Smart Network Operator Platform Enabling Shared, Integrated and More Sustainable Urban Freight Logistics

[D4.6] Design Catalogue for Zaragoza and Dublin

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List of abbreviations

ABBREVIATION	DESCRIPTION
DCC	Dublin City Council
FZC	Fundación Zaragoza Ciudad del Conocimiento
GHG	Greenhouse Gases
HFV	Heavy Freight Vehicles
LFV	Light Freight Vehicles
LEZ	Low Emission Zone
PIN	Prior Information Notice
SCVLZ	Single Commercial Vehicle Loading/Unloading Zone
SULP	Sustainable Urban Logistics Plan
TAZ	Traffic Analysis Zone
VRU	Vulnerable Road Users

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1 Executive Summary

As part of the task 4.5 of SENATOR project, the deliverable 4.6 – "Design catalogue for Zaragoza and Dublin" presents a design catalogue for both cities, which considers an integrated road network design for a sustainable urban logistics system, and that could be replicated in other cities.

Grounded on design principles that situate pedestrians and bikes on top of the pyramid of priorities and that echoes best practices worldwide in the matter, the document provides a "Design Catalogue" including guidelines for the main urban design elements -such as streets, intersections, parking spaces and urban logistic points-, adapted to Zaragoza's and Dublin's respective local context with a strong focus on adapted street categories for cargo handling.

Additionally, this deliverable outlines potential locations for elements in the urban network of last mile logistics, including micro consolidation centres and parcel lockers, based on static and dynamic data (obtained directly from the SENATOR platform) that ground the subsequent suitability analysis for both pilot sites, Zaragoza and Dublin.

This work constitutes a baseline to further develop the layout of the urban network of last mile logistics to include in the second report of the specific pilots' deliverables D5.6 (Zaragoza) and D5.8 (Dublin).

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2 Introduction

2.1 Purpose

The objective of this deliverable is to create a design catalogue for the cities of Zaragoza and Dublin, showcasing an integrated road network design for a sustainable urban logistics system. The catalogue will provide guidelines for designing various urban elements, including streets, intersections, lanes, and parking lots, while considering cargo handling. It will also outline potential locations for micro consolidation centres based on suitability analysis.

2.2 Relation to other Deliverables

Some of the definitions used in this deliverable were taken from the Sustainable Urban Logistics Plan (SULP) Guidelines, which are explained in detail in the deliverable D4.2.

This deliverable, in turn, sets the grounds for some of the work reflected in deliverables D5.6 “Pilot Case 1 results and follow-up (Zaragoza) Report 2” and D5.8 “Pilot Case 2 results and follow-up (Dublin) Report 2.”

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3 Road user's hierarchy

For the purposes of this document, the hierarchy of road users illustrated in Figure 1 will be used. This hierarchy prioritises the safety of the most vulnerable road users. At the pinnacle of the hierarchy are pedestrians as they represent the most universal mode of transport and at the same time have the lowest environmental impact. In contrast, the private vehicle for individual use is located at the bottom of the pyramid, representing the least sustainable mode of transport. Nevertheless, depending on the type of street, this hierarchy may be subject to change in accordance with the individual streets in a city.

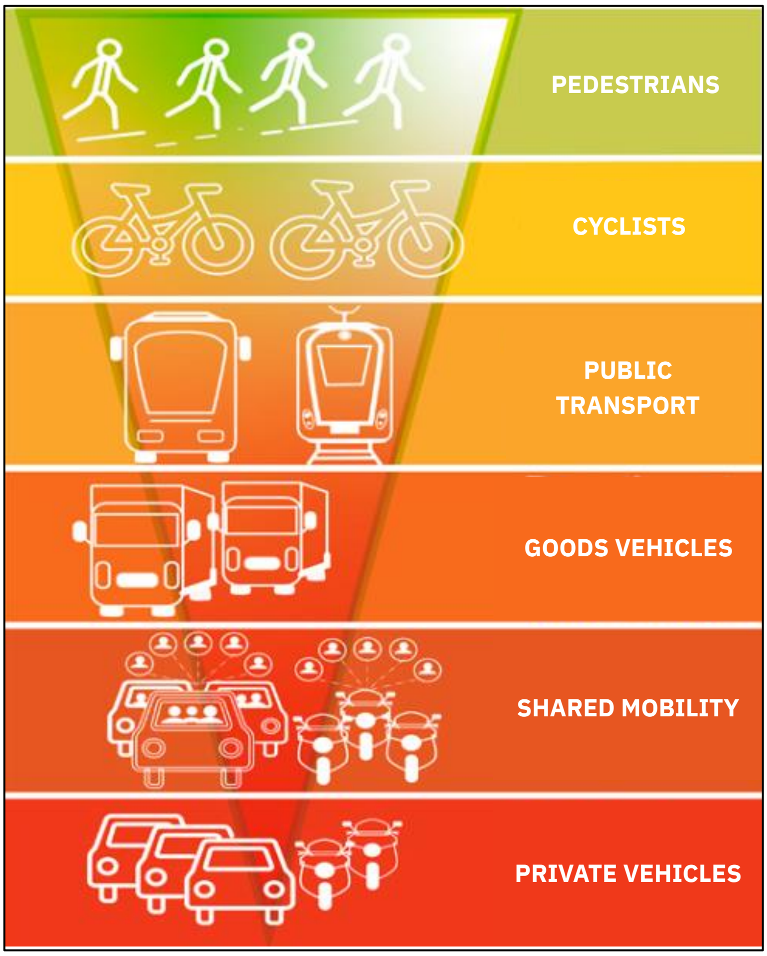

Figure 1: Road users' hierarchy [1]

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4 Design Catalogue

For freight transport, the types of vehicles commonly used in urban areas mainly differ by external dimensions and mass at full load [2]. For the purpose of this section, average dimensions of urban freight vehicles shall be used and will be described in the following sections.

4.1 Parking spaces

On-street parking solutions aim at adapting existing street designs and loading areas to accommodate current and future traffic and commercial vehicle volumes. The measures focus on allocating adequate curb space for parking and loading activities. Strategies for parking places and loading zones include designating and enforcing curb-side parking, reallocating curb space, and identifying potential freight traffic parking locations [3].

4.1.1 Dimensioning of parking spaces for Light Freight Vehicles

The Light Freight Vehicles (LFV) are vehicles designed for the transportation of goods, whose gross weight do not exceed 3,500 kg (e.g. vans and pick-ups) [4] These vehicles are normally used for local distribution of goods, delivery services, and other activities that require a smaller and more manoeuvrable vehicle than heavy-duty vehicles (ibid).

The specific dimensions of LFV can vary significantly depending on the type of vehicle. Throughout this document a width of 1.90 meters, length of 5.20 meters, and height of 2.00 meters will be considered. In this way, when designing parking spaces for LFV with rear loading/unloading, it is necessary for them to have dimensions of at least 2.00 m width and 7.50 m length to ensure enough manoeuvring and loading/unloading space at the rear end.

Figure 2 illustrates the composition of a two-way road with on-street parking, with one traffic lane and one parking lane in each direction. In Figure 3 instead, there is a composition for a one-way street with two travel lanes and one parking lane. These two displays both lateral and rear loading.

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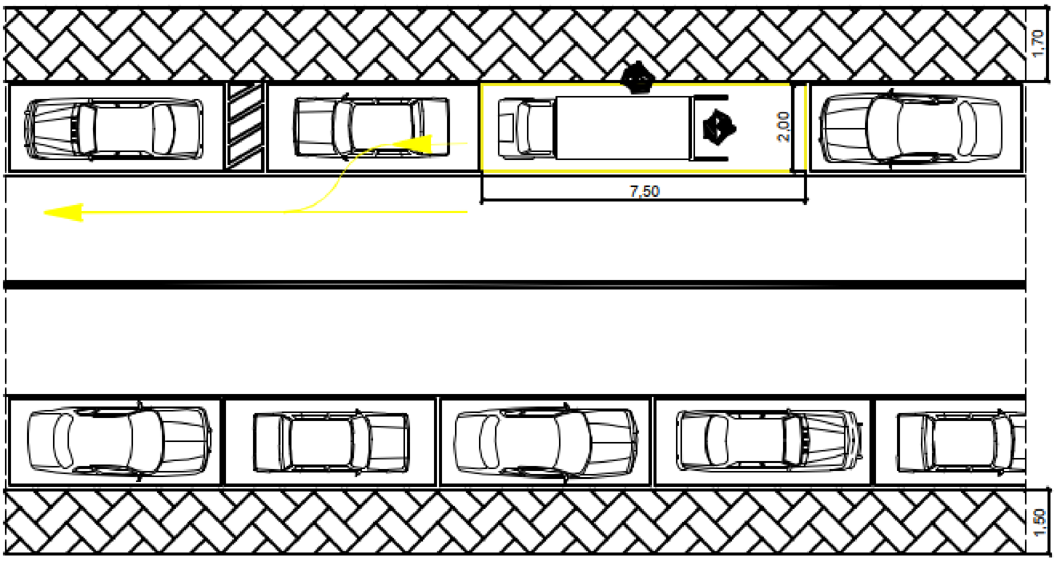

Figure 2: Dimensioning of parking lots for LFV

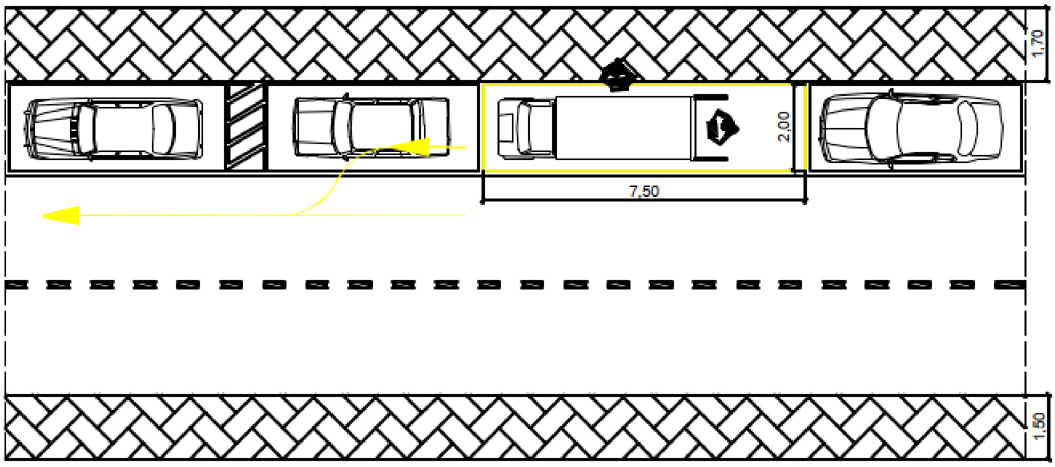

Figure 3: Dimensioning of parking lots for LFV on one side

4.1.1.1 Dimensioning of parking bays with additional space for manoeuvring

It is possible to study the minimum dimensions of a Single Commercial Vehicle Loading/Unloading Zone (SCVLZ) capable of accommodating the parking of a LFV, allowing the operator a correct and easy parking and loading/unloading manoeuvre. Typically, a freight vehicle is equipped with side doors and sliding rear end doors: in the former case, the opening process results in an increase of 0.30 meters. Secondly, the rotating opening of the door has a radius equal to the size of the door (0.80 ÷ 0.90 meters) and describes an angle usually between 90° and 180°. Additionally, for the purposes of loading/unloading operations to be carried out on three sides of the vehicle, additional spaces must be considered, taking into account the average size of the parcels, loading/unloading devices, and activities performed by the operator.

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Through studies, these sample areas have been estimated to be between 0.50 and 0.60 meters in the case of the side opening and in the range of 0.70 ÷ 0.80 meters in the case of the rear opening [2]. Figure 4, Figure 5, and Figure 6 indicate a total length of 7.00 meters and a width of 2.50 meters for such additional area.

In Figure 4, linear or parallel parking stalls are observed with additional space for the rear loading and unloading of freight. This way, the staff can work safely, having access to a ramp for transportation.

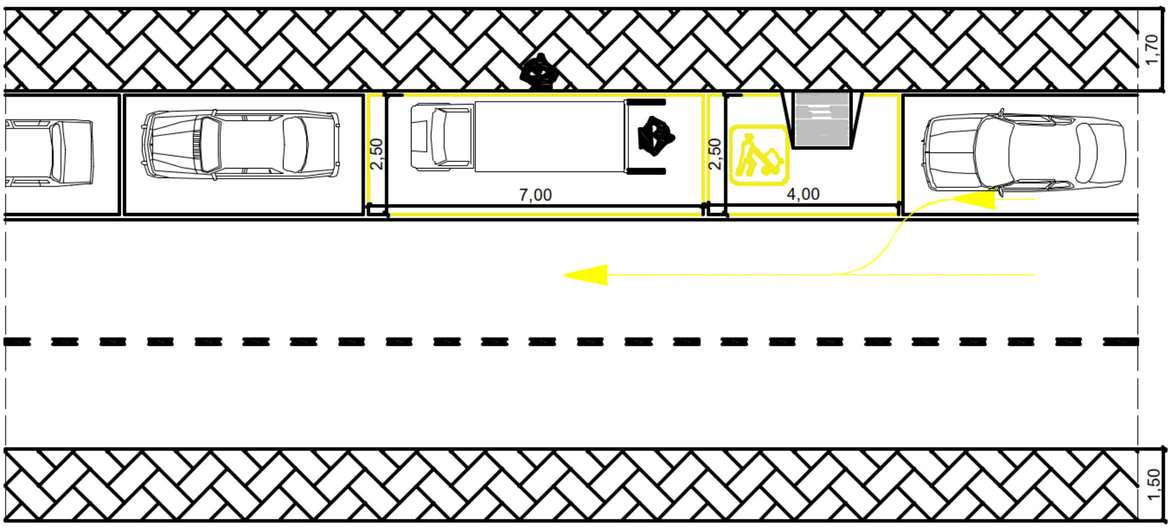

Figure 4: Type of parking stalls: parallel.

The same composition can be observed in Figure 5, with 90°'s parking stalls, and in Figure 8, with 30°'s parking stalls, considering both rear and lateral loading/unloading.

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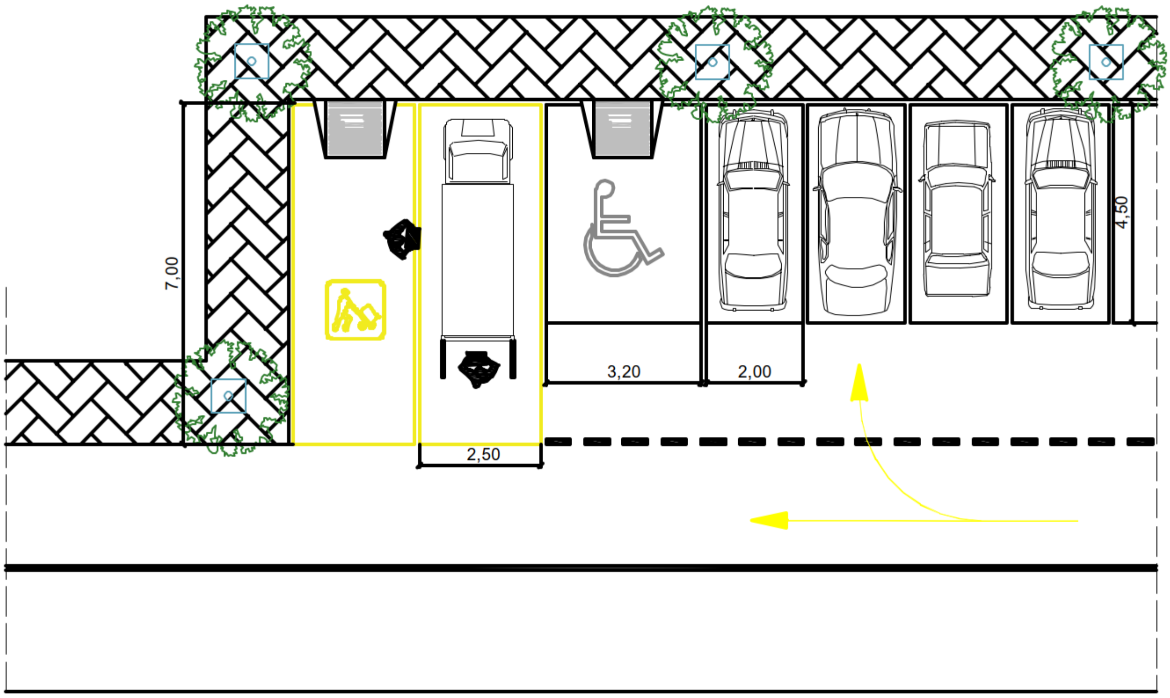

Figure 5: Type of parking stalls: 90°

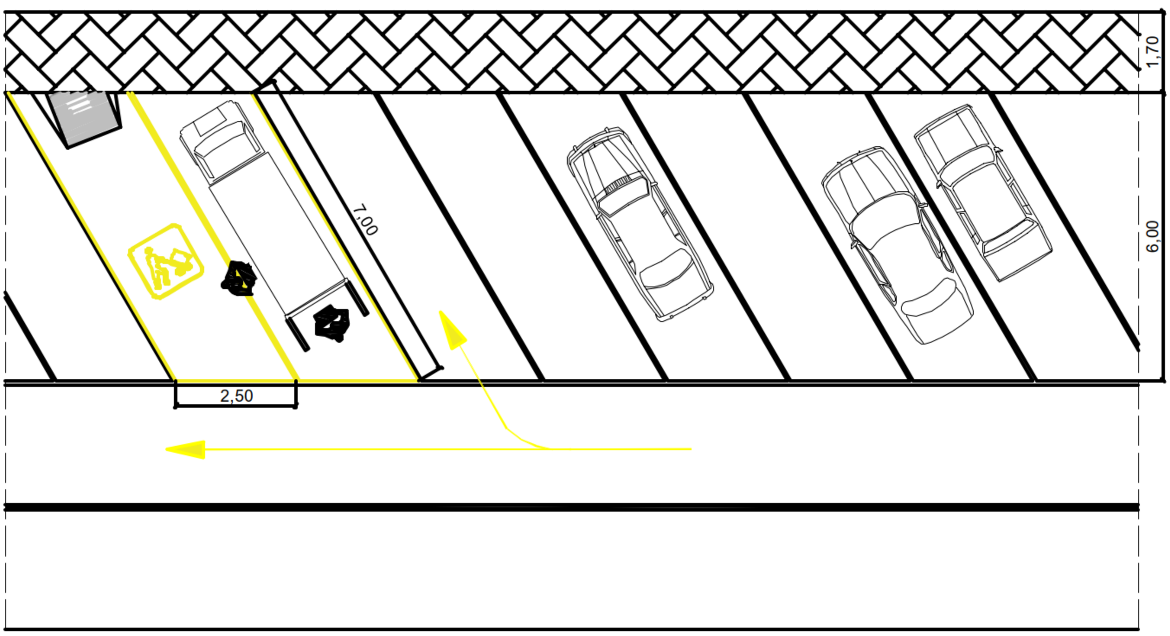

Figure 6: Type of parking stalls: 30°

4.1.2 Dimensioning of parking spaces for Heavy Freight Vehicles

The Heavy Freight Vehicles (HFV) are designed to have a gross vehicles weight above 3,500 kg. Their dimensions and weight can vary significantly depending on the specific type of vehicle, its configuration, and local regulations.

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For this document, an average of 8.5 m length, 2.4 m width, and a maximum of 4.0 m height will be considered. Therefore, to accommodate rear loading and unloading manoeuvres, a parking space with dimensions of 2.5 m width and 11.0 m length is necessary.

As in the case of LFVs, Figure 7 shows a proposed dimensioning for HFV traveling on a two-way road with on-street parking, with one traffic lane and one parking lane in each direction, while Figure 8 displays a one-way road with two travel lanes and one parking lane.

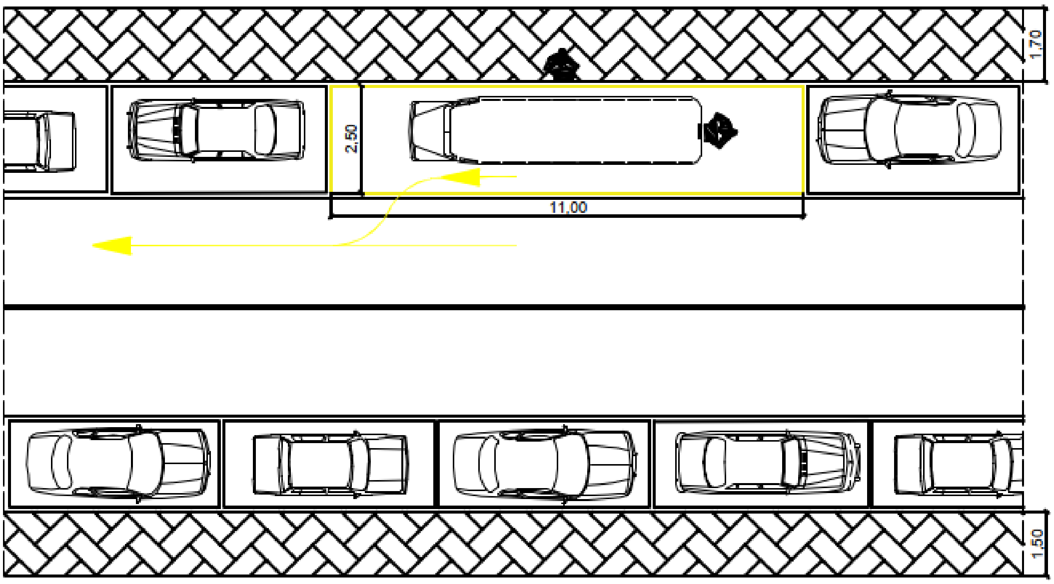

Figure 7: Dimensioning of parking lots for HFV on both sides

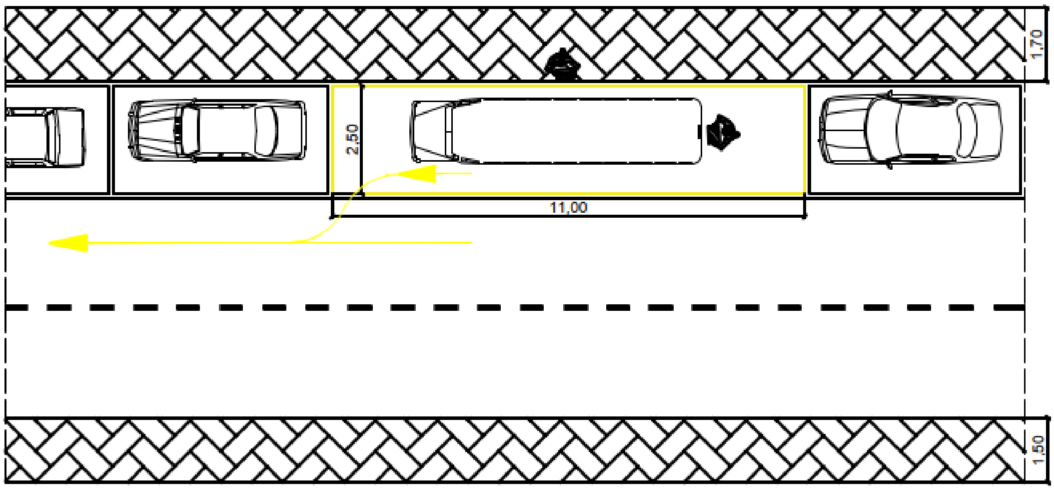

Figure 8: Dimensioning of parking lots for HFV on one side

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4.1.3 Parking delimitation

In Figure 9, an example of horizontal signage is proposed to demarcate loading and unloading areas in parking lots (bays). The colour yellow is used to make a distinction between these specific parking zones and regular parking zones.

