D2.4: Valladolid Demonstrator

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Executive summary

The present document summarises the work carried out in the framework of Task 2.4: Valladolid Living Lab (LL) Implementation. In essence, the report describes the actions conducted in the Valladolid LL, which aim to solve the problems derived from the distribution of goods in the city and the externalities that are connected with this in both environmental and operational terms. With this view, the report is structured around three use cases: (i) monitoring of loading and unloading (L/U) areas using artificial intelligence; (ii) implementation of an innovative and sustainable solution of contactless parcel delivery; and (iii) techno-economic comparison of the use of combustion vehicles and I-FEVS prototype vehicles in delivery services. Thus, it begins by describing the starting point of the LL, together with its purposes, and then exposes the methodology for the implementation of the three use cases. This methodology sets out a series of guidelines and useful information to understand the specific purpose of each use case.

Following that, the document includes a detailed list of the most relevant stakeholders and of the set of laws and regulations that influence the formulated use cases.

The report continues by detailing the implementation plan followed for each use case and the evolution of the performance indicators. Special attention is placed onto the digital tools, both owned by the municipality and resulting from the URBANE project, which apply to the purposes of the LL.

Lastly, the report provides concrete information on the situation at the time of initiation of the use cases that establishes the "starting point" for the interventions. The document concludes with a description of lessons learned and a number of recommendations aimed at facilitating the implementation of the actions in the follower cities aiming to address similar challenges.

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List of abbreviations

ACRONYM	DESCRIPTION
BPMN	Business Process Modelling Notation
CCAM	Connected, Cooperative and Autonomous Mobility
CCTV	Close-Circuit Television
CNN	Convolutional Neural Network
COCO	Common Objects in Context
CV	Computer Vision
DoA	Description of the Action
DT	Digital Twin
DUMinVAL	Distribución de Última Milla en Valladolid (Last-mile delivery in Valladolid)
EDV	Electric Delivery Vehicle
EV	Electric Vehicle
GIS	Geographic Information System
ICE	Internal Combustion Engine
ICT	Information and Communication Technologies
IT	Information Technologies
KPI	Key Performance Indicator
L/U	Loading and unloading
LEZ	Low Emission Zone
LL	Living Lab
LSP	Logistic service provider
OCR	Optical Character Recognition
PI	Physical Internet
PI	Physical Internet
PV	Photovoltaics
QR	Quick Response
ROI	Region of Interest

ROI	Region of Interest
SULP	Sustainable Urban Logistics Plan
UC	Use Case
UDR	User Defined Route
UPM	Universidad Politécnica de Madrid
V2G	Vehicle-to-Grid
V2I	Vehicle-to-Infrastructure
V2V	Vehicle-to-Vehicle
V2X	Vehicle-to-everything
VRP	Vehicle Routing Problem
VRU	Vulnerable Road User
YOLO	You Only Look Once

1. Introduction

The aim of this deliverable is to provide a detailed analysis of the Valladolid Lighthouse Living Lab (LL) as part of Work Package 2 (WP2) of the URBANE project. As such, the document describes the overall characteristics of Valladolid LL (location, problems to be solved, policy priorities and commitments, etc.) that motivates the definition of the Use Cases (UCs) proposed. For each of these UCs, a thorough description of their objectives, setup and implementation aspects is provided, together with the main results obtained during the trials and the subsequent operational and environmental impact assessment. The different UCs integrate a number of technological innovations in order to enable more efficient and sustainable last-mile operations, leveraging for this purpose on several models and digital tools developed within the scope of URBANE. The document also includes the main KPIs (see D2.1 for the complete KPI list per UC) measured during the trials, as well as lessons learned and recommendations to support replication and scaling up.

1.1 URBANE Outputs Mapping to GA Commitments

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

GA Item	URBANE GA Item Description	Document Chapter(s)	Justification
		TASK	
T2.4	The LL will operate a fleet of fully electric vehicles with solar panels and CCAM capabilities in Valladolid LL.	Sections 4.3, 4.3.1	Section 4.3 presents the framework within which such fleet will operate while section 4.3.1 presents the steps that have been taken to bring the vehicles into circulation. Section 3.4 explains how Vehicle-to-Everything (V2X) communication capabilities are addressed through the application of various innovative solutions across the three use cases implemented in Valladolid.
	Stakeholders will co-design the operative model and design safety measures.	Chapters 2, 5, Section 7.2.3	Chapter 2 presents the data collection and analysis process. Chapter 5 presents the stakeholders and their role in the Valladolid LL. Section 7.2.3 explains the operative model of the electric vehicle fleet and how the design of a new safety functionality has been approached.

	First activity is the requirements analysis, user stories development and implementation plan.	Chapters 2, 4, 6, 7	Chapter 2 presents the data collection and analysis process. Chapter 4 focuses on the needs and the benefits that each use case will bring to the stakeholders. Chapter 6 examines all those policies and regulations that influence the uses cases. Chapter 7 presents the implementation plan at use case level.
	Secondly, the implementation in real life settings.	Section 7.2 Chapters 9,10,11	Section 7.2 describes the implementation of the use cases in real life settings. Chapter 9 presents the baseline measurements of the KPIs selected to evaluate the impact of interventions. Chapters 10 and 11 present the lessons learnt and the recommendations that derive from the demonstrations.
DELIVERABLE			
D2.4	D2.4 will describe the requirements for last mile delivery operations with a fleet of fully electric vehicles including e-bikes, urban electric vans and urban electric pick-up.	Section 4.3	Section 4.3 describes the requirements in the framework of use case 3, related to the deployment of a fleet of fully electric vehicles.
	The LL will demonstrate dynamic e-routing to minimize energy consumption and maximize energy harvesting, V2V, V2G and V2I communications, and collaborative delivery.	Section 4.4	Section 4.4 presents how all these concepts are addressed in the framework of the finally formulated use cases.
	It will include specifications for vulnerable road users' safety, fleet details, user stories involving all stakeholders, the LL DT models, a detailed implementation plan, measurements during operation in real life settings and lessons learned for wide adoption.	Chapters 4, 7, 8, 9, 10	Chapter 4 describes the particularities of each use case. Chapter 7 presents the steps followed in the implementation process of each use case. Chapter 8 describes the physical and digital infrastructure (including the LL DT models) on which the LL is built. Chapter 9 recapitulates the measurements carried out before and after the implementation of the use cases. Chapter 10 summarises the

			lessons learned from the development of the use cases.

1.2 Deliverable overview and Report Structure

The deliverable is structured as follows:

- Chapter 2 focuses on describing the data collection and analysis processes for Task 2.1.
- Chapter 3 presents the general background of the living lab, the context and the objectives pursued with the development of the project.
- Following that, chapter 4 takes a closer look at each individual use case on which the actions to be developed are structured. In particular, the benefits and results expected with each one of them and the interventions done in the scope of URBANE are described.
- Chapter 5 is devoted to the stakeholders' analysis.
- In sixth place, chapter 6 summarises the key aspects of the main policies and regulations affecting the use cases formulated.
- Chapter 7 presents the actions carried out during the implementation process of each use case. It goes on by describing the survey conducted in the framework of Task 2.1 on the technologies implemented.
- Chapter 8 describes the physical and digital infrastructure on which the living lab is built.
- Chapter 9 collects in a table the KPIs associated to the Valladolid LL.
- Chapter 10 summarises the lessons learned from the development and implementation of the use cases.
- Finally, chapter 11 concludes this report by offering a series of recommendations derived from the work undertaken in Task 2.4.

2. Data collection and analysis

Data collection is the process of gathering information for research or analysis. In URBANE Work Package 2 (WP2), the purposes are to: I) perform a mapping of stakeholders in the different Living Labs (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, iv) 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 Sustainable Urban Logistics Plans (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 Key Performance Indicators (KPIs), accompanied by general guidelines on the use of sheets and by descriptions, units of measurement, target group, and calculation methodology for each KPI.
- **Business Process Modelling Notation (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 (coordinates, climate, HDD, CDD, etc.):

Valladolid (41º 39’ 8.1036’’ N, 4º 43’ 28.3152’’ W) is a Spanish city with roughly 300,000 inhabitants located north-western Spain (Figure 1), at the confluence of the Pisuerga and Esgueva rivers. The city is situated on an important economic axis between Galicia, the Basque Country and Madrid; in fact, it is an hour by high-speed train from Madrid. Its average altitude is approximately 700 metres above sea level, and it is located in predominantly flat area. Its location also coincides with the Helsinki-Lisbon transport hub, which connects Portugal with the rest of Europe. Its climate is mild, generally warm and temperate. The average annual temperature is 12.5 ºC and about 490 mm of precipitation falls annually.

In connection with its economy, Valladolid has evolved from an agricultural base towards a diversification that includes industry and services. In particular, the automotive industry stands out along with technology companies. Tourism and the education sector, driven by the University of Valladolid, also play an important role in the local economy.

FIGURE 1. VALLADOLID LOCATION ON THE EUROPE AND SPAIN MAPS

3.1.1.1 100 climate-neutral and smart cities by 2030

Thanks to its commitment to the Sustainable Development Goals, its strategy for sustainable mobility and its commitment to energy transition, Valladolid is one of the cities that the European Commission has selected to be part of the 100 climate-neutral cities before 2030 scheme [1]. Its actions focused on offering greener and smarter transport, combined with its support for “clean” and connected vehicles and shared transport models, have made Valladolid recognised at the European level to address the urban transformation towards zero emissions as an example to follow. The city achieved this distinction in October 2023, along with 99 other cities, 5 of them Spanish.

At the forefront of climate action, being part of this ambitious mission not only allows Valladolid to benefit from additional funding, but also to disseminate its actions throughout Europe and that means to publicise URBANE too.

3.1.2 Context

From early 2023, Spanish municipalities with more than 50,000 inhabitants are required to define a Low Emissions Zone, a restricted urban area to which the most pollutant vehicles cannot access. This imposition responds to the Climate Change Law approved in 2021 by the Government [2]. While the regulation establishes specific measures and deadlines, according to the report by the Clean Cities network [3], only 19 of the 151 municipal governments that were supposed to implement these zones have done so within the established timeframe. Meanwhile, 113 municipalities are in the process of doing so and 20, according to the report, have chosen no to comply with this obligation at all. The reason for this lies mainly in the complexity of its implementation, especially for less populated cities.

This situation, arising from confusion over what to do in the short term and the absence of clear guidelines, has led Spanish municipalities to call for a delay in the implementation of low emission zones. In the case of Valladolid, the municipality has already set a date on which the Low Emission Zone (LEZ), envisioned as shown in Figure 2, will come into force; however, it is not envisaged that the restrictions will come into effect until late 2024 or 2025. In this regard, the municipal government proposes that drivers with lower incomes can continue to drive their current vehicles, even if they do not have the environmental label [4]. The same applies to loading and unloading (L/U) vehicles, which, regardless of their environmental classification, will be authorised to carry out urban distribution operations within the LEZ. This fact contradicts the main objective of the regulatory tool, which is to improve air quality.

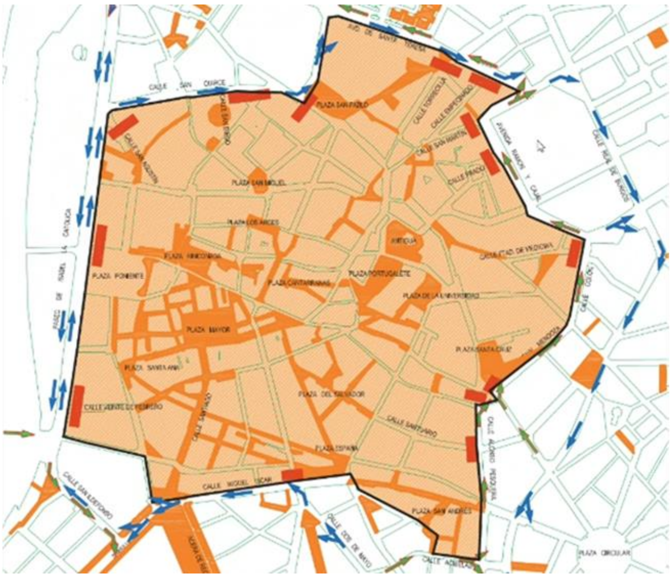


FIGURE 2. VALLADOLID'S LOW EMISSIONS ZONE

Using the example of Barcelona, where the LEZ has been in place since several years ago and all types of L/U vehicles are allowed to circulate, municipal sources [5] estimate that 20% of the vehicles circulating in the metropolis are light-duty vehicles and vans. Of this 20%, 6% do not have environmental label. If we translate this data into terms of emissions, this 20% is responsible for 40% of total pollution and of this percentage; half is attributed to vehicles without label. This fact is worrying, especially in view of the current growth of e-commerce and the increasing demand for fast delivery.

Faced with this background, the Government of Valladolid is committed to a sustainable trade model based on zero-emission freight distribution solutions, which minimise or completely eliminate the negative impacts of urban freight distribution on the environment and public health. Although no access restrictions are foreseen for the freight delivery sector, Valladolid will use URBANE's positive and innovative experience related to the delivery of goods with electric vehicles to promote the use of electric fleets among logistics operators.

On the other hand, the city faces an urban planning problem that affects the operability of L/U zones, partly because of the lack of a smart system to identify the vehicles authorised to park in these zones (many deliverers encounter unauthorised users in the space reserved for them on a daily basis). According to data from the Centre for Innovation in Logistics and Transport of Goods (Citet), in more than 65% of Spanish establishments, L/U operations are carried out outside the dedicated areas, either in a double row or in a bay of the regulated parking zone [6]. This widespread non-compliance obstructs traffic and causes traffic congestion. Valladolid, in an attempt to solve this problem for the benefit of citizens, will implement a monitoring system to collect data on the use of parking spaces reserved for L/U that will allow to take action based on real data. Through this system, the municipal government intents that in the future, the L/U zones will be managed more effectively with the support of technology.

Lastly, the city also faces the need to adapt to the new requirement of e-commerce and, consequently, to new, less pollution intense and more efficient delivery models. According to information from the Harvard Business Review [7], it is estimated that up to 20% of packages purchased in e-commerce are not delivered to the recipient on the first attempt. This has a negative impact on the costs of delivery companies as well as on the environment. In addition, failed deliveries affect customer satisfaction, creating uncertainty and stress as they do not know when they will receive their order. Also, from a planning perspective, city centres are characterised by the need of delivering multiple parcels in close proximity. This, if not managed conveniently, may lead to multiple parcel reshuffling needs, which affect the efficiency and quality of the delivery service and add strain to logistics operations [8]. In order to greatly simplify the work of delivery companies (better balance between load capacity and delivery efficiency, minimising parcel reshuffling operations) and to facilitate the daily life of citizens (ensuring a successful and timely delivery of the parcel), Valladolid will promote, within the framework of URBANE, a model of trunk delivery in park & rides. In this way, the municipality aims to reduce the possibility of failure in parcel delivery, while contributing to a more sustainable model of urban freight distribution. In the context of URBANE, the advantages of this delivery model compared to a conventional delivery model will be analysed in various scenarios with different vehicles.

3.1.3 Governance and Business models

According to the Annual Report of a major Spanish bank, there are 5899 retail companies in Valladolid [9]. These companies represent a sector of great interest for the city, both in terms of their impact on employment and on economic activity; however, if we compare their range of services with that of the large retail stores, this is undoubtedly much lower. This reason has motivated the municipality to take action to promote the modernisation and competitiveness of small retail. Through the development of a common sales platform for the companies that form part of the municipal markets (marketplace), Municipality of Valladolid intends to give a boost to retail trade. This measure comes together with other complementary activities that will make it possible to obtain a comprehensive proposal. Among them, one of the actions envisaged is the implementation of a unified sustainable distribution system based on zero-emissions vehicles, which will be built on the experience gained from the development of the project.

In connection with L/U areas, in order to promote a balanced commercial structure that favours the presence of local businesses in certain areas, the municipal government aims to improve mobility by improving L/U areas. Added to this action is the promotion of park & rides through the creation of a differentiating experience.

These measures, along with others, are part of the comprehensive support plan for the local commerce [10], which inspires the development of public polices for retail trade.

3.1.4 Supporting market-based measures

The main Valladolid policies with relevance for last mile logistics activities are listed below. The points mentioned are taken from the Municipal Regulation on Traffic, Parking and Road Safety.

- Time window for L/U tasks (it varies according to the street).
- Parking regulation: L/U is only allowed for up to 30 minutes in parking bays and areas reserved for this purpose.
- Size and weight restrictions for delivery vehicles.

Additionally, and outside of the project, the municipality is working on the development of a smart parking platform called 'DUMinVAL' [11], focused on the management of L/U areas. This system, which seeks efficiency and accessibility to information in real time, will replace the current control method based on the well-known 'time control disc'. This system of managing L/U available slots consists of a physical device (a disc), in which the person parking the vehicle indicates the time at which the vehicle was parked, so that the employees of the municipality can check whether or not the rules are being followed. Compared to a smart system, this 'time control disc' system requires a high surveillance effort from the municipality staff, as well as trust on the fact that the drivers will make an honest use of it. The new system will be extended to parking spaces for electric vehicles and those reversed for people with reduced mobility.

3.2 Vision and challenge to be addressed in URBANE

3.2.1 LL Objectives

In the framework of URBANE, Valladolid has three main objectives: (i) to make L/U zones more efficient, with view to achieving a more sustainable, orderly and efficient urban goods distribution; (ii) to promote sustainable and environmentally friendly delivery practices; and (iii) to build a safer city for pedestrians.

In order to achieve these general objectives, a number of specific interventions/measures were set out, which are detailed below:

1. **Develop an analysis tool for L/U zone usage focused on decision-making based on real data**

   The first objective focuses on developing an image processing software, using artificial intelligence and deep learning technologies, capable of recording data on the use of L/U areas. This approach will allow the LL to identify usage patterns and parking slots availability on which to base strategic decisions.

2. **Demonstrate the environmental benefits associated with collaborative delivery models**

   The second objective is to prove that the model of trunk delivery has a lower impact on the environment than the conventional one, partly because of an increase in the effectiveness of the delivery operations. This approach will promote the implementation of this delivery model among logistics operators.

3. **Put on the road full electric vehicles adapted for the delivery of small goods**

   The third objective, for its part, seeks to test a series of electric vehicles specifically designed for delivery tasks under real-life conditions. This will be supported by the public postal service, that will use the vehicles for its daily activity.

4. **Implement a Vulnerable Road User Detection system in delivery vehicles**

   Finally, the fourth objective involves the integration of a system, based on image processing, in a delivery vehicle capable of recognising pedestrians, detecting them and warning the driver. By analysing the failure rate, the LL aims to demonstrate that the application of this type of system reduces the likelihood of accidents in metropolitan environments.

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

In essence, Valladolid LL seeks to achieve a balance between last-mile delivery operators and other users of the public space to enable it to improve urban goods distribution operations without harming the urban and environmental quality of the city.

Regarding the problems to be addressed in the context of URBANE, they are as follows:

- Misuse of L/U zones
- Overcrowding of these zones (L/U areas)
- Pedestrian injuries on urban roads
- And finally, "poor" air quality

4. Use cases

In line with the objectives outlined in section 3.2.1, the following sections provide a description of the use cases into that have structured the various actions undertaken. Specifically, three use cases have been implemented: (i) monitoring of L/U areas using artificial intelligence (Objective 1) ; (ii) implementation of an innovative and sustainable solution of contactless parcel delivery (Objective 2); and (iii) techno-economic comparison of the use of combustion vehicles and I-FEVS prototype vehicles (electric, safe, urban-designed vehicles) equipped with CCAM functionalities in delivery services (Objectives 3 and 4).

4.1 Use case 1

Over the past decades, the growth of urban freight distribution (owing to the expansion of new business models such as e-commerce), combined with the increase in the number of journeys with private vehicles in the urban area, explain the extraordinary volume of movements in cities. In light of this situation, there are aspects that represent a challenge for the urban goods distribution, and in particular for L/U areas. Lack of space and dense traffic, combined with the volume of movements, make delivery operations increasingly difficult in urban areas, while at the same time encourage inappropriate use of L/U areas. Referring again to the study indicated in section 3.1.2, in more than 50% of the cases the deliverers are forced to double park, partly because of vehicles being improperly parked in designated areas. This practise, which is becoming increasingly common, significantly disrupts traffic flow, leading to slower movement and causing congestion.

