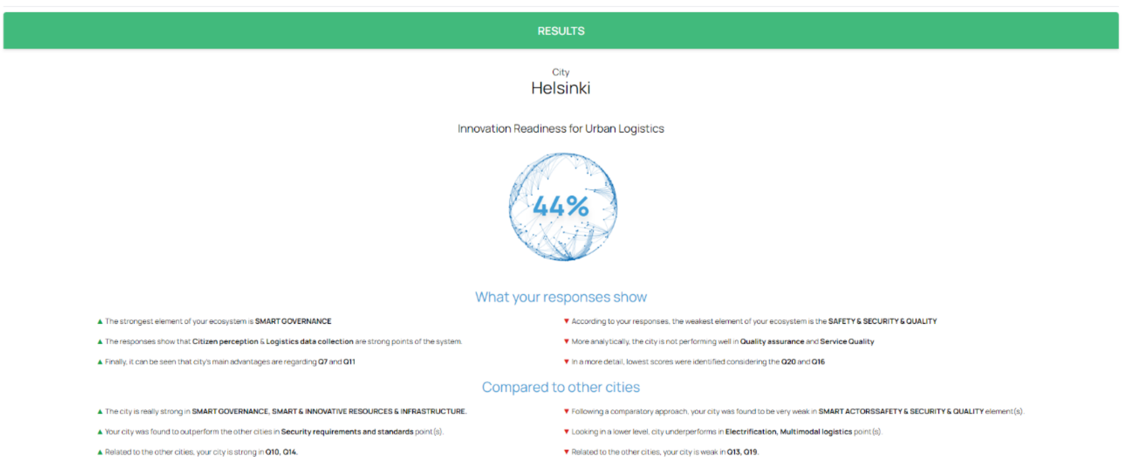

FIGURE 30 HELSINKI'S RESULTS IN 1ST LEVEL IMPACT ASSESSMENT - STRATEGIC OBJECTIVES

For the second use case, the impact assessment radar provided the optimal number of microhubs within the city to cover the demand. Also, different scenarios of integrating various logistics providers' operations into the microhub managed by LMAD, focusing on maximizing efficiency and reducing emissions for both B2B and B2C deliveries were assessed to understand the impact of the collaborative operations for the city and decide the design of the microhub.