Figure 9: Parking lines [5]

4.2 Anti-parking systems

In every type of area, it is necessary to implement systems that prevent other vehicles from parking in the areas designated for loading and unloading goods. In following several systems to such scope are presented.

4.2.1 Retractable Bollards

In Figure 10, flexible deterrent bollards are shown. These are designed to protect people, structures, machinery, and equipment from potential impact damage with vehicles. They can be made of polymer and have a diameter of 20 cm. They can also feature an automatic retraction system controlled by the vehicle that needs access.

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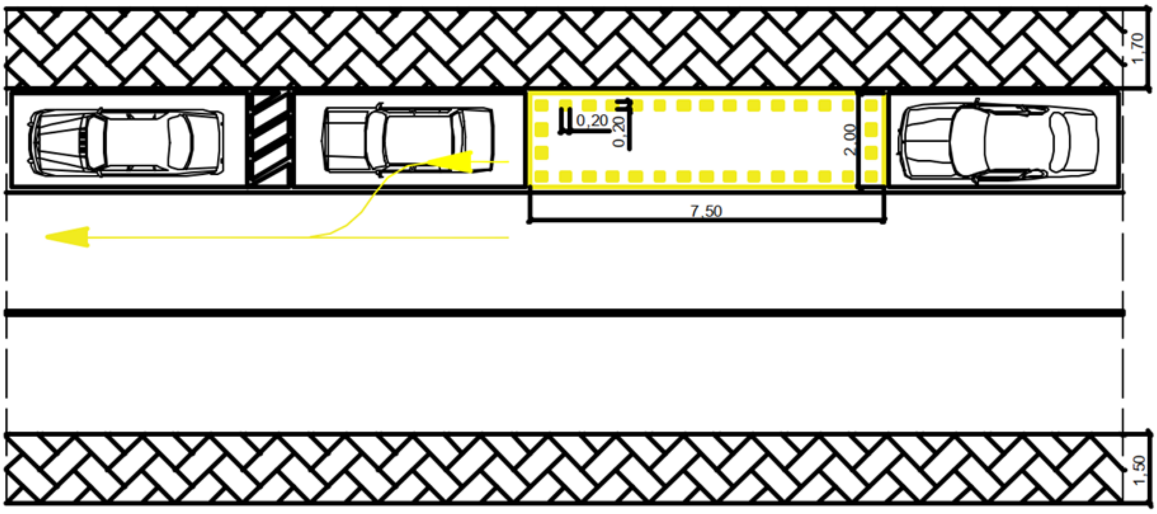

Figure 10: Automatic telescopic retractable bollards

4.2.2 Simple Delineation

In Figure 11 and Figure 12, it is highlighted a simple delineation system for the loading and unloading area through yellow horizontal signage, both for Light Freight Vehicles (LFV) and Heavy Freight Vehicles (HFV).

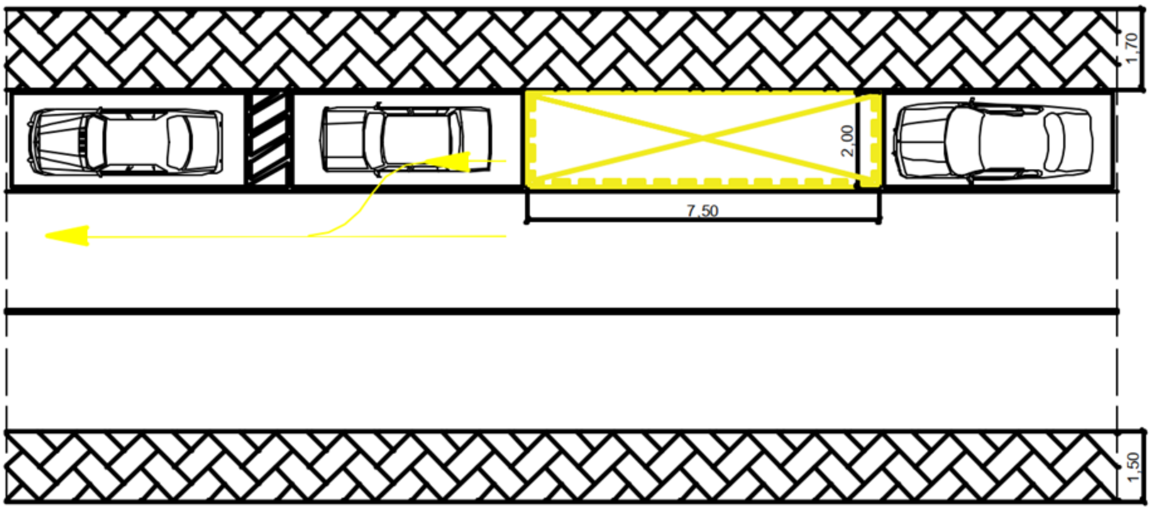

Figure 11: Anti-parking lines for LFV

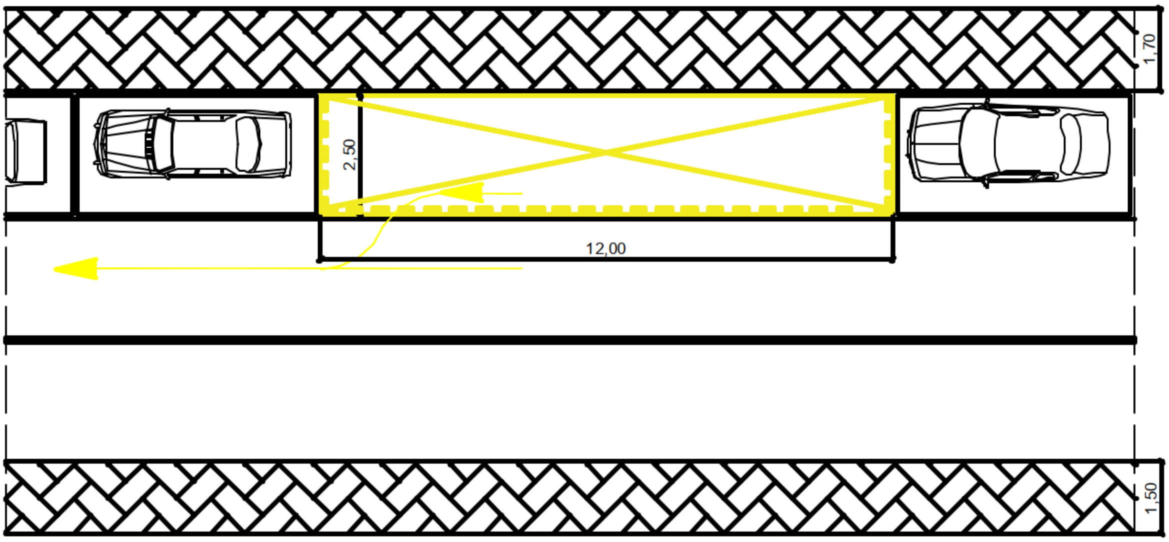

Figure 12: Anti-parking lines for HFV

4.2.3 Arches

In Figure 13, it is depicted a manual anti-parking system consisting of an arch with a padlock that can be lowered. This provides the same functionality as the bollards shown in Figure 10.

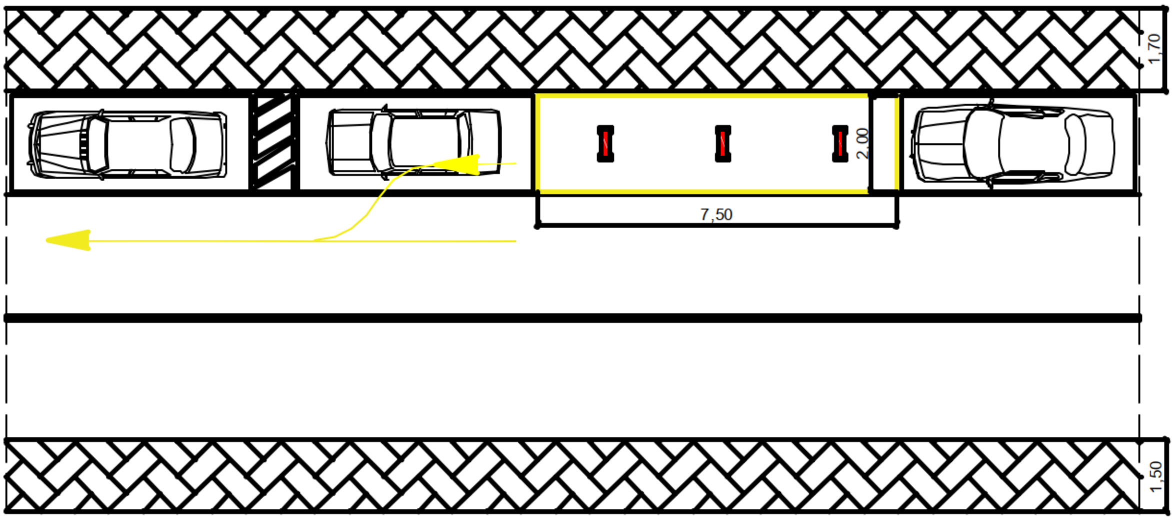

Figure 13: Manual anti-parking arches with padlock.

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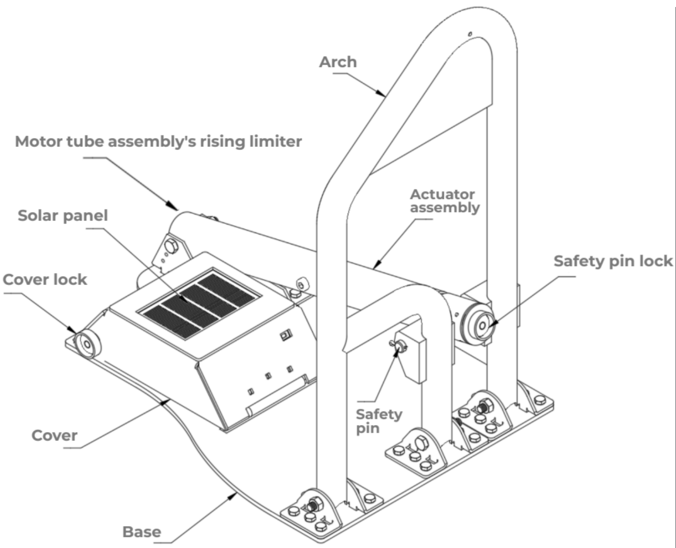
4.2.4 Real examples

4.2.4.1 Automatic parking barrier

There are several companies on the market that offer anti-parking systems: Parklio Company is one of them. One of the systems they offer is the automatic parking barrier (Figure 14). This device can be controlled through either a remote control or a mobile app. It also closes automatically when the vehicle departs, has a dual power option, and has an integrated solar panel.

Figure 14: Automatic parking barrier

In Figure 15, it is displayed all the device components as well as its technical features. This device proves to be an excellent solution, also incorporating a sustainable system.



OPENING TIME	4 s
HEIGHT OF OPEN ARCH	51.7 cm / 20.35 in
WIDTH	33.1 cm / 13.03 in
LENGTH	91.8 cm / 36.14 in
WEIGHT	15 kg / 33 lbs
PACKAGE SIZE	59 x 40 x 16 cm / 23.23 x 15.75 x 6.3 in
WEIGHT RESISTANCE	9 t / 9.92 t (US)
MATERIAL	GALVANIZED STEEL STAINLESS STEEL

Figure 15: Parking barrier: components and technical features.

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Furthermore, Figure 16 shows the device from different perspectives as well as its overall dimensions (in millimetres).

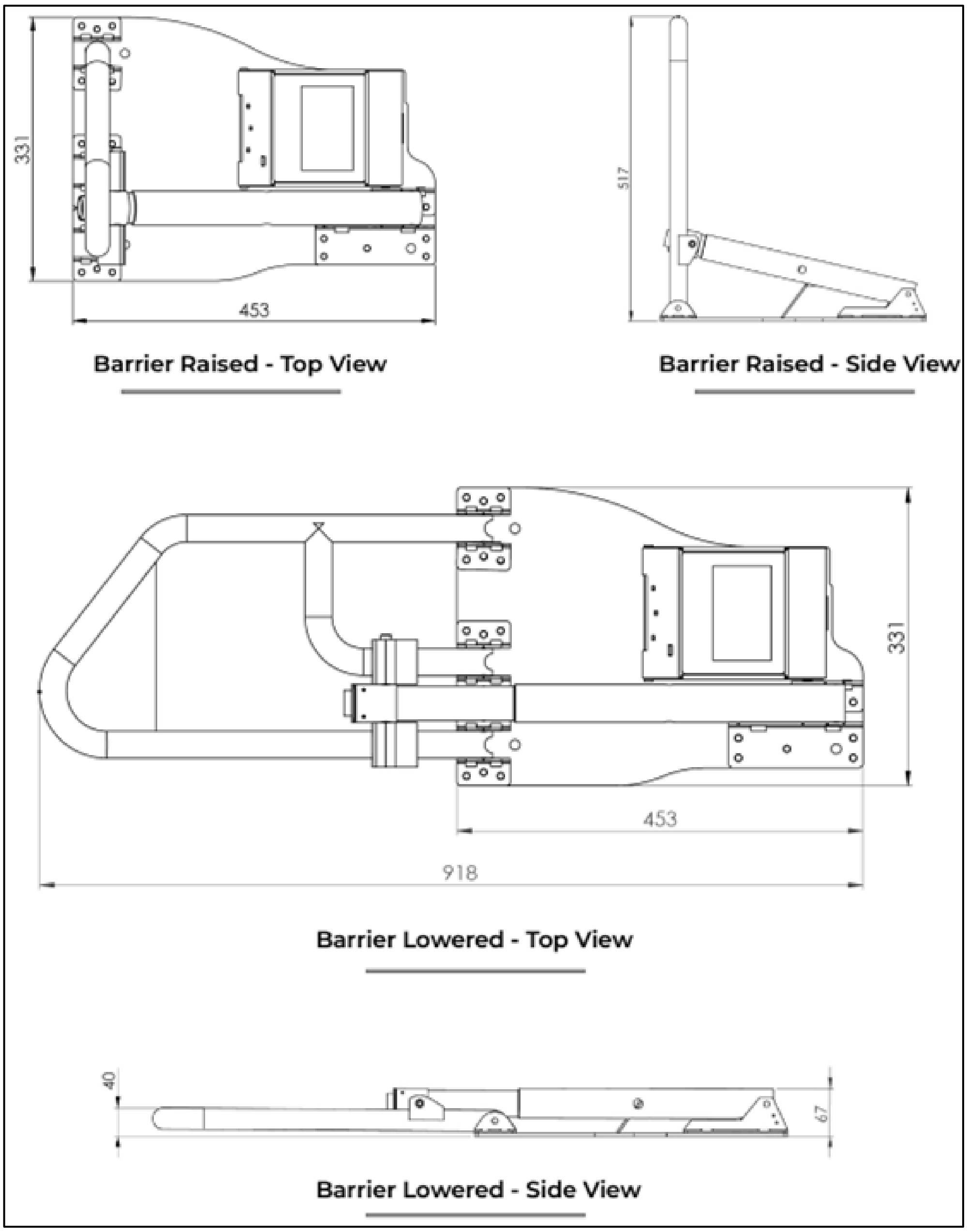

Figure 16 Overall barrier dimensions.

4.2.4.2 Automatic retractable bollard

Retractable bollards with automatic closure are also available on the market (see Figure 17), and these are also offered by Parklio. They can be controlled via remote control or smartphone and are generally made of stainless steel, with a special motor for increased speed and durability. The bollards rely on solar power, which is converted into electricity by the panel, ensuring continuous functionality.

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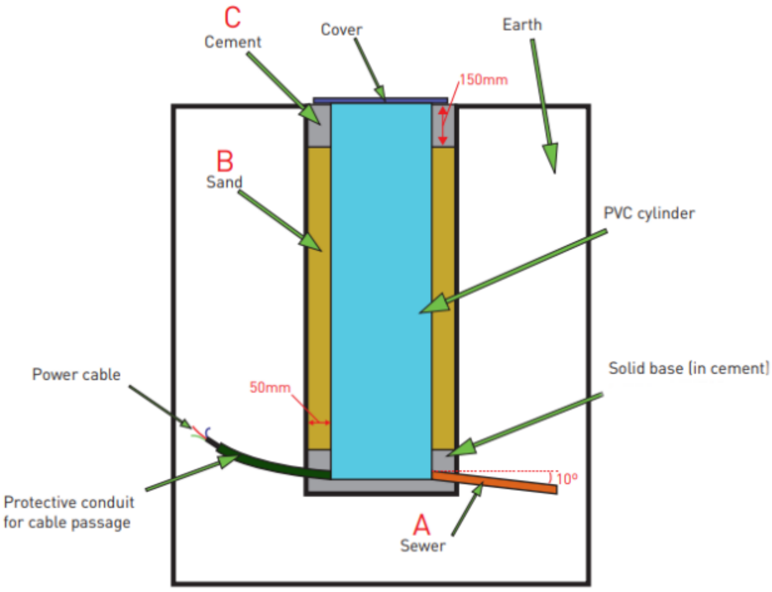
Figure 17: Automatic retractable bollard.

In Figure 18, it is displayed all the device components as well as some technical features, and Figure 19 shows the device's overall dimensions. This device proves to be an excellent solution, also incorporating a sustainable system.



MODEL	600/800
POWER SUPPLY	230 VAC
MOTOR POWER SUPPLY	24 VDC
POWER	60 W
DUTY CYCLE	70%
OPERATING TEMPERATURE	-20ºC to +50ºC / -4ºF to +122ºF
COVERS	ANTI-SLIP STAINLESS STEEL 4 MM
WEIGHT CAPACITY WHEN CLOSED	20000 KG / 44100 LB
DIAMETER	204 MM / 8 IN

Figure 18: Bollard components and technical specifications.

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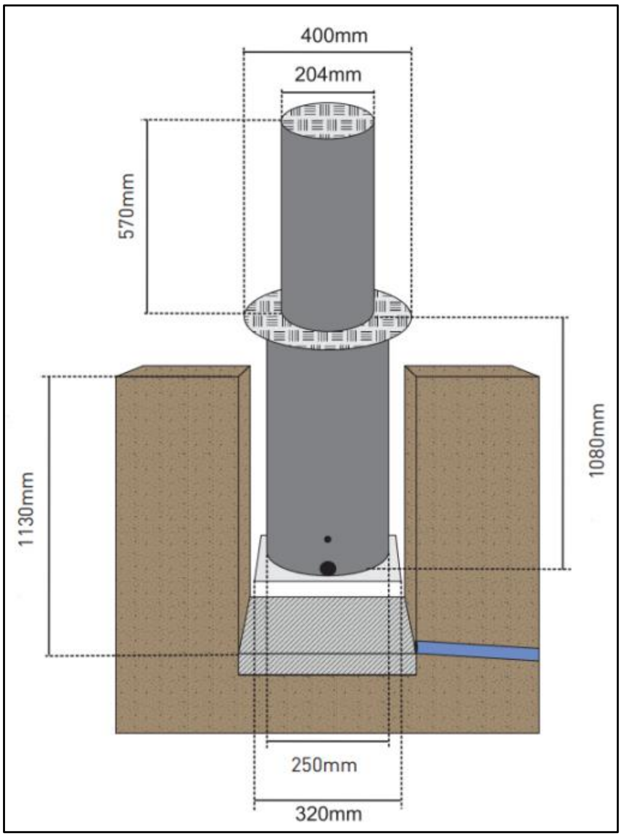

Figure 19: Overall bollard dimensions.

4.2.4.3 Manual arch with padlock

A further solution, and an alternative to automatic systems, is the use of arches with padlocks (see Figure 20). These arches typically measure 700x500x460 mm and have a central tube with a diameter of 38 mm. Red reflective strips are included to improve their visibility in low light or under unfavourable conditions.

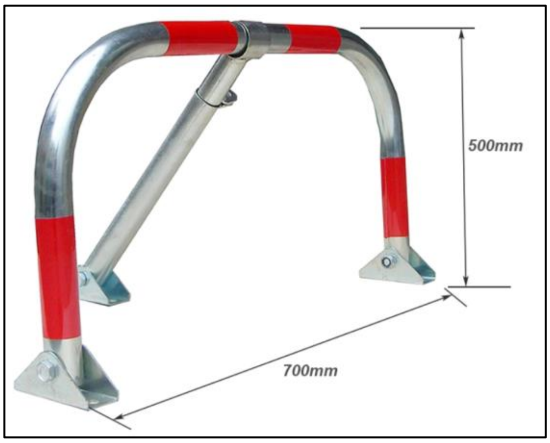

Figure 20: Manual arch with padlock.

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4.3 Parking in pedestrian areas

In pedestrian areas, regular vehicles are not allowed to pass through. However, there could be designated time slots during which freight vehicles can transit for loading or unloading goods, as shown in Figure 21. Thus, it is important to designate a specific area for vehicle temporary parking during these times.

Figure 21: Example of pedestrian zones signalling [6].

In Figure 22 and Figure 23, a parking area for Light Freight Vehicles and Heavy Freight Vehicles, respectively, has been inserted in a pedestrian zone. For the former, a length of 7.50 m is considered, while for the latter 11.50 m. In both cases a width of 2.50 m, which allows both rear and lateral loading/unloading, is considered [7]. Regardless of the case, it is highly recommended that these areas are clearly marked and that time slots, preferably during off-peak hours, are set aside to ensure pedestrian safety.

During peak hours, when vehicles are prohibited from entering the pedestrian area, cargo vehicles are required to utilise designated parking areas situated outside the restricted zone. It is therefore necessary to transfer the goods to smaller, pedestrian-friendly delivery methods, such as hand trucks or bicycles, in order that they may be delivered to their final destinations. This approach strikes a balance between the needs of urban logistics and pedestrian accessibility and safety.