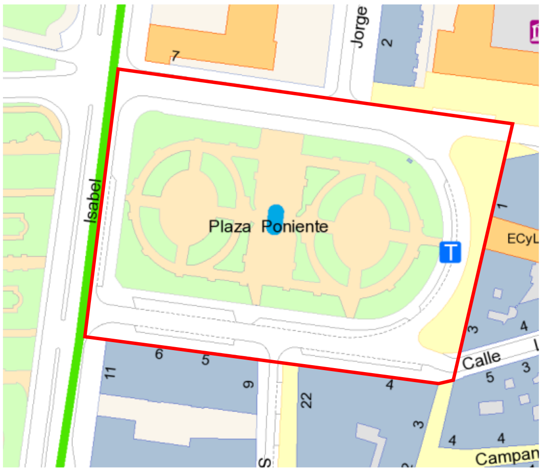


FIGURE 3. PILOT AREA OF THE USE CASE, LOCATED IN THE DOWNTOWN AREA

To better understand the characteristics of L/U operations in Valladolid, especially in the downtown area (including parking times), and to enhance traffic management efficiency, this use case aims to develop an intelligent system based on image processing. This system aims to control and monitor L/U zones.

The use case has been implemented on a pilot area of Valladolid, located within the low emission zone and delimited by the "Plaza Poniente", presented schematically in Figure 3. Although this area has two parking spaces reserved for L/U operations, the traffic density and the high number of businesses in the surrounding area present challenges for carrying out these operations efficiently (see Figure 4).

FIGURE 4. PREVIEW OF THE LOADING AND UNLOADING STUDY AREAS ON ANY GIVEN WORKING DAY

The intention of implementing a computer vision-based system for monitoring the use of loading and unloading zones is to find out precise information on the following:

- Percentage of occupancy of the zone
- Type of vehicles using the zones
- Average parking time

- Number of double-parking violations per day

It is clear that knowing and understanding the behaviour of the stakeholders involved in the urban freight distribution allows political leaders making better decisions. It is widely recognised that evidence-based policies increase the probability of success of the interventions, as objectives are better met. Leveraging technology provides the municipal government with an effective tool to design L/U zones that are better aligned with local needs, using data-driven indicators. In parallel, the implementation of this systems opens the door to the ability of collectively managing L/U zones through the DUMinVAL application (DUMinVAL stands for "Distribución de Última Milla en Valladolid – Last-Mile delivery in Valladolid"), since it could act as a double verification mechanism that would increase the reliability of the application. In addition, it enhances the interaction between vehicle and infrastructure, enabling communication between L/U areas and vehicles.

In essence, the monitoring of L/U zones seeks a more efficient infrastructure reorganisation based on data exchange. In this way, this use case addresses inefficiencies in logistics systems in the same way as the Internet did years ago: by optimising the utilisation of existing assets. This approach responds to the concept of "Physical Internet" (PI), on which URBANE project is based upon (URBANE D1.1. URBANE framework for optimised green last mile operation). Specifically, Use Case 1 supports the concept of PI with the following:

- Further support municipality's purposes for efficient deliveries in the city centre from multiple Logistics Service Providers (LSPs) through the network optimization thanks to Information Technologies-assisted (IT-assisted) decision making.
- Better design, deployment and use of L/U infrastructure (PI-nodes)

4.1.1 Interventions done in the scope of URBANE

- Definition, in close collaboration with the municipal government, of the features of the L/U zones to be monitored (e.g parking of unauthorised vehicles, double-parking violations, occupancy level of the zones, etc.).
- Study of the characteristics of the pilot area: electricity supply, available infrastructure, lighting, signal, etc.
- Selection and training of vehicle classification and tracking algorithms, based on the defined indicators. Specifically, YOLOv8 (YOLO is the acronym of "You Only Look Once") algorithm has been used for vehicle detection and DeepSORT for vehicle tracking.
- Analysis of current privacy regulations and obligations to be met when installing cameras in public spaces.
- Market study and selection of the video cameras to be used.
- Pre-commissioning of the system in CIDAUT's facilities, including activities such as defining the electrical connections, video/image capturing setup and transfer to the processing units, data handling procedures, etc. For these purposes, a L/U area inside CIDAUT/s premises was employed as test site.
- Implementation of the system in the pilot area.

- Processing and analysis of the measured data.
- Analysis of the characteristics of the L/U study zones by calculating the defined indicators.
- Pilot test of a system that informs vehicles about the level of occupation of the L/U zones using short-range communications.

4.1.2 BPMN diagram of the AS-IS and TO-BE scenarios for Use Case 1

For the Use Case 1, the AS-IS scenario is presented in Figure 5. In this scenario, a potential buyer (either a business or an individual) makes a purchase. The shipper, who can be a manufacturer or a retailer, processes and dispatches the orders. Once this is completed, the courier departs from the warehouse according to their own planning and optimal routes for a particular day. Once it arrives to the city centre, by default the courier will intend to park the vehicle in the closest L/U zone to the delivery address. If it is not possible to park in the optimal location (e.g. no free slots, double parking not feasible…), the courier will follow an iterative process until a free slot is found. After that, the parcel is distributed to the final client.

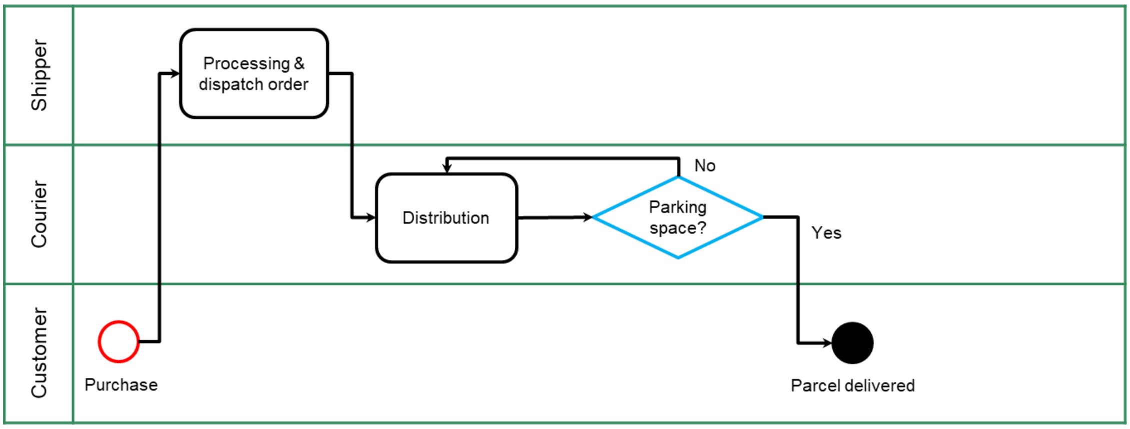


FIGURE 5. BPMN DIAGRAM OF THE AS-IS SCENARIO BEFORE USE CASE 1 IMPLEMENTATION.

The TO-BE scenario is presented in Figure 6. In this case, the L/U zones are monitored, therefore it is possible to know the occupancy level of the zones at any given time, the expected demand of the (potentially) available free slots, as well as any other significant historical data about how each zone is used. So in this scenario, the courier will check the status of different loading/unloading zones from which the parcel can be delivered to the buyer. In parallel, the courier will also analyse the information provided by the city regarding the probability of finding a free parking slot (based on the expected demand) in the different loading/unloading zones. Using all this data, the courier can now plan a more efficient route. After that, the parcel is distributed to the final client.

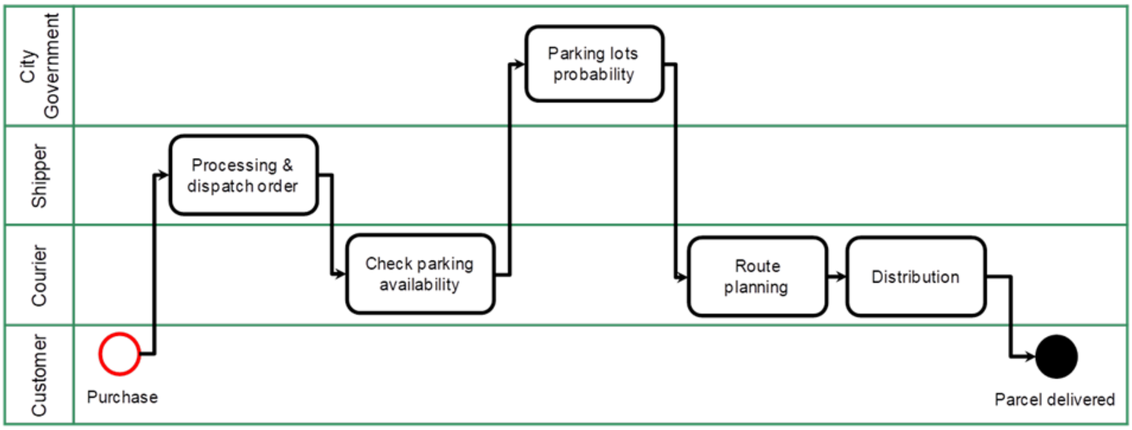


FIGURE 6. BPMN DIAGRAM OF THE AS-IS SCENARIO AFTER USE CASE 1 IMPLEMENTATION

4.2 Use case 2

In full boom of the e-commerce, the parcel delivery companies are launching new initiatives to make life easier for consumers. The inefficiency associated with failed deliveries, coupled with customer dissatisfaction, have led many operators to implement new delivery models. Such is the case of the in-trunk delivery service. Through this service, customers have the possibility to receive their parcels using their cars, rather than at home. For their part, the logistics provider can deliver the packages without requiring the customer to be present. For this purpose, they have single-use digital key associated with the order, which can unlock the trunk of the vehicle.

Within the framework of the Valladolid Urban Agenda 2030, this use case aims to promote the in-trunk delivery model by comparing it with the standard home delivery service. The objective is to assess the environmental and economic advantages connected with this delivery model, using specific indicators, when compared to the traditional service. With this vision, the Valladolid LL goes a step further and transfers this concept to the park & ride car parks.

With the entry into force of the restrictions associated with the Low Emission Zone, the concepts of deterrent parking and last-mile logistics are set to increasingly converge. As these concepts will become essential tools for those living far from their workplaces, use case 2 aims to raise the interest of logistics operators in the in-trunk delivery model, demonstrating with real data the benefits that this service provides, compared to the conventional service, particularly when combined with deterrent parking.

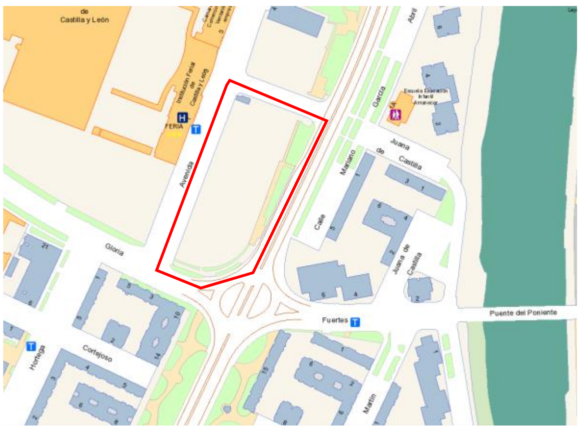


FIGURE 7. LOCATION OF THE SELECTED DETERRENT PARKING

The use case has focused on a deterrent parking located outside of the Low Emission Zone, with a capacity for 514 vehicles and approximately 15 minutes walking from the downtown area (Figure 7). In addition, it considers different types of vehicles: (i) hybrid vehicles and (ii) electric bicycles, as alternative to diesel-powered vehicles. This use case thus addresses the differences in performance and impact that arise when different vehicle types travel the same route. In both scenarios the use case relies on the following indicators to assess the environmental impact of the models (in-trunk vs. at home/business delivery service) with respect to using one type of vehicles or the other:

- CO2 emissions
- Total distance travelled
- Distance travelled in LEZ

In view of the lines of argument, and similar to Use Case 1, this use case supports the concept of Physical Internet (PI) through leveraging existing infrastructure, in this case deterrent parkings, as logistics nodes. Specifically, this concept goes a step further in the achievement of more efficient and sustainable logistics through the promotion of deterrent parkings as convergence point within the logistics network. In other words, use case 2 supports the concept of PI with the following:

- Enabling additional end nodes to increase the flexibility of the logistic operations regarding the users.

FIGURE 8. PREVIEW OF THE SELECTED DETERRENT PARKING FOR USE CASE 2.

4.2.1 Interventions done in the scope of URBANE

- Definition of the study scenarios (see Table 5 in section 7.2.2 for further details).
- Design of the routes. For this purpose, a free route optimisation and planning software (MapQuest) was used that allowed the routes to be designed in the most optimal way: avoiding unnecessary journeys and minimising travel times.
- Installation of measuring devices into the two classes of vehicles considered: a hybrid vehicle and an electric delivery bicycle.
- Execution of the delivery routes with both vehicles.

- Analysis of the benefits of in-trunk delivery versus home delivery, with respect to using one type of vehicle or the other, by calculating the indicators.
- Discussion with the municipality of possible policy initiatives to encourage the use of this type of delivery (free parking, etc.).

4.2.2 BPMN diagram of the TO-BE situation for Use Case 2

For the Use Case 2, the AS-IS scenario is presented in Figure 9. In this scenario, initially a customer (either an individual or a business) makes a purchase. Then the shipper, who can be a manufacturer or a retailer, processes and dispatches the order. After that, the courier departs from the warehouse according to their own planning and optimal routes for a particular day. Once it arrives to the city centre, the courier will park the vehicle in the most suitable location to deliver the parcel. Finally, the parcel is delivered to the final client.

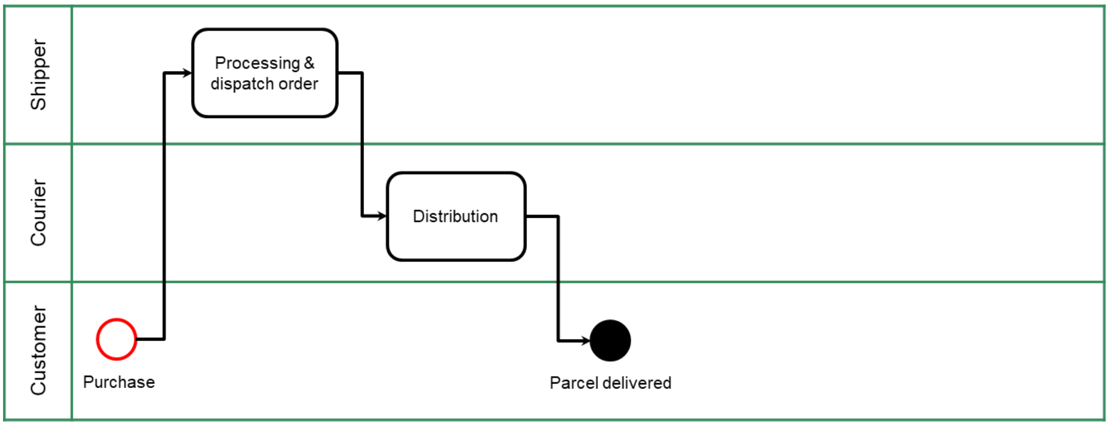


FIGURE 9. BPMN DIAGRAM OF THE AS-IS SCENARIO BEFORE USE CASE 2 IMPLEMENTATION.

The TO-BE scenario is presented in Figure 10. In the TO BE scenario, the buyer can choose “trunk delivery” as an alternative to the conventional delivery at a certain address. This means that the courier can make use of the buyer’s car, provided that it will be parked in a deterrent parking, to make the delivery in a more efficient way, if there is an explicit permission from the buyer to do this. In the TO BE scenario, if the user selects “trunk delivery” as an alternative delivery option, he/she must indicate where the vehicle is parked for this purpose. After that, there will be an intermediate stage in which it is checked whether the parcel fits in the vehicle’s trunk (dimensional check). If not, the buyer will be informed, so that the parcel can be delivered at a specified address following the AS-IS method. If yes, the courier departs from the warehouse according to their own planning and routes for the day. Once it arrives to the deterrent parking, in which the buyer’s vehicle is supposed to be parked, the courier will check that the vehicle is in the position indicated. If the vehicle is not there, the delivery process cannot be completed. If the vehicle is there, the buyer will allow the courier to access the trunk of the car (through a digital key) and the parcel is delivered.

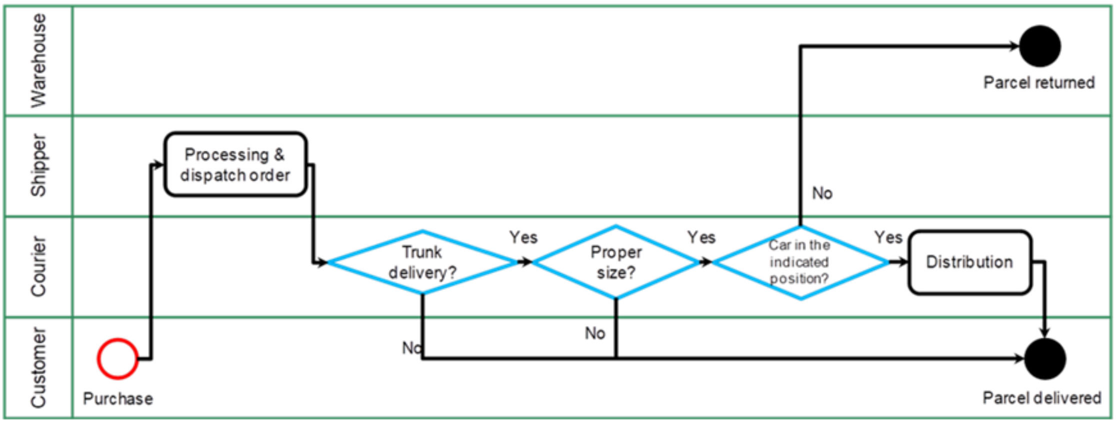


FIGURE 10. BPMN DIAGRAM OF THE TO-BE SCENARIO BEFORE USE CASE 2 IMPLEMENTATION.

4.3 Use case 3

Last mile logistics is undoubtedly a critical challenge for cities' air quality, especially for that of larger cities. Its relevance in the total greenhouse gas emissions is driving logistics operators to electrify their fleets. Whereas in the past, consumers valued the speed of service more highly, there is now a greater concern for sustainability and the environment, especially after the entry into force of the law regulating the Low Emissions Zones. However, making urban logistics more sustainable requires support from the public administration at this point.

The price difference between electric vehicles and conventional vehicles is a major barrier to the decarbonisation of transport in general. While price parity is expected by 2027 [12], the implementation of this use case aims in itself to accelerate the migration to electromobility into logistics operations. To this end, it focuses on demonstrating the benefits of an urban delivery service based on zero-emissions vehicles through a set of indicators. In order to also promote the adoption of new vehicle tailored to the freight industry, Use Case 3 incorporates several prototype vehicles from the I-FEVS brand (presented in Figure 11), partially powered by photovoltaic energy. The focus is particularly on the brand's van and cargo bike models. I-FEVS to assess their impact on the improvement of the city's air quality, the emissions of the different vehicles currently used by national postal service (CORREOS) will be compared with those of the I-FEVS vehicles. This comparison will be carried out on the basis of a predefined route model; specifically, based on the route travelled daily by the postman in the vicinity of the CIDAUT facilities.

Under this framework, this use case is implemented on the Boecillo Technological Park, a space dedicated to the installation of innovative technology-based companies. This park spans a significant area of 118 hectares, with high distribution demand from various industries, and a large number of pedestrians and cyclists. Given these unique characteristics, Use Case 3 addresses the need to provide more space for pedestrian movement by improving safety from a technological approach. Specifically, through the development and implementation of a **pedestrian detection system**, based on image processing, into one of the vehicles to be used; in particular the I-FEVS van.

FIGURE 11. I-FEVS PROTOTYPE VEHICLES.

All this effort is framed within the concept of the PI. The transformation pursued by this use case towards a more sustainable and more respectful transport, especially for the most vulnerable users, reinforce the ambition of the PI to contribute to the mitigation of the environmental and social impact of global logistics. With this vision, use case 3 supports the concept of the PI through the following:

- Further support the use of multiple vehicles to optimize delivery networks. The introduction of new types of vehicles will encourage the exchange of packages between cars, leading to a reduction in emissions.