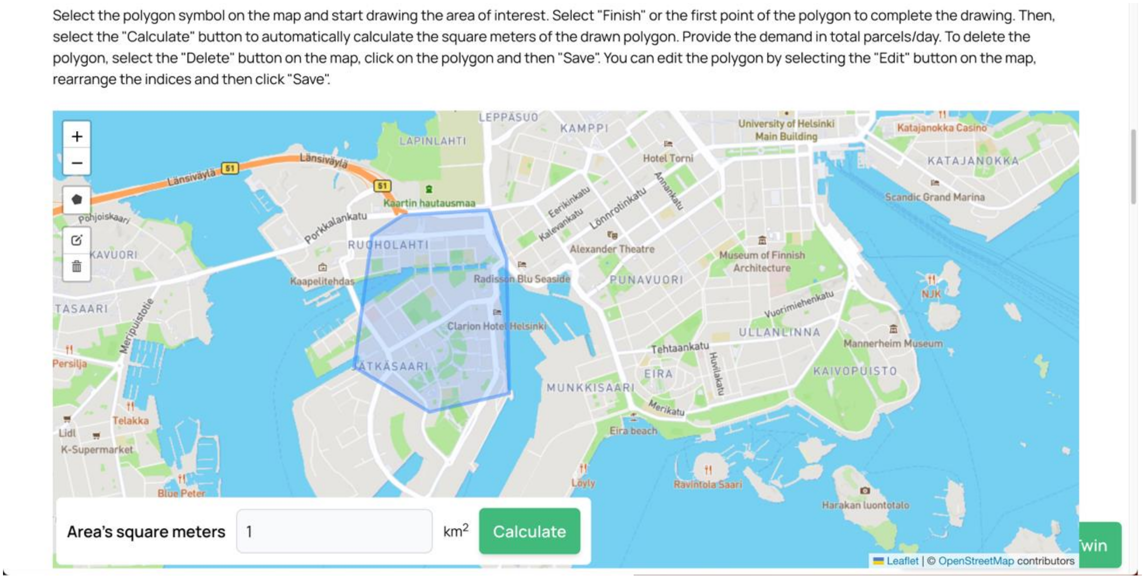

FIGURE 31 THE USER INTERFACE FOR CHOOSING THE AREA IN IMPACT ASSESSMENT RADAR

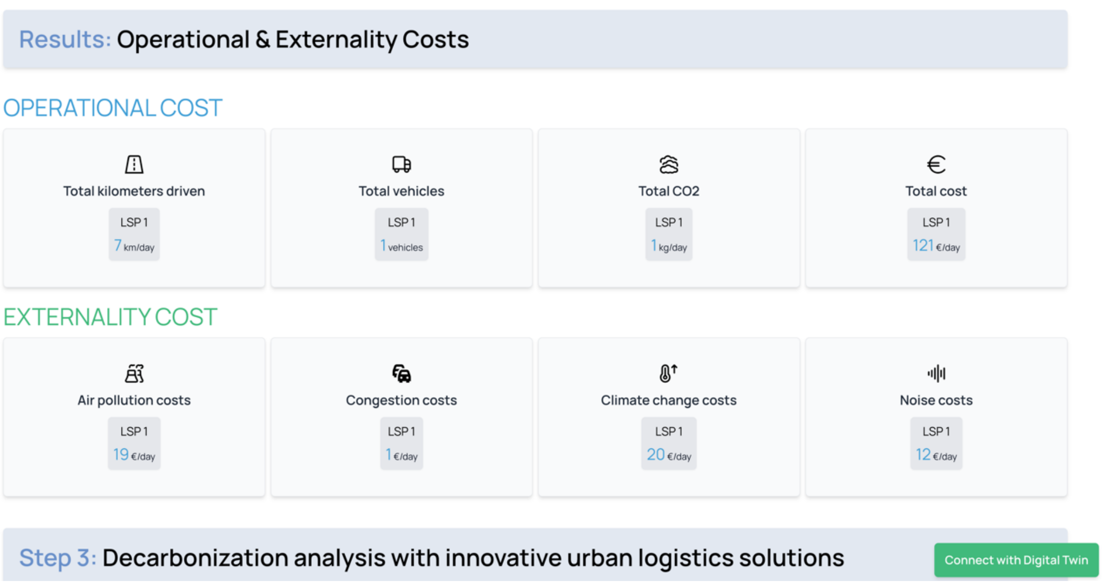

FIGURE 32 THE DASHBOARD SHOWING THE RESULTS FOR A SCENARIO

In the operational phase, the radar facilitated real-time monitoring of various Key Performance Indicators (KPIs) to assess the efficiency and sustainability of the implemented solutions. The radar's insights aid in calculating KPIs based on this optimization. Key metrics monitored include the effectiveness of the new microhub system, the performance of ADVs in actual logistics operations, and the success of integrating various logistics providers. Essential KPIs such as delivery times, emission levels, and integration success are critical for continuously assessing operations and enabling iterative improvements based on real-time data.

The impact assessment radar tool has plenty of benefits for Helsinki LL's decision-making practices, but a further development is needed to suit the unique features of the use cases. The data input fields require fuel consumption and fuel cost data even though the ADVs and cargo bikes consume only electricity. Also, the other costs should be defined more clearly to be able to fill the data according to the actual costs. In general, describing as clearly as possible all values, formulas and results would make the tool user-friendlier, ensuring that the scenarios match reality. Then the results could be utilized as a part of Helsinki's decision-making processes. The obvious benefit of this tool is the ability to present value provision easily and fast in a visual format, gather data in one platform, customizing the platform for each use case and therefore being able to provide output for exactly those results the city is looking for.

9. Evaluation/Impact assessment

9.1 KPIs

These data come from the work carried out in Task 3.2 Impact Assessment Methodology and KPIs, where FIT Consulting provided all URBANE LLs with a holistic and comprehensive framework, KPIs, tools and methodologies to perform their impact assessment. In the table below the Helsinki LL KPIs have been defined and the baselines have been collected. The KPIs are connected to use cases/sprints accordingly. The final values collected after the pilot implementation are included in D2.1 Validation Report.

For each partner in Helsinki LL, the one goal is to increase the customer satisfaction rate by providing services that create value for its users. Therefore, the most important KPI on high level is the NPS score which measures the quality of the services in general.

TABLE 6 HELSINKI HIGH LEVEL KPIS

KPI name	Measurement unit	Data source	Baseline Value	Value at M23/24	Support from URBANE platform/models/other tools	Comments
L33. Residents' acceptance level (Helsinki: (NPS score) (>70%)) - Quality of services	Percentage	Baseline: DB Schenker's parcel delivery service in 2023, Final value: Forum Virium Helsinki survey	75%	86,66%	HUMAT-MASS-GT	Note: the response rate was quite low due to low volumes.