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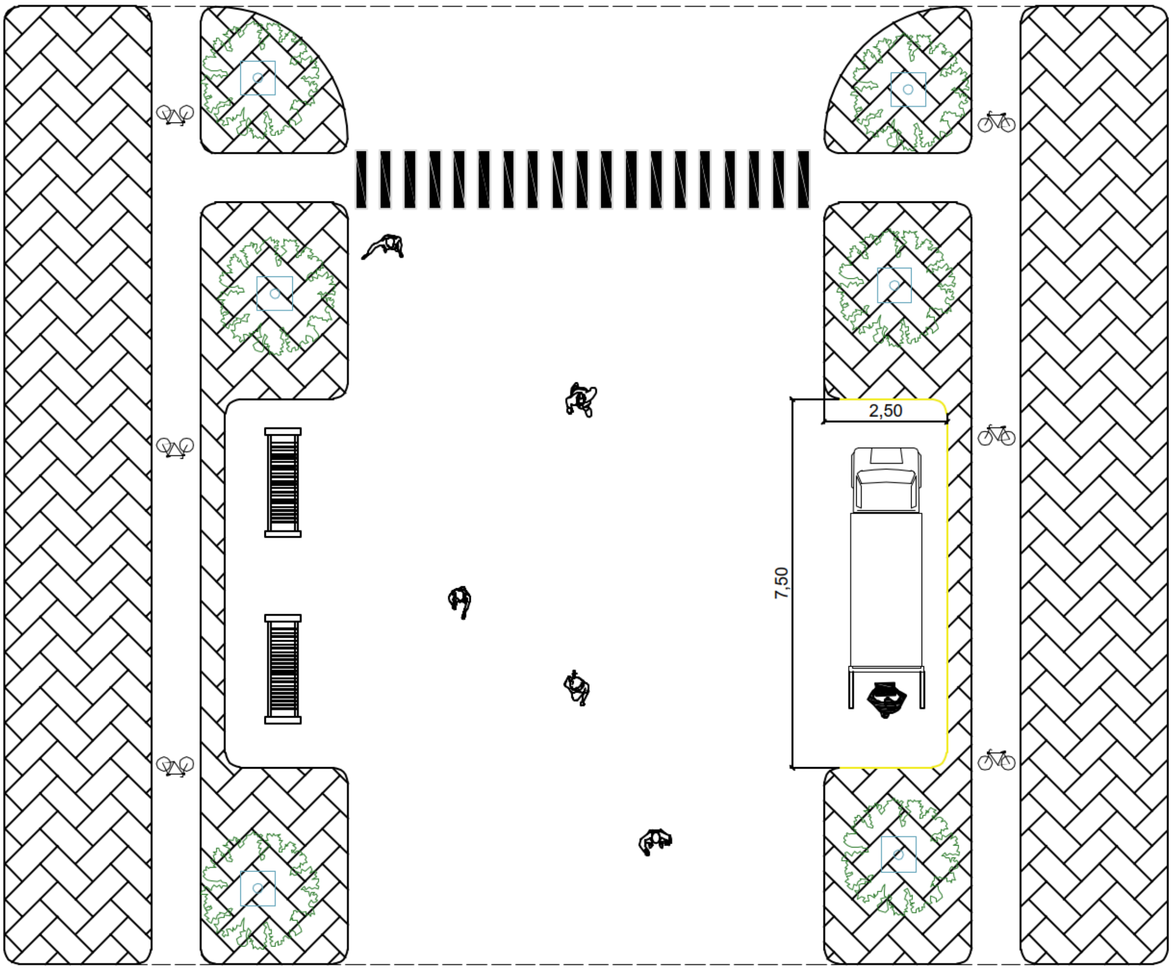

Figure 22: LFV parking in pedestrian zones

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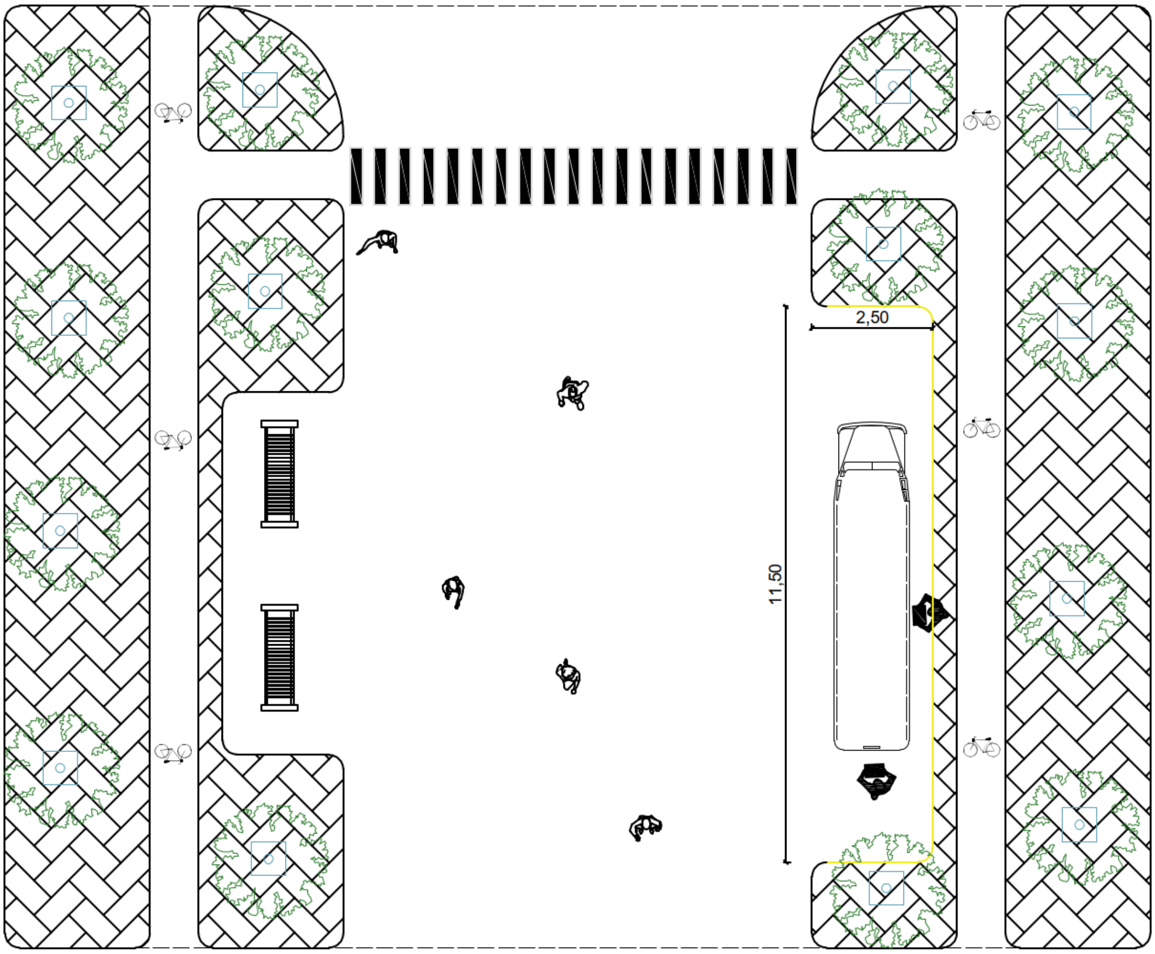

Figure 23: HFV parking in pedestrian zones

4.4 Streets and Intersections

4.4.1 Urban Streets

Urban streets are to be designed to accommodate users of all ages and abilities who travel by a variety of modes of transport, including walking, cycling, public transport and car. A common feature of urban streets is interrupted traffic flow, which can be controlled by traffic signals, STOP signs or roundabouts [8].

The design of streets and intersections should consider the challenges that larger vehicles, including emergency vehicles, may face. However, these occasional challenges should not compromise the safety or comfort of a site for the majority of daily users [7]. To this purpose, there are several measures than can be implemented so that low vehicle speeds can be encouraged, for example:

- Narrowing traffic lanes.
- Vertical deflections.

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- Horizontal deflections.

In the context of this project, it is likely that there will be narrow commercial streets that will require frequent loading and unloading. Therefore, a commercial shared street environment design should be considered (see Figure 24).

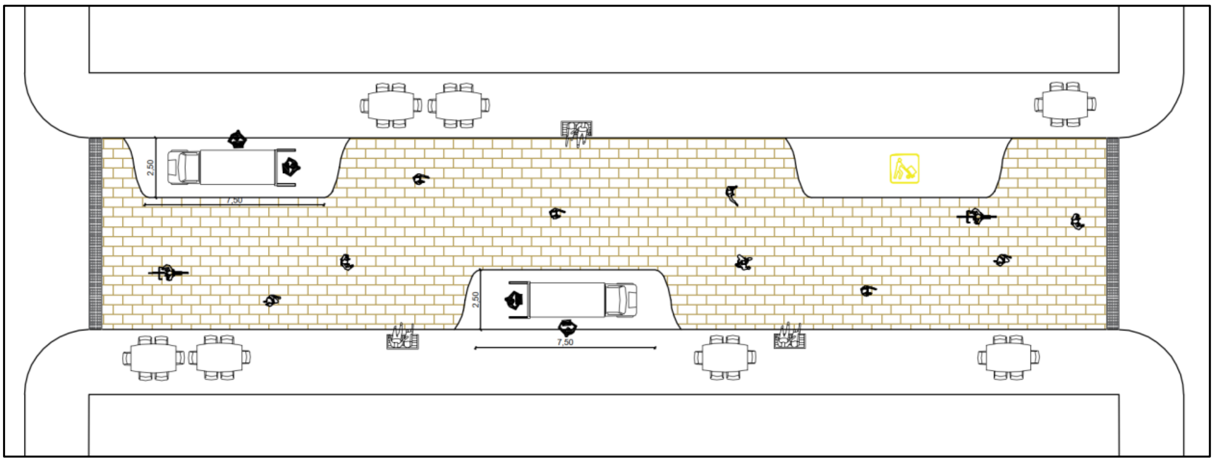

Figure 24: Commercial shared street.

4.4.2 Intersections

The design of intersections plays a pivotal role in facilitating urban logistics and ensuring the safety of pedestrians. The planning of efficient intersections with features such as crosswalks, pedestrian islands, and dedicated cycling lanes creates safer environments for all road users.

To this end, there are several elements that can be implemented, including a change in surfacing, the presence of street furniture in unconventional positions, introducing visual narrowing, and using tighter geometry. [9] Some of these will be further detail in the following sections.

4.4.2.1 Curb Extension

Curb extensions are an extension of the curb line into the roadway (see Figure 25). They are typically installed on streets with on-street parking and their length should at least be equal to the width of the crosswalk.

Curb extensions serve different purposes, such as enhancing pedestrian safety and traffic calming. For pedestrian safety, curb extensions shorten the crossing distances and enhance their visibility, especially when used in conjunction with high-visibility markings.

For traffic calming, by narrowing the lanes, curb extensions typically extend into the travel lane to reduce the speeds of vehicles, including those turning. In addition, a series of curb

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extensions at intersection or mid-block locations is usually used to reduce speeds along an entire corridor [10]. Figure 25 provides an illustration of the curb extension on the street going from right to left.

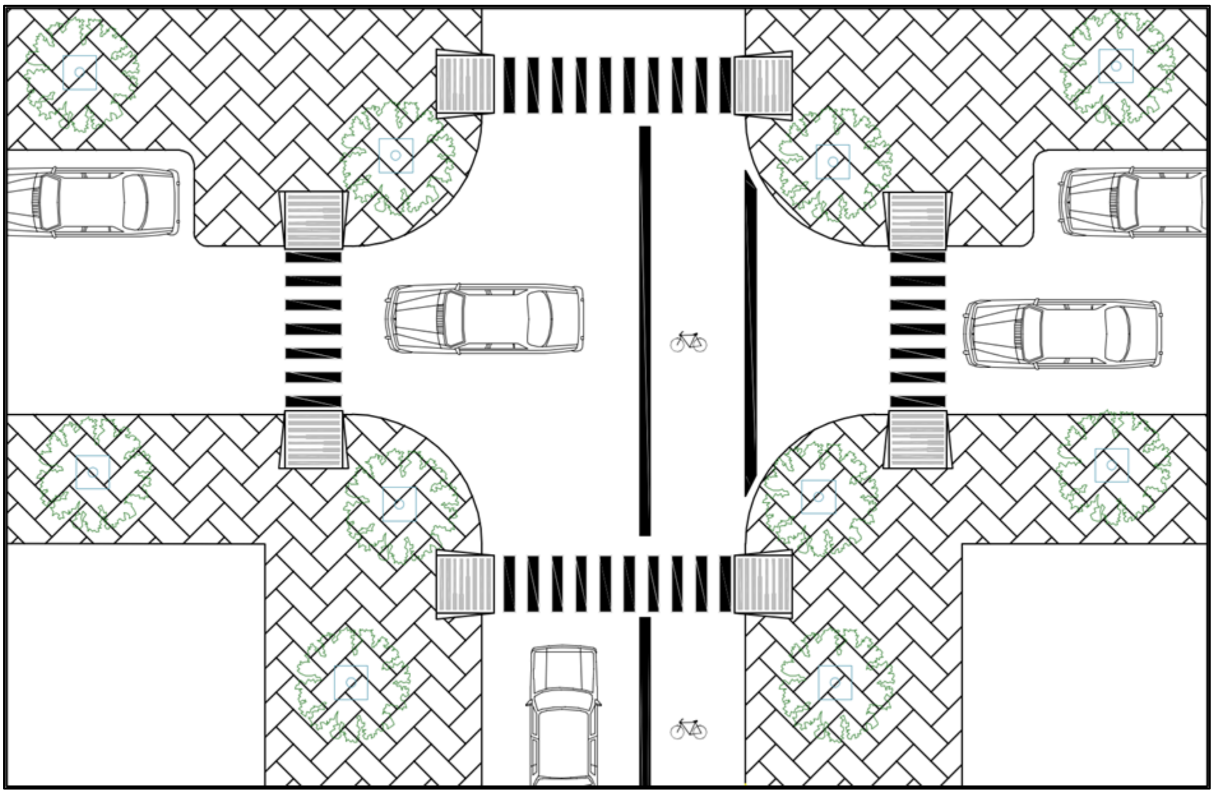

Figure 25: Curb Extensions

4.4.2.2 Raised Crosswalk

Raised crosswalks are speed tables that are elevated above the surrounding roadway surface. They are often placed at intersections or midblock crossing locations. The crosswalk is delineated by the application of paint and/or special paving materials. These crosswalks serve as traffic-calming measures that provide a continuous route for pedestrians to cross at the same level as the sidewalk. [11]

The implementation of raised crosswalks can be undertaken in conjunction with curb extensions, thus creating an even safer space for pedestrians. Figure 26 provides an illustration of the implementation of both measures in a street intersection.

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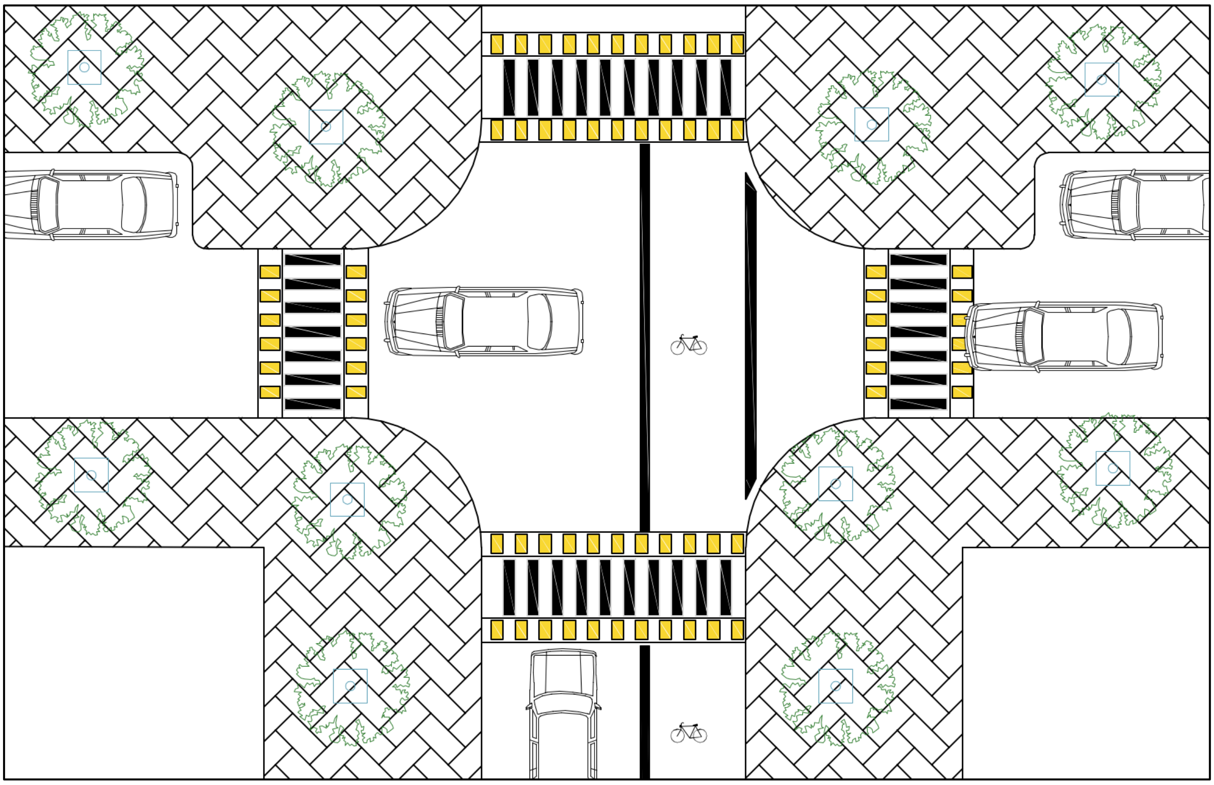

Figure 26: Raised Crosswalk and Curb Extension

4.4.3 Comfort space in urban streets

A comfort space is an area of an urban street designed primarily for pedestrian use where motor vehicles are unlikely to be present [12]. Comfort spaces are most useful in busy streets and become less necessary as vehicular traffic decreases. Indeed, on quieter streets, providing specific measures for comfort space may not be needed. They are particularly beneficial for disabled and older individuals, and especially crucial for blind and partially sighted individuals. Therefore, it is essential to design comfort spaces with the needs of pedestrians in mind.

The design of the comfort space varies depending on the street integration. In a conventional street, kerbed footways typically provide the comfort space, while in a level surface street, other means are used to provide it. Therefore, designing for comfort space is only necessary when a level surface is used (ibid).

The Comfort Space along the street should remain uninterrupted between junctions and connect to suitable crossing points. It is not necessary to have a continuous barrier as this would defeat the purpose of shared space. Delineation can range from a tactile strip to a row of bollards every few metres, or even be largely absent, such as when the comfort space is in front of a row of shops that are some distance away from vehicle paths (see Figure 27). Comfort space can also be indicated by different features in combination (ibid).

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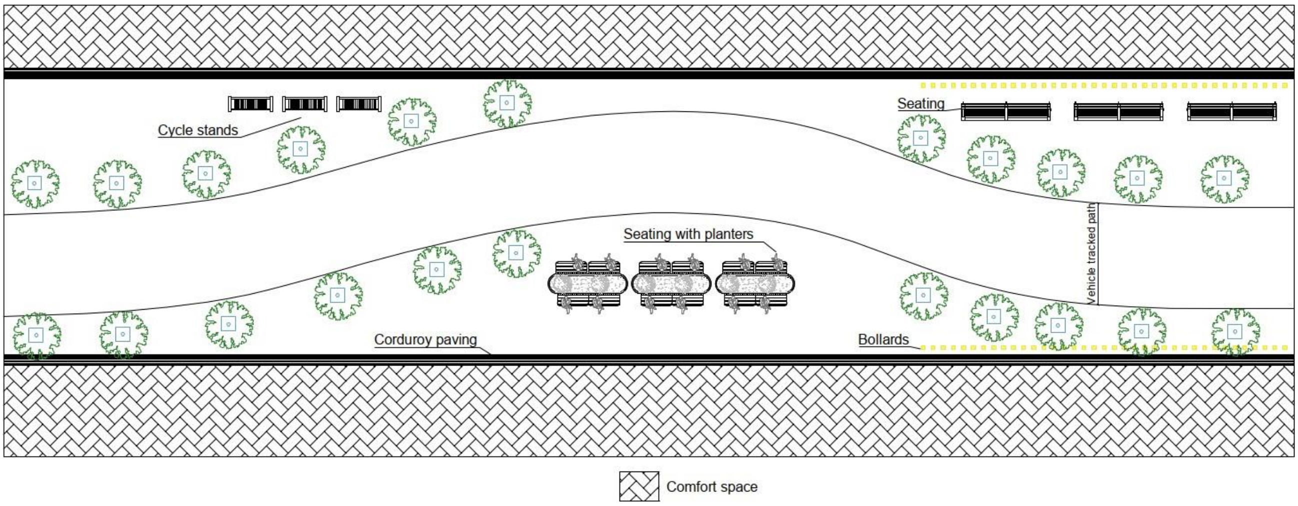

Figure 27: Comfort Space

4.5 Urban Logistics Points

The first and last-mile problem is a common issue in city centres, particularly due to pedestrianized areas. In this section possible solutions to tackle this problem are presented.

4.5.1 Micro consolidation centres

A Micro Consolidation Centre is a strategically positioned logistics facility within an urban area. Its function is to consolidate cargo shipments at a single urban terminal that serves a defined area, after which the parcels are distributed to the end recipient. Ideally, the location should be strategically positioned within high-density zones, covering both residential and commercial areas.

The micro consolidation centre facilitates a transition to low-emission vehicles or alternative transportation modes, such as walking and cargo bikes, for the final phase of product deliveries. Indeed, it should integrate pickup points, warehouses, and delivery through sustainable vehicles (as illustrated in Figure 28).