4.3.1 Interventions done in the scope of URBANE

- Definition of AS-IS and TO-BE scenarios (see section 4.3.2).
- Installation of measurement devices into the vehicles, both into those used by postman daily and into the prototype vehicles developed and owned by I-FEVS brand.
- Data collection for the AS-IS scenario.
- Development of a tool adapted for data processing.
- Putting into circulation of the prototype vehicles, partly powered by photovoltaic energy.
- Data collection for the TO-BE scenarios.
- Analysis of the environmental impact of the new vehicles by calculating indicators.
- Development and implementation of a pedestrian detection system, based on image processing, into one of the I-FEVS vehicles, specifically into the van.
- Analysis and validation of the pedestrian recognition function integrated in the vehicle.

4.3.2 BPMN diagram of the TO-BE scenario for Use Case 3

For the Use Case 3, the AS-IS scenario is presented in Figure 12. In this scenario, initially a customer (either an individual or a business) makes a purchase. Then the shipper, who can be a manufacturer or a retailer, processes and dispatches the order. After that, the courier departs from the warehouse according to their own planning and optimal routes for a particular day. Once it arrives to the city centre, the courier will park the vehicle in the most suitable location to deliver the parcel. Finally, the parcel is delivered to the final client.

In the TO BE scenario, also represented by the BMPN diagram of Figure 12, the courier also departs from the warehouse according to their own planning and optimal routes for a particular day. The difference with respect to the AS IS scenario is that in now only electric vehicles (either cars or cargo e-bikes) are used to deliver the parcels. The vehicle selected will mainly depend on the features of the parcels to be delivered, but also on the preferences of the courier. The use of these vehicles may have an impact on the route planning and the delivery strategy, as the distance to be travelled as well as the available charging infrastructure will influence the delivery planning process.

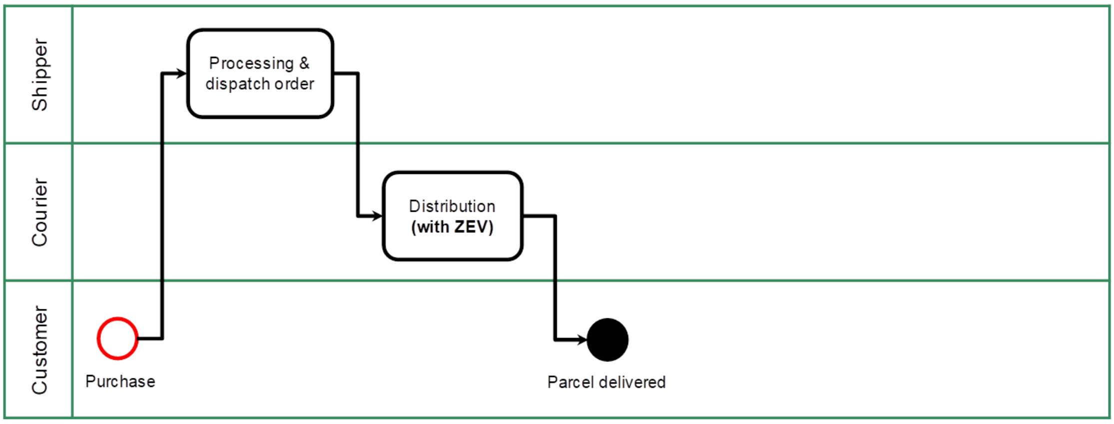


FIGURE 12. BPMN DIAGRAM OF THE AS-IS AND TO-BE SCENARIOS OF USE CASE 3.

4.4 Relationship of use cases to DoA

This section addresses the changes that have taken place around the use cases initially proposed in the Description of Action (DoA) as a consequence of a number of unforeseen circumstances, mainly also connected with the priorities set by the new municipal government changed in 2023. For the sake of clarity and simplicity, the following bullet points explain the relationship between the demonstration activities envisaged and the final use cases.

- **Zero emission urban deliveries** are covered in Use Case 3 with the usage of I-FEVS fully electric vehicles, and also tackled in Use Case 2.
- **Dynamic e-routing to minimize energy consumption and maximize energy harvesting** is partially covered in Use Case 2 through the application of an open access route optimisation software (MapQuest, available at https://www.mapquest.com/) during the design of the study scenarios.
- **Vehicle-to-everything (V2X) communication** is covered by the application of different innovative solutions in the three use cases deployed in Valladolid:
  - Vehicle-to-Vehicle (V2V): In Use Case 1, the developed communication pilot facilitates the vehicle arriving at the L/U area communicates via short-range technology with the infrastructure. Additionally, the installed equipment allows the information shared with

the vehicle to be distributed by long-range communication to other vehicles far from the area, thus enabling it to act as a communication bridge between vehicles.

- Vehicle-to-Grid (V2G): In Use Case 3 and Use Case 2, the charging process of the different vehicles involved was monitored to optimise the energy consumption. This was done through the charging infrastructure itself.
- Vehicle-to-Infrastructure (V2I): It takes places in Use Case 1, where the infrastructure itself informs vehicles on the status of the L/U zones. The method used can be extrapolated to other applications such as access control to traffic-restricted areas or traffic management by switching traffic lights on/off.

- **Collaborative delivery**. In view of the integration of new functionalities in vehicles, such as remote boot opening, and combined with the URBANE's strong bias towards reusability of delivery solutions, the efforts within Use Case 2 have been directed towards evaluating two different delivery modes: in-trunk delivery vs conventional at home/business delivery.
- **Improved vulnerable road users' safety**. Based on the experience of previous projects (like H2020 Multi-Moby- GA no. 101006953), CIDAUT has developed a machine vision system for the recognition of vulnerable road users, in particular pedestrians, which has been tested in the framework of USE CASE 3.

5. Stakeholders and their role

The following Table 2 presents the stakeholders identified in the Valladolid LL together with its role and main objectives in relation with the UCs of the LL.

TABLE 2. LL STAKEHOLDERS AND ROLES

Stakeholder	Role	Internal/external	Objective
Users			
City Government (AYUNTAMIENTO DE VALLADOLID)	Pilot support and facilitation	External	Improve the wellbeing and quality of life of the city's residents
Agency for innovation	Fostering the participation of all departments of the City Government	Internal	Make Valladolid a smart, sustainable and climate-neutral city
Urban mobility center (Centro de Movilidad Urbana de Valladolid)	Manager and policy-maker of the mobility in the city	External	Improve mobility in the city, with the minimum environmental impact

Last-mile carriers	Users of the L/U parking areas	External	Deliver the parcel as quickly and cost-effectively as possible
General population	Responsible for the proper functioning of the measures introduced - They do not know about the LL yet.	External	(i) Move around the city in an agile way (ii) Enjoy a healthy environment
Last mile delivery providers			
Spanish postal service	Promotion of cargo bikes and partially solar-powered vehicles in logistics sector	External	Reach as many customers as possible
Courier and transport operators	Main party affected by the implementation of the CCTV system that monitors the L/U areas	External	Cover all areas where end customers are located in the shortest possible time
Technical Providers			
CIDAUT (Research Center)	IT solutions developer and Valladolid LL leader	Internal	Gain knowledge
I-FEVS (EV developer)	EV and cargo bike developer	Internal	Position its products among the favourites of its target public
Others			
Valladolid Association of Cyclists	Promotion of the practice of cycling and meetings between cyclists within Valladolid, whatever their type (cargo bike, mountain bike, road bike...)	External	Promote the bicycle as a means of transport

6. Governance Analysis

The following is a summary of the most relevant policies and regulations structured according to the competent authority.

6.1 Policies and regulations at city level

The following is a summary of the current regulatory framework at local scale that has motivated and guided the actions to be carried out in the context of URBANE, within the Valladolid LL.

- ***Municipal Regulation on Traffic, Parking and Road Safety*** (City Government, 2006): https://www.valladolid.es/es/ayuntamiento/normativa/reglamento-municipal-trafico-aparcamiento-seguridad-vial.ficheros/3261-ReglamentoTraficoAparcamientoSeguridadVial.pdf: The regulation contained in this document aims to regulate urban traffic in the municipality of Valladolid. Specifically, it is responsible for regulating the following issues:
    - Speed limits on urban roads, direction of traffic, right of way rules, overtaking...
    - Circulation of bicycles
    - Pedestrian movements
    - Signposting
    - Transport of people
    - Penalty procedures
    - And finally, parking and L/U operations
- **PIMUSSVA** (City Government, 2021): https://www.pimussva.com/wp-content/uploads/2022/01/PIMUSSVA_AprDef.pdf Document which sets out Valladolid's mobility and transport planning for the coming years and where the current mobility situation is analysed. For it, it takes into account both existing planning practices and the principles of integration, participation and evaluation.
- **Agenda Urbana de Valladolid 2030 – AUVA 2030** (City Government, 2022): https://www.valladolid.es/es/actualidad/noticias/valladolid-verde-igualitaria-innovadora-objetivo-agenda-urb.ficheros/662230-AGENDA%20URBANA%20%20Final.pdf: Collaborative and strategic document which proposes the development of a series of strategic priorities, strategic objectives and specific objectives, interrelated with each other and with the various action lines of the city. Among the aspects that it covers, mobility and sustainable transport is one of them.
- **Climate change adaptation strategy** (City Government, 2022): http://www.valladolidadelante.es/sites/default/files/Climate_Plan.pdf Strategic document that presents the framework within which Valladolid will develop its future operational plan to achieve climate neutrality by 2030. The strategy that it describes rests on 4 basis pillars, which in turn are the city's goals: an increase of the adaptive capacity, digitalisation, data and information management to support the transparency of the processes and putting the citizens at the centre.
- **Plan de Innovación y Ciudad Inteligente SmartVa!** (City Government, 2022): http://www.valladolidadelante.es/sites/default/files/Innovation_Plan.pdf Plan focused and aimed at boosting the development of the local economy, which aspire to enhance the development of the digital economy and to incorporate several enabling technologies in all productive sectors. Under this vision, the document describes a sustainable and smart economic model driven by the digital transformation of the companies and particularised for the case of Valladolid.

6.2 Regional government policies and regulations

- **Estrategia Regional de Desarrollo Sostenible** (Castile and Leon Regional Government, 2009): https://medioambiente.jcyl.es/web/jcyl/binarios/396/636/Estrategia%20Regional%20de%20Desarrollo%20Sostenible%20de%20Castilla%20y%20Le%C3%B3n%202009-2014.pdf?blobheader=application%2Fpdf%3Bcharset%3DUTF-8&blobnocache=true Strategic document which incorporates policies, programmes and action plans, with the aim of achieving a balance between the conservation of the environment and the socio-economic models. As action document that is, it begins with a global analysis of social, economic and environmental aspects, and then describes a series of actions that take into account the different sectoral policies.
- **Estrategia Regional de Cambio Climático** (Castile and Leon Regional Government, 2009): https://medioambiente.jcyl.es/web/jcyl/binarios/61/183/Estrategia,1.pdf?blobheader=application%2Fpdf%3Bcharset%3DUTF-8&blobheadername1=Cache-Control&blobheadername2=Expires&blobheadername3=Site&blobheadervalue1=no-store%2Cno-cache%2Cmust-revalidate&blobheadervalue2=0&blobheadervalue3=JCYL_MedioAmbiente&blobnocache=true Document which coordinates all the actions to stop climate change at regional level. Combining adaptation and mitigation measures, the document includes a total of 104 measures grouped into 7 sectoral plans and one cross-cutting plan. Each measure, in turn, comprises a series of specific actions.

6.3 Policies and regulations at national level

- **Royal Decree 1052/2022** (Ministry of the Presidency, Parliamentary Relations and Democratic Memory, 2022): https://www.boe.es/diario_boe/txt.php?id=BOE-A-2022-22689 This Royal Decree regulates Low Emission Zones in Spain. According to it, all municipalities over 50.000 inhabitants (the case of Valladolid) and municipalities over 20.000 inhabitants exceeding the limit values of pollutants set in Royal Decree 102/2011 must adopt before 2023 specific sustainable urban mobility plans that include the definition of a LEZ, with the aim of improving air quality and mitigate the impact of GHG. Access, circulation and parking within the LEZ must be restricted to some extent to the most pollutant vehicles, although no specific actions are included in its scope. At present the city government has published a draft version of this document that has to be set to public feedback for amendments and suggestions before it is approved.
- **Sustainable Mobility Law** (Ministry of Transport, Mobility and Urban Agenda, still in draft form). Currently in the process of parliamentary approval, expected for late 2023, the main objective of this Law is to provide a legal framework for the development of a sustainable mobility system at national scale, that will enhance social and territorial cohesion, economic development and will help to reach climate change mitigation agreements. In what concerns logistics, this Law foresees the creation of a multimodal logistics system focusing on efficiency, sustainability and resilience.
- **Secure, Sustainable and Connected Mobility Strategy 2030** (Ministry of Transport, Mobility and Urban Agenda, 2021): https://cdn.mitma.gob.es/portal-web-drupal/esmovilidad/ejes/211223_es.movilidad_accesibilidad_BAJA_vf.pdf This Strategy is

considered the cornerstone for the development of mobility policies during this decade, and is based on three pillars: safe mobility at vehicle and infrastructure levels, sustainable mobility of both passenger and freight vehicles and connected mobility focusing on multimodality. The Strategy is dividid in 9 main topics, each of them with specific courses of action and measures to be implemented. One of them, titled “Intelligent and Multimodal Logistic Chains” considerd the development of policies about urban freight distribution considering digitalization as key enabler.

6.4 EU-level policies and regulations

- **Euro 7 emission standards** (European Commission, 2025). This new standard has not entered into force yet, but its enforcement will very likely boost the adoption of EVs as more severe pollutant limits from vehicles will be set as a means of improving air quality. Compared with previous standards, the Euro 7 will homogenise emission limits for all motor vehicles (cars, vans, buses and lorries) under a single set of rules. Not only pollutant emissions are expected to be regulated, but also emissions coming from brakes and tyres, as well as the durability of batteries for EVs will be included into the scope of the Euro 7
- **EU ban on the sale of new petrol and diesel cars** (European Commission, Regulation 2023/851). In line with the Paris Agreement and the European Green Deal, the European Commission has established that from 2035, all new cars that come on the market cannot emit any CO2, to ensure that by 2050 the transport sector becomes carbon neutral. This ban on petrol- and diesel driven cars will not apply to neither already circulating vehicles nor second-hand ones, although an increase in the TCO for this kind of vehicles is foreseen.

7. URBANE LL implementation

7.1 Timeline

The following Table 3 presents the timeline of the different interventions implemented in the Valladolid LL

TABLE 3. VALLADOLID LL TIMELINE

	2022				2023												2024							
	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A
Use case 1																								
Definition of the metrics of interest			■	■	■																			
Vehicle classification and tracking models: programming & testing						■	■	■	■	■	■	■	■	■	■									
CV-based system architecture: definition and implementation in CIDAUT's premises																■	■							
Models validation																		■	■	■				
Installation of the CV-based system in the pilot area																				■	■			
Commissioning																					■	■		
Data collection & analysis																						■	■	■
Use case 2																								
Definition of the study scenarios																■	■							
Design of the routes																	■	■						
Execution of the delivery routes & data collection																			■	■	■			
Environmental impact assessment																					■	■	■	
Use case 3																								
Search for potential services that may be willing to use I-FEVS' vehicles					■	■	■	■	■															
Definition of AS-IS and TO-BE scenarios										■	■	■												
Reception of the bicycles (with and without solar panels)													★											
Data collection for scenario AS-IS														■	■									
Installation of measurement devices into the I-FEVS' bicycles																■	■							
Execution of the scenarios TO-BE (I) & data collection																		■	■	■	■	■		
Installation of measurement devices into the van																							■	
Execution of the scenario TO-BE (II) & data collection																							■	
Development and installation of a pedestrian detection system into the I-FEVS' van																							■	
Data analysis															■	■	■	■	■	■	■	■	■	

7.2 LL trial set up and preparation

This section presents an overview of the preparatory activities and demonstrations that have been carried out in the framework of the use cases described in Section 4. During the execution, the change in the local government in May 2023 had a direct impact on the actions performed, basically by delaying the decision-making procedures and causing deviations in the timetable. Considering this context, this section focuses on describing the flow of actions at use case level.

7.2.1 Use case 1

This use case addresses the problem of L/U of good in the downtown area of Valladolid. Specifically, it focuses on a pilot are delimited by the "Plaza Poniente" and in which two L/U zones are located. In order to know the characteristics of the operations that take place in such areas, a system based on image processing has been developed and implemented to control the L/U tasks. In this regard, actions started with the definition of the location of the video cameras that support the operation of the new technology. For this purpose, the infrastructure available in the surrounding area was considered: connections, signal, etc. The final scheme of the operational area can be seen in Figure 13. Simultaneously, a market analysis of the most suitable cameras for this type of application was carried out. Finally, the Dahua DH-IPC-HFW3441DGP-AS-4G-NL668EAU-B-0280B model was selected for its practical advantages, in relation to the digital model created for this purpose (see section 8.3.2).

FIGURE 13. LOCATION OF THE L/U ZONES AND THE VIDEO CAMERAS INSIDE THE OPERATIONAL AREA

Following the cameras' location and model definition, with a view of easing the deployment phase and partly due to the delay in obtaining the necessary permits to record the public space as a result of the change of government, the technology was tested in another pilot area. Specifically, in a private L/U area owned by CIDAUT, as shown in Figure 14. This action allowed the performance of the digital model to be considerably improved prior to its commissioning.

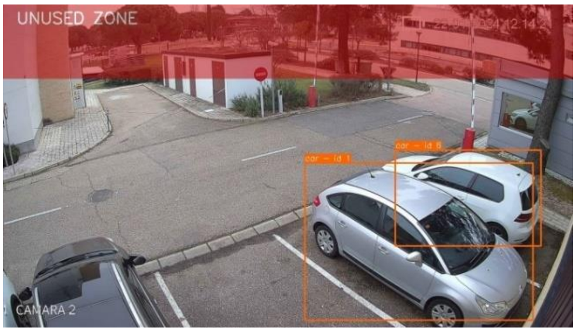


FIGURE 14. RESULTS OF THE COMMISSIONING OF THE TECHNOLOGY AT CIDAUT'S PREMISES

In essence, the Figure 15 summarises the functioning of the model created formulating the core of the technology. While a more detailed description is provided in section 8.3.3., in broad terms the digital model provides accurate information on the following aspects: percentage of occupancy, type of vehicles using the zones, average parking time and number of double-parking spaces per day.

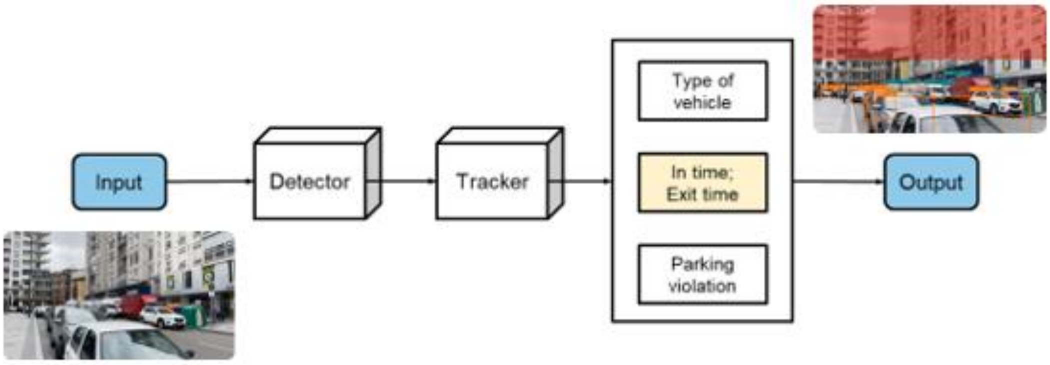


FIGURE 15. SCHEME OF THE FUNCTIONING OF THE DIGITAL MODEL USED IN THE FRAMEWORK OF USE CASE 1

On the way towards achieving such outputs, the open access COCO (Common Objects in Context) [13] and Market-1501 [14] datasets were used to train and evaluate the model. In particular, the COCO database was used to train the classification algorithm and Market-1501 in the tuning of the tracking algorithm. Additionally, during the fine-tuning phase, some of the images recorded at CIDAUT's premises were used to increase the accuracy of the model, particularly where vans appeared.