Following, KPIs related to each of the 3 Sprints to be demonstrated in Helsinki are reported.

Sprint 1 - Delivering tools from the Würth Center Sörnäinen to nearby construction sites in Kalasatama region

TABLE 7 HELSINKI SPRINT 1 KPIS

KPI name	Measurement unit	Data source	Baseline Value	Value at M23/24	Support from URBANE platform/models/tools	Comments
L.9 Average number of km per trip - Efficiency	Kilometres	Baseline: DB Schenker, Final value: LMAD	Van: 65km Construction van: 2km	Van: 45km Cargobike: 15km ADV: 0.7km	2-echelon	Average per trip excludes the travelling outside the city area. Van vs. ADV
L10. Average number of km per vehicle - Efficiency	Kilometres	Baseline: DB Schenker, Final value: LMAD	Van: 65km Construction van: 2km	Van: 45km Cargobike: 15km ADV: 0.7km		Van vs ADV
L11. Total distance travelled in urban area - Efficiency	Kilometres	Baseline: DB Schenker, Final value: LMAD	Van: 20km Construction van: 2km	Van: 10km Cargo bike: 15km ADV: 17km		Excludes the travelling outside the city area
L22. Average deliveries per trip - Efficiency	Average number of parcels delivered per trip	Baseline: DB Schenker, Final value: LMAD	Van: 15 Construction van: 1	Cargo bike: 7 ADV: 1		Demand volume was low

KPI name	Measurement unit	Data source	Baseline Value	Value at M23/24	Support from URBANE platform/models/tools	Comments
L1. CO2 emissions - Sustainability	g/km	Baseline: DB Schenker, Final value: LMAD	EUR-5 CLASS 670 g/km	Van: 670 g/km Cargo bike: 0 g/km ADV: 0 g/km		Van vs ADV
L14. Time to complete a delivery route - Efficiency	Hours and minutes	Baseline: DB Schenker, Final value: LMAD	Van: 6h 0 minutes Construction van: 1h	Van: 50 minutes Cargo bike: 1h 30min ADV: 0 hours 24 minutes	2-echelon	Van vs van + cargo bike Construction van vs ADV
L8. Fuel consumption per Km - Sustainability	Liters / 100 kilometres	Baseline: DB Schenker,	Diesel 25L/100km	Van: 25L/100km Cargo bike: 0l/100km		Van vs van + cargo bike

		Final value: LMAD		ADV: 0L/100km		Construction Van vs ADV
NEW. Number of parcels delivered through ADVs - Efficiency	Total number of successful deliveries	Baseline: DB Schenker, Final value: LMAD	0	40		
L37. Security of deliveries (no losses or thefts) - Quality of services	Safely delivered parcels / Total parcels	Baseline: DB Schenker, Final value: LMAD	99.999%	100%	Blockchain	ADV under constant supervision
L36. Safety of deliveries (no damages) - Quality of services	Undamaged parcels / Total parcels	Baseline: DB Schenker, Final values: LMAD	99.998%	100%		ADV under constant supervision
NEW. Missed deliveries due to vehicle issue – Quality of services	Missed deliveries / Total deliveries	Baseline: DB Schenker, Final value: LMAD	0.001%	0		The number of failed deliveries due to an issue in the vehicle.
L67. Rate of successful delivery from 1st attempt - Efficiency	Successful delivery / total deliveries	Baseline: DB Schenker, Final value: LMAD	98%	96.15%		Communication issues
L57. Number of failed deliveries per trip - Efficiency	Failed deliveries / total deliveries	Baseline: DB Schenker, Final value: LMAD	2%	4%		Due to low demand volume the number becomes higher

KPI name	Measurement unit	Data source	Baseline Value	Value at M23/24	Support from URBANE platform/models/tools	Comments
L52. Presence of IT and AI driven optimisation system – Efficiency	yes/no	Baseline: DB Schenker, Final value: LMAD	No	Yes	2-echelon	LMAD's VRP solution
L50. Failures in the IT system - Quality of services	Failed deliveries / Total deliveries	Baseline: DB Schenker, Final value: LMAD	1%	0%		The number of failed deliveries due to a problem in the IT system.

Sprint 2 Delivering B2B and B2C e-commerce parcels in the Ruoholahti and Jätkäsaari region using the ADV.