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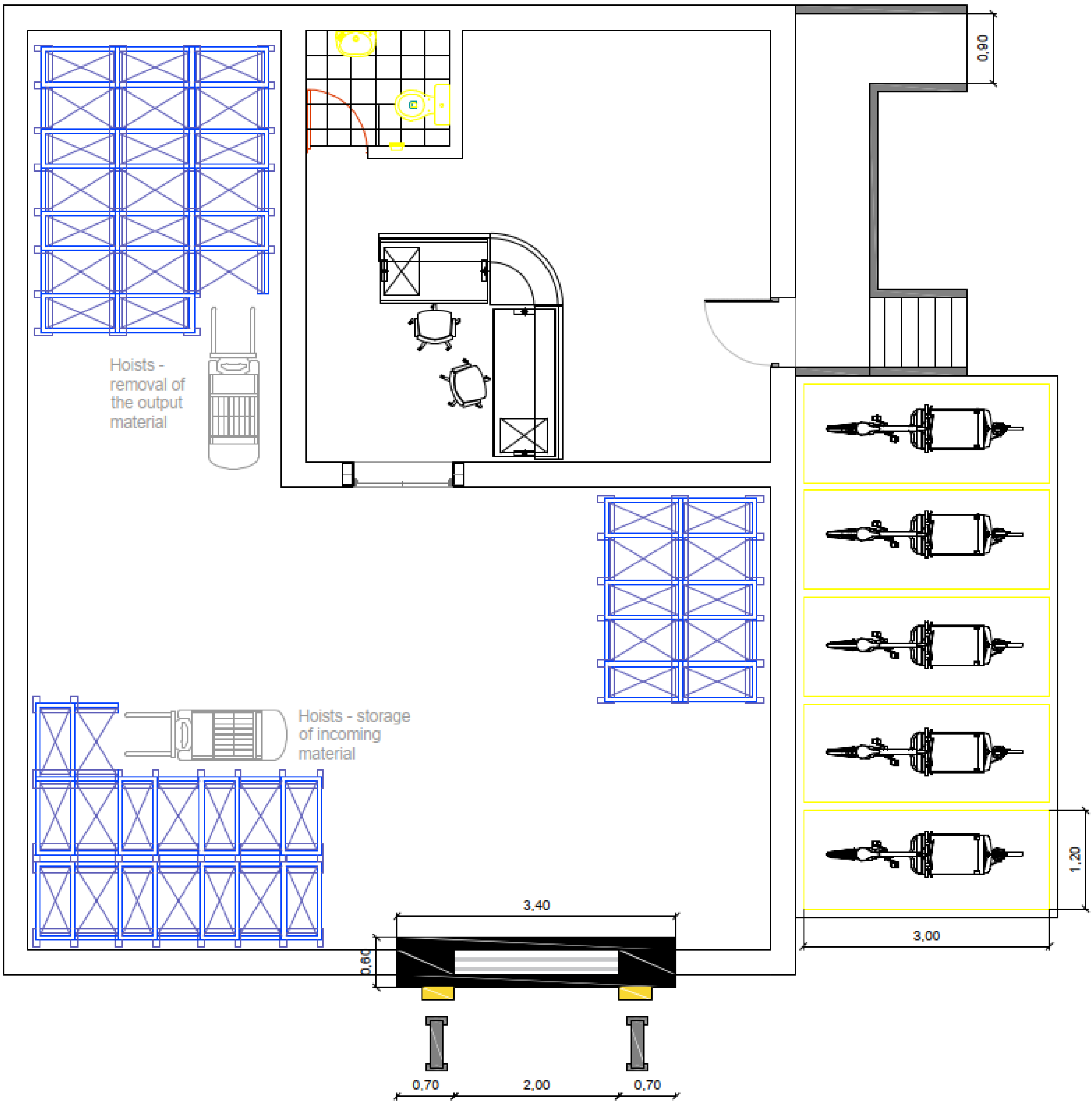

Figure 28: Micro Consolidation Centre

The micro consolidation centres shall consist of at least two rooms: a warehouse connected by loading and unloading bays) and an office point where users can collect their packages (refer to Figure 29). All vehicles load and unload goods within the bays, in direct contact with the warehouse.

Inside the warehouse, incoming goods will be sorted from outgoing ones, either manually or by using lifts. It is also connected to a room designated for users, accessible through a door next to the bay. The room will consist of a reception area and a restroom. Users will approach the reception to drop off or pick up a package.

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Figure 29: Dimensioning of loading/unloading bays.

4.5.1.1 Loading/unloading bays

The technical specifications of the loading and unloading bays (see Figure 30) depend on the vehicles that can access them. It must be possible for multiple different vehicles (see Figure 31) to access the same bay, so its features must be suitable for all of them.

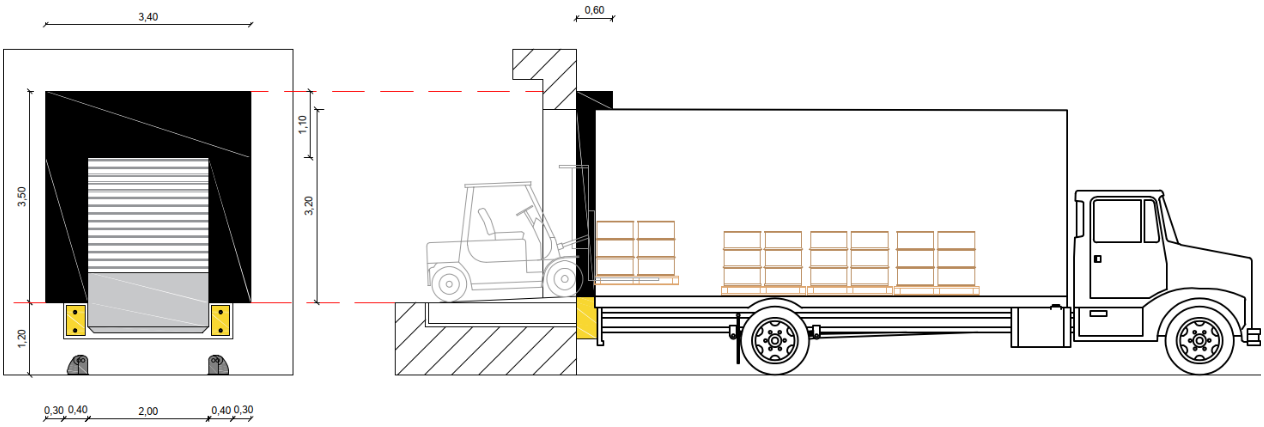

Figure 30: Dimensioning of loading/unloading bays: front view (left) and lateral view (right)

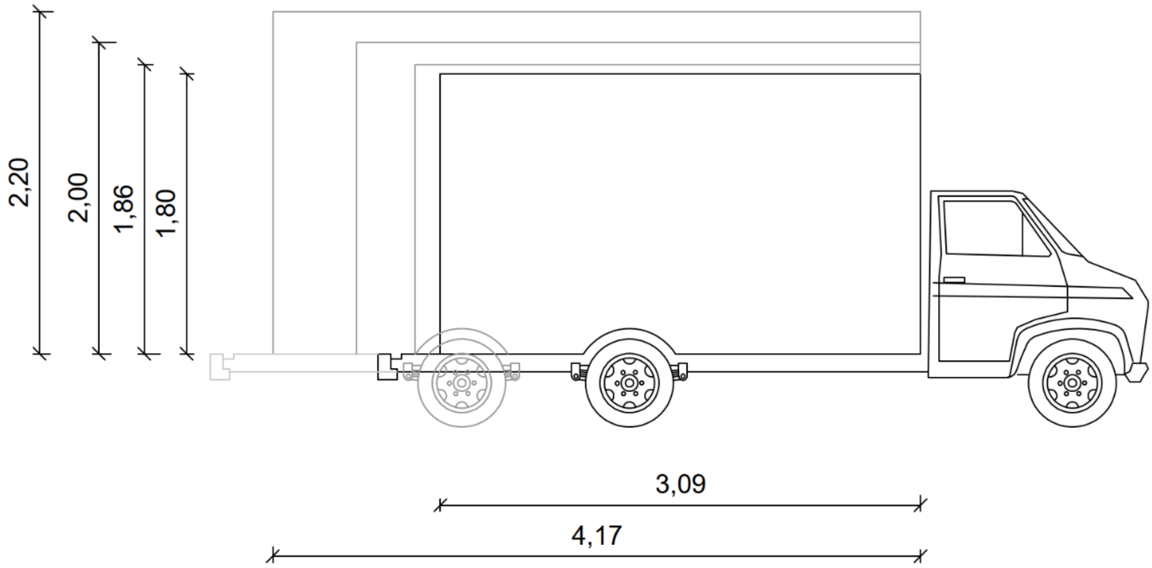

Figure 31: Dimensioning of LFV and HFV

The loading and unloading bay comprises an insulated portal, a sectional door, a ramp, and rubber bumpers (see Figure 32). The **insulated portal** is an opening and closing device that uses swinging arms and has a front made of differentiated rigidity black rubber. When a vehicle backs up, the seal structure compresses without causing damage. The supporting structure is made of tubular material. The curtains are made of PVC and have signage to aid in centring the vehicle. Furthermore, there is an edge with an extruded natural aluminium angle. [13].

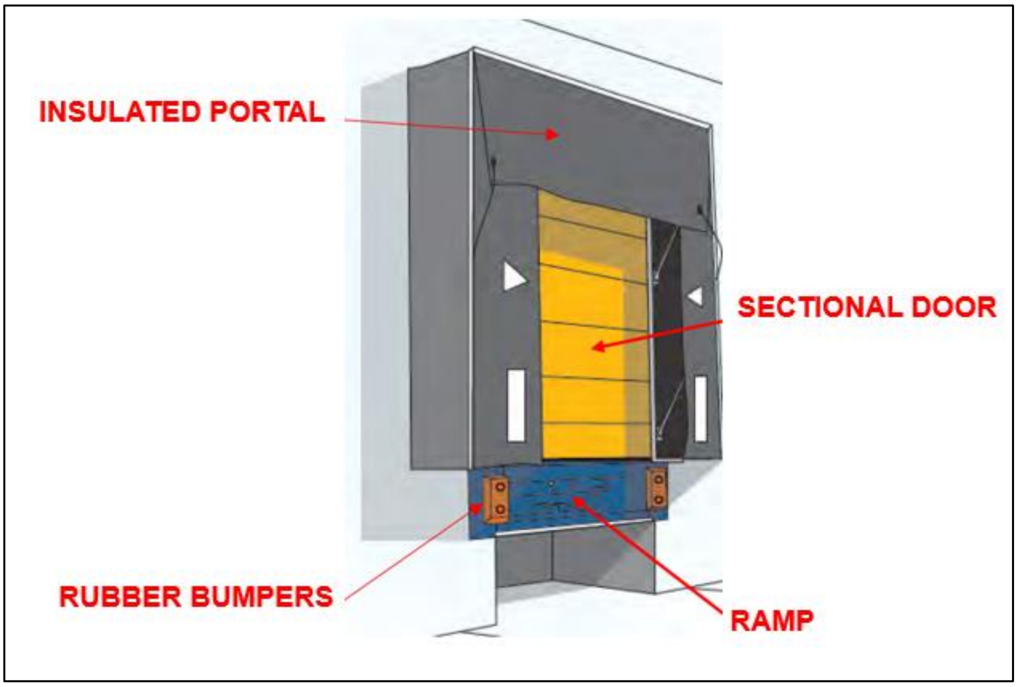

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Figure 32: Loading/unloading bay's parts.

The **sectional door** provides fast and unobstructed access to the loading platform. Along with the seal and ramp, it helps to create a seamless transition between the platform and the warehouse. The **ramp** is a device that bridges the gap between a loading dock and the surface of a vehicle, compensating for any level differences. **Rubber bumpers** on both sides of the ramp ensure safe approach of the truck to the loading bay, protecting the ramp from impacts and damage.

The flooring features a pair of galvanized steel guide rails (see Figure 33) that are fixed to the ground with concrete. These rails enhance safety during loading and unloading operations by compelling vehicles to enter a central position. The rounded shapes of the guide rails are also safe for the tires.

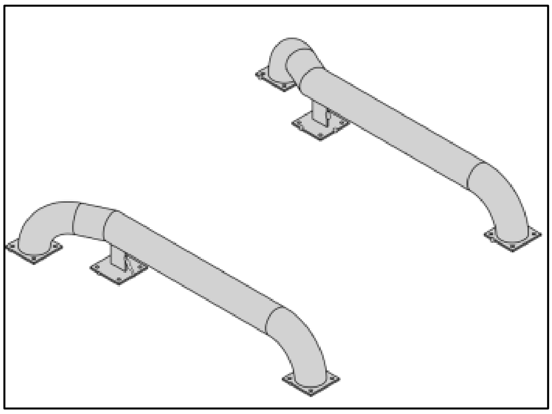

Figure 33: Galvanized steel guide rails.

Figure 34 shows everything described above. The bay dimensions are essential and must be respected, while the warehouse dimensions depend on the anticipated quantity of goods.

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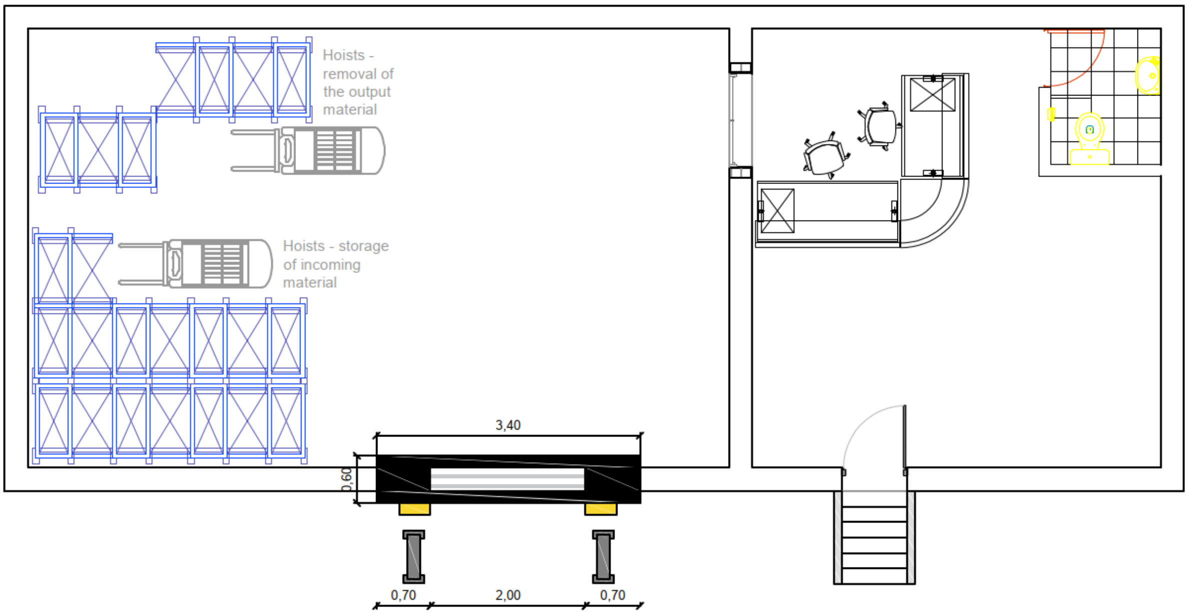

Figure 34: Layout of the pickup point with loading and unloading bay.

Figure 35 proposes an alternative public access connected by a ramp. This is useful both for heavy packages and for users with disabilities.

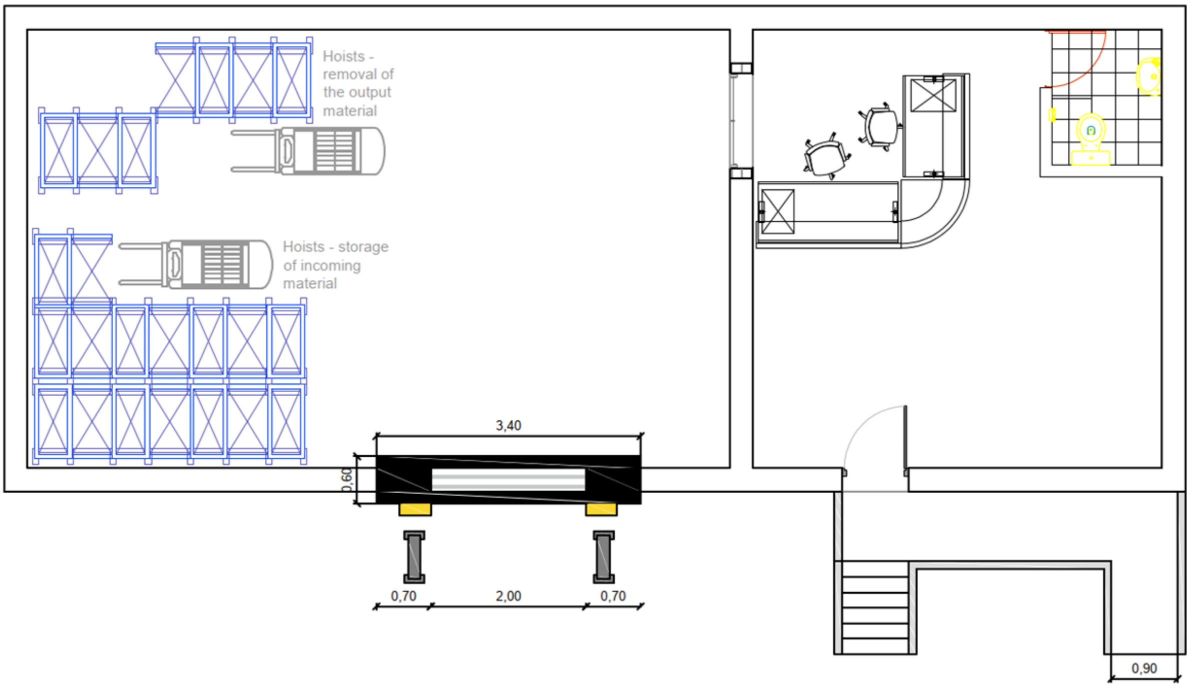

Figure 35: Alternative layout of the pickup point with loading and unloading bay.

In order to improve the service provided by the pickup points, a cargo-bike system can be integrated to offer a door-to-door delivery service, which would be undoubtedly more convenient for most users. Sections 5.1 provides additional information on cargo bikes.

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4.5.1.2 Charging Infrastructure

For the establishment of a sustainable Micro Consolidation Centre, the presence of electric charging stations is essential. The solution should provide the charging of electric vehicles during loading/unloading operations and/or during driver rest breaks. This will help achieve the maximum mileage using electric vehicles, thereby enhancing the business case for the same.

4.5.1.2.1 Bike Energy charging stations

Several enterprises provide charging stations for electric bikes, for instance Bike Energy. They offer various models of charging stations that can charge multiple units simultaneously, eliminating the need to bring a charger from home. The Tower, Point, and Line models (see Figure 36) are available to choose from depending on requirements [14].

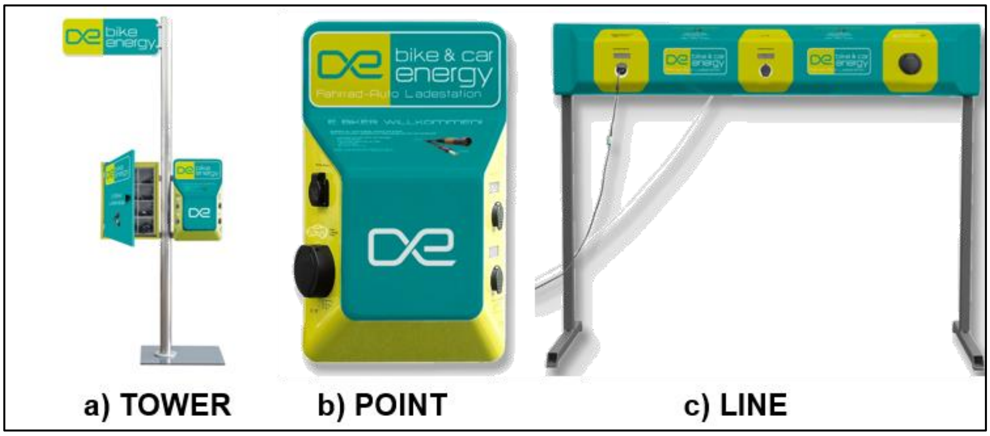

Figure 36: Bike Energy charging stations.

4.5.1.2.2 Solum Helios

Solum, a Spanish company, offers an innovative parking solution called ‘Helios’. It is a parking and charging solution for electric bikes, that serves as an alternative to traditional parking. It includes a smart lock to ensure vehicle security and can accommodate up to 16 vehicles. Helios is also a sustainable and intelligent solution that generates its own energy through the solar pavement installed around it (see Figure 37). The solar pavement and internal battery make it unnecessary to connect to the electrical grid. Furthermore, this solution is completely autonomous and can be easily relocated (see Figure 38) [15].

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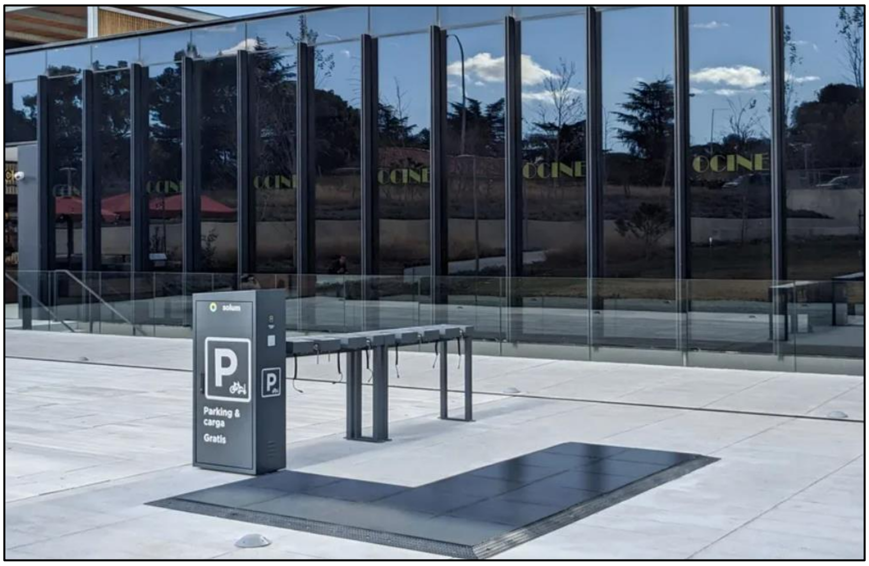

Figure 37: ‘Helios’ parking by Solum.