At the time in which the administrative authorisation to record the public road was obtained, the technology was deployed in the pilot area according to the scheme in Figure 13. During this phase, it was necessary to adjust the parameters of the model base on the characteristics of the environment and the cameras, i.e. spatial location of the L/U areas, frame rate, etc. This allowed -among other things- to generate a Region of Interest (ROI) and extract information only from the pixels contained in it (see Figure 16).

Table 4 shows an extract of the parameters measured in one of the L/U zones; specifically within the defined region of interest, on any given working day and during a limited period of time. Note that in order to avoid any indirect identification of people, the model is based on synthetic IDs that prevent any linkage to the subject. All this information is collected in an .xlsx file, together with approximate data on the occupancy status of the zone for the visualisation of the pilot area (see section 4.1).

FIGURE 16. PERFORMANCE OF THE MODEL IN THE DYNAMICS OF THE PILOT AREA CONSIDERED UNDER USE CASE 1

TABLE 4. EXAMPLE OF THE DATA MEASURED BY THE TECHNOLOGY IN ONE OF THE L/U ZONES DURING A LIMITED PERIOD OF TIME

Assigned ID	Status	Parking time [s]	Time of entry	Time of departure	Type of vehicle	Parking violation
193	L/U	124,48	2024-07-19 12:09:57	2024-07-19 12:12:01	truck	N
902	L/U	97	2024-07-19 12:17:22	2024-07-19 12:18:59	car	N
912	L/U	91,6	2024-07-19 12:17:33	2024-07-19 12:19:05	car	N
1746	L/U	110,04	2024-07-19 12:38:38	2024-07-19 12:40:28	car	N
1922	L/U	169,16	NA	2024-07-19 12:44:35	car	N
2071	L/U	102	NA	2024-07-19 12:45:38	car	N
2073	L/U	99,16	NA	2024-07-19 12:45:36	car	Y
2385	L/U	123,64	2024-07-19 12:47:41	2024-07-19 12:49:45	car	N
2386	L/U	91,96	2024-07-19 12:47:42	2024-07-19 12:49:14	car	N
2599	L/U	116,32	2024-07-19 12:50:55	2024-07-19 12:52:51	car	N
2612	L/U	110,04	NA	2024-07-19 12:52:48	car	Y
2948	L/U	100,08	2024-07-19 12:54:28	2024-07-19 12:56:08	car	N
3031	Double parking	99,4	2024-07-19 12:55:38	2024-07-19 12:57:17	car	Y

The operations of carriers

In view of the results obtained for a number of days of video-recording, the first key observation regarding the use made of the L/U areas is that cars, including vans, are the most frequent users of the spaces. The data reveals that these vehicles tend to park while conducting their operations in the bay on the right-hand side of Figure 16, leading to a lower incidence of double parking in the other bay. In contrast, the level of intrusion in this second bay is higher than that observed in the more popular bay. Additionally, it was identified that the level of intrusion in both bays is higher during the morning period. This pattern is repeated in the rate of double-parked vehicles. This pattern may partly be attributed to the recordings being made during the summer period.

The role of V2X

It is clear that the current system for regulating L/U in this particular area does not work. The excessive use of the one zone compared to the other, together with the high level of intrusion, make it advisable to look for solutions other than increasing the number of reserved bays and reinforce the proper use of the L/U zones. Against this background, an interesting alternative, which has been worked on in the framework of URBANE, is get delivery vehicles to communicate with the infrastructure.

In this regard, a pilot test has been carried out -with a single user- to assess the feasibility of a communication solution for the transmission of information on the occupancy status of L/U areas. With a view to scaling the solution to more users, the solution has been developed on Cohda Wireless's MK6 technology (see Figure 1717), which includes long-range communication modules. The basis for the pilot test is very simple: the occupancy rate calculated by the model is transmitted to the Cohda Wireless's device and from there to the pilot vehicle, all using short-range technology.

FIGURE 1717. DEVICE ON WHICH THE V2I COMMUNICATION PILOT DEVELOPED UNDER UC1 IS BASED

This pilot test opens the door to further work on a more complex application that makes use of the long-range technology embedded in the device and that could also enable communication between delivery vehicles.

7.2.2 Use case 2

Referring back to section 4.2, the overall objective of Use Case 2 is to place value on the in-trunk delivery model. For this purpose, it relies on the comparison of the CO_2 emissions against the standard home delivery model. With this approach, a study has been carried out with two types of vehicles: a hybrid vehicle (current trend) and an electric cargo bicycle (sustainable option). This section presents the methodology followed and the results of the environmental assessment of the two types of delivery with the vehicles considered.

In this context, Figure 18 summarises the process that has been followed in this use case to estimate the CO_2 emissions in each of the models.

The scheme shows the four major stages that describe the phases into which the methodology has been divided and on which the final results are based. From this point of view, the actions began with the definition of the level of detail of the study, through the selection of six scenarios representative of the usual activity of logistics operators in the city (see Table 5). Once this was done, the routes to be followed in each scenario were defined, taking into account the city car park selected to implement this delivery model. Within this stage, open access software was used to optimise the transport routes, with the aim of minimising the distance travelled and thus the CO_2 emissions (see the results of applying this tool in the Table 6).

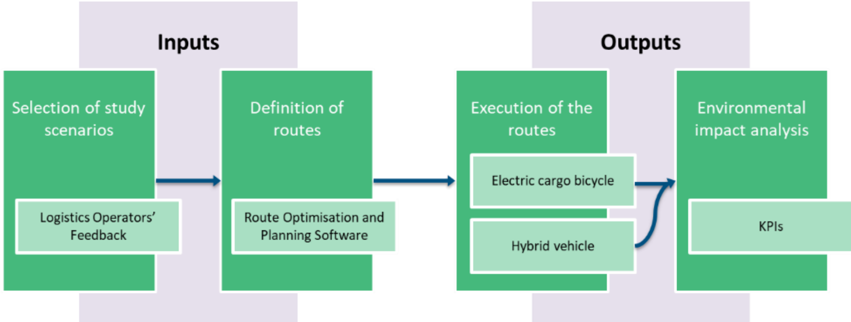
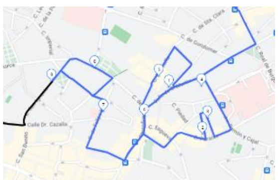


FIGURE 18. METHODOLOGY FOLLOWED FOR THE ENVIRONMENTAL ANALYSIS OF THE IN-TRUNK DELIVERY SERVICE

TABLE 5. MATRIX OF SCENARIOS CONSIDERED WITHIN THE USE CASE 2

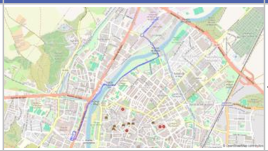
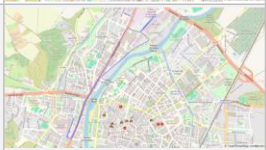
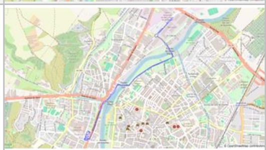
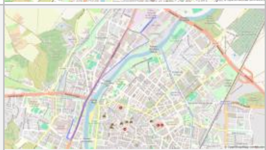
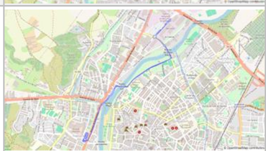
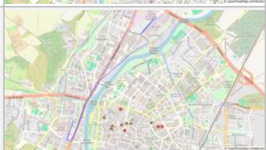
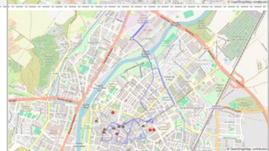
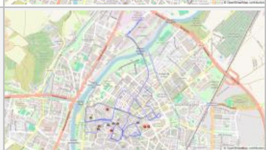
		Total deliveries		
		Low (3)	Medium (9)	High (15)
Delivery locations	Slightly concentrated	Scenario 1	Scenario 2	Scenario 3
	Highly concentrated	Scenario 4	Scenario 5	Scenario 6

TABLE 6. RESULTS OF THE ROUTE OPTIMISATION SOFTWARE

Delivery points	3	9	15
Slightly concentrated delivery locations			
Highly concentrated delivery locations			

Having undertaken the previous stages, the CO_2 emissions were quantified for each study scenario by executing the delivery routes themselves, first with the bicycle (Figure 19) and then with the hybrid vehicle (see Table 7 for measured data and route information). Note that in Table 7 in which the measured data are presented , the cases where not all deliveries were completed are also presented (see Delivery Points 7 and 12). Finally, once the figures for each scenario were known, the environmental impact of the standard and in-trunk parcel delivery models (see Section 4.2.2 for more details about how the different delivery models work) were analysed based on the indicators defined in section 4.2: CO_2 emissions, total distance travelled, and km travelled in the LEZ.

TABLE 7. SUMMARY OF THE DATA MEASURED DURING THE EXECUTION OF THE ROUTES IN THE FRAMEWORK OF USE CASE 2

Title	Delivery points	Date	Map	Delivery method	Distance travelled (km)	km travelled in LEZ	% of total distance	Energy consumption (Wh) / Fuel consumption (L)	Wh/km	CO_2 emissions (gCO_2)
Scenario 1	3	08/05/2024		by bicycle - **trunk delivery**	7.2703	0	0.00%	70.1220	9.6450	4.9085
		05/06/2024		by car - **trunk delivery**	6.9426	0	0.00%	0.3610		848.3875
Scenario 2	7	08/05/2024		by bicycle - **trunk delivery**	7.4457	0	0.00%	74.6450	10.0252	5.2252
		05/06/2024		by car - **trunk delivery**	6.9426	0	0.00%	0.3610		848.3875
Scenario 3	12	08/05/2024		by bicycle - **trunk delivery**	7.7259	0	0.00%	75.9864	9.8353	5.3190
		05/06/2024		by car - **trunk delivery**	6.9426	0	0.00%	0.3610		848.3875
Scenario 4	9	03/05/2024		by bicycle - highly concentrated delivery locations	10.4814	5.3360	50.91%	108.7277	10.3734	7.6109
		05/06/2024		by car - highly concentrated delivery locations	16.8271	12.3435	73.35%	0.8750		2056.2686
Scenario 5	15	03/05/2024		by bicycle - highly concentrated delivery locations	11.6546	6.5092	55.85%	114.3815	9.8143	8.0067
		05/06/2024		by car - highly concentrated delivery locations	15.9251	11.4238	71.73%	0.8281		1946.0444

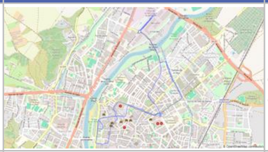
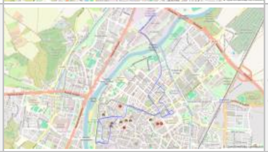
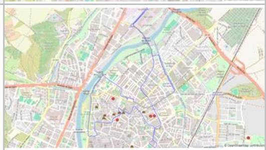
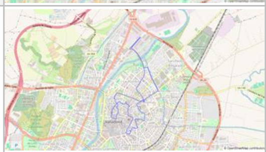
Title	Delivery points	Date	Map	Delivery method	Distance travelled (km)	km travelled in LEZ	% of total distance	Energy consumption (Wh) / Fuel consumption (L)	Wh/km	CO2 emissions (gCO2)
Scenario 6	3	08/05/2024		by bicycle - highly concentrated delivery locations	9.3760	4.2306	45.12%	79.8468	8.5161	5.5893
		05/06/2024		by car - highly concentrated delivery locations	10.4910	5.9897	57.09%	0.5455		1281.9944
Scenario 7	3	03/05/2024		by bicycle - slightly concentrated delivery locations	11.1073	5.9619	53.68%	82.3899	7.4177	5.7673
		05/06/2024		by car - slightly concentrated delivery locations	11.8074	7.3061	61.88%	0.6140		1442.8605
Scenario 8	9	08/05/2024		by bicycle - slightly concentrated delivery locations	10.7323	5.5765	51.96%	101.1741	9.4271	7.0822
		05/06/2024		by car - slightly concentrated delivery locations	16.8956	12.3943	73.36%	0.8786		2064.6386
Scenario 9	15	08/05/2024		by bicycle - slightly concentrated delivery locations	13.9575	8.8017	63.06%	129.9150	9.3079	9.0940
		05/06/2024		by car - slightly concentrated delivery locations	19.3204	14.8191	76.70%	1.0047		2360.9519

FIGURE 19. PICTURES TAKEN DURING THE EXECUTION OF THE ROUTES IN THE FRAMEWORK OF USE CASE 2

The Figure 20 shows the results comparison of both parcel delivery models, based on the indicators mentioned in the previous paragraph, per vehicle category. Note that the total distance travelled in the LEZ in the in-trunk delivery scenario is always zero. This is due to the fact that the selected car park is located outside the restricted zone. On the other hand, the total distance travelled is greater in the standard delivery model. As a result, the in-trunk delivery model has a lower environmental impact in both cases (hybrid vehicle and electric cargo bicycle). This is reflected in the upper part of the below figure, where the CO_2 emissions are not comparable between the two graphs (vehicles).

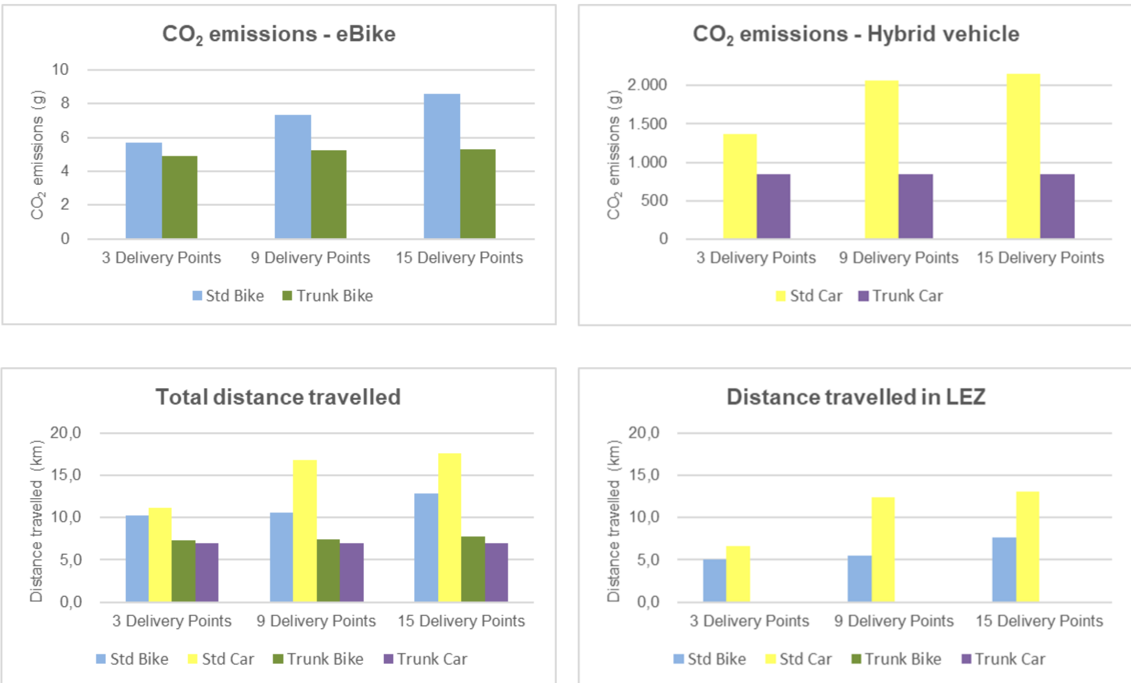


FIGURE 20. INDICATORS COMPARISON IN THE FRAMEWORK OF USE CASE 2

On the differences between using one type of vehicle over the other, in all scenarios raised for the case of the standard delivery model, the distance travelled is shorter when the route is executed by bicycle. This evidence is consistent with the statement of many cities and cycling associations that the bicycle is faster than the car over short distances in metropolitan environments [15]. The reason for this relies on the complex road network that characterises European cities, composed mostly of one-way roads. This difference is no longer noticeable in the case of in-trunk delivery. As in the in-trunk delivery scenarios there is a single delivery point that is located outside the city centre, this implies that the route is almost the same regardless of the vehicle employed to deliver the parcels, therefore there are no remarkable differences in the distance covered.

The reaction of the municipality

In view of the indicators, and considering the strategic priorities established in the Valladolid Urban Agenda 2030, which include the adaptation of the city to the needs of e-commerce, the Valladolid City Council is immersed in promoting the in-trunk delivery model. Specifically, one of the measures being discussing is to offer free parking to those who make use of this delivery service. In fact, the City Council is considering, as a future step, to reserve several parking spaces for the users of in-trunk delivery service. These measures, if implemented, will be out of the scope of URBANE.

7.2.3 Use case 3

This use case turns its attention to a series of environmentally friendly prototype vehicles adapted for goods delivery, owned by I-FEVS. In order to assess the benefits that these vehicles bring compared to conventional vehicles, currently used by most courier companies, the Valladolid LL has reached an agreement with the national postal service (Correos) so that the postman in charge of the Boecillo Technological Park makes deliveries of letters and parcels using the I-FEVS' vehicles. The selection of the Boecillo Technological Park scenario is mainly due to the fact that the distribution is more dispersed that the one that can take place in the centre of Valladolid. Consequently, it is easier to detect atypical values in the measured data.

FIGURE 21. CURRENT POSTMAN DELIVERY MODES WITHIN THE TECHNOLOGICAL PARK OF BOECILLO AND SURROUNDINGS

Bearing in mind the above, the use case has been structured in three phases (see Table 8), specifically the following:

- In the first stage (AS-IS scenario, Figure 21), the postman's operations using the regular vehicles were monitored to establish an appropriate baseline for comparison. In particular, the vehicles used during this stage correspond to a conventional bike and an Internal Combustion Engine (ICE) van, depending on the size/weight of the parcels to be transported and the distance to the delivery area.
- Following that, the second stage (TO-BE (I) scenario) considers the I-FEVS' electric cargo bicycle prototypes, both the model that integrates photovoltaic panels (to maximize range

and reduce the charging frequency) and one that does not. During the duration of this stage, both vehicles were equipped with a monitoring device to collect data regarding energy consumption and power generated by the PV panels (if applicable), and a GPS tracker.

- Finally, the third stage (TO-BE (II) scenario) concludes the use case with the electric van of the brand. While the scenario foreseen for this phase was also the Boecillo Technological Park, a series of problems related to the shipment of the vehicle to Spain made it necessary to transfer the operating scenario for this stage to Italy. Against this background, in order to make the TO-BE (II) scenario comparable to the previous ones, the route pattern followed by the postman was replicated in the surroundings of the I-FEVS' facilities. Similar to the previous phase, the vehicle was equipped with a monitoring device and a GPS tracker.

TABLE 8. AS-IS AND TO-BE SCENARIOS FOR THE DELIVERY OPERATIONS CONSEIDERED WITHIN UC3.

AS-IS	TO-BE (I)	TO-BE (II)
		

Under this scheme, in total, data from 70 different service days were recorded: 13 corresponding to the AS-IS scenario, 36 to the TO-BE (I) scenario - bicycle without PV panels case, 20 to the TO-BE(I) scenario - bicycle with PV panels case and 1 to the TO-BE (II) scenario (see Figure 22 and Figure 23 for an example of the raw data extracted in each stage). With the aim of discovering patterns and relationships between different scenarios, work was performed on an advanced data analysis tool, adapted to the particularities of the available files. Specifically, an application was built to obtain the speed profile, the total distance travelled per vehicle and the average delivery time per parcel from the data collected by the GPS tracker. Additionally, the software created allows combining geographic data and speed in the same graph (see Figure 24). The construction of this tool was key in the process of collecting the KPIs (available in deliverable D2.1). Due to many of them are not direct measures, data analytics was necessary to calculate and compare the environmental and operational impacts of the different scenarios.