TABLE 8 HELSINKI SPRINT 2 KPIS

KPI name	Measurement unit	Data source	Baseline Value	Value at M23/24	Support from URBANE platform/models/tools	Comments
L.9 Average number of km per trip - Efficiency	Kilometres	Baseline: DB Schenker, Final value: LMAD	45km	Van: 45km ADV: 0.6km	2-echelon	Van vs van + ADV Baseline value considers delivery to only one collection point, while van + ADV is closer to home delivery
L10. Average number of km per vehicle - Efficiency	Kilometres	Baseline: DB Schenker, Final value: LMAD	45km	Van: same as above ADV: 0.6km		Van vs Van + ADV
L11. Total distance travelled in urban area - Efficiency	Kilometres	Baseline: DB Schenker, Final value: LMAD	20km	Van: 10km ADV: 11.1km		Excludes the travelling outside the city area
L22. Average deliveries per trip - Efficiency	Average number of parcels delivered per trip	Baseline: DB Schenker, Final value: LMAD	15	1.1	2-echelon	Demand volume was still quite low
L1. CO2 emissions - Sustainability	g/km	Baseline: DB Schenker, Final value: LMAD	EUR-5 CLASS 670 g/km	0 g/km		Van vs ADV
L14. Time to complete a delivery route - Efficiency	Hours and minutes	Baseline: DB Schenker, Final value: LMAD	1 hour	Van: 1 hour ADV: 0 hours 22 minutes	2-echelon	Van vs van + ADV Baseline value considers delivery to only one collection point, while van + ADV is closer to home delivery
L8. Fuel consumption per Km - Sustainability	Liters / 100 kilometres	Baseline: DB Schenker, Final value: LMAD	Diesel - 25l/100km	0l/100km		Van vs ADV

KPI name	Measurement unit	Data source	Baseline Value	Value at M23/24	Support from URBANE platform/models/tools	Comments
NEW. Number of parcels delivered through ADVs - Efficiency	Total number of successful deliveries	Baseline: DB Schenker, Final value: LMAD	0	50		
L36. Safety of deliveries (no damages) - Quality of services	Damaged parcels / Total parcels	Baseline: DB Schenker, Final values: LMAD	99.998%	100%	Blockchain	ADV under constant supervision
L37. Security of deliveries (no losses or thefts) - Quality of services	Safely delivered parcels / Total parcels	Baseline: DB Schenker, Final value: LMAD	99.999%	100%	Blockchain	ADV under constant supervision
NEW. Missed deliveries due to vehicle issue – Quality of services	Missed deliveries / Total deliveries	Baseline: DB Schenker, Final value: LMAD	0.001%	0		The number of failed deliveries due to an issue in the vehicle.
L57. Number of failed deliveries per trip - Efficiency	Failed deliveries / total deliveries	Baseline: DB Schenker, Final value: LMAD	2%	2%		Ways to decrease the number is under investigation for sprint 3
L67. Rate of successful delivery from 1st attempt - Efficiency	Successful delivery / total deliveries	Baseline: DB Schenker, Final value: LMAD	98%	98%	2-echelon	Ways to increase the number is under investigation for sprint 3

KPI name	Measurement unit	Data source	Baseline Value	Value at M23/24	Support from URBANE platform/models/tools	Comments
L52. Presence of IT and AI driven optimisation system – Efficiency	yes/no	Baseline: DB Schenker, Final value: LMAD	No	Yes	2-echelon	LMAD's VRP solution
L50. Failures in the IT system - Quality of services	Total number of failures	Baseline:	1	0		The number of failed deliveries due to a problem in the IT system.
L65. Fuel cost (euros per litre) and electricity cost (euros per	€/l or €/kWh	Baseline: DB Schenker, Final value: LMAD	Diesel M5/2023: 1,86 € / l – M6: 1.85 € /l - M7: 1,85	0.13 €/kWh		Van vs ADV

kWh) - Financial sustainability			€ /l - M8 1,94 € /l			
NEW. Electricity consumption per Km - Sustainability	kWh/100km	Baseline: DB Schenker, Final value: LMAD	0 kWh/100km	10 kWh/100 km		Van vs ADV

Sprint 3 was an iteration based on the previous sprints.