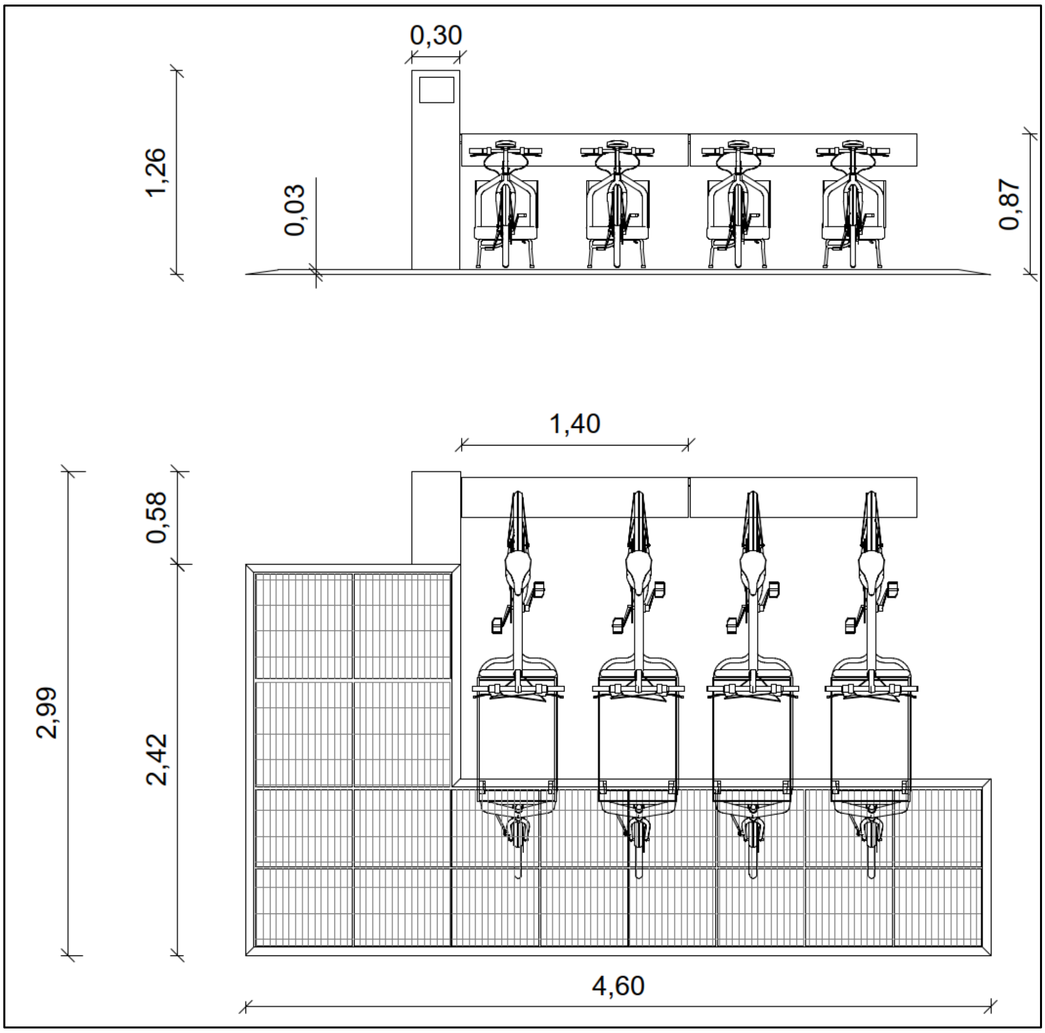

Figure 38: Dimensions of ‘Helios’ parking.

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By placing a solution such as Helios outside a Micro Consolidation Centre (as shown in Figure 39), it is possible to achieve the most environmentally friendly solution for last-mile logistics in urban areas.

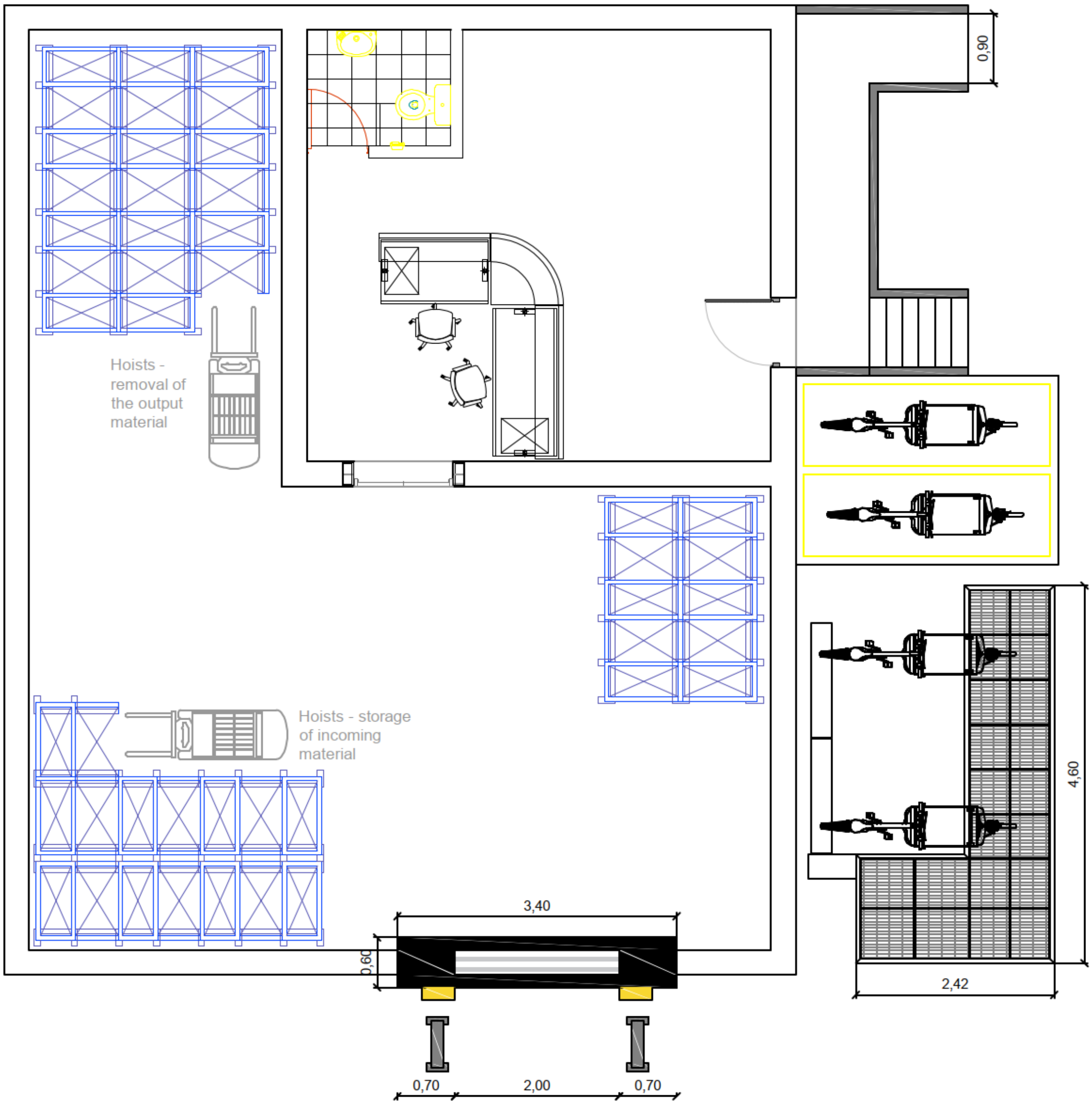

Figure 39: Green Local Hub with Solum Helios

4.5.2 Parcel Lockers

Lockers are self-service structures that allow customers to receive products purchased online [3]. Customers can select their desired Locker during the online purchase and retrieve the package at their convenience. In Europe, there are tens of thousands of active Lockers located within supermarkets, shopping malls, universities, service areas, banks, and office

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locations. In recent years, these have become increasingly popular as a solution to e-commerce challenges, contributing to the sustainability of the city and logistics.

Opting for a Locker allows for better control over purchases and a sustainable last mile. Couriers will not lose or misplace packages, and delivery costs will be optimised. The last-mile delivery from the warehouse to the destination, whether it be a home or office, incurs significant costs and requires the deployment of numerous vehicles to reach individual addresses within the specified timeframe. This has a detrimental effect on city traffic and air pollution.

Additionally, these lockers reduce the number of courier movements, resulting in improved transport efficiency, optimized routes, and reduced costs. The opening hours for Outdoor Lockers are generally 24/7, while the hours for Indoor Lockers vary depending on the hosting venue. The lockers can also be used for order returns, which is known as reverse logistics.

4.5.2.1 Locker sizes

Parcel lockers are modular, and their size is determined by the number of compartments and the dimensions of the goods they are authorised to ship. Several delivery companies have begun installing lockers in cities as part of their logistics supply chain. Namely, Amazon, a globally recognised company, has lockers that can ship packages of various sizes and weights, from the smallest to the largest. Therefore, it may be useful to use the locker dimensions as a reference.

The lockers are 204 cm high and 60 cm deep (refer to Figure 40), and their length depends on the number of compartments. For instance, a locker with 42 compartments must be at least 180 cm in length, with each additional module measuring 90 cm [16].

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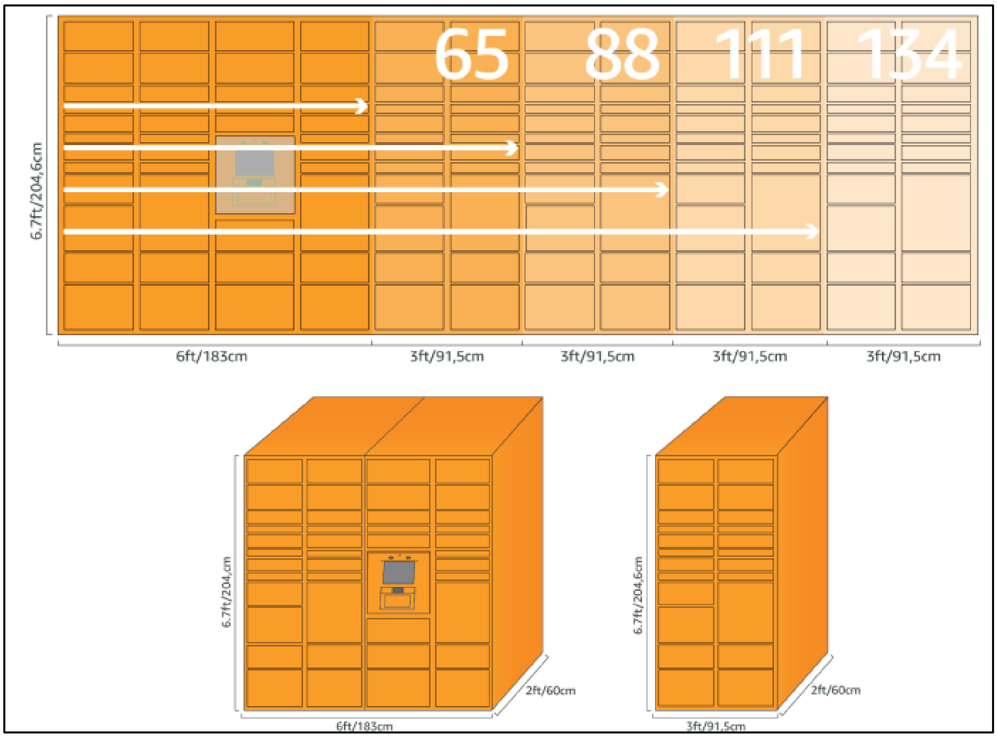

Figure 40: Amazon Locker sizes [16].

Table 4.1 below shows the most common locker models used by ‘Amazon’.

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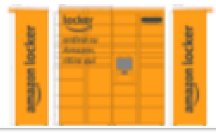
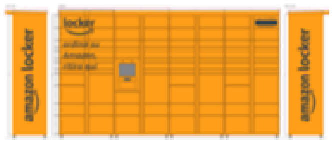
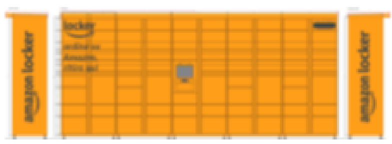
Model	Number of modules	Dimensions (including 9 cm antenna)	Weight per module	Examples
Gen3_43_Lockers_AS_Indoor	2	183x60x214	125,6 kg(S) + 123,4 kg (A)	
Gen3_43_Lockers_AS_Outdoor	2	183x60x220	211.0 kg (S) + 188.5 kg (A)	
Gen3_66_Lockers_ASA_Indoor	3	274x60x214	125,6 kg(S) + 2*123,4 kg (A)	
Gen3_66_Lockers_ASA_Outdoor	3	274x60x220	211.0 kg (S) + 2*188.5 kg (A)	
Gen3_89_Lockers_ASAA_Indoor	4	366x60x214	125,6 kg(S) + 3*123,4 kg (A)	
Gen3_89_Lockers_ASAA_Outdoor	4	366x60x220	211.0 kg (S) + 3*188.5 kg (A)	
Gen3_112_Lockers_AASAA_Indoor	5	457x60x214	125,6 kg(S) + 4*123,4 kg (A)	
Gen3_112_Lockers_AASAA_Outdoor	5	457x60x220	211.0 kg (S) + 4*188.5 kg (A)	

S=starter (module containing the main hardware components); A=adder (expansion module)

Table 4.1: Common Locker models [16].

4.5.2.2 Locker positioning

It is recommended that parcel lockers be situated in pedestrianised areas, to facilitate the maximum accessibility and convenience for recipients, hence providing a seamless solution for individuals to send, receive, and return packages in easily accessible areas.

This also facilitates the efficient delivery and collection of packages without the necessity for vehicular transportation. Consequently, this contributes to urban sustainability initiatives by reducing the reliance on individual vehicle deliveries for last-mile deliveries. Figure 41 presents a parcel locker area within pedestrian area.

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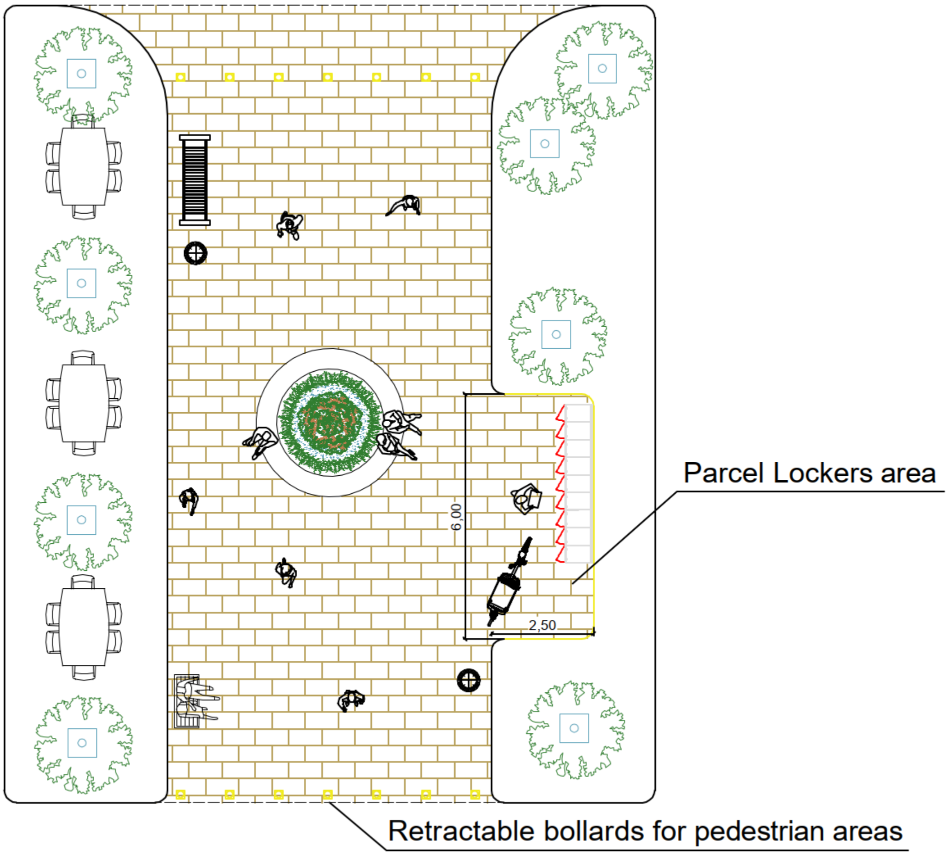

Figure 41: Parcel lockers in a pedestrian area.

These parcel lockers must be visible, secure, and accessible, including for people with disabilities. They should comply with local regulations and be well-lit to ensure security. It should not obstruct security systems and there should be a clear space of at least one meter in front of the locker

Should there be a risk of interference with vehicles, it is highly recommended to install anti-parking systems such as bollards (see Figure 42).

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Figure 42: Example of parcel locker with parking bollards.

Indoor Lockers should be positioned against the wall, while Outdoor Lockers have more specific requirements: they should be anchored to the ground with at least 12 M10x100mm screws on a concrete base. To ensure secure and compliant fastening, it is frequently necessary to construct a concrete base that is level with the original flooring (see Figure 43). However, this may not always be required and should be assessed on a case-by-case basis.

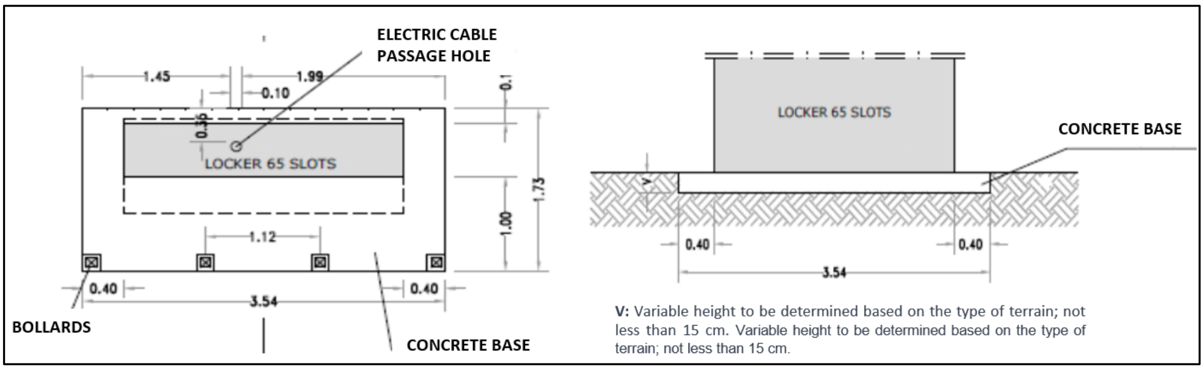

Figure 43: Concrete base for parcel locker.

The locker must remain connected to a dedicated power outlet and a reliable internet connection 24 hours a day. On the one hand, the power supply is essential to operate the locker mechanisms, digital displays, and any integrated lighting systems. The type of outlet required for the power connection depends on local standards. For outdoor lockers, a waterproof outlet is necessary. The power outlet must be positioned in a location not accessible to the public, for example, behind or above. On the other hand, the internet connection is critical for real-time updates, managing user access, and communicating with delivery services and recipients.

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In the context of this project, it is also necessary to establish data elements, and a standardised framework required for effective data sharing between different stakeholders. These might include key attributes such as locker location, availability status, user access logs, parcel information, and delivery schedules. By creating and adhering to a common vocabulary and data structure, interoperability can be ensured, enabling seamless communication and data exchange, while enhancing the coordination, efficiency, and transparency of parcel locker operations within the urban logistics ecosystem

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5 Low emissions vehicles

In numerous urban areas across the globe, the transportation of goods is predominantly conducted by conventional trucks and other large delivery vehicles. These vehicles, however, not only pose a significant risk to vulnerable road users (VRU) but also contribute to traffic congestion and the emission of greenhouse gases (GHG). [17]

One potential solution to these challenges is the replacement of conventionally fuelled vehicles with alternative options, such as cargo bikes or electric vehicles. This transition not only enhances safety, but also reduces noise, lowers emissions and pollution levels, and liberates valuable public space. Furthermore, the use of electric bicycles has demonstrated their viability for serving as a preferred mode of transportation for the 'last mile' in densely populated and congested urban areas. (ibid)

5.1 Cargo-bikes

Cargo-bikes (as shown in Figure 44) are utility bicycles designed to carry heavier loads compared to traditional bikes. There are various types of cargo-bikes available in the market, which can be selected based on the volume of goods to be transported, comfort, and the type of assisted pedalling.

Figure 44: Example of cargo-bike

The cargo-bike system is a highly favourable means of reducing the use of vehicles that contribute to pollution and congestion. They are strongly recommended for environmentally friendly transportation in the historic centres of cities, in line with environmental policies, and can be integrated to offer a door-to-door delivery service.

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In order to illustrate this, two cargo-bike models offered by the Italian company 'Cargo Bike' will be presented in the following sections.

5.1.1 'Italy HD Green Delivery' Tricycle

The 'Italy HD Green Delivery' tricycle (see Figure 45) is an optimal vehicle for last-mile couriers to perform sustainable transportation in city centres during package and mail deliveries. It allows the movement of goods in areas where vehicle traffic is prohibited and is ideal for urban couriers looking to perform zero environmental impact home delivery.

This vehicle boasts considerable robustness, manoeuvrability, and ease of riding. The differential provides stability in curves and enables the vehicle to start in a 90-degree curve, both to the right and to the left.

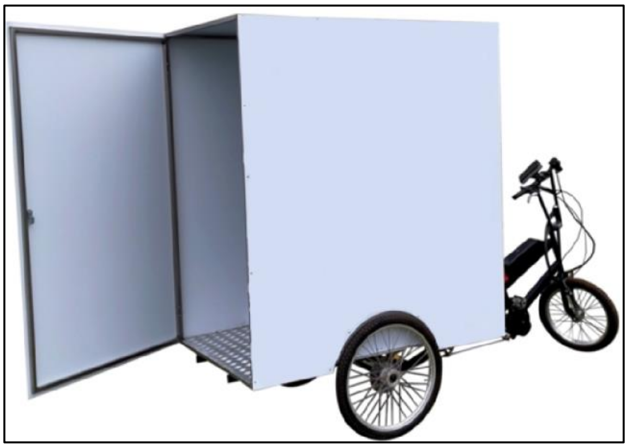

Figure 45: 'Italy HD Green Delivery' Tricycle.

The model displayed in Figure 45 has been designed to accommodate loads of up to 200 kg, inclusive of the box. In this model, the box has dimensions of 80x150x150 cm. However, it is also possible to utilise boxes with different dimensions, depending on the volume of goods.

5.1.2 'Nordik HD' Tricycle

An alternative for lighter loads is a cargo-bike with front fiberglass loading (see Figure 46). In the option provided by the company 'Cargo Bike It', the platform has a width of 78 cm and a length of 100 cm, extendable up to 125 cm.

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Figure 46: ‘Nordik’ Tricycle

5.2 ‘Moby Bikes’

Moby Bikes is an Irish company dedicated to reducing congestion and car usage in urban areas by manufacturing electric bikes that are intended for use in the delivery of goods and packages. The company offers a variety of models that are tailored to the distance to be covered and the size of the packages in question.

Among the offered solutions, there is the ‘K-RYOLE E-TRAILER’ (see Figure 47). This vehicle is capable of effortlessly transporting 350 kg, thanks to an electrically assisted servo trailer with a power of 3000 W. Cargo boxes ranging from 1.3 m^3 to 2 m^3 can be carried while maintaining high manoeuvrability. This proves valuable in confined spaces of micro-hubs and pedestrian areas where cycling might be restricted.

Figure 47: Moby Bikes’ K-RYOLE E-TRAILER.

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6 Potential locations for micro consolidation centres

The identification of suitable locations for micro consolidation centres, **also known as small logistics hubs**, will be conducted through a suitability analysis. The 'Suitability Analysis' is a method of ranking and scoring sites based on a number of weighted criteria. The suitability of a candidate site can be ranked based on data variables, site attributes, or proximity to point features. The selected criteria are assigned weights to determine the scores for each potential site [18].