INDEX	RCR	UTC DATE	UTC TIME	LOCAL DATE	LOCAL TIME	MS	VALID	LATITUDE	N/S	LONGITUDE	E/W	HEIGHT (m)	SPEED (km/h	DSTA
1	T	09/02/2004	8:47:34	09/02/2004	9:47:34	0	SPS	41.53339393	N	-4.71457269	W	150	0.575	0
2	T	09/02/2004	8:47:35	09/02/2004	9:47:35	0	SPS	41.53335792	N	-4.714645131	W	150	0.656	0
3	T	09/02/2004	8:47:36	09/02/2004	9:47:36	0	SPS	41.53333110	N	-4.714710811	W	150	0.781	0
4	T	09/02/2004	8:47:37	09/02/2004	9:47:37	0	SPS	41.53331335	N	-4.71476467	W	150	0.934	0
5	T	09/02/2004	8:47:38	09/02/2004	9:47:38	0	SPS	41.53329061	N	-4.71481161	W	150	0.947	0
6	T	09/02/2004	8:47:39	09/02/2004	9:47:39	0	SPS	41.53327972	N	-4.7148				
7	T	09/02/2004	8:47:40	09/02/2004	9:47:40	0	SPS	41.53326657	N	-4.7148				
8	T	09/02/2004	8:47:41	09/02/2004	9:47:41	0	Estimated (d	41.53325844	N	-4.7148				
9	T	09/02/2004	8:47:42	09/02/2004	9:47:42	0	Estimated (d	41.53325135	N	-4.7148				
10	T	09/02/2004	8:47:43	09/02/2004	9:47:43	0	SPS	41.53324087	N	-4.7148				
11	T	09/02/2004	8:47:44	09/02/2004	9:47:44	0	SPS	41.53322881	N	-4.7148				
12	T	09/02/2004	8:47:45	09/02/2004	9:47:45	0	SPS	41.53324224	N	-4.7148				
13	T	09/02/2004	8:47:46	09/02/2004	9:47:46	0	SPS	41.53330311	N	-4.7149				
14	T	09/02/2004	8:47:47	09/02/2004	9:47:47	0	SPS	41.53331091	N	-4.7148				
15	T	09/02/2004	8:47:48	09/02/2004	9:47:48	0	SPS	41.53331280	N	-4.7148				
16	T	09/02/2004	8:47:49	09/02/2004	9:47:49	0	SPS	41.53332279	N	-4.7147				
17	T	09/02/2004	8:47:50	09/02/2004	9:47:50	0	SPS	41.53333708	N	-4.7147				
18	T	09/02/2004	8:47:51	09/02/2004	9:47:51	0	SPS	41.53334533	N	-4.7146				
19	T	09/02/2004	8:47:52	09/02/2004	9:47:52	0	SPS	41.53334246	N	-4.7146				
20	T	09/02/2004	8:47:53	09/02/2004	9:47:53	0	SPS	41.53334060	N	-4.7146				
21	T	09/02/2004	8:47:54	09/02/2004	9:47:54	0	SPS	41.53333820	N	-4.7146				
22	T	09/02/2004	8:47:55	09/02/2004	9:47:55	0	SPS	41.53325589	N	-4.7125				

FIGURE 22. EXAMPLE OF THE RAW DATA COLLECTED BY THE GPS TRACKER

Time (s)	V Bateria principal (voltios) (V)	I Bateria principal (Amperios) (V)	V Cargador (Voltios) (V)	I Cargador (Amperios) (V)
0.000000	39.806	5.630,00	39.853	0
1.000.000	39.719	6.213,00	39.771	0
2.000.000	39.694	6.312,00	39.747	0
3.000.000	39.889	4.505,00	39.926	0
4.000.000	40.350	0,87	40.358	0
5.000.000	40.112	2.678,00	40.135	0
6.000.000	40.629	0,86	40.635	0
7.000.000	41.743	0,15	41.745	0
8.000.000	41.748	0,15	41.750	0
9.000.000	41.589	1.716,00	41.604	0
10.000.000	41.209	5.208,00	41.252	0
11.000.000	41.254	4.621,00	41.293	0
12.000.000	41.065	6.195,00	41.116	0
13.000.000	41.228	4.518,00	41.266	0
14.000.000	41.041	6.156,00	41.092	0
15.000.000	41.066	5.842,00	41.115	0
16.000.000	41.468	2.006,00	41.485	0
17.000.000	41.175	4.683,00	41.214	0
18.000.000	41.514	1.560,00	41.528	0
19.000.000	41.559	1.202,00	41.570	0
20.000.000	41.675	0,16	41.677	0
21.000.000	41.684	0,15	41.686	0
22.000.000	41.689	0,15	41.691	0
23.000.000	41.693	0,15	41.695	0

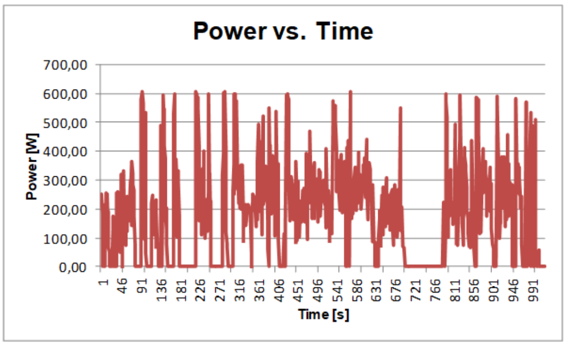


FIGURE 23. EXAMPLE OF THE RAW DATA MEASURED BY THE MONITORING DEVICE INSTALLED IN THE VEHICLES

Date	Total deliveries	Total distance by bike (km)	Total distance by car (km)	Average delivery time (s)
20231011	27	5.640550246	10.51120918	46.37037037

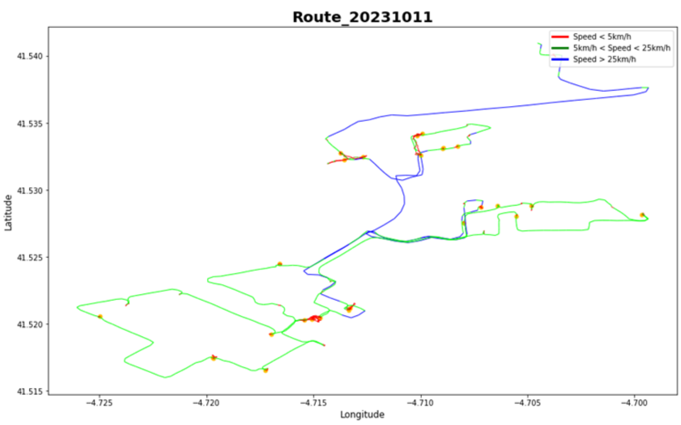


FIGURE 24. EXAMPLE OF THE DATA PROVIDED BY THE TOOL CREATED WITHIN THE FRAMEWORK OF USE CASE 3

Table 9 and Table 10 show an extract of the most relevant data recorded for the AS-IS and TO-BE (I) scenarios.

TABLE 9. EXTRACT OF DATA RECORDED OVER THE AS-IS SCENARIO

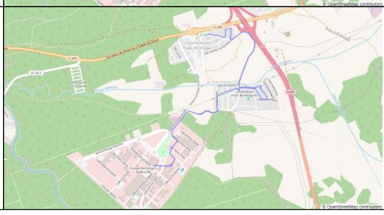
Date	Map	Total deliveries	Total distance by bike (km)	Total distance by car (km)	Average speed (km/h)	CO2 emissions (gCO2)
04/10/2023		22	4.784875142	3.219990291	15.03	804.354
05/10/2023		36	4.675228113	5.11676237	14.2272	1278.167
06/10/2023		15	0	4.165903379	14.3451	1040.643

TABLE 10. EXTRACT OF DATA RECORDED OVER THE TO-BE (I) SCENARIO - BICYCLE WITH PV PANELS CASE

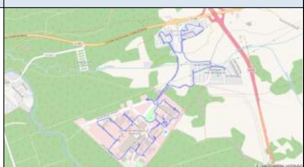
Date	Map	Total deliveries	Total distance by bike (km)	Average speed (km/h)	Energy consumption (Wh)	Energy from solar panels (Wh)	% solar energy	Wh/km	CO2 emissions (gCO2)
24/05/2024		26	12.14236752	17.379	165.2165384	9.407663597	5.69%	12.832	10.907
27/05/2024		20	11.06770846	17.003	139.8573633	12.84385923	9.18%	11.476	8.891
28/05/2024		23	10.30039459	16.502	122.5984291	8.107574643	6.61%	11.115	8.014

Figure 26 shows the results of the comparison of the three scenarios (note that the TO-BE (I) scenario is divided into two), based on the indicators formulated in D2.1. Considering that the TO-BE (II) took place in a different setting than the other scenarios, it is not possible to compare operational metrics. By contrast, environmental metrics are comparable.

FIGURE 25. ELECTRIC CARGO BICYCLES USED DURING THE SECOND STAGE OF THE USE CASE 3

With this view, the first inference that can be drawn is that electric vehicles (like those of Figure 25 and Figure 27) are definitely better for the environment. This is reflected in the CO_2, NO_2 and noise emissions, which are much lower than in the AS-IS scenario. On the differences between using a vehicle that integrates photovoltaic panels or not, the consumption data of the TO-BE (I)-no PV scenarios versus the TO-BE (I) scenario prove that there is an increase in range. On the other hand, while the average speed achieved in the TO-BE (I) scenarios does not differ significantly from that of the mixed scenario (AS-IS), the costs per delivery are considerable reduced when the fully service is done by bicycle. Contrary to the common opinion that the bicycle lowers the performance of the delivery service, in the case of CORREOS, it has been demonstrated that the migration to this vehicle does not affect the efficiency of the processes.

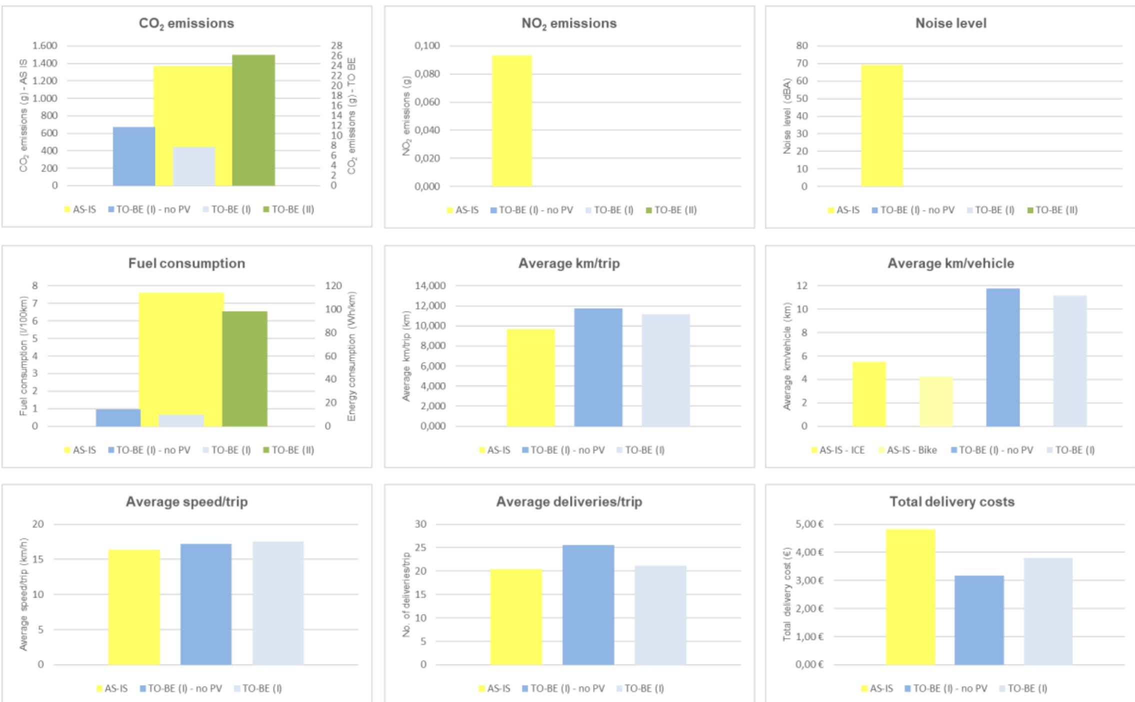


FIGURE 26. METRICS COMPARISON IN THE FRAMEWORK OF USE CASE 3

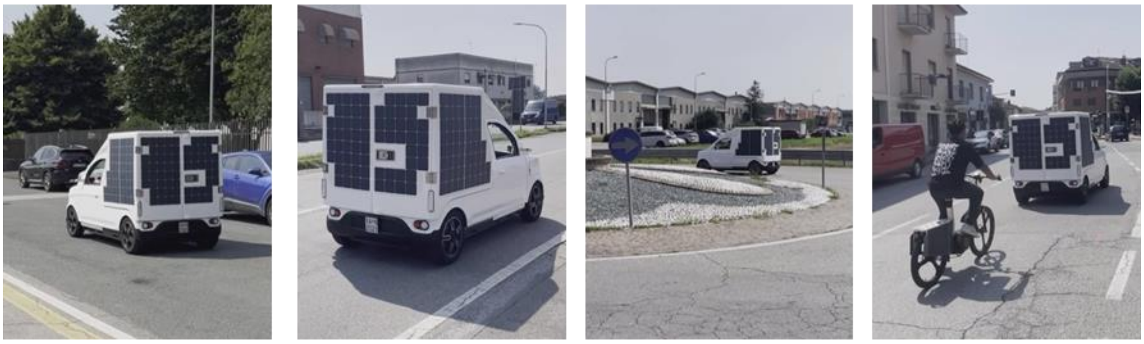


FIGURE 27. SEQUENCES OF THE TO-BE (II) SCENARIO

Safety of Vulnerable Road Users

Amidst the current trend towards pedestrianisation of urban spaces, which is also reflected in the Boecillo Technological Park, pedestrian protection technology has become increasingly important, particularly in the logistics sector. The businesses located in pedestrian zones oblige deliverers to circulate daily in these areas. Against this background, within the framework of this use case, a pedestrian detection system based on image processing has been developed.

FIGURE 28. DETAIL VIEW OF THE PEDESTRIAN DETECTION SYSTEM DEVELOPED WITHIN THE FRAMEWORK OF UC3

The system is based on a camera placed in the front grille of the vehicle which, connected to a recognition software, interprets the environment and warns the driver of the presence of pedestrians. The system has already been installed and tested in one of I-FEVS' vehicles, specifically in the van model of the brand, demonstrating high detection accuracy (see Figure 28 and Figure 29). The results obtained show a detection success rate of approximately 90%.

FIGURE 29. VALIDATION TESTS CARRIED OUT DURING THE DEVELOPMENT OF THE PEDESTRIAN DETECTION SYSTEM

7.2.4 Survey on the social perception of urban goods distribution

Finally, this sub-section presents an activity that, although it strays from the common thread of the previous ones, was key to the development of the project in general. From this point of view, the City Council of Valladolid, in collaboration with CIDAUT and NORCE, carried out a survey on the social perception of urban goods distribution. In order to find out the citizens' perception of developments in logistics, particularly in last mile logistics, and of their capability to improve the quality of life of population, a 27-question survey was conducted within the framework of the Valladolid LL. The survey was divided into 3 parts; (1) use and perception of urban goods distribution; (2) innovative alternatives to home delivery and (3) socio-demographic information. The questions and response options of each section are specified in Annex I, while the survey outcomes are available in URBANE D2.1. Validation report of Lighthouse LLs Implementation.

With the purpose of encouraging citizen involvement, the City Council raffled 20 public transport smart cards among the participants. This initiative proved to be effective, with a total of 169 responses recorded.

8. Existing infrastructure

8.1 Existing physical infrastructure

Table 11 summarises the existing physical infrastructure on which the LL is built upon.

TABLE 11 EXISTING PHYSICAL INFRASTRUCTURE

	Description
Consolidation & Network Infrastructure	
City Infrastructure	• Deterrent parking spaces (related to UC2) • City's L/U parking spaces (UC1)
Vehicle Fleet	Postal service (UC3): • Number of vehicles: 2 • Vehicle type – model: 1 conventional bicycle and 1 van (renault KANGOO)
Link with URBANE: Physical resources on which the proposed use cases are developed.	
Land-use planning & City infrastructure	
General planning tools	• LEZ ordinance • Municipal Regulation on Traffic, Parking and Road Safety (time windows for parking, size and weight restrictions...) • Municipal road traffic monitoring system
Link with URBANE: Obligatory regulation that calls for a more sustainable mobility and advocates the efficient use of L/U zones.	
Delivery Schemes & smart logistics solutions	
Logistics planning tools	• 'Time control disc'

	• DUMinVAL (smart parking platform specified for delivery vehicles)
Vehicle Technologies	
Technology used in URBANE	• Public charging points • I-FEVS' prototypes vehicles, partly powered by photovoltaic energy (related to UC3)

8.1.1 Additional equipment/infrastructure needed for URBANE

- 2 video cameras (related to UC1). Specifically, the model selected was Dahua DH-IPC-HFW3441DGP-AS-4G-NL668EAU-B-0280B.
- 1 wireless communications module. In particular, Cohda Wireless's MK6 technology was chosen.
- 1 data acquisition unit (for recording vehicles data).

8.2 Existing digital infrastructure

Before going deeper into this section, it is necessary to know that the vast majority of digital tools described here are property of some of the external stakeholders indicated in the section 5. Therefore, the formal authorisation of the person responsible for the tool is required. Additionally, although the owners of the tools have access to real time data through APIs, these tools are not for public use. Consequently, the Valladolid LL only have access to reports created by the APIs, following an application process.

Having said that, further information on the existing digital tools related to the scope of the project is provided in the subsections below.

8.2.1 Existing ICT Solutions and Operational information systems

- At present, the Urban Mobility Centre operates a sensor network on the city's streets that allows them to have an overview of the traffic situation and, thus, make decisions that help to optimise the flow of vehicles. The information extracted corresponds to the number of vehicles that pass through the streets at different days and times.
- On the other hand, there is a smart city data platform aimed at centralising and integrating all the city's subsystem (traffic data, public transport, measurements form air quality monitoring sites...). This platform is currently under development and still has not neither data analysis nor data visualisation tools.

8.2.2 Digital models and Decision Support tools already in place

- The DUMinVAL app, although not yet developed, is a platform aimed at organising loading and unloading (L/U) zones more efficiently. For that purpose, couriers and transport operators will be obliged to register in the app, with a user profile, and indicate the zone that they want to use and the time limits. When the driver arrives to the parking space, they will capture the QR code that appears on it so that the system can geolocate its location and record the data provided. By using this information, important decisions aimed at optimising and adapting the L/U areas to the needs of workers and citizens may be taken.
- Additionally, there is an event management system that provides an overview of the traffic situation under days of football matches, sport events, road works, etc. The data that feed this model is confidential for security reasons.

8.2.3 Available datasets related to LL scope

The available datasets that are related to the LL interventions are presented in Table 12.

TABLE 12. AVAILABLE DATASETS

Dataset title	Use Case	Date	Access to dataset link
Loading & unloading zones location	UC1	2022	https://www10.ava.es/cartografia/ficheros_shp.html
Data on the use of the considered L/U zones	UC1	2024	SharePoint Link
Location of deterrent car parks	UC2	2015	https://www.valladolid.es/es/temas/hacemos/open-data-datos-abiertos/catalogo-datos/ficheros-datos-elaborados-clasificados-sectores/transporte
Routes-related data	UC2	2024	SharePoint Link
Electric vehicle charging stations	UC3	2017	https://www.valladolid.es/es/temas/hacemos/open-data-datos-abiertos/catalogo-datos/ficheros-datos-elaborados-clasificados-sectores/transporte
AS-IS and TO-BE scenarios dataset	UC3	2023 2024	SharePoint Link
Geographic location of Valladolid	ALL	2004	https://www.valladolid.es/es/ciudad/estadisticas/utilidad/servicios/observatorio-urbano-datos-estadisticos-ciudad/datos-estadisticos-temas/informacion-estadistica-ciudad/territorio-clima
Census districts and sections	ALL	2021	https://www.valladolid.es/es/temas/hacemos/open-data-datos-abiertos/catalogo-datos/ficheros-datos-elaborados-clasificados-sectores/urbanismo-infraestructuras

Population by section and gender	ALL	2023	https://www.valladolid.es/es/ciudad/estadisticas/utilidad/servicios/observatorio-urbano-datos-estadisticos-ciudad/datos-estadisticos-temas/informacion-estadistica-ciudad/poblacion/caracteristicas-poblacion
Valladolid market share	ALL	2014	https://www.valladolid.es/es/temas/hacemos/open-data-datos-abiertos/catalogo-datos/informacion-estadistica-ciudad/economia

8.2.4 Other software or hardware tools to support daily operations

- EMPARK is the private platform that controls the regulated on-street parking spaces. Its databases are not open access; however, the municipality could have access to the infringements in the use of L/U zones registered by the platform. The information they would have access is the following: the date and time when the sanction occurs, the L/U zone where it takes place and the model of the infringer vehicle.