TABLE 9 HELSINKI SPRINT 3 KPIS

KPI name	Measurement unit	Data source	Baseline Value	Value at M23/24	Support from URBANE platform/models/tools	Comments
L2. NO2 emissions - Sustainability	g/km	Baseline: DB Schenker, Final value: DB Schenker	0.18g/km	0 g/km		
L3. PM10 emissions - Sustainability	g/km	Baseline: DB Schenker, Final value: DB Schenker	0.005g/km	0 g/km		
L.9 Average number of km per trip - Efficiency	Kilometres	Baseline: DB Schenker, Final value: LMAD	45km	Van: 45kmADV: 1.252km	2-echelon	Van vs van + ADV Baseline value considers delivery to only one collection point, while van + ADV is closer to home delivery
L10. Average number of km per vehicle - Efficiency	Kilometres	Baseline: DB Schenker, Final value: LMAD	45km	Van: same as above ADV: 1,252km		Van vs Van + ADV
L11. Total distance travelled in urban area - Efficiency	Kilometres	Baseline: DB Schenker, Final value: LMAD	20km	Van: 10km ADV: 20km		Excludes the travelling outside the city area
L22. Average deliveries per trip - Efficiency	Average number of parcels delivered per trip	Baseline: DB Schenker, Final value: LMAD	15	1	2-echelon	Demand volume was still quite low

KPI name	Measurement unit	Data source	Baseline Value	Value at M23/24	Support from URBANE platform/ models/tools	Comments
L1. CO2 emissions - Sustainability	g/km	Baseline: DB Schenker, Final value: LMAD	EUR-5 CLASS 670 g/km	0 g/km		Van vs ADV
L14. Time to complete a delivery route - Efficiency	Hours and minutes	Baseline: DB Schenker, Final value: LMAD	1 hour	Van: 1 hour ADV: 0 hours 25 minutes	2-echelon	Van vs van + ADV Baseline value considers delivery to only one collection point, while van + ADV is closer to home delivery
L8. Fuel consumption per Km - Sustainability	Liters / 100 kilometres	Baseline: DB Schenker, Final value: LMAD	Diesel - 25l/100km	0l/100km		Van vs ADV
NEW. Number of parcels delivered through ADVs - Efficiency	Total number of successful deliveries	Baseline: DB Schenker, Final value: LMAD	0	8		Note, that volume is still low, and we are in the middle of the pilot sprint
NEW. Number of parcels delivered through cargo bike - Efficiency	Total number of successful deliveries	Baseline: DB Schenker, Final value: DB Schenker	0	464		Between 3 June and 31 July 2024.
NEW. Average number of parcels delivered per day using a cargo bike	Average of deliveries per day	Baseline: DB Schenker, Final value: DB Schenker	0	12.23		Between 3 June and 31 July 2024.
L36. Safety of deliveries (no damages) - Quality of services	Damaged parcels / Total parcels	Baseline: DB Schenker, Final values: LMAD	99.998%	100%	Blockchain	ADV under constant supervision
L37. Security of deliveries (no losses or thefts) - Quality of services	Safely delivered parcels / Total parcels	Baseline: DB Schenker, Final value: LMAD	99.999%	100%	Blockchain	ADV under constant supervision
NEW. Missed deliveries due to vehicle issue – Quality of services	Missed deliveries / Total deliveries	Baseline: DB Schenker, Final value: LMAD	0.001%	0		The number of failed deliveries due to an issue in the vehicle.
L57. Number of failed deliveries per trip - Efficiency	Failed deliveries / total deliveries	Baseline: DB Schenker, Final value: LMAD	2%	0%		Ways to decrease the number is under investigation for sprint 3
L67. Rate of successful delivery from 1st attempt - Efficiency	Successful delivery / total deliveries	Baseline: DB Schenker, Final value: LMAD	98%	100%	2-echelon	Ways to increase the number is under investigation for sprint 3

KPI name	Measurement unit	Data source	Baseline Value	Value at M23/24	Support from URBANE platform/models/tools	Comments
L52. Presence of IT and AI driven optimisation system – Efficiency	yes/no	Baseline: DB Schenker, Final value: LMAD	No	Yes	2-echelon	LMAD's VRP solution
L50. Failures in the IT system - Quality of services	Total number of failures	Baseline:	1	0		The number of failed deliveries due to a problem in the IT system.
L65. Fuel cost (euros per litre) and electricity cost (euros per kWh) - Financial sustainability	€/l or €/kWh	Baseline: DB Schenker, Final value: LMAD	Diesel M5/2023: 1,86 € / l – M6: 1.85 € /l - M7: 1,85 € /l - M8 1,94 € /l	0.13 €/kWh		Van vs ADV
NEW. Electricity consumption per Km - Sustainability	kWh/100km	Baseline: DB Schenker, Final value: LMAD	0 kWh/100km	10 kWh/100 km		Van vs ADV

10. Lessons Learnt and recommendations

In this chapter, each stakeholder has presented their lessons learned and recommendations for the future development. During the three piloting sprints executed in Helsinki LL, the biggest constraint turned out to be finding the suitable location for the operations. The permit process to rent land from Helsinki took too much time and resources. Media visibility was very high and overall feedback was highly positive. It is recommended to increase the volume of deliveries, engage the city of Helsinki, and scale up the operations.