In this context, in order to identify the most suitable locations for the micro consolidation centres for each demo city, the following criteria will be considered:

Table 6.1: Criteria for Suitability Analysis

Zaragoza	Dublin
Population density	Population density
Percentage of population between 25 and 65 y.o.	Percentage of population between 25 and 40 y.o.
Net average income per capita	Persons at work
Presence of attractors (parking lots, business centres)	Parking buildings
Senator's trip density	Senator's trip density

The criteria were selected based on the information available in the official open sources for each city. For the purposes of this analysis, to all criteria will be assigned the same weight.

In the case of Zaragoza, the data granularity is the so-called "census tracts" (*secciones censales* in Spanish, Figure 48), while for Dublin it is the "Small Areas" (Figure 49). In the following sections the analysis for the potential locations of the small logistics hubs will be detailed.

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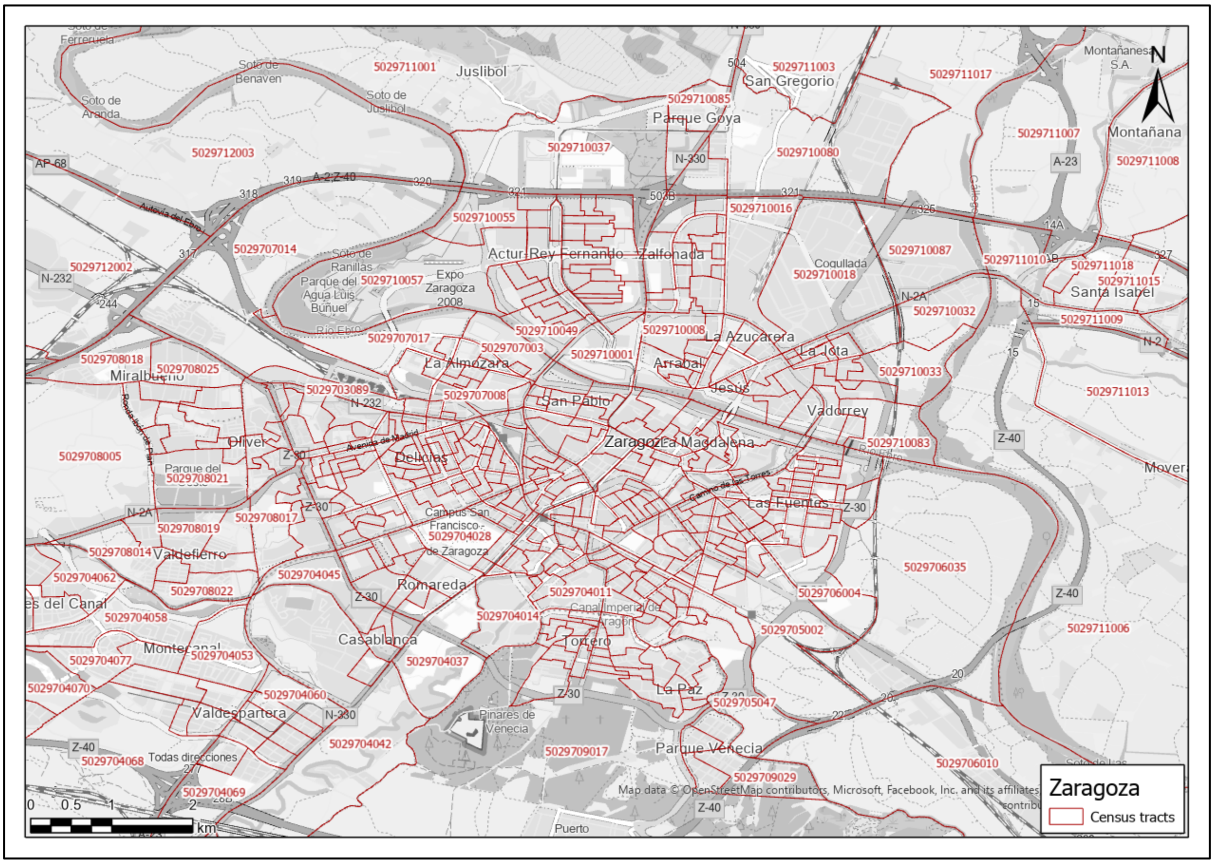

Figure 48: Zaragoza's census tracts

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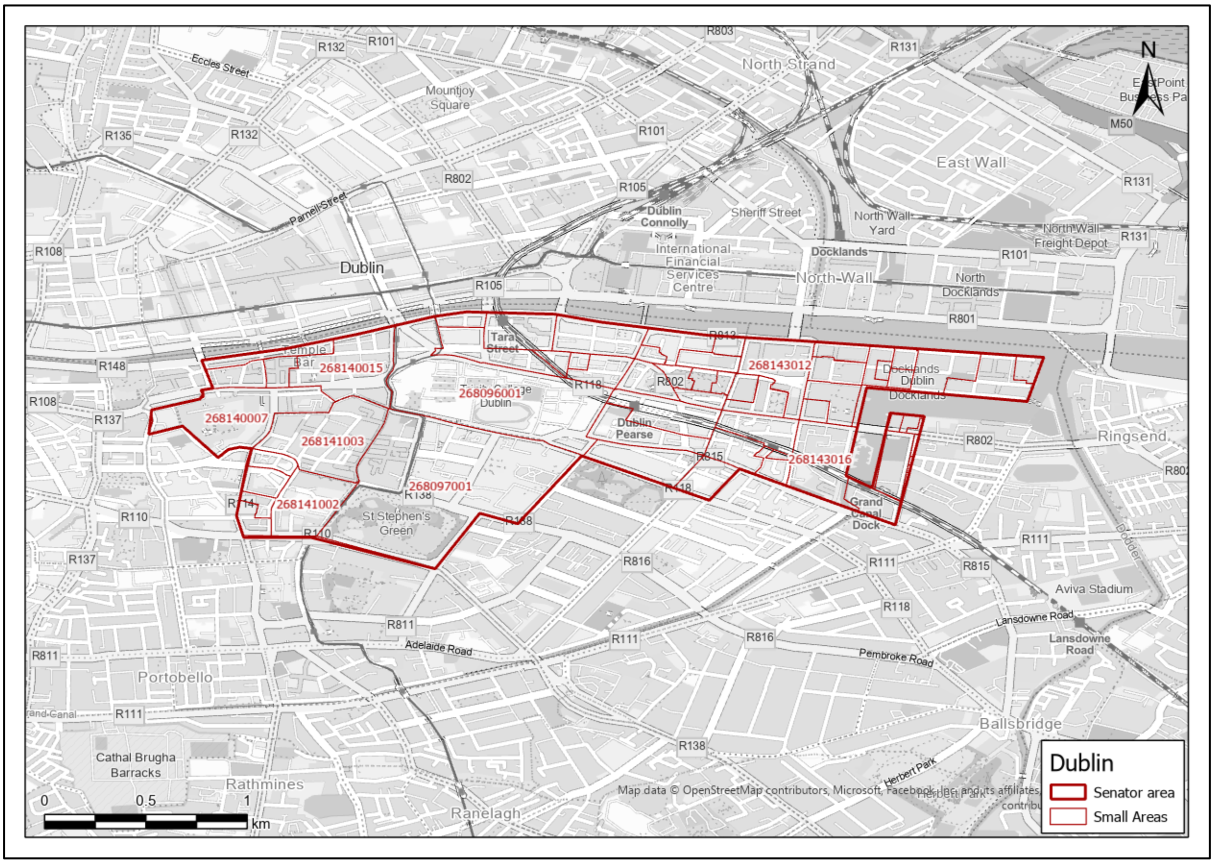

Figure 49: Dublin's Small Areas

6.1 Zaragoza

As previously stated, the identification of the most suitable locations for the micro consolidation centres will be conducted through a Suitability Analysis. In the case of Zaragoza, and as illustrated in Table 6.1, the analysis will consider the following criteria: population density, percentage of the population between the ages of 25 and 65, net average income per capita, presence of attractors (parking lots, business centres), and senator trip density.

These criteria were selected as the most suitable for the scope of this analysis, based on the data available on the official open data sources of Zaragoza's municipality. These were analysed using the TransCad software and the results are presented in following.

Population Density

Population density is an important indicator for determining potential locations of micro consolidation centres due to its direct correlation with potential demand. Areas with higher population densities generally indicate a larger number of residents who might require

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convenient and efficient parcel delivery solutions. Figure 50 displays in red the areas with the highest population density in Zaragoza.

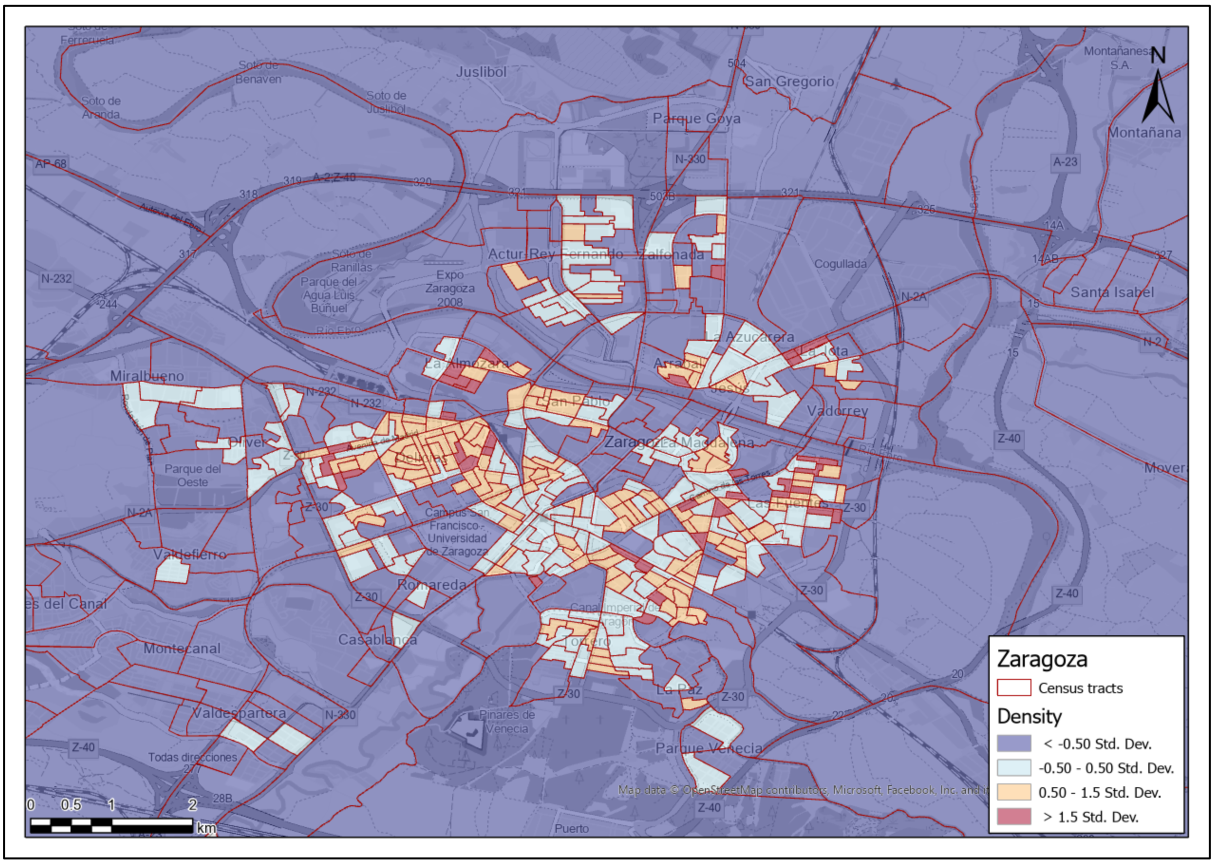

Figure 50: Zaragoza - Population Density

The table below presents the census tracts with the highest population density.

Table 6.2: IDs (CUSEC) of census tracts with the highest pop. density

5029704013	5029706009	5029705026	5029705041	5029707004
5029710026	5029703020	5029703061	5029703084	5029705007
5029701033	5029703087	5029705028	5029707009	5029703062
5029710025	5029703052	5029705039	5029706028	5029706033
5029705004	5029707006	5029703053	5029705014	5029703019
5029706017	5029706037	5029703083	5029706020	5029707020
5029706029	5029710004	5029710028	5029706022	5029710017

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Percentage of population between the ages of 25 and 65

The percentage of individuals between the ages of 25 and 65 represents a valuable indicator for the placement of micro consolidation centres, as this demographic is typically the most active segment of online shoppers.

The age range of 25 to 65 was selected as it is the most appropriate among the three categories provided by official sources: less than 25, from 25 to 65, and over 65. Those belonging to this age group are frequently gainfully employed, financially secure, and more likely to engage in e-commerce. Figure 51 depicts the areas of Zaragoza with the highest percentage of the population of this group in dark brown.

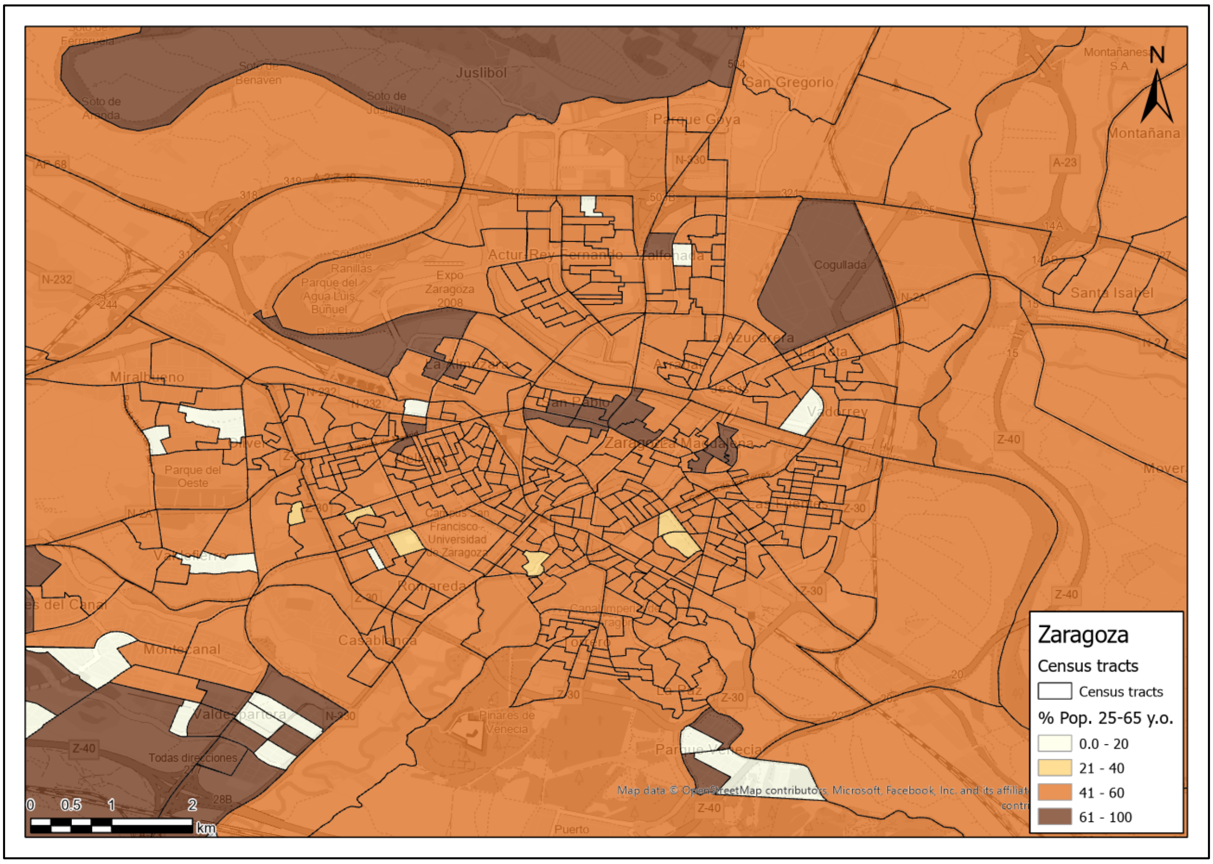

Figure 51: Zaragoza - Percentage of population between the ages of 25 and 65

The table below presents the census tracts with the highest percentage of the population between the ages of 25 and 65.

Table 6.3: IDs (CUSEC) of census tracts with the highest % of pop. 25-65

5029704070	5029701020	5029701041	5029701038	5029707006
5029704071	5029701036	5029704063	5029703035	5029710018

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5029711001	5029704067	5029704064	5029704066	5029710054
5029707018	5029709027	5029704065	5029701006	-
5029704069	5029704060	5029707017	5029701021	-
5029704068	5029701008	5029709028	5029701030	-
5029701015	5029701034	5029704061	5029703069	-

Net average income per capita

The net average income per capita is a measure of the purchasing power and economic activity within a given area. Higher income levels generally correlate with increased spending on goods and services, including online shopping. Thus, areas with higher net average income per capita are likely to have residents who frequently purchase products online, thereby generating a substantial volume of parcels that require efficient delivery solutions. Figure 52 shows the areas of Zaragoza with the highest net average income per capita per year.

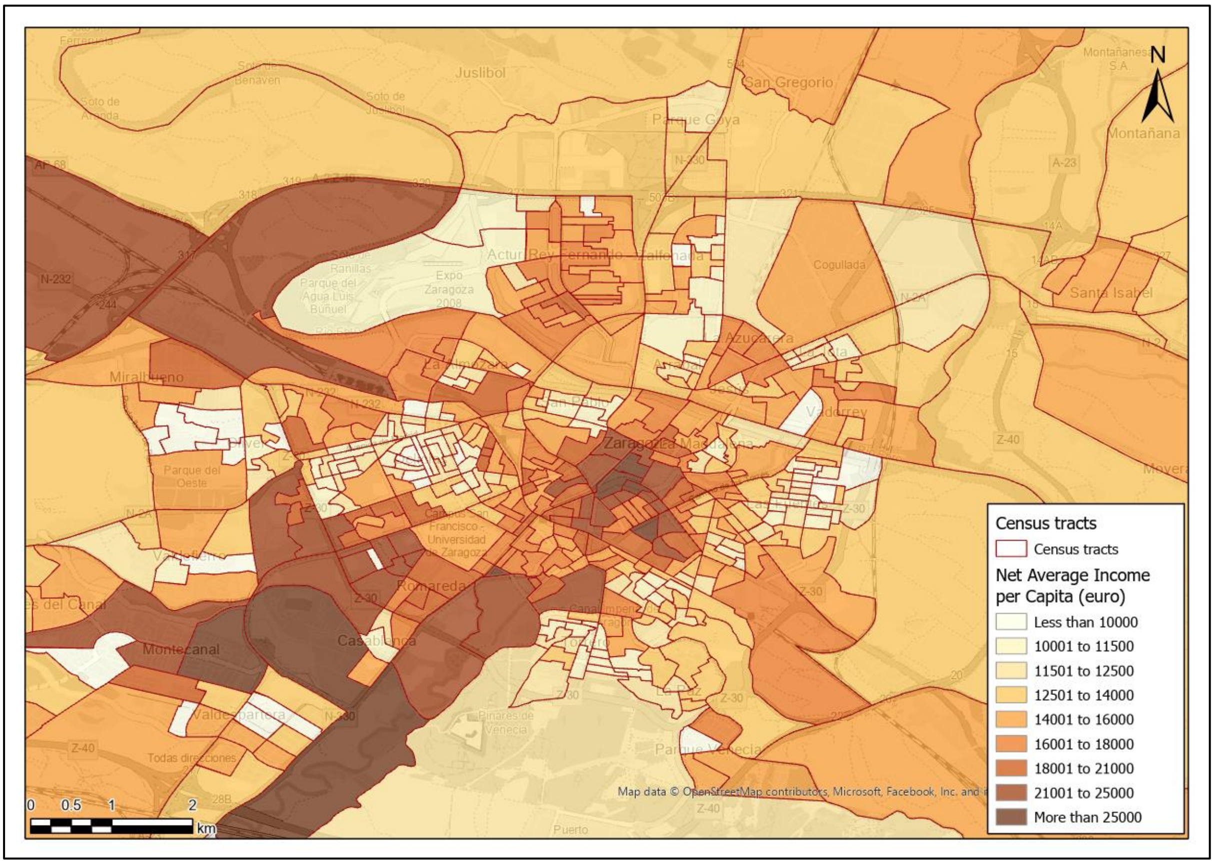

Figure 52: Zaragoza - Net average income per capita

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The table below presents the census tracts whose net average income per capita per year is greater than 25000 euros.

Table 6.4: IDs (CUSEC) of census tracts with the highest net average income per year

5029702053	5029702005	5029702029	5029704042
5029704052	5029704053	5029702026	-

Possible attractors

Attractors, such as business centres and parking facilities, are included in this analysis as they attract significant foot traffic and provide convenient access points for a broad range of users.

Business centres host a large number of employees who can benefit from the convenience of retrieving parcels during their workday, reducing the need for home deliveries and missed package attempts.

Parking facilities, particularly those situated near shopping centres, transport hubs, or residential complexes, serve as strategic locations where individuals frequently pass through or park their vehicles, making it convenient to incorporate a brief stop to collect parcels.

Public markets also attract a diverse group of shoppers and vendors, offering a centralised and vibrant environment where micro consolidation centres can be easily accessed during routine market visits.

Figure 53 displays the location of these attractors in Zaragoza.