8.2.5 Existing Digital Twin

- The City Government is currently working on the development of a Digital Twin to boost tourism and improve the tourist experience. This tool will allow the city to monitor the data from the real world in a coordinate way and provide answers to a number of questions that can only be answered by estimations nowadays. While the focus of this tool is far from being relevant to the project, URBANE is a good opportunity to extend and enrich this Digital Twin with other relevant data from the city.

8.2.6 Other background info

- The municipal Geographic Information System (GIS) integrates geographic information (spatial locations of the elements) and alphanumeric data (description of these elements), that allows an organised management of the georeferenced data. Among the data included are the location and characteristics of the L/U areas of the entire city (see section 8.2.3).

8.3 Models & tools in URBANE

The implementation of the Valladolid LL UCs leverages on the development and/or application of a number of algorithms, models, and digital tools and services pursuing several specific objectives. On the algorithm side, they are essentially devoted to the monitoring of specific aspects of the last-mile delivery in the city, such as the status of L/U zones (UC1). In that sense, they have been tailored to the requirements of the municipality in terms of performance, variables to be collected, and data processing and storage procedures. The assessment of the UCs relies heavily on the application of different techno-economic models that address the most important impacts (KPI evaluation) of the implementation of the solutions proposed in different scenarios within UC2 and UC3. Other models (see section 8.3.1) have been applied using as inputs the data collected during the LL operations to assess different potential what-if scenarios, in order to ease decision-making processes. Also, on the issue of simulating alternative scenarios, the digital tools and services developed within URBANE, like the URBANE Digital Twin Platform, simplify the process of creating what-if scenarios, streamlining the process of defining, running and presenting the results of simulations using one or more models included in the URBANE platform.

8.3.1 New services in the URBANE

Within the context of Use Case 1, a computer vision algorithm has been developed for the control of L/U areas, with the aim of improving the urban logistics. This algorithm collects data related to the occupation of the L/U areas, such as percentage of occupancy, type of vehicles using the zones and average parking time. Moreover, the technology is able to distinguish when double parking is taking place.

With this vision, the LL aims to increase the availability of parking spaces and avoid double-parking. Additionally, the information collected opens the door to the possibility of managing the use of L/U areas more efficiently and adapting their characteristics to the needs of the end users. The algorithm also presents a good basis towards effective kerbside management, as it leverages data-driven decision-making to optimize space usage, provide the basis to predict demand, and enhance the overall functionality of urban streetscapes.

8.3.2 Decision Support Digital models

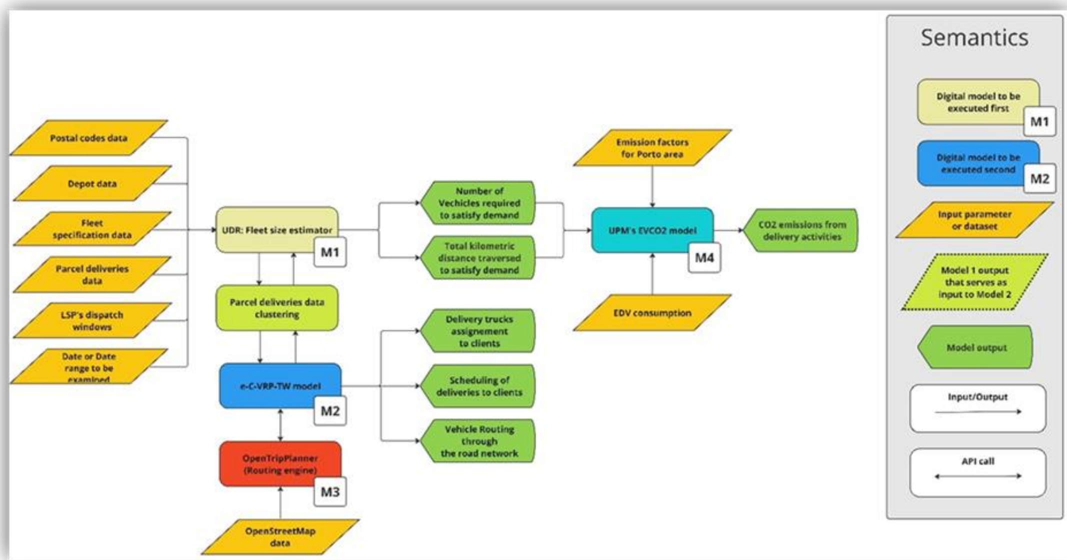
The Valladolid LL engaged in a series of meetings with digital models' developers of the URBANE project (T3.4, T3.5, T3.6) in order to identify the digital modelling solutions to be developed and extended in URBANE with the goal of providing decision support regarding the efficient deployment of interventions to the Valladolid LL last-mile network.

Given Valladolid LL's Use Cases (Section 4) and objectives (Section 3.2), after the discussions held in M9, M10, M11 of the project, it was decided that Use Cases 1 & 3 are the ones where digital modelling, and the URBANE Models Library can offer effective decision support.

Starting with Use Case 3, it has been considered as the prominent Use Case for digital modelling application. With Use Case 3 the Valladolid LL aims at assessing the adoption of electromobility in the last-mile deliveries of Valladolid and especially within the Boecillo Technological Park. More specifically, the goal is to conduct a techno-economic analysis of adopting different Electric Delivery Vehicles (EDVs) and how the performance of the last-mile logistics network changes compared to using conventional modes of transport. As included in the Use Case description, the "AS-IS" scenario includes the execution of deliveries with conventional modes of transport, and the "TO-BE" includes the execution by the I-FEVS prototype delivery vehicles.

To provide some additional quantitative metrics for this techno-economic analysis, INLE has utilized and extended an already existing model, developed in previous projects. The digital model is called UDR Supply Resources Estimator model, and it has been previously used to estimate the resources (number of vehicles, kilometres traversed, CO_2 emissions) required to cover parcel delivery demand, through simulation. As it can be seen in Figure 30, the digital model requires several inputs parameters and datasets, such as fleet characteristics, locations and time-windows of deliveries, and then based on the solution of multiple Vehicle Routing Problem (VRP) instances, it can estimate the number of minimum number of delivery vehicles needed, kilometres and CO_2 emissions in order to cover the transport demand within the area of study. The UDR Digital model is based on the integration of several state-of-the-art technologies, open dataset and digital models, such as Google's OR-Tools library, OpenTripPlanner Routing engine, OpenStreetMap data and Universidad Politécnica de Madrid (UPM) EVCO2 methodology.

FIGURE 30. THE UDR SUPPLY RESOURCES ESTIMATOR MODEL.



Although the UDR digital model is already developed and applied to a sufficient extent, a calibration of the software implementation of the model was required according to the data for Use Case 3. More specifically, the digital model application requires the following datasets:

- Parcel delivery demand dataset in the area under study,
- Postal codes dataset for Valladolid,
- Depot or delivery rounds' starting locations in the area under study,
- Fleet characteristics (conventional gas-powered vehicles, bicycles, EDVs, I-FEVS Prototype EDVs),
- Cartography data (from OpenStreetMap, already available online),
- For the estimation of CO_2 emissions from EDVs: Electricity production information for the area of Valladolid (energy sources participation, carbon intensity of power sources),
- For the application of COPERT model:
    - Monthly average temperatures in Valladolid,
    - Average monthly humidity in Valladolid,
    - Average traffic estimates,
- Generic information about the delivery operations in the area under study (i.e., dispatch windows, vehicle recharging methods, etc.)

All these data sources were communicated with the Valladolid LL and data availability was confirmed. With all that in mind, the decision support offered by the digital models in Valladolid focused on the following "What-if" questions:

- "What-if" we replace current delivery vehicles with electric delivery vehicles?
- "What-if" we replace current delivery vehicles with I-FEVS electric delivery vehicles?
- "What-if" the bicycle is still used for days with good weather conditions and an electric delivery vehicle is used for rainy/bad weather days?
- "What-if" the bicycle is still used for days with good weather conditions, and the I-FEVS vehicle is used for rainy/bad weather days?

Given the results of the UC3 simulations (available in section 8.3.3), the following assessment of the models employed therein (UDR and related) can be made:

Applicability of the model for decision-making purposes: the model allows simulating different implementation scenarios (covering a certain demand using different typologies of vehicles) assessing their operational and environmental impact

Added value for the LL: using a limited amount of on-field collected data as input, the UDR model allows simulating potential implementation scenarios, providing quantitative comparisons between the impact of employing different vehicle typologies. This allows anticipating the consequences of transitioning from diesel-powered vehicles (current scenarios) to electric ones, prior to making any investment in new vehicle fleets.

Suggestions for improvement: Valladolid LL can also use UDR model to potentially examine the collaborative routing application if a second LSP or if other logistical flows are identified (adjacent to the study area). In that case, further implementation of the PI concept can be tested, either in the physical pilot or by simulation. In that case, the following "What-if" question could be answered:

- "What-if" we employ collaborative routing (centrally planned) for deliveries from multiple providers and services in the study area?

Additionally, UC3 study was further supported by SKEMA's Predictive Demand Model that was developed in URBANE. This model uses clustering and a time-series formulation to generate, based on historical data, the forecasted number of parcels to be delivered at certain locations (clusters) for a given future date. About the performance of the model, it is important to remark that due to the limited amount of historical data available (less than one month's data), only short periods of time (1 to 3 days) can be simulated. In this case, the demand for one single day has been calculated. As more data is collected over the coming months and years, the model can be used to forecast up to several months ahead.

Moving on to the digital models application to the Valladolid LL's Use Case 1, the goal of the municipality of Valladolid is to more efficiently plan and design the loading/unloading areas within the city. This problem is a strategic level planning problem which affects prospective investments and utilization of infrastructure in the city for the years to come. Given the discussion between modelling teams of WP3 and Valladolid LL, it is considered that a modelling solution will be used to provide decision support to Valladolid LL. The digital models to be used in for UC1 are i) the computer vision algorithm that allows identifying different vehicle typologies, developed by CIDAUT, ii) the computer vision algorithm that allows tracking objects (vehicles) across video frames, developed also by CIDAUT and iii) VLTN's Dynamic parcel reshuffling model. It is expected that the third model will generalize the results coming from the two previous models and that the study will benefit from the availability of data from AI pattern recognition algorithms.

As mentioned, from a modelling perspective, one of the main assets of this UC1 is the vehicle detection and tracking algorithm that has already been briefly described in Section 7. This algorithm is the core tool that will be used to monitor the usage of the targeted L/U zones, due to the two functionalities it enables: (1) it is able to detect the presence of a vehicle and classify it according to whether it is a "car" or a "truck" (vans are included in this category for the sake of simplicity) and assign a synthetic ID to each one of them (so data is anonymised); then, (2) these IDs are tracked across the subsequent video frames to determine variables such as "In-time", "Exit time", and "Parking violation". Three parking violations are targeted: double parking, exceeding of the maximum allowed parking time (30') and parking of vehicles not allowed. It is important to remark that the last one currently depends on the availability of whitelists of allowed vehicles that should be provided by the municipality and would require the installation of a third videocamera counting with Optical Character Recognition (OCR) algorithms embedded (currently under development by Cidaut) to read the plate numbers of all vehicles crossing the pilot area.

Regarding the **detection model**, it is responsible for detection vehicles in each frame. It is based on the YOLOv3 model, that is pre-trained to recognise 80 different object categories (the COCO dataset categories) from representative features using the Darknet53 Convolutional Neural Network (CNN). At a high level, its architecture can be divided into four parts: input, backbone, neck and prediction head, as presented in Figure 31.

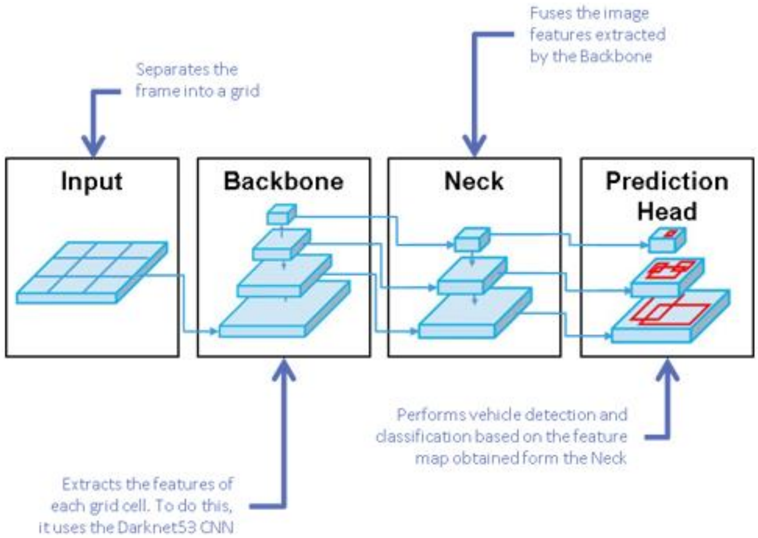


FIGURE 31. ARCHITECTURE OF YOLO MODEL.

On the other hand, the **vehicle tracking model** aims at correlating vehicles in adjacent frames, therefore it operates after the vehicle detection model. It is based on the Deep SORT algorithm, that allows multiple object tracking. For this purpose, a Kalman filter is employed to estimate the position of the detected vehicle in the subsequent frame; after that, the predicted position is compared with the actual position of the vehicle in the n+1 frame, and the appearance of the vehicle is compared between both frames. If both features are coherent, then it is concluded that the object is the same in the two frames and therefore is tracked successfully. A scheme of the working principles of the Deep SORT model is presented in Figure 32.

FIGURE 32. OPERATION OF DEEP SORT MODEL

The Valladolid LL aim to produce two static datasets of historical data as shown in the Excel Spreadsheet file (.xlsx) of Figure 16, for two occasions:

- For the "AS-IS" scenario, in which the cameras monitor the trucks, and it is up to the drivers to follow the time-windows (cards), usually extending the time that they remain there, leading to higher occupancy times. The city police can't apply penalties in most of the violations, because it is hard to get notified in time,
- For the "TO-BE" scenario, in which the drivers are aware of the occupancy level of a certain L/U zone and therefore can make decisions regarding their route based on it.

On the side of the modelers, this dataset is expected to bring two main pieces of information: i) The shift in drivers behaviour from the "AS-IS" to the "TO-BE", which will be connected to the time windows of attendance as it is expected to be shown in the Excel spreadsheet, and ii) The demand for different locations of different loading/unloading zones in the city centre. Regarding the first point, a shift in drivers' behaviour is expected given the CCTV deployment.

After the implementation of the algorithms used in UC1, the following assessment of the models employed therein can be made:

Applicability of the model for decision-making purposes: the algorithms provide quantitative KPIs to analyse the use of infrastructure assets (L/U zones). Compared to current evaluation methods (consisting basically of a person visiting the area and giving feedback about their status at a given moment), these models enable data-driven decision-making practices.

Added value for the LL: the availability of data regarding the usage of L/U zones allows the municipality to assess whether an optimal use of them is being made, and design policies accordingly.

Suggestions for improvement: Concerning the algorithm, a potential improvement should be made once the digital application for the management of last-mile operations in Valladolid (DUMinVAL) is deployed, in order to cross-check the information gathered by the models with that collected by the digital app and gain further knowledge about the usage of L/U zones. Another potential area of improvement may consists on generalizing the results from the computer vision algorithms to all of the 300 zones in Valladolid (see Figure 33), which would help support the Municipality of Valladolid towards the strategic planning of the L/U zones and in their attempts to promote collaborative delivery.

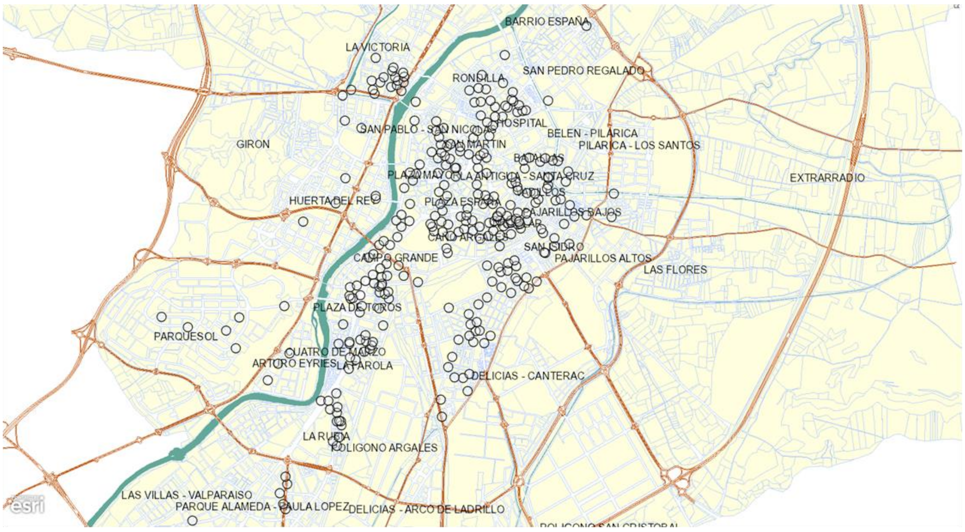


FIGURE 33. MAP OF THE CITY'S L/U ZONES

Finally, in the context of Use Case 2, remember that the goal is to encourage a non-contact mode of delivery away from the City Centre that reduces traffic and emissions. To quantify how much this type of model can reduce pollution, SKEMA has put its model "delivery demand forecasting" at the service of the LL. After using it, the following assessment can be made:

Applicability of the model for decision-making purposes: the possibility of knowing in advance the potential demand for a period of time allows better planning of the delivery operations.

Added value for the LL: the possibility of forecasting delivery demand is of interest of almost every stakeholder involved in the LL. Furthermore, the possibility of introducing as constraint the type of vehicle to be used provides insights about which option would be best to choose to meet a certain future demand.

Suggestions for improvement: the potential of the model to forecast delivery demand cannot be unlocked until enough data is collected. Hence, the model's performance is expected to improve once a fair amount of data is available to feed it. Also, further update of the model itself or adjustment of its main hyperparameters can be made when more data is available.

8.3.3 DT Decision support capabilities and services to facilitate the vision

The URBANE Digital Twin Platform (DT) simulates different delivery scenarios aspiring to answer different “what-if” questions. This allows the LL to test new strategies, such as adding new micro hubs or changing delivery vehicles, and see how they impact efficiency, costs, and the environment before implementing them in the real world. In the case of the Valladolid LL, it aspires to promote more sustainable modes of delivery but also gather robust data on how the electrification of urban freight transport may affect the functioning of the city.

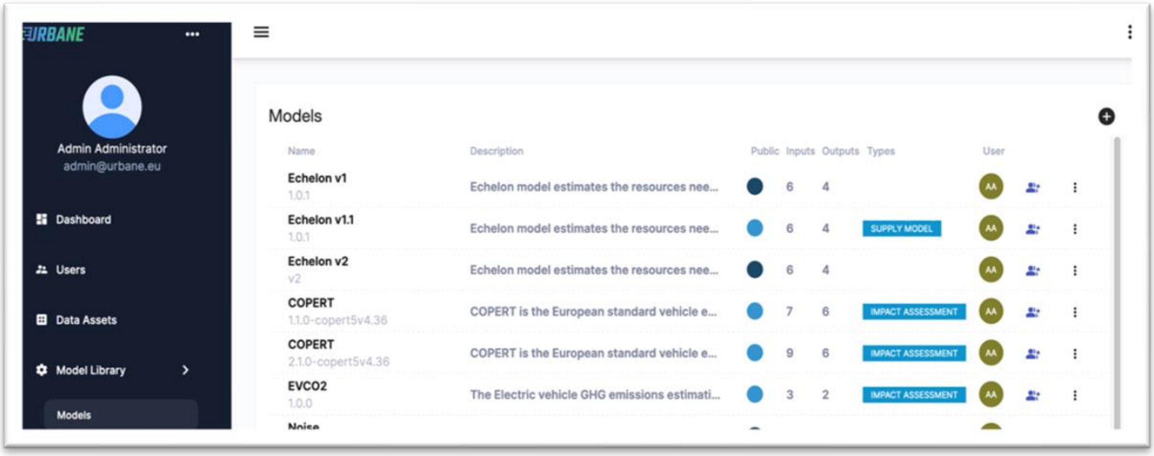


FIGURE 34. URBANE DIGITAL TWIN PLATFORM

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 34. 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.