Lessons Learned from the Pilot as described by DB Schenker

Collaboration with LMAD was very smooth, with LMAD taking the lead in operations due to the integration. However, the project highlighted several critical challenges:

- Volume Dependence: The success of the hub concept is heavily reliant on scaling up the operations, as profitability is directly linked to high delivery volumes.
- Location Challenges: Finding a suitable location for the hub proved to be the most significant obstacle. Lengthy permit processes and limited availability of spaces with necessary infrastructure (electricity, van access, autonomous vehicle compatibility) hindered the endeavor.
- Cost Pressures: The high cost of the suitable location raises concerns about the financial feasibility of similar implementations. Sharing costs with multiple operators could be a potential solution but requires further exploration.
- Need for Dedicated Hub Management: The absence of a dedicated person responsible for hub operations became apparent. This role would involve parcel management and overall coordination. This role should be signed done in a neutral party, which assisted by the blockchain technology could ensure smooth collaboration among the transport operators.

Despite these challenges, the core operations functioned well once the location and infrastructure were in place. Customer feedback, while limited due to low response rates, was positive.

Recommendations for Future Development as described by DB Schenker

To address the challenges identified in the pilot, the following recommendations are proposed:

- Scale up operations by increasing the number of logistics service providers to improve financial sustainability.
- Secure city support by encouraging active involvement in identifying and providing suitable, affordable hub locations, with assistance from the EC for funding and resources.
- Establish a dedicated hub management role to oversee operations and parcel coordination.

- Invest in electric vehicles at a national level and develop KPIs to measure progress.

By implementing these recommendations, the potential of the hub concept can be maximized, and the challenges encountered in the pilot project can be mitigated.

Lessons Learned from the Pilot as described by LMAD

The pilot project demonstrated the potential of robot-based delivery. When such operations are complemented with the hub, they can serve as a vital part of the last mile logistics transformation towards greener operations. However, several challenges were encountered:

- Location and Planning: Finding and securing a suitable hub location proved to be a significant issue, blocking the further planning of the operations beforehand. Eventually, the operations and planning occurred simultaneously, which was adding extra uncertainty and pressure.
- Robot Size and Capacity: The smaller robot demonstrated better adaptability to the urban environment and gathered more positive public responses when residents encountered it in urban environment. Optimal robot size depends on delivery volume, with larger robots requiring higher parcel quantities to justify their use.
- Customer Behavior: While overall customer satisfaction was positive, there's a need to understand why some customers opted for traditional pickup points instead of robot delivery.
- Operational Efficiency: The hub concept functioned well with the robots acting as a standalone collection point to choose for the recipients, but other use cases could be implemented, such as exploring the robots' potential as an overflow capacity for busy pickup locations.
- Public Perception: While most interactions were positive, negative reactions from some pedestrians highlight the need for further research.
- URBANE Blockchain: The URBANE blockchain successfully provided a real-time data interface for tracking delivery progress. However, the platform's full potential for data sharing and security enhancements remains to be explored.

Recommendations for Future Development as described by LMAD

To build upon the pilot's successes and address identified challenges, the following recommendations are proposed:

- Prioritize Location and Planning: Early location selection is crucial for efficient operations. Implementing more comprehensive planning phases before launching new pilots is essential.
- Optimize Robot Deployment: Conduct further analysis to determine the optimal robot size based on delivery volume and urban environment characteristics.
- Enhance Customer Experience: Conduct in-depth research to understand customer preferences and reasons for choosing alternative delivery options. Implement strategies to improve service visibility and measuring customer satisfaction.
- Explore Additional Hub Functions: Investigate the potential of using the robot as an overflow capacity for busy pickup points to optimize customer satisfaction.

- Scale Operations: Expand the number of robots to achieve economies of scale and validate the financial feasibility of the concept using more volume.
- Dedicated Hub Management: Assign a dedicated party to oversee hub operations, including parcel sorting, receiving, and overall management of the premises.
- Strengthen Partnerships: Continue fostering strong collaborations with logistics providers and technology partners to optimize the delivery process. Involve the city’s decision makers to provide land for the operations.
- URBANE Platform Development: Explore further the integration of blockchain technology to enhance data protection and transparency between multiple different stakeholders.

By implementing these recommendations, the robot delivery service can be further developed into a reliable, efficient, and customer-centric solution.