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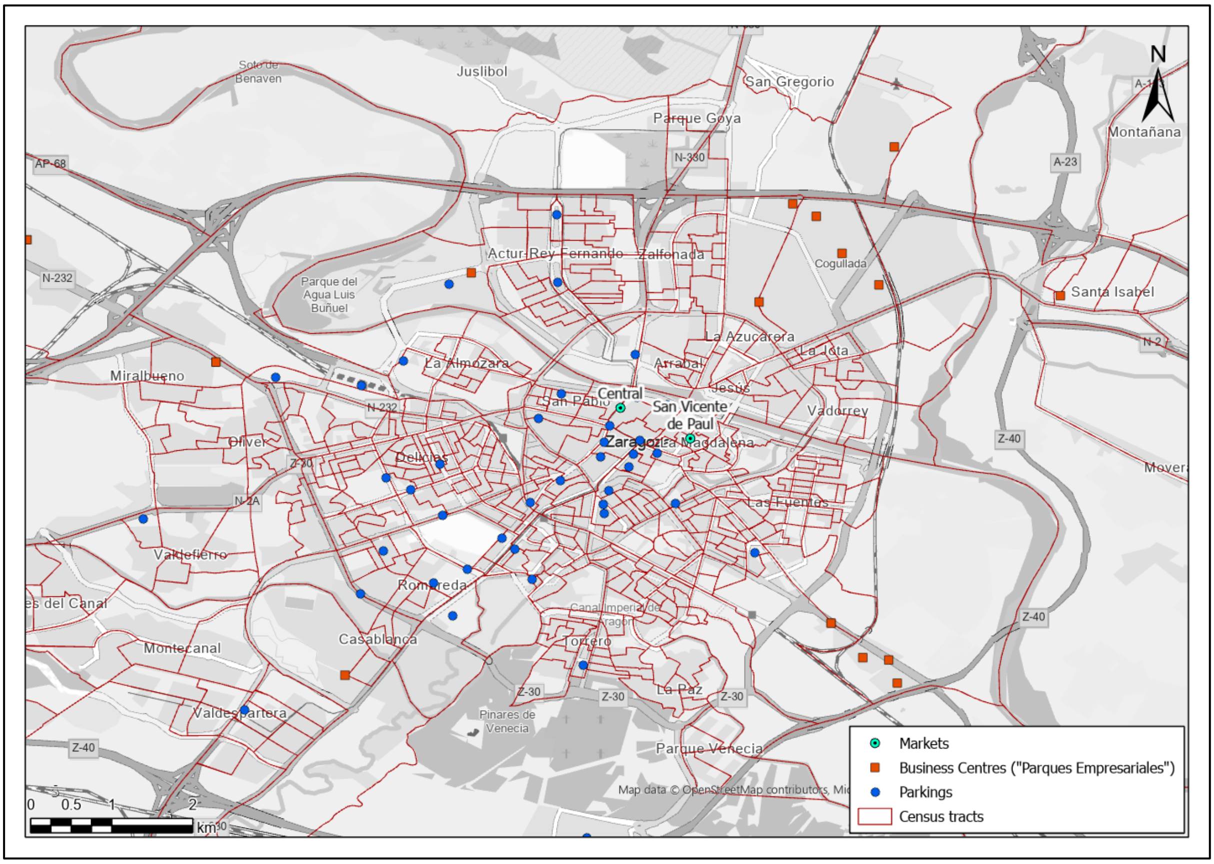

Figure 53: Zaragoza – Attractors

Senator trip density

Trip density is defined as the frequency and volume of trips made within a specific area. For the purposes of this analysis, the data pertaining to the trips was obtained directly from the **Senator** platform. Areas with high trip density are distinguished by a considerable volume of parcel vehicles, which renders them optimal locations for micro consolidation centres due to their constant movement and accessibility.

Figure 54 depicts the areas of Zaragoza through which most of the senator trips are conducted.

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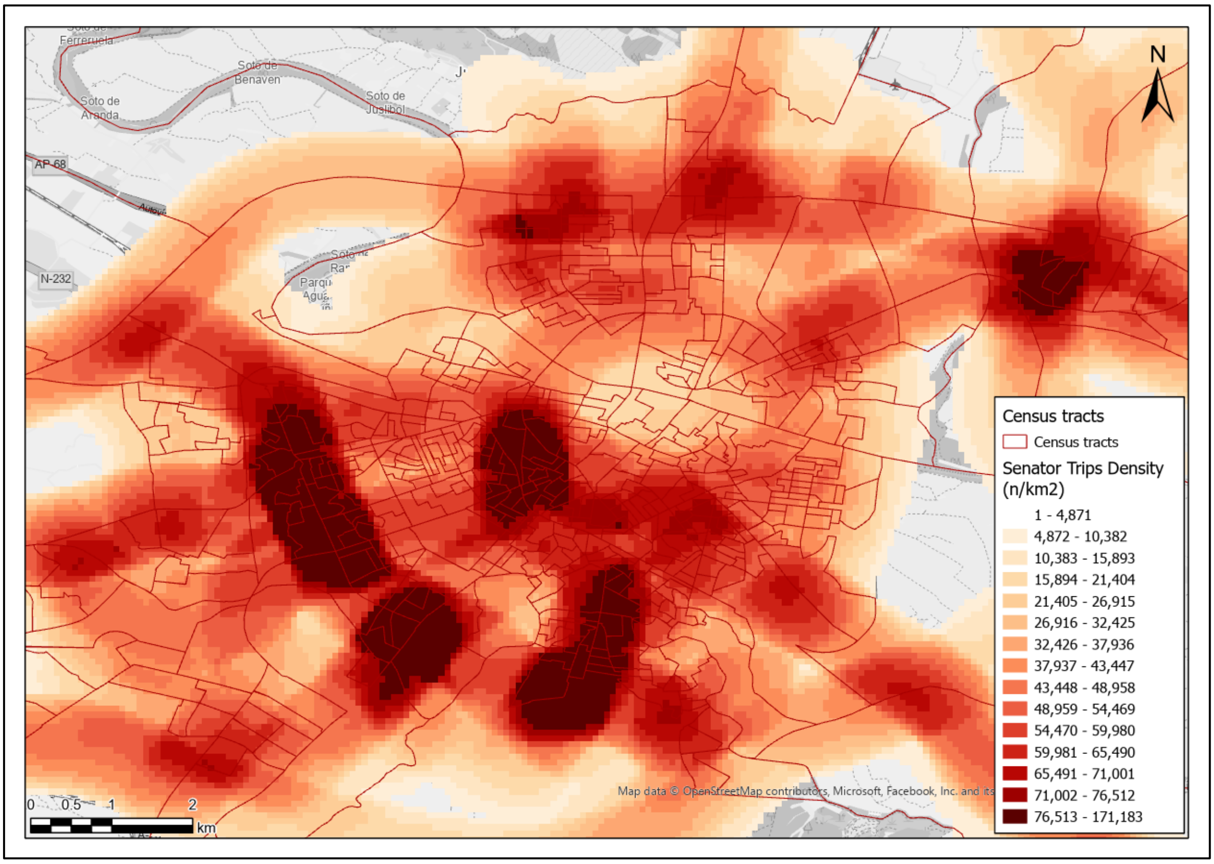

Figure 54: Zaragoza - Senator's trip density

The census tracts with the highest concentration of trips from the Senator platform in June 2024 are shown in the table below.

Table 6.5: IDs (CUSEC) of census tracts with the highest Senator Trip Density

5029702009	5029702049	5029703064	5029704044	5029709005
5029702010	5029703007	5029703078	5029708001	5029709013
5029702013	5029703012	5029703082	5029708010	5029709014
5029702015	5029703048	5029703084	5029708015	5029709015
5029702047	5029703051	5029704001	5029708016	5029709025
5029702048	5029703063	5029704038	5029709004	5029704076

RESULTS

Once all the criteria have been mapped and analysed, the next step is to conduct the suitability analysis to determine the best potential locations in Zaragoza for micro

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consolidation centres. In this process, all the previously described criteria are given equal weight in the analysis. Thus, the best potential locations for the micro consolidation centres are displayed in Figure 55 and the associated Small Area ID can be found in Table 6.6

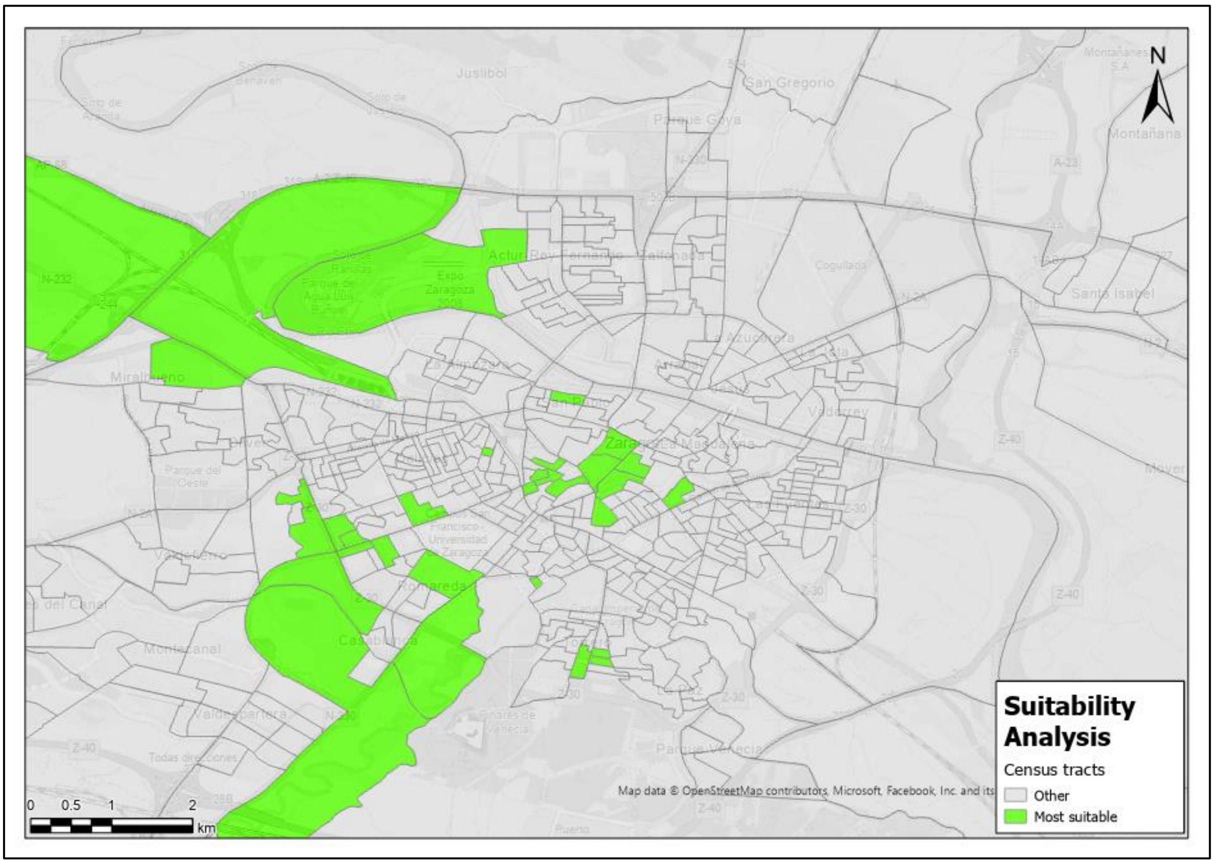

Figure 55: Potential locations for micro consolidation centres – Zaragoza

Table 6.6: IDs of potential Census Tracts to allocate micro consolidation centres - Zaragoza

5029704013	5029702005	5029704037	5029712002	5029703084
5029709013	5029703082	5029707014	5029704033	5029702013
5029710057	5029702018	5029704051	5029703030	5029702009
5029704044	5029702006	5029702001	5029709014	5029702049
5029704042	5029708025	5029704045	5029708016	
5029702026	5029702025	5029703078	5029701023	
5029702015	5029702012	5029708010	5029709015	

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6.2 Dublin

In the case of Zaragoza, and as illustrated in Table 6.1, the analysis will consider the following criteria: population density, persons at work, parking buildings, percentage of the population between the ages of 25 and 40, net average income per capita, presence of attractors (parking lots, business centres), and Senator's trip density.

These criteria were selected as the most suitable for the scope of this analysis, based on the data available on the official open data sources of Dublin's municipality. These were analysed using the TransCad software and the results are presented in following.

Population Density

As previously stated, areas with higher population densities generally indicate a larger number of residents who might require convenient and efficient parcel delivery solutions. Figure 56 displays in red the areas with the highest population density in Dublin's Senator Area.

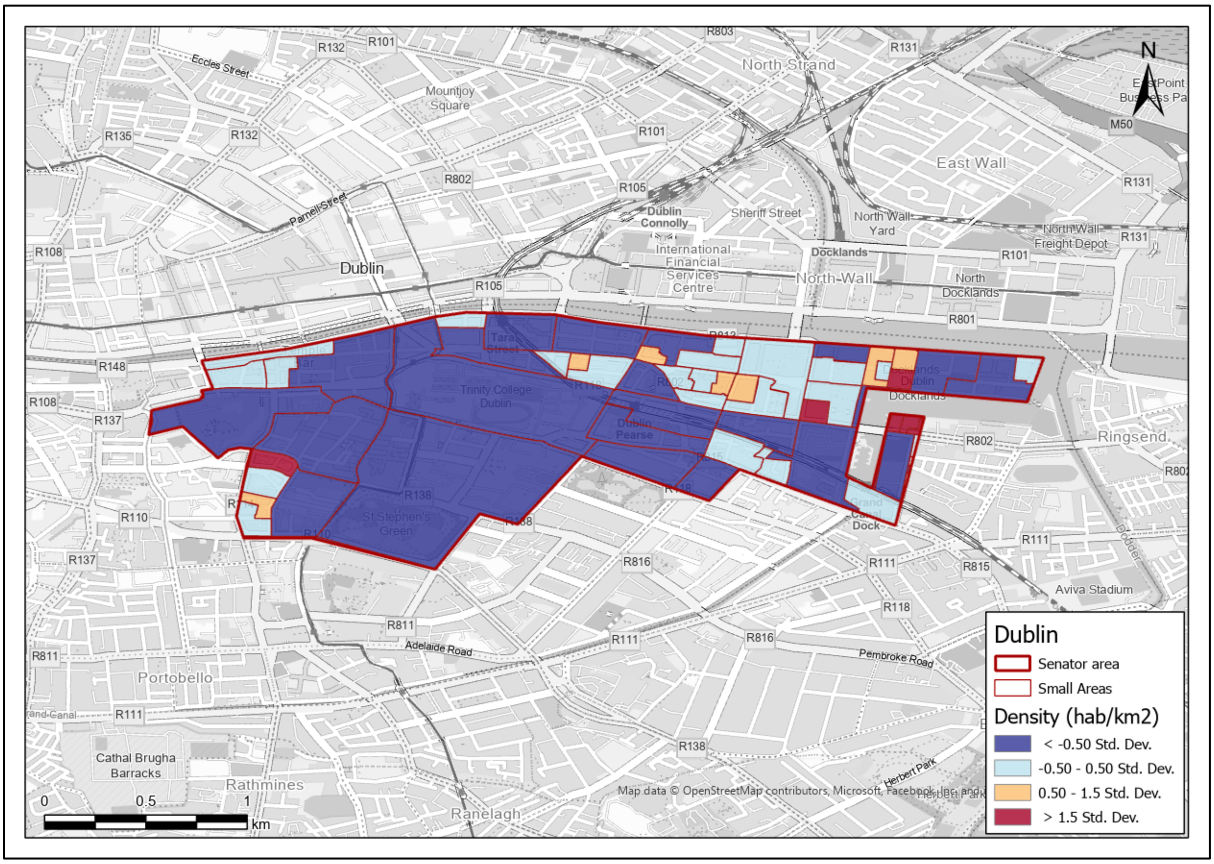

Figure 56: Dublin - Population Density

The table below presents the Small Areas with the highest population density.

Table 6.7: IDs of Small Areas with the highest pop. density

268143029	268140001	268143030	268140017	268143021
268143019	268143023	268141005	268096012	268096008
268096010	268140004	268143025	268140010	268143022
268143010	268141006			

Persons at work

The term "persons at work" refers to the segment of the population that is actively engaged in paid employment. The areas with a higher density of this segment can be used as an indicator of people who might require convenient and efficient parcel delivery solutions, as they are more likely to engage in e-commerce. Figure 57Figure 56 displays in dark red the areas with the highest concentration of employed people in Dublin's Senator Area.

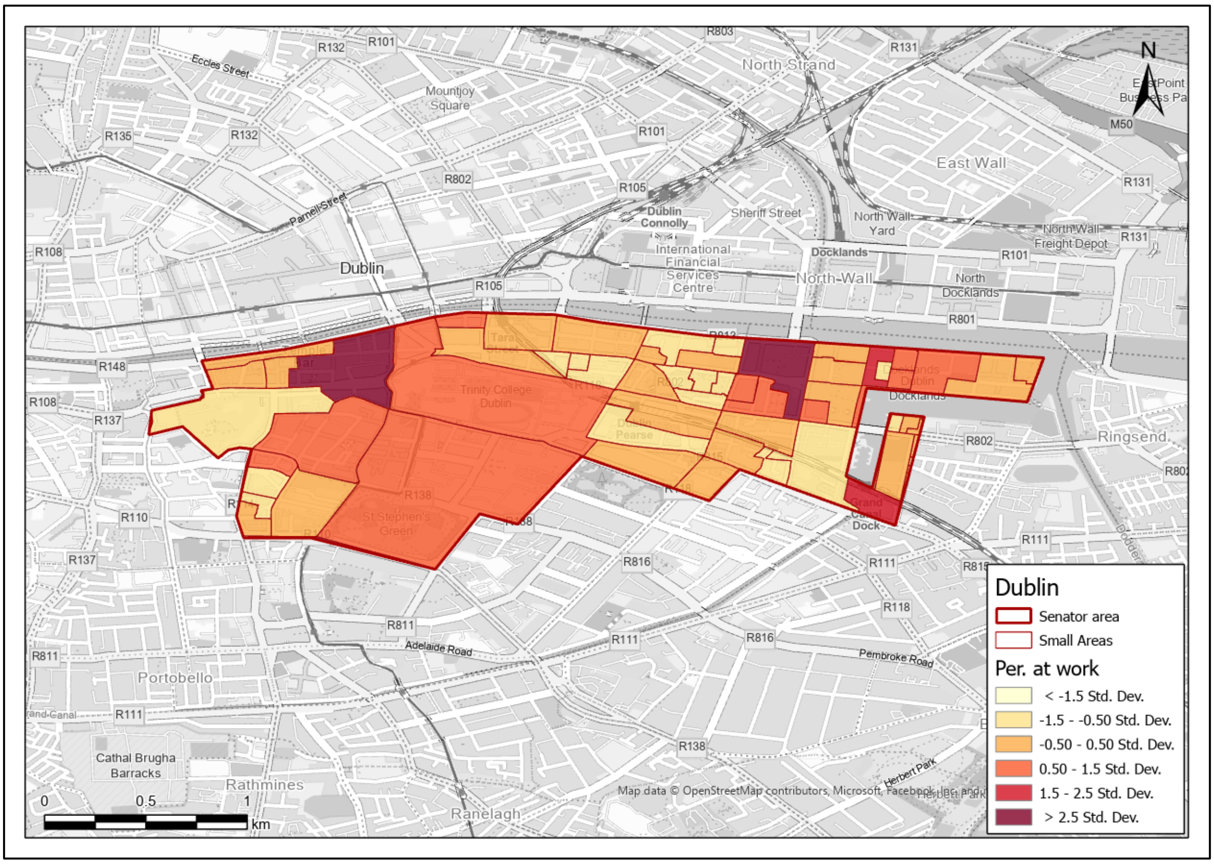

Figure 57: Dublin - Persons at work

The table below presents the Small Areas with the highest concentration of 'persons at work.'

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Table 6.8: IDs of Small Areas with the highest concentration of persons at work

268096001	268096002	268140015	268140017	268143012
268143025	268143022	268143011	268143023	268143010
268143019	268143013	268142009	268141003	268141005
268097001	268143024/02			

Parking Buildings

In pursuit of establishing a Micro Hub Operation – which, for all intents and purposes, is equivalent to a micro-consolidation centre – within the Dublin City Centre Area, Dublin City Council (DCC) released a Prior Information Notice (PIN) on 26 April 2023 [19]. This attracted participation from different entities, including car park operators. As they manage various parking facilities, which may attract considerable traffic, and have already expressed interest, these parking facilities will be included in the current analysis. The parking buildings of the interested car park operators are shown in Figure 58.

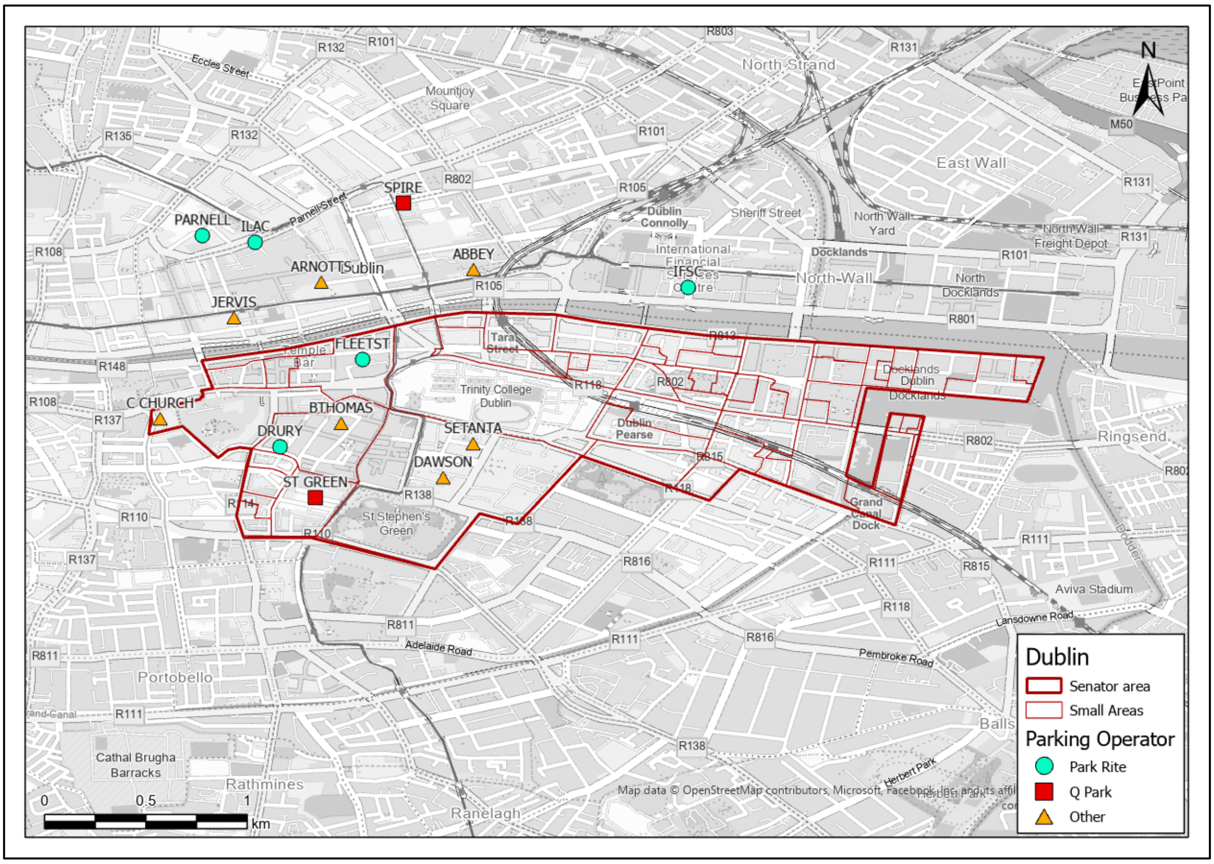

Figure 58: Dublin - Parking Buildings

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The table below provides an overview of the small areas where parking buildings belonging to interested car parking operators are located.

Table 6.9: IDs of Small Areas with Parking Buildings

268140015	268140007	268141002	268141003	268097001

Percentage of population between the ages of 25 and 40

The percentage of individuals between the ages of 25 and 40 represents a valuable indicator for the placement of micro-consolidation centres as this demographic is typically the most active segment of online shoppers. Those belonging to this age group are frequently gainfully employed, financially secure, and more likely to engage in e-commerce. Figure 59 depicts the areas of Dublin with the highest percentage of the population between the ages of 25 and 40 in dark brown.