In Valladolid, the UDR model (as presented in section 8.3.2) has been integrated into the DT allowing users to explore different types of last-mile delivery modes as part of Use Case 3 of the LL. The DT empowers users to test and compare several cases of the utilisation of EDVs and solar assisted vans along with conventional vehicles for the delivery of parcels in the CIDAUT campus, as presented in Figure 35.

FIGURE 35. DELIVERY POINTS IN BOECILLO TECHNOLOGICAL PARK

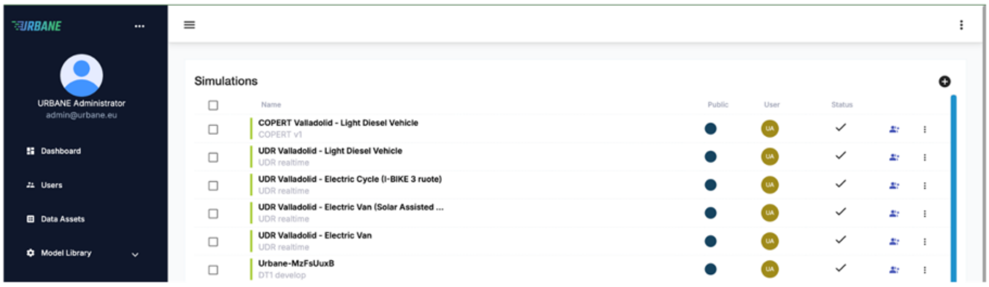


FIGURE 36. VEHICLES AND MODELS USED IN DT

The different vehicles used to trigger the scenarios, and the involved models are presented in Figure 36. For all electric vehicles, the EVCO2 model is also executed to calculate CO_2 emissions, while in the case of conventional vehicles the same calculation is performed by the COPERT model[1]. Both models have been used previously in the Horizon LEAD project[2]. This sequence of models that is executed one after the other constitutes a scenario in the DT. The actual execution of each scenario is called a simulation. All simulations for the Use Case are accessible through the Portal of the DT, as shown in Figure 37. Following the successful execution of all the simulated scenarios, a comparative analysis of the outcomes for each delivery vehicle can be viewed in the Portal.

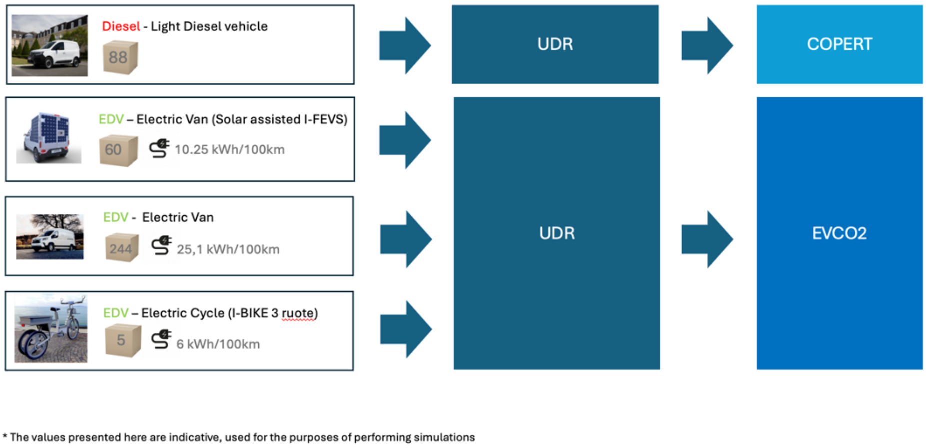


FIGURE 37. SIMULATIONS IN THE DT PLATFORM

Table 13 presents a summary of the simulation results for the purposes of this report.

TABLE 13. COMPARISON OF 86 PARCEL DELIVERIES BY DIFFERENT VEHICLES

Vehicle	Number of vehicles needed	Total Distance (km)	Emissions (gCO2)
Electric Van (Solar assisted I-FEVS)	2	13,143	220,754
Electric Cycle (I-BIKE 3 route)	12	36,292	356,823
Electric Van	1	12,283	505,207

[1] https://copert.emisia.com/
[2] https://www.leadproject.eu/

Light Diesel	1	12,283	3340,936

In view of the results obtained and the values indicated in table 15 of URBANE deliverable 2.1, where the data measured during the period of activity of use case 3 are collected, specifically those referring to CO2 emissions, it is concluded that the model satisfactorily predicts CO2 emissions, showing a high coincidence with the experimental values. This demonstrates its validity for the sizing of vehicle fleets in the scenario considered. Using the example of the case of the solar-assisted electric van, note that although the experimental values were measured in Italy, but reproducing the same conditions of the Valladolid scenario, the simulation results (8,398 g/km) are in the range of the values reported in D2.1 (6,88 g/km). Note that in this particular case an estimated consumption data (10,25 kWh/100km) was assumed, which proved to be very close to the actual measured consumption (9,83 kWh/100km, table 15-D2.1). Under these evidences, it can be concluded that the developed model is suitable to explore future decisions on different types of last mile delivery modes in the Boecillo Technological Park, where the Use Case 3 of the LL is framed.

Regarding SKEMA's Predictive Demand model, employed within UC2, the model provided as output the forecasted demand of parcels for one given day, considering i) that the parcels can be grouped in a number of groups ("clusters") characterised by their latitude and longitude, and ii) that the parcels can be delivered either by car or by bike. As illustrated in Figure 38, the simulation results demonstrate the model's ability

a)

Delivery_ID	Date of delivery	Delivery time slot	Delivery latitude	Delivery longtitude	Method of Delivery	Total parcels/letters	Vehicle type
0	2023-10-19	9:00-14:00	41.528615	-4.70431107	Home	3	Car
1	2023-10-19	9:00-14:00	41.53360596	-4.710129752	Home	10	Car

b)

Delivery_ID	Date of delivery	Delivery time slot	Delivery latitude	Delivery longtitude	Method of Delivery	Total parcels/letters	Vehicle type
0	2023-10-19	9:00-14:00	41.528615	-4.70431107	Home	6	Bike
1	2023-10-19	9:00-14:00	41.52055637	-4.716876164	Home	15	Bike
2	2023-10-19	9:00-14:00	41.53360596	-4.710129752	Home	3	Bike

FIGURE 38. OUTPUTS OF THE SKEMA'S PREDICTIVE DEMAND MODEL APPLIED TO UC2. A) DELIVERIES MADE BY CAR, B) DELIVERIES MADE BY BIKE.

to predict parcel demand with high accuracy. The forecasted demand is distributed across various clusters, indicating areas of high and low demand. This information is critical for logistics companies to allocate their delivery vehicles appropriately, ensuring that high-demand areas are sufficiently covered while avoiding underutilization of resources in low-demand areas. In terms of recommendations, the model's output could be integrated with real-time traffic data and vehicle-infrastructure communication systems to dynamically adjust delivery routes.

8.3.4 Impact Assessment radar

The initial phase of the Impact Assessment Radar (strategic stage) undertook a comprehensive evaluation of Valladolid's capacity to adopt advanced urban logistics solutions. The aim of this level was to understand inadequacies towards the operations of a cargo bike tailored for the delivery of small goods within the city centre. This strategic analysis (Figure 39) pinpointed crucial areas requiring policy updates and infrastructure improvements to facilitate the integration of these cutting-edge logistics solutions.

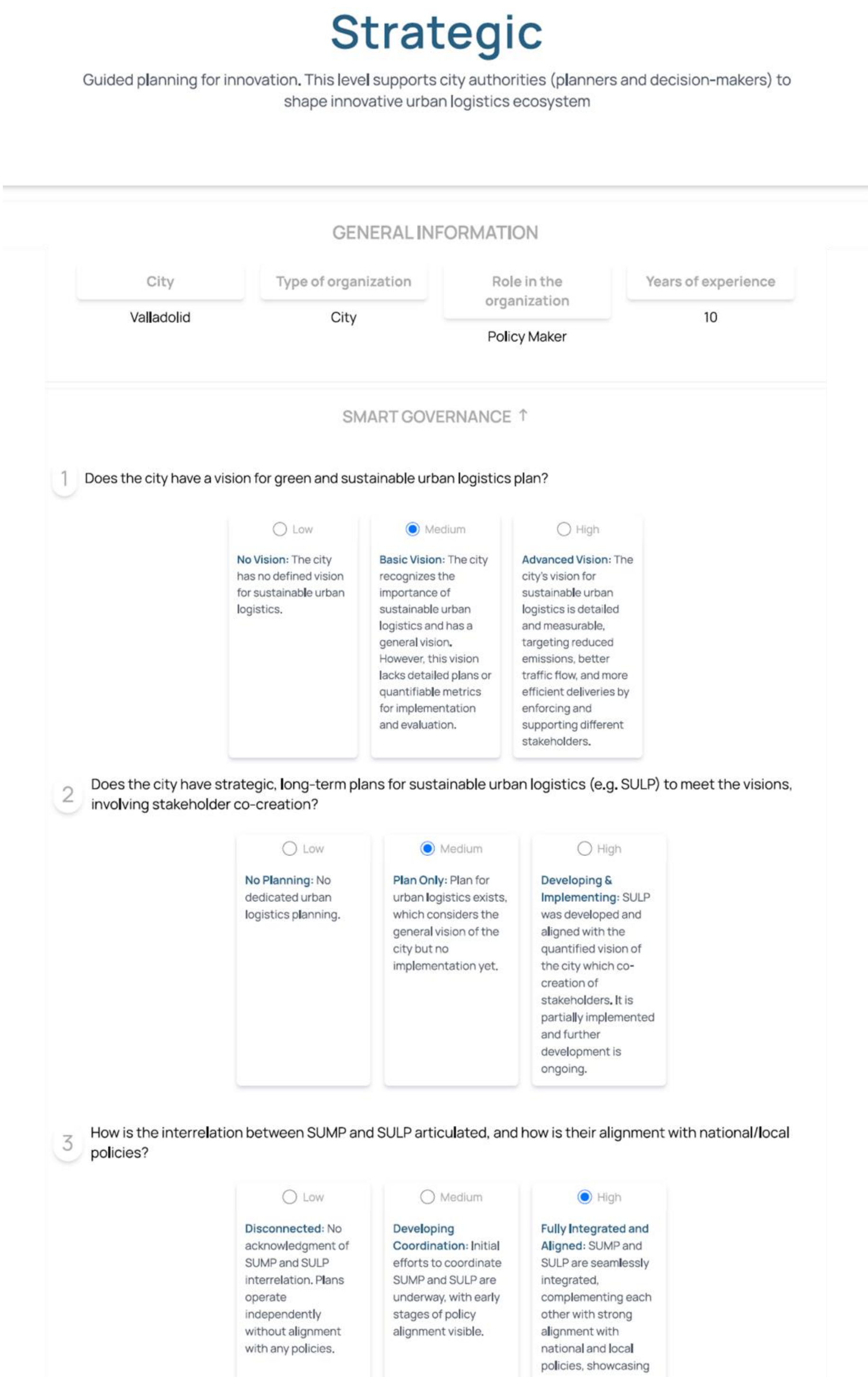


FIGURE 39. EXTRACT FROM THE IMPACT ASSESSMENT RADAR - 1ST LEVEL: STRATEGIC.

The full set of responses to the 1st level of the Impact Assessment Radar, made by Valladolid municipality, is provided below in Table 14.

TABLE 14. RESPONSES FROM VALLADOLID LL TO THE IMPACT ASSESSMENT RADAR – 1ST LEVEL: STRATEGIC.

SMART GOVERNANCE
Q1: Does the city have a vision for green and sustainable urban logistics plan?
A1: Basic vision – The city recognizes the importance of sustainable urban logistics and has a general vision. However, this vision lacks detailed plans or quantifiable metrics for implementation and evaluation.
Q2: Does the city have strategic, long-term plans for sustainable urban logistics (e.g SULP) to meet the visions, involving stakeholder co-creation?
A2: Plan only – A plan for urban logistics exists, which considers the general vision of the city but no implementation yet.
Q3: How is the interrelation between SUMP and SULP articulated, and how is their alignment with national/local policies?
A3: Fully integrated and aligned – SUMP and SULP are seamlessly integrated, complementing each other with strong alignment with national and local policies, showcasing comprehensive urban mobility and logistics planning.
Q4: Is there a dedicated team/department/responsible person for orchestrating and planning city logistics (infrastructure, operations)?
A4: No dedicated team – There is no dedicated team specifically assigned to sustainable urban logistics planning within the city
Q5: How data-driven is the current planning process, and to what extent are dedicated tools utilized?
A5: Minimal data utilization – data-driven approaches are sporadically used in the planning process, with minimal utilization of dedicated tools.
Q6: How is communication facilitated among municipality departments and region, for coordinating and planning city logistics?
A6: Effective internal communication – Good communication and collaboration internally, but without external consultants.
Q7: How engaged were the stakeholders in the development and design of the urban logistics plan, and how is their ongoing involvement ensured?
A7: Feedback – Stakeholders provide feedback through bilateral meetings but have no direct planning participation
Q8: Is the current regulatory framework adaptive to changes in order to accommodate emerging trends for logistics activities?
A8: Inflexible – Slow adaptation to innovations, rigid regulatory framework
SMART & INNOVATIVE RESOURCES & INFRASTRUCTURE
Q9: Which of the following regulatory constraints are actively implemented in the city?

A9: Space access limitations; Time access limitations; Size and/or weight restrictions; Loading/Unloading parking spaces; Night-time access
Q10: How many last-mile delivery companies in the city have established their own innovative logistics infrastructure (e.g private parcel lockers)?
A10: Few companies – A few last-mile delivery companies have established their own infrastructure for innovative urban logistics solutions, indicating early adoption of this innovation.
Q11: Which of the following smart city logistics initiatives have been implemented by the city's big LSPs?
A11: Parcel lockers
Q12: To what extent do last-mile companies use digital tools, smart technologies, and platforms for their operations?
A12: Advanced tools – Utilization of advanced digital tools, e.g. cloud-based software and mobile apps.
Q13: How widely do companies adopt green transportation modes (EVs, cargo bikes, hydrogen), and how do city infrastructure and incentives facilitate this?
A13: Moderate utilization – The city is beginning to establish public infrastructure for green transportation, including a growing number of EV chargers and some hydrogen stations. Limited public incentives exist, leading to an increase in company adoption supported by initial infrastructure and promotional efforts.
Q14: What is the availability of (public) unutilized spaces that can potentially be used for city logistics operations?
A14: Limited utilization – Several unutilized spaces exist, but strict regulations limit their use for logistics.
SMART ACTORS
Q15: To what extent do the last-mile companies working with IoT, AI, and big data technologies to enhance operations or provide cost savings?
A15: Next-year planning: LSPs use summarized data for large-scale long-term planning (e.g annually)
Q16: What is the presence and market dynamics of major LSP players in the city's last mile delivery ecosystem?
A16: Many companies – Numerous large LSPs operate in the city, reflecting a high demand for deliveries or a key role in the national distribution network, indicating a mature logistics ecosystem
Q17: What was the response of the citizens of your city to the past city logistics solutions that have been implemented?
A17: Slow adoption – Positive towards new solutions but slow to adopt them
Q18: To what extent do LSPs in the city adopt standardized data storage and participate in secure data exchange with other companies?

A18: Non-standardized and isolated: LSPs use proprietary data formats with no standardization. There are currently no interoperability actions in place.
Q19: What is the extent of public infrastructure utilization for multimodal transportation operations in the urban and peri-urban area of the city?
A19: Minimal utilization – The existing infrastructure, while present, is significantly underutilized for multimodal transport purposes.
SAFETY & SECURITY & QUALITY
Q20: To what extent do the last-mile companies of your city provide a platform with live tracking of the parcel?
A20: Basic access – some companies have live tracking, but limited user access
Q21: How efficiently does the city's regulatory framework adapt to and establish security requirements for new innovative logistics solutions?
A21: Very slow adaptation – The city's regulatory process for implementing security requirements for new logistics solutions is significantly delayed, often taking several years to adapt to innovations.
Q22: Which administrative level assumes primary responsibility for conduction environmental impact assessments related to urban logistics activities?
A22: Local level - municipality

In the upcoming months, the 2nd level (Tactical) and 3rd level (Operational) of the Impact Assessment Radar will be used a tool for quantifying the optimal fleet size of cargo bikes to cover a certain delivery demand of the city. This tool can be used to assess different scenarios and design the potential scale up of the logistics solution. Likewise, the radar will be used for exploiting the information from the digital twin optimization in routing, thanks to the calculation of the city specific KPIs to monitor the efficiency of the operations.

So far, the 1st stage of the Impact Assessment Radar has allowed the municipality to assess their last-mile ecosystem, detecting strong areas as well as aspects to be improved. The use of the 2nd and 3rd levels of the radar will let the municipality know how big the impact of adopting EV fleets would be, so that they can decide which policies must be prioritised in order to reach the city environmental objectives by the end of the decade.

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 Valladolid LL KPIs have been defined and the baselines have been collected. The KPIs are connected to use case n.1: Monitoring of L/U areas using artificial intelligence, use case 2: Implementation of an innovative and sustainable solution of contactless parcel delivery and use case 3: Techno-economic comparison of the use of combustion vehicles and I-FEVS prototype vehicles in delivery services.

The final values collected after the pilot implementation are included in D2.1 Validation Report

LL	KPI description	UC	Baseline KPI	Comments
Valladolid	L1. CO2 emissions	UC3; UC2	196 g/km (1st stage) Bicycle: 1 g/parcel Hybrid vehicle: 275,6 g/parcel	Average CO2 emissions per vehicle-km (UC3) and parcel (UC2)
	L2. NO2 emissions	UC3	0,017 g/km	Average NO2 emissions per vehicle-km by vehicle type and fuel type (CIDAUT campus case)
	L5. Noise level	UC3	69,35 dBA (ICE-based vehicle, 50km/h)	Noise reduction considering e-vehicle type and speed compared to ICE (Test Track)
	L8. Fuel consumption per km	UC3	7,6 l/100km	Energy consumption per km and vehicle type (CIDAUT campus case)
	L9. Average km/trip	UC3; UC2	9,72 km (CIDAUT campus case) Bicycle: 1,82 km/parcel Hybrid vehicle: 2,25 km/parcel	Average number of km per trip (CIDAUT campus case) and parcel (UC2)
	L10. Average km/vehicle	UC3	4,24 km (by bike) 5,48 km (by car)	Total distance travelled in urban area per vehicle (CIDAUT campus case)
	L13. No. of freight vehicles per category	UC3	Commercial vans: 452.531 (<500 kg) 1.254.247 (500-749 kg) 409.714 (750-999 kg) 500.653 (>1000 kg) Light-duty trucks: 1.582.730 (<1 T) 454.184 (1-1.5 T) 113.830 (1.5-3 T)	Data extracted from national statistics and organised according to load capacity
	L15. Average time for L/U operations	UC1	Unknown	Average time between start (vehicle completely parks in

				the L/U area) and end (vehicle leaves the L/U area) There is no record of data on it prior to the implementation of UC1.
	L16. Number of L/U areas	UC1	301 (2)	Number of areas in the city (number of areas in the demo site)
	L17. Average speed/trip	UC3	16,40 km/h	Average speed per trip (CIDAUT campus case)
	L20. No. of unauthorised parking in the urban area	UC1	Unknown	Number of commercial vehicles parked outside the L/U area There is no record of data on it prior to the implementation of UC1.
	L22. Average deliveries/trip	UC3	20	Average number of deliveries made in each trip. In view of the characteristics of the postal service, this KPI is understood as the average number of stops made per trip.
	L24. Total delivery costs	UC3	4,824 €	Average costs paid by the operators for the transportation of a good. This includes labour costs, vehicle and fuel costs, insurance costs...
	L25. Investment in clean energy networks and vehicles	UC3	-	Price of each type of zero-emission vehicle The use of zero-emission vehicles is not contemplated in the AS-IS scenario.
	L50. Failures in the IT system	UC1	-	
	L52. Presence of IT and AI driven optimisation system	UC1	0	
	L56. Information accessibility	UC1	-	Quality with which information on traffic is shared with LSPs
	L62. L/U bays availability	UC1	-	Occupancy rate over time, in other words, average time in

				which the parking bay is free per hour
	L65. Fuel cost (€/L) and electricity cost (€/kWh)	UC3	1,5624 €/l 0,1496 €/kWh	Costs incurred by LSP to power vehicles in operations
	Km travelled in LEZ	UC2	Bicycle: 0,94 km Hybrid vehicle: 1,49km	Average distance travelled by the vehicle within the LEZ
	VRU identification accuracy	UC3	-	Number of vulnerable road users correctly classified by the vehicle divided by the actual total number The AS-IS scenario vehicles do not include CCAM technology

10.Lessons Learnt and results

In general terms, the development and implementation of the use cases described throughout this report have provided a tale of urban logistics transformation. Developed in a context characterised by political reforms, due to the change of local government, increased environmental concerns as a consequence of the entry into force of low emission zones and the lack of active engagement of some relevant stakeholders; the implementation of these use cases provided some remarkable elements, such as a new evidence-based approach to urban planning, an innovative delivery model, and a forward-looking approach that favours the exploitation of solar energy as a source of energy in last mile deliveries. Nonetheless, bureaucratic barriers limit the extensive roll-out of changes, especially the more disruptive ones related to the organisational aspects of the city.