Lessons Learned from the Pilot as described by A2B

A2B participated in URBANE sprint 3 operations by executing the last-mile deliveries for DB Schenker’s parcels using the cargo bike and electric vans. The pilot provided valuable insights. While operations ran smoothly overall, the late selection of the hub location proved to be a challenge for proper planning of the operations. The cargo bike's timely arrival in June and the driver's readiness to start the deliveries ensured a smooth beginning. Collaborating with DB Schenker for additional parcels enhanced the delivery volume and thus helped during the slower summer months.

Two delivery methods were tested by A2B: direct from the hub to the cargo bike for daytime deliveries, and direct from the terminal to the bike, bypassing the hub. The latter method, referred to as a mobile microhub, proved more efficient due to time savings for the driver within the city center. This efficiency was particularly evident during the summer holiday period when delivery volumes were naturally lower.

A key finding was that delivery volume must be higher to not only justify the hub’s existence but also to calculate the viability of the hub concept in general. Additionally, a neutral party is required to manage hub operations, facilitating collaboration among multiple delivery partners.

The pilot also highlighted the need for consolidation to optimize resource utilization. By sharing space, costs, drivers, vehicles, and parcels among multiple stakeholders, efficiency can be significantly improved. Clear responsibilities and more preparation time are essential for successful hub operations.

Recommendations for Future Development as described by A2B

- Increase Delivery Volume: Actively seek additional customers and partners to boost delivery volume and make the hub financially sustainable.
- Establish a Neutral Hub Manager: Identify a neutral party to oversee hub operations and facilitate collaboration among stakeholders.
- Consolidate Operations: Implement strategies to share resources and reduce costs through consolidation.
- Extended Planning: Allocate at least six months for planning and preparation before initiating new hub operations.

- Secure Suitable Locations: Conduct thorough site selection processes to identify optimal hub locations.

Furthermore, to address broader challenges and opportunities, the following recommendations are made:

- Explore Alternative Vehicles: Consider using electric vans as a complement to cargo bikes during winter months or in case of driver absences.
- Advocate for Clean Air Zones: Support the implementation of low and zero-emission zones in Helsinki to promote sustainable delivery practices.
- Improve Urban Infrastructure: Advocate for the creation of dedicated loading zones and bike lanes to enhance delivery efficiency and safety.
- Public Education and Awareness: Conduct public education campaigns to increase understanding of traffic rules and the benefits of cargo bikes.

By implementing these recommendations, the hub concept can be further developed into a sustainable and efficient LMD solution.

Other Possible Uses for the Robots

The ciTHy M and L droids have been used by LMAD for:

- Delivering equipment for construction with Wurth:
- Unique box with a rolling shutter.
- Wooden platform box for heavy objects.

Delivering dry parcels:

- 25-locker box for ciTHy L.
- 6-locker box for ciTHy M.

But these mobile bases can be more shared between different professions/users throughout a day with interchangeable boxes. In other experiments TwinswHeel is testing:

- Assisting elderly and mobility-impaired people.
- Carrying luggage at ski resorts and campsites.
- Delivering meals and snacks.
- Assisting in the maintenance of city networks (water, gas, electricity, etc.).
- Street cleaning.
- Collecting and delivering bulk parcels.
- Collecting mail.
- Restocking stores and relay points with dry and fresh products.

The Future of Logistics with ADVs from TwinswHeel's point of view:

The regulation and approval of such logistics robots are still an issue at the European level. Things are moving, but very slowly. TwinswHeel's forecasts show that by 2030, regulations should have evolved for the mass deployment of logistics ADVs in Europe. The European market size should be 100,000 ADVs by that horizon. But to get there, the road is still long:

- Further technical development.
- Evolution of regulations.
- Acceptance by the citizens.
- Access to funding
- Competition outside EU(eg Chinese ADVs)

Lessons from Urbane Experiments for TwinswHeel:

- Operate the droids in Northern Europe with non-Soben personnel.
- Test the robustness of the droids.
- Test B2C use cases that we do not address in France.

Use of Data Collected by the Droids

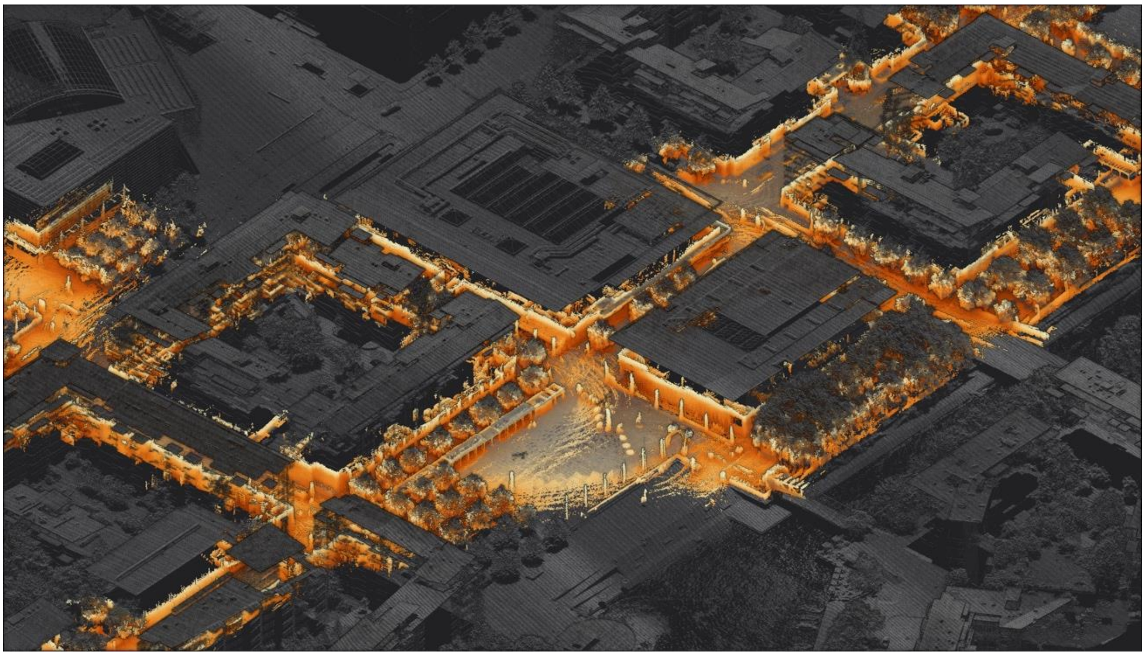

FIGURE 33 3D POINT CLOUD VISUALIZATION

The data collected by the droids during map creation provides a point cloud of the locations. This point cloud can help urban planners and road managers in their tasks (Figure 33). To date, this data is in the early stages of exploitation.

LMD robots utilize lidar sensors to detect obstacles in their surrounding environment, generating 3D point clouds from the collected data. The point cloud produced by the Twinswheel delivery robot is visualized in color and overlaid on the grey-scale aerial laser scanning point cloud provided by the City of Helsinki (2021).

Final Conclusions

The operations in the Helsinki Living Lab (LL) were highly successful. The Helsinki LL effectively designed Automated Delivery Vehicle (ADV) services tailored to users' and stakeholders' needs. Customer behavior and the deployment of multiple ADVs were simulated using the Digital Twin (DT) technology and digital models. The integration of different logistics service providers (LSPs) was facilitated through blockchain-based smart contracts, enhancing collaboration. The real-life demonstration of ADVs and cargo bikes garnered positive media attention, generating enough visibility to foster a basic understanding of the services' potential feasibility and future scalability.

Helsinki tested various delivery modes, including B2B, B2C, on-demand, fixed pre-determined pick-up locations, one-hour time slots, manned service points, and consolidation among different stakeholders. Locations were optimized based on continuous feedback and data collected throughout the iterative design of piloting sprints. These insights proved valuable for city decision-makers, emphasizing the importance of selecting optimal microhub locations as bases for Light Electric Vehicles (LEVs). Although the use of loading and unloading zones was tested in real-life operations, they were less relevant for ADVs, which primarily utilized pedestrian lanes for movement. The ADV movements were captured as point cloud data, which was then used for visualizations in the city environment. Business value simulations revealed that parcel demand is a critical success factor for ensuring the financial sustainability of operations.

From an environmental perspective, it was evident that significant CO2 reductions could be achieved, particularly by using renewable energy for charging robots and cargo bikes. Additionally, the shift to ADVs and cargo bikes reduced the kilometers driven by combustion engine vans, thus alleviating urban traffic congestion.

However, the project faced limitations, including a lack of time to prepare piloting operations due to lengthy permit processes, especially for sprints 2 and 3. This time constraint hindered the implementation of relevant technical solutions for reverse logistics in ADVs, with only DHL Express' service point enabling the reverse sending of packages. Future research should focus on scaling up these operations and identifying the optimal way to implement microhubs that incorporate ADVs, cargo bikes, service points, parcel lockers, reverse logistics, and other relevant services to further promote sustainable urban logistics.

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