One of the major results of the described actions is considered the change in the culture of the municipality regarding urban goods distributions, taking into account the benefits of the zero emission vehicles in the logistics sector. Going into more detail, the major lessons learned from each use case are presented below.

UC1: Monitoring of L/U areas using artificial intelligence

While the development and application of computer vision technology in L/U zones (linked to LL's Objective 1: "Develop an analysis tool for L/U zone usage focused on decision-making based on real data") has proven to be valid and reliable in assessing both usage patterns and the level of intrusion by unauthorised vehicles, the bureaucracy associated with installing a video camera in a public space entails a large number of permits. Due to the high potential impact that recording public spaces has on the privacy of citizens, this was mitigated by masking all sensitive information to prevent misuse. In this way, the model was configured to take into account the hesitation of the public authorities by collecting only the type of vehicle (no number plates are collected) and focus on the area of interest, "erasing" the rest of the image. Furthermore, once the images are processed by algorithm, a record of them was not kept, thereby any identifying information were deleted.

Another lesson is related to the technological part of the innovation and the performance of the model. The speed requirements imposed by the cameras' frame rates led to the use of the recognition algorithm YOLOv8 and the tracking algorithm DeepSORT. The results obtained show an excellent performance of the recognition algorithm (thanks to training with real images), which is not comparable with that of the tracking algorithm. The noise associated with the urban environment negatively affects the performance of the tracking algorithm, which confuses adjacent vehicles, sometimes distorting the measurement of parking time.

Finally, the implemented functionality has great potential to improve the operational efficiency of L/U areas in combination with a vehicle/infrastructure communication system. While the initial purpose of this use case was to extract relevant insights from the collected data to support decision making, the implementation of a pilot test of V2I communication has shown great potential, in particular by informing drivers about the availability of parking spaces, to improve traffic flow. The advantages offered by connectivity are decisive when it comes to improving order delivery times and increasing customer satisfaction. This is why the next step is to connect the DUMinVAL application (still under development) with the developed functionality, from a more functional paradigm, using V2X technology.

UC2: Implementation of an innovative and sustainable solution of contactless parcel delivery

In-trunk delivery in deterrent car parks as a solution for last mile delivery (linked to LL's objective 2: "Demonstrate the environmental benefits associated with collaborative delivery models") allows efficient grouping of deliveries and eliminates direct interaction between distributors and receivers. In this way, this new delivery model allows routes to be optimised, reducing kilometres and improving productivity (shorter order delivery times). In addition, it avoids missed deliveries, facilitating collection at any time. In short, the combination of this delivery model and deterrent car parks is a way of moving towards sustainable mobility and proposes a change in urban logistics focused on customer needs.

UC3: Techno-economic comparison of the use of combustion vehicles and I-FEVS prototype vehicles in delivery services

The incorporation of electric and partially solar-powered means of transport in a particular delivery service (linked to LL's objective 3: "Put on the road full electric vehicles adapted for the delivery of small goods") has proven not to affect the efficiency and quality of deliveries, maintaining the same key performance indicators. With lower CO2 emissions, the use of electric vehicles has contributed to minimising the carbon footprint of logistics operations and improving air quality of the surroundings. In parallel, and in the face of the generalised rise in fuel prices, the replacement of combustion vehicles with electric alternatives has helped to reduce the cost of delivery. Although the price per kWh has also risen, electric vehicles are always more cost-effective than fossil fuel vehicles. Also, within this Use Case, a VRU detection system has been developed and installed in the vans (linked to LL's objective 4: "Implement a Vulnerable Road User Detection system in delivery vehicles"). This system, conceived as a plug-and-play solution, does not require extensive tuning (it is pre-trained to detect pedestrians and cyclists) and can be incorporated to any kind of vehicle with very limited extra cost, as it relies almost exclusively on a camera and a processing unit. The VRU detection system is expected to act as a trigger to a series of actions, that can range from a simple sound or visual warning to the driver, to automated driving manoeuvres such as emergency braking.

To conclude this chapter, the measures collected during the course of the use case demonstrate that the integration of photovoltaic panels into the vehicle body contributes to increasing the range of EVs. Although the measures were taken during the summer season, the incorporation of the photovoltaic technology resulted in lower consumption which translated into increased range. This finding opens the door to new horizons in the electrification of transport and, in particular, in urban logistics.

11. Conclusions and recommendations

The Valladolid LL, through its Use Cases, has met its main objective of developing and demonstrating a set of innovative solutions aiming to improve urban goods distribution operations in the city centre and make a better use of public infrastructure assets while reducing the environmental impact of last-mile logistic operations in the city. Considering the LL objectives described in section 3.2.1, the following main conclusions and KPIs are highlighted:

1. **O1: Develop an analysis tool for L/U zone usage focused on decision-making based on real data**

   An IT system that can be installed in existing urban infrastructure (e.g light poles) to monitor L/U zones has been developed. Thanks to this system, current practices based on manual surveillance of the zones at certain moments of the day can be substituted by a continuous monitoring of these infrastructure assets. During the trials, the average parking time per vehicle was around 25 minutes. Also, on average, a 45% of the L/U zones analysed were free for parking, although it must be mentioned that the usage pattern of these zones is not homogeneous during the day. This model can be part of an overall effective for curb side management for cities aiming to balance these competing demands to improve traffic flow, enhance safety, support local businesses, and accommodate new forms of transportation.

2. **O2: Demonstrate the environmental benefits associated with collaborative delivery models**

   The environmental and operational impact of the in-trunk delivery option deployed in deterrent parking spaces outside of the LEZ of Valladolid was explored as a novel courier-customer collaborative delivery model. In general, between 30-50% reduction of distance travelled can be expected, leading to a 15-50% CO_2 emissions reduction depending on the characteristics of the route and the vehicle employed. Besides, thanks to route simplification, up to 40% distance can be saved if cars are substituted by bikes to make the deliveries in city centres.

3. **O3: Put on the road full electric vehicles adapted for the delivery of small goods**

   Both e-bikes and e-vans have been tested in real environments to assess the environmental gains compared with conventional diesel-powered vehicles. The impact of adding PV panels to the vehicles was also assessed as a means of increase range and decrease electric energy consumption. In terms of CO_2 emissions, the electrification of the fleet leads to massive environmental gains: -96% emissions for vans, and -99% emissions for bikes (plus, nitrogen oxide emissions are fully avoided). Besides, photovoltaic assistance in bikes led to 30% less energy consumption.

4. **O4: Implement a Vulnerable Road User Detection system in delivery vehicles**

A camera-based system was implemented into the I-FEVS vans that allows early VRU user detection, triggering a warning to the driver. In the trials performed, the system was able to detect VRUs with around 90% accuracy.

Considering the lessons learned outlined in the previous chapter, here are some recommendations to facilitate the implementation of the use cases in other cities:

- Before proceeding with the installation of video cameras on public roads, it is important to have all the information regarding the application and to be aware of the relevant privacy legislation and recommended procedures. In addition, it is necessary to ensure that the data management that is carried out does not violate the right to privacy.
- The tracking algorithm included in the model on Use Case 1 needs to be accurate enough to avoid errors in the measurement of parking time. Another algorithm different from the one used should be also used to raise the level of accuracy, penalising the processing time.
- The improvement of the efficiency of L/U areas, particularly in downtown areas, involves implementing the developed computer vision technology combined with a V2X communication system. Vehicle-infrastructure communication is necessary to improve urban logistics, and in particular to facilitate L/U operations and minimise traffic congestion since vehicles can receive real-time information about available loading zones, allowing them to navigate directly to the nearest spot, thereby reducing unnecessary circling and associated traffic congestion. Additionally, smart infrastructure can reserve loading spaces for delivery vehicles, further minimizing disruptions.
- In order for the in-trunk delivery model to succeed and its effects to be visible, it is important to first have the support of vehicle manufacturers and logistics operators. In this context, the administration is the only competent body that can encourage both stakeholders to bet on this innovative delivery model, as well as the citizens.
- Lastly, it is advisable to provide financial incentives for the purchase of electric vehicles so that they are attractive and a viable option to logistics operators. This action would help to increase the sales of electric vehicles and, consequently, to invest more in innovation in order to increase competitiveness in a growing market. As a result, the scope of innovations such as the integration of photovoltaic panels into the body of vehicles would be extended, making their benefits for the performance of the logistics operation more visible.

Finally, it is important to remark that all the innovations developed and tested within the scope of Valladolid LL, as well as the digital tools and models employed herein, can be directly transferred to other cities, requiring at most minor adjustments of the IT systems or the models' parameters. This is because they have been developed so they are easily interoperable and scalable, which makes then suitable to be adopted for both small and big LSPs/municipalities. Some of them (for instance the monitoring system developed in UC1) could also be adapted for its use in purposes other than the ones proposed in this LL.

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Annex I

Survey on urban logistics in Valladolid

URBANE European Project

Within the scope of the European project URBANE (https://www.urbane-horizoneurope.eu/) the living labs are studying measures to improve the efficiency and sustainability of urban freight distribution (UFD). The purpose of this survey is to find out the citizen behaviour and their opinion regarding some of these measures.

The survey will take about 10 minutes. The Agency for Innovation and Economic Development (IdeVa) will draw among the participants 20 bus cards with 15 euros each. Your email is only used to contact you and will never be linked to your answers, which will be used anonymously.

The survey is divided into 3 parts: (1) use and perception of of urban freight distribution (UFD); (2) innovative alternatives to home delivery, and (3) sociodemographic information.

1. Email

Use and Perception of Urban Freight Distribution (UFD)

2. How many online orders did you place in the last 3 months?
    a. None
    b. 1 to 3
    c. 4 to 6
    d. 7 to 13
    e. More than 13
    f. Do not know/ Do not answer (Dk/Da)
3. When online shopping or using delivery services, where do you usually shop? (multiple choice)
    a. Large Internet portals (Amazon, Shein, Ali Express…)
    b. Stores/supermarkets of specific brands (El Corte Inglés, Zara, Carrefour, Decathlon…)
    c. Specific stores that have establishments in my city (food, clothing, food delivery...)
    d. Platforms for buying and selling between individuals (Vinted, Wallapop...)
    e. I'm only interested in the product, I don't care about the vendor
    f. Dk/Da
4. What kind of logistics services do you use in Valladolid? (multiple choice)
    a. Home delivery service of supermarkets (Mercadona, Mercado del Val, Gadis...)
    b. Couriers (Seur, Correos Express...)
    c. Collection points (shops, lockers-...)

d. Postal Service (Correos)
e. Glovo, Just Eat or similar
f. Home delivery (Home2Home)
g. I don't use any
h. Don't know/don't answer

5. How often do you choose one of these delivery options when making an online purchase? (0. Never, 1. Rarely, 2. Sometimes, 3. Often, 4. Always)
    a. pick-up in store
    b. home/work delivery
    c. locker
    d. collection point
6. Usually how much are you paying to have a package shipped to your home/work? (If you have an annual service like Amazon Prime, calculate the approximate average per packa ge)
    a. 0 € (free shipping)
    b. 2 €
    c. 5 €
    d. 10 €
    e. More than 10 €
    f. DK/DA
7. How important is it to you that the logistics services you use are environmentally friendly?
    a. Not important at all
    b. Unimportant
    c. Moderately important
    d. Pretty important
    e. Very important
8. How much more would you be willing to pay on each shipment for a sustainable and environmentally friendly delivery option?
    a. 0 € (only if it's free)
    b. 2 €
    c. 5 €
    d. 10 €
    e. More than 10 €
    f. DK/DA

9. When you pick up a parcel at a collection point, what mode of transport do you use (within Valladolid)? (multiple choice)
    a. Public transport (bus)
    b. Public transport (taxi)
    c. Personal vehicle
    d. Own bicycle/scooter
    e. Bike rental service (BIKI)
    f. On foot
    g. N/A (I don't use collection points in Valladolid)
10. Which of these phrases best describes your ordering and returns habits?
    a. I order infrequently and never return orders
    b. I almost never return orders unless they have significant defects
    c. I return orders only when I want to change products (colour, size, etc.)
    d. I return orders frequently (if they don't meet my expectations)
    e. I always order several products to compare and return the ones I don't want
    f. I return products every time I place orders
11. Which return method do you mainly use?
    a. Home/work pickup
    b. Collection point/Post Office/Transport agency
    c. Physical store
    d. None
    e. Other
12. For returns, what mode of transport do you use (within Valladolid)? (multiple choice)
    a. Public transport (bus)
    b. Public transport (taxi)
    c. Personal vehicle
    d. Own bicycle/scooter
    e. Bike rental service (BIKI)
    f. On foot
    g. None (I use the home pick-up service)
    h. Not applicable (I never return orders in Valladolid)
13. When deciding whether you want the goods delivered to your home or to a collection point, how important are the following aspects for you? 0. Not important at all, 1. Unimportant, 2. Moderately important, 3. Pretty important, 4.Very important
    a. I can receive/pick up the package at a time that suits me

  b. Convenient location
  c. Environmental impact of delivery
  d. Working conditions of the delivery person
  e. Shipping cost
  f. Data Privacy Guarantee
  g. Speed of delivery
14. The parcel logistics sector is moving towards more sustainable and efficient delivery modes, do you know the following trends? 0. I have never heard about this, 1. I have heard a little bit about this, 2. I have heard a lot about it but never used it myself, 3. I have used it myself, 4. Dk/Da
  a. Lockers (mailbox inside an automated locker that allows you to safely pick up packages 24/7)
  b. Robot delivery system (autonomous delivery vehicle)
  c. Zero emissions delivery (through the use of electric vehicles and bicycles)
  d. Access restrictions for large cargo vehicles to the city centre
  e. Trunk delivery in your private vehicle in a public car park
15. What is your opinion on the trends exposed in the previous question? (-3. Very negative to 3. Very positive)
  a. Lockers (mailbox inside an automated locker that allows you to safely pick up packages 24/7)
  b. Robot delivery system (autonomous delivery vehicle)
  c. Zero emissions delivery (through the use of electric vehicles and bicycles)
  d. Access restrictions for large cargo vehicles to the city centre
  e. Trunk delivery in your private vehicle in a public car park
16. Conflicts in UFD: understanding the concept of urban freight distribution (UFD) as the entire flow of goods that takes place within the city, to what extent do you agree with the following statements? (from -3. Strongly disagree to 3. Strongly agree)
  a. UFD significantly affects traffic in the city
  b. UFD is a source of environmental and noise pollution
  c. UFD generates road safety problems
  d. In the area where I usually move UFD is a problem
17. Solutions for UFD: understanding the concept of urban freight distribution (UFD) as the entire flow of goods that takes place within the city, to what extent do you agree with the following statements? (from -3. Strongly disagree to 3. Strongly agree)
  - The current management of the UFD with L/U zones is sufficient and adequate
  a. The impact of UFD should be limited by further restricting access to the city centre

b. Sustainability should be promoted in the UFD either with restrictions or with incentives for cleaner and/or lighter vehicles
c. It would be convenient for the use of the UFD to have a higher cost, linked to the impact it has on the city and on the pollution, to promote efficiency
d. I would be willing to change my habits for a more sustainable and efficient UFD
e. It should be encouraged to group parcels from different operators/orders to be delivered together at home or sent to collection points

18. Which of these sectors do you think has the greatest impact on the UFD? Please order them from highest to lowest impact using the arrows.
    a. E-commerce
    b. Supply for shops, markets and supermarkets
    c. Supply for HORECA (hotels, bars, restaurants, etc.)
    d. Supply for pharmacies and hospitals
    e. Express couriers
    f. Works and construction deliveries
    g. Other

Innovative alternatives in home delivery

19. Having explained the trends in parcel logistics in question 14, to what extent do you agree with the following statements about trunk delivery service? (from -3. Strongly disagree to 3. Strongly agree)
    a. I would not be able to use the trunk delivery service because my vehicle does not have remote opening
    b. I do not use park-and-ride or public parking
    c. I would select the trunk delivery option if it was available in my area
    d. Trunk delivery service is reliable and safe
    e. I would like to try this new sustainable delivery option
    f. I appreciate the flexible delivery schedule offered by this solution

Socio-demographics

20. Age
    a. Less than 16
    b. 16 – 24
    c. 25 – 44
    d. 45 – 64
    e. 65 and more
21. Gender

a. Female
b. Male
c. Other

22. Highest level of education successfully completed
    a. Primary education and Secondary compulsory education
    b. Post-compulsory Secondary education
    c. Technical education
    d. Bachelor's or equivalent level
    e. Master's or equivalent level
    f. Doctoral or equivalent level
    g. Total number of members in the household (household size)
23. Main activity status/employment situation:
    a. Employed
    b. Unemployed
    c. Retired
    d. Unable to work due to a long–standing health problems
    e. Student (other than University Student)
    f. University Student
    g. Fulfilling domestic tasks / care tasks
    h. Other
24. Which of the following best describes your typical out-of-home schedule due to work or other commitments?
    a. Mostly at home (I work from home or do not have regular out-of-home commitments)
    b. Out of home, irregular hours (my schedule varies from day to day)
    c. Out of home, regular daytime hours (e.g., 9 AM to 5 PM)
    d. Out of home, regular evening/night hours (e.g., 5 PM to midnight or night shifts)
    e. Mostly out of home all day
    f. Other
25. Which of the descriptions comes closest to your current housing situation:
    a. I live in a flat or apartment
    b. I live in a semi-detached, row or terrace house
    c. I live in a separate house
    d. Other.
26. Where do you live?
    a. Valladolid city center

b. Valladolid (not the center)
c. Housing development
d. In a village near Valladolid
e. Dk/Da
f. Other

27. Which of the descriptions comes closest to how you feel about your household's income nowadays?
    a. Living comfortably on present income
    b. Coping on present income
    c. Finding it difficult on present income
    d. Finding it very difficult on present income
    e. Dk/Da

Thank you so much for coming this far!

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Thank you for your willingness to fill out this survey. The survey is carried out within the framework of the URBANE (https://www.ideva.es/innovacion/proyectos/urbane) project, an initiative funded by the European Commission that aims to promote the path towards more efficient, resilient and sustainable last-mile mobility through four living labs in Valladolid (Spain), Helsinki (Finland), Bologna (Italy) and Thessaloniki (Greece). By participating in this survey, you consent to the data provided being used in the URBANE project and made available to the public anonymously (contact details will only be used in the event that you are awarded in the prize draw and will be separated from your answers and discarded). Your privacy is extremely important to us and therefore the information will be protected in accordance with all applicable European privacy protection laws.

Thank you once again for your collaboration.

If you want to know more about innovation and urban distribution of goods, here is a brief read: https://www.ideva.es/blog/innovacion-distribucion-urbana-mercancias

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