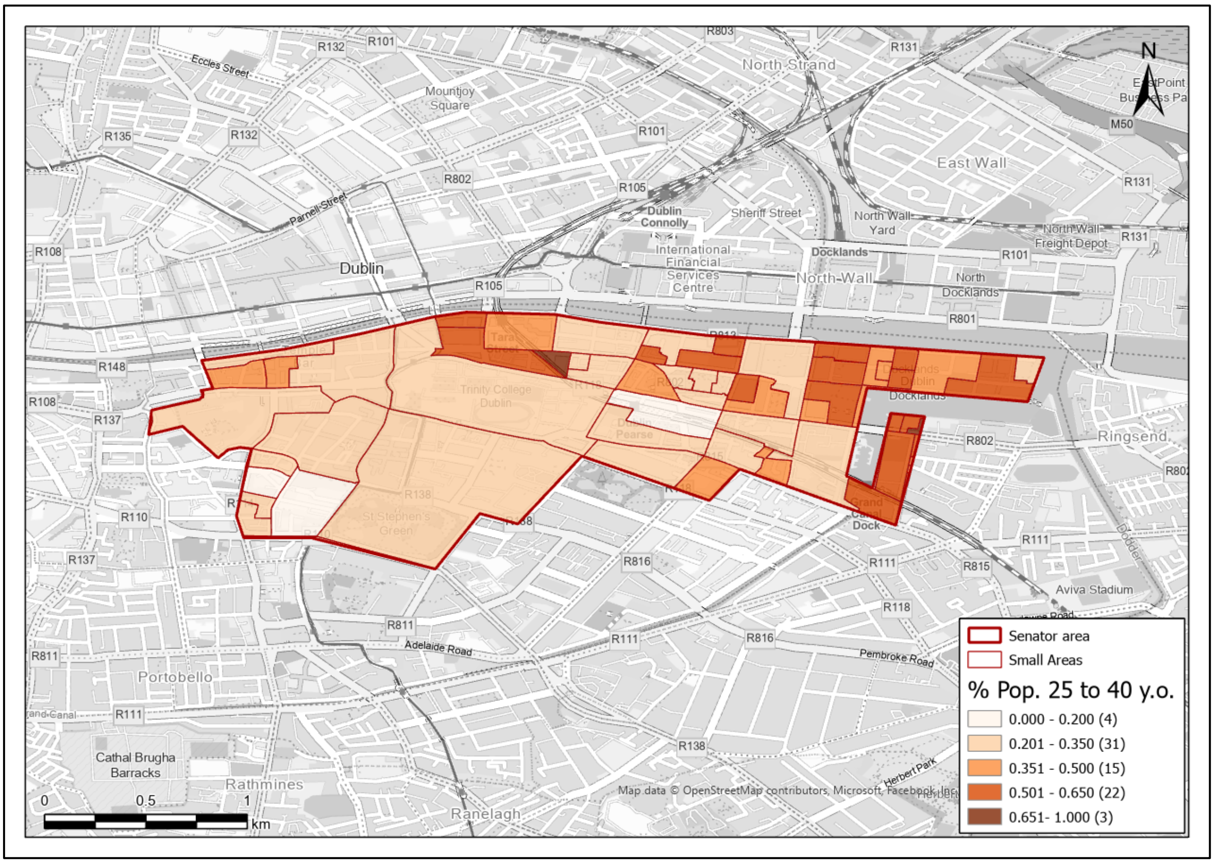

Figure 59: Dublin - Percentage of population between the ages of 25 and 40

The table below presents the Small Areas with the highest Percentage of population between the ages of 25 and 40.

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Table 6.10: IDs of Small Areas with the highest the highest % of pop. 25-40

268096004	268096010	268143024/04	268143030	268143018/01
268096002	268140001	268143014	268143023	268143018/02
268096019	268140010	268143020	268143010	268115010
268096005	268140017	268143022	268143021	268115006
268096018	268140005	268143029	268143013	268115008

Senator trip density

Trip density is defined as the frequency and volume of trips made within a specific area. For the purposes of this analysis, the data pertaining to the trips was obtained directly from the **Senator** platform. Areas with high trip density are distinguished by a considerable volume of parcel vehicles, which renders them optimal locations for micro-consolidation centres due to their constant movement and accessibility.

The placement of micro-consolidation centres in these densely populated areas allows logistics companies to provide convenient pick-up points that align with the daily routines of residents and commuters. Figure 60 depicts the areas of Dublin through which most of the senator trips are conducted.

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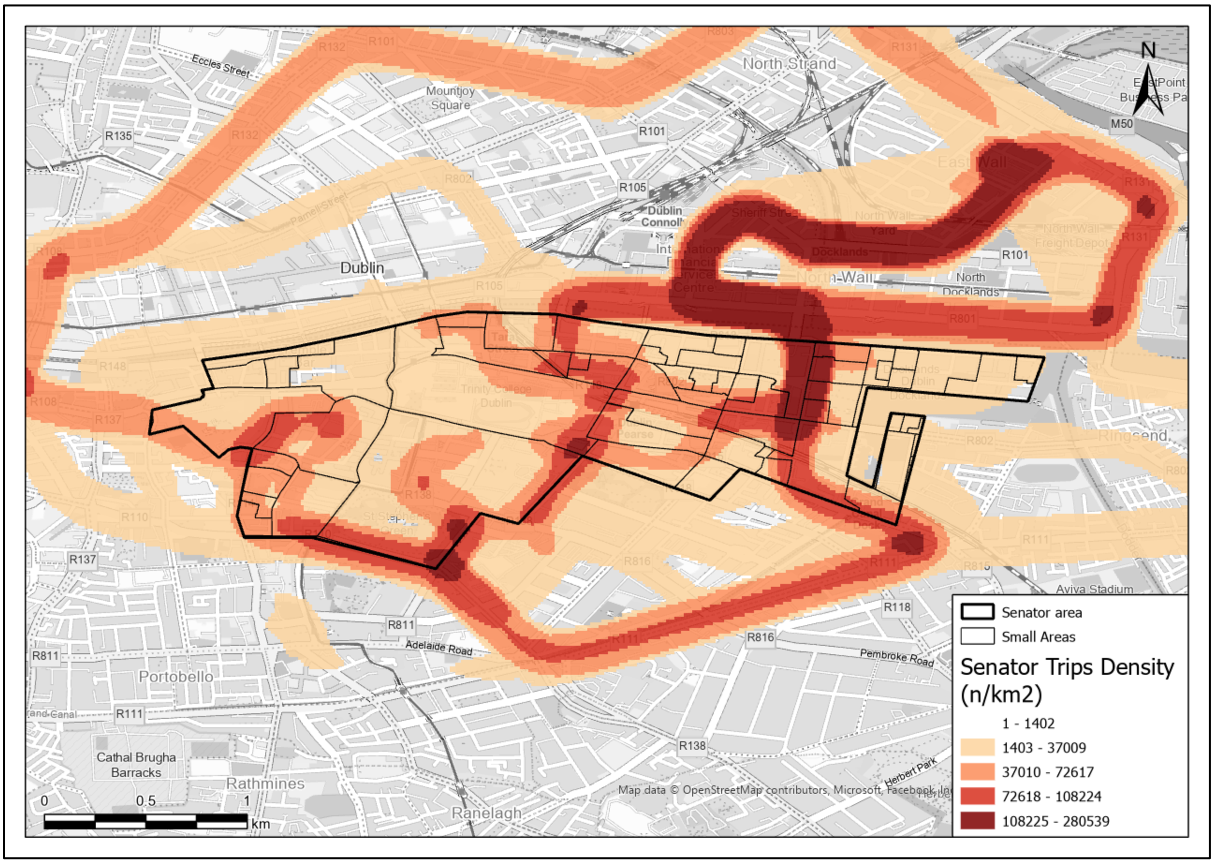

Figure 60: Dublin - Senator's trip density

The table below shows the Small Areas through which the highest concentration of trips from the Senator platform passed in June 2024.

Table 6.11: IDs of the Small Areas with the highest Senator Trip Density

268143012	268143020	268143019	268143018/01	268143018/02

RESULTS

Once all the criteria have been mapped and analysed, the next step is to conduct the suitability analysis to determine the best potential locations in Dublin for micro consolidation centres. In this process, all the previously described criteria are given equal weight in the analysis. Thus, the best potential locations for the micro consolidation centres are displayed in Figure 61 and the associated Small Area ID can be found in Table 6.12

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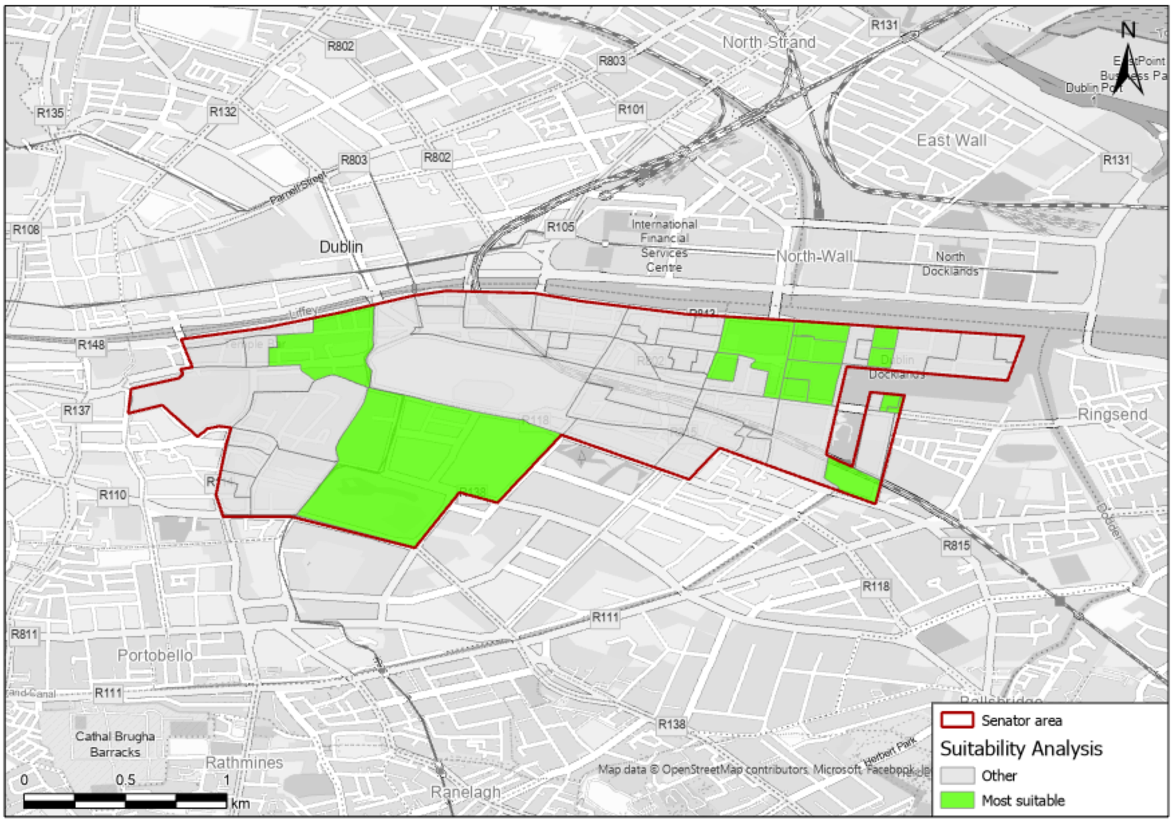

Figure 61: Potential locations for micro consolidation centres - Dublin

Table 6.12: IDs of potential Small Areas to allocate micro consolidation centres - Dublin

268143019	268143020	268140017	268140001	268143022
268140015	268143029	268143018/02	268097001	268143013
268143012	268143030	268143018/01	268143023	268143010

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7 Guidelines application in Zaragoza and Dublin

7.1 Zaragoza

This catalogue proposes adapting the concept of parcel lockers to be installed at so-called “friendly or informal delivery pick-up points” in the city of Zaragoza, such as local shops and markets. These can be used as pick-up points by users who frequent them daily, thus encouraging their use instead of home delivery. This practice helps to reduce the carbon footprint and traffic congestion, as well as to revitalize neighbourhood shops and local markets.

An idea for parcel lockers’ location in Zaragoza has been identified in the Mercado de San Vicente de Paul area, in the Casco Antiguo neighbourhood. Figure 62 shows a parcel locker positioned at the main entrance of the market and a loading/unloading area for goods. The presence of the ramp facilitates the transport of goods to the lockers.

Figure 62: Parcel lockers and loading/unloading area in C. de San Vicente de Paùl

Figure 63 shows various options for the lockers’ positioning, depending on the size of the area. Each locker can have different dimensions, tailored to the type of orders.

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Figure 63: Parcel lockers' positioning

Considering the main attractors (Figure 53) and the Senator's trip density (Figure 54), the catalogue suggests placing a parcel locker at Plaza del Pilar-Murallas, near the Mercado Central. This location meets user needs by combining the attraction of the central market with the pedestrian area of the plaza, which is full of shops.

The first option proposes placing a locker near the Mercado Central (Figure 64). This location already features a sidewalk with retractable bollards and a loading/unloading area (Figure 65).

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Figure 64: Parcel locker's positioning near Mercado Central

Figure 65: Loading/unloading area

The second option involves placing the parcel locker in the pedestrian area of Plaza del Pilar-Murallas, near bars, restaurants and shops (Figure 66).

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Figure 66: Parcel locker's positioning in Plaza del Pilar-Murallas

Another option proposed by the catalogue is the installation of a parcel locker in the historic centre of Zaragoza. The pedestrian area in question includes the installation of a parcel locker, accessible exclusively by pedestrians. Deliveries are made using cargo bikes. Figure 67 shows C. de Matías Carrica, a street in the historic centre of Zaragoza, near Plaza de San Felipe.

Figure 67: Parcel locker and delivery with Cargo-bike (1)

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Alternatively, the catalogue proposes locating the parcel locker in a more central area, such as Plaza de San Felipe (Figure 68). In this case as well, deliveries would be made using cargo bikes, as it is a pedestrian area with shops and dining services.

Figure 68: Parcel locker and delivery with Cargo-bike (2)

7.2 Dublin

Considering the aspects described in paragraph 6.2, including PIN parking buildings, population density, and senator's trip density, this catalogue proposes location options for parcel lockers within the identified area in the city of Dublin.

The considerations made for Zaragoza regarding the concept of "friendly or informal delivery pick-up points" (paragraph 7.1) are also applied to Dublin.

The first option considers the proximity to the Fleet Street parking and the presence of the Tesco Express market. Figure 69 shows the possibility of placing the parcel lockers inside and/or outside the market: the indoor locker will follow the market's opening hours, while the outdoor locker will be operational 24/7. Additionally, a loading/unloading area will need to be set up near the market and the sidewalk.

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Figure 69: Parcel lockers in Fleet Street

The second option considers the Drury Street – Car Park (highlighted in red in Figure 70). Given the high Senator Trips Density in that area, the catalogue suggests installing a parcel locker service inside George's Street Arcade. This is an old shopping centre accessible from the R114, Fade Street and Drury Street.

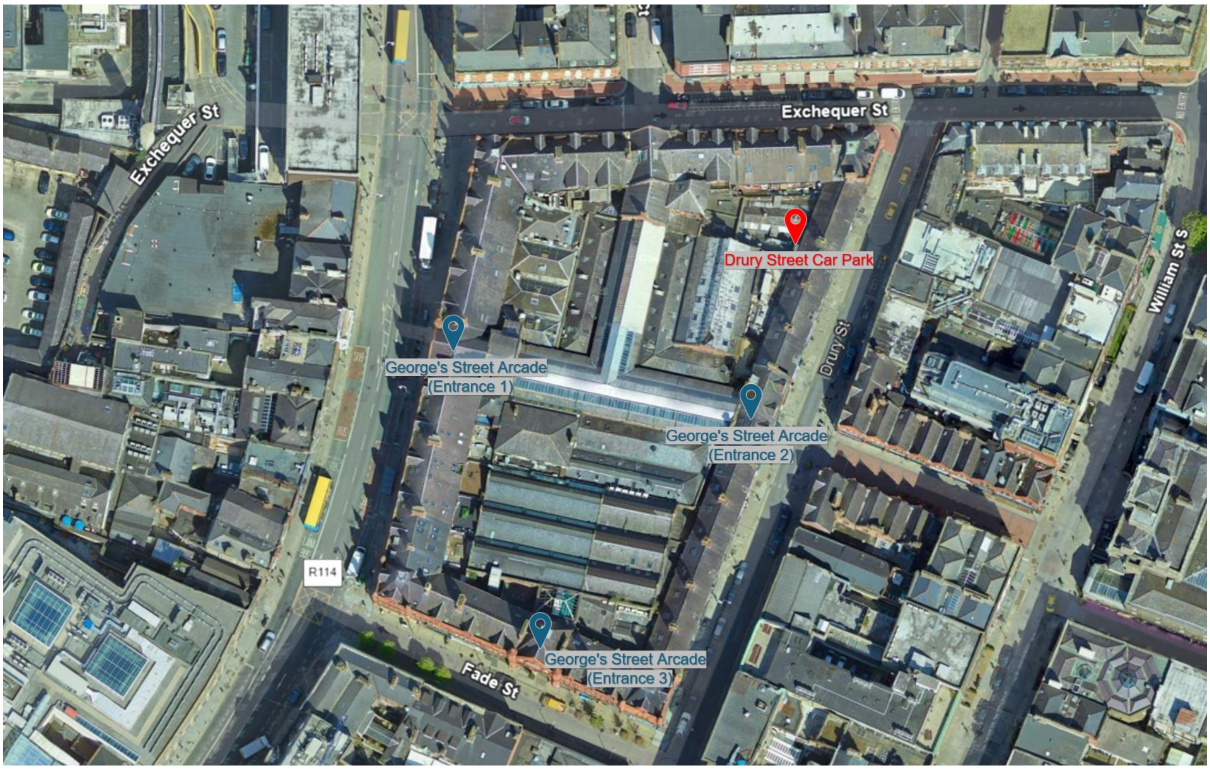

Figure 70: Parcel lockers in George's Street Arcade

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The block has many shops and markets, making the streets very busy. The installation of a parcel locker inside the shopping centre (Figure 71) could reduce traffic and pollution caused by door-to-door delivery.

Figure 71: Parcel lockers in George's Street Arcade (indoor view)

There is already a loading/unloading area on Fade Street for George's Street Arcade (Figure 72), which can also be used for delivering packages to the locker (Entrance 3).

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Figure 72: Loading/unloading area on Fade Street

The third option, unlike the first two, is located outside the Senator Area, on the north side of the River Liffey, but it boasts the presence of a parking lot (IFSC in Figure 58), Excise Walk and the National College of Ireland. This area has the highest Senator Trip's Density and is connected to the high traffic of the R801 and R813 on both sides of the river. The catalogue suggests a parcel locker on Excise Walk, a pedestrian area full of shops, outside the M&S market (Figure 73).

A loading/unloading area could be installed at the intersection with Clarion Quay and Alderman Way, but Excise Walk is already equipped with retractable bollards for loading and unloading goods for the existing shops.

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Figure 73: Parcel lockers in Excise Walk

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8 Conclusion

The deliverable 4.6, entitled 'Design catalogue for Zaragoza and Dublin', presents a design catalogue for both cities. It considers the integration of a road network design into a sustainable urban logistics system and sets out a framework that can be replicated in other cities. The document has been structured into five main sections, with the objective of defining both a general catalogue and an applied one, as well as the identification of potential locations for micro consolidation centres.

The initial section, chapter 3, has been developed with the intention of defining the hierarchy of road users to be considered for the purpose of this deliverable. At the pinnacle of the pyramid, the most vulnerable road users are situated, while at the lowest point, there are private vehicles for individual use.

The second section, chapter 4, aimed to present a general cargo-based design catalogue that can be replicated in not only Dublin and Zaragoza, but also other cities, thereby providing a replicable model for the implementation of urban logistics infrastructure. It included the production of guidelines for the design of **parking spaces, anti-parking systems, parking in pedestrian areas, streets and intersections, and urban logistics points**. In order to facilitate replication in other cities, the definition of the various solutions, as well as the dimensions of heavy and light freight vehicles, were based on best practices in urban planning.

The third section, chapter 5, presented an overview of low-emissions vehicles, including cargo bikes and electric vehicles, which have the potential to replace conventionally fuelled vehicles. The transition to low-emissions vehicles has the potential to enhance the safety of vulnerable road users, while simultaneously reducing noise, lowering emissions and pollution levels, and reducing the public space occupied by conventional vehicles. Furthermore, the utilisation of low-emissions vehicles can facilitate enhanced logistics for 'last-mile' deliveries in densely populated and congested urban areas.

The fourth section, chapter 6, was dedicated to the identification of potential locations for micro consolidation centres. This was achieved through a suitability analysis, in accordance with the 'workflow for case study mapping' set out in the Grant Agreement for this project.

The initial stage of the process involved the collation of data, which was conducted concurrently with the formulation of decision-making criteria. In the case of Zaragoza, the analysis took into account a number of factors, including population density, the percentage of the population between the ages of 25 and 65, net average income per capita, the presence of attractors (such as parking lots and business centres), and senator trip density. Conversely, the analysis for Dublin considered population density, the number of people in employment, the availability of parking, the percentage of the population between the ages

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of 25 and 40, net average income per capita, the presence of attractors (parking lots, business centres), and Senator's trip density. Indeed, data obtained from the **Senator platform** was employed to identify the most frequently traversed areas by Senator vehicles, thereby providing insights into the locations in both cities where the highest concentration of trips was observed. In both cases, the criteria were selected as the most appropriate for the scope of this analysis based on the data available from official open data sources, which were of the highest possible granularity, and following discussions with both municipalities.

Once the criteria had been established, the subsequent phase of the project was to construct a bespoke geodatabase, incorporating all of the data that had been gathered, and to standardise this data in accordance with the established criteria. Subsequently, the geo data was processed using TransCad software. In accordance with the nature of the criterion, certain data were subjected to statistical processing utilising the standard deviation (e.g. population density), whereas others were defined by a threshold. Irrespective of the method employed for data processing, the objective was to identify the zones within each city where the criterion in question exerts the greatest influence in identifying potential locations for micro consolidation centres. The aforementioned activity resulted in the generation of factor criterion maps.

Subsequently, the factor criteria maps for each city were aggregated into a unified criteria map. In order to achieve this, a score of 1 was assigned to the highest value within each criterion, with the remaining values proportioned in reference to this value. This process ensured that all data was assigned a value between 0 and 1. Once this process was complete, the standardised data were combined and plotted, giving each criterion the same weight in the suitability analysis. This resulted in a unique criteria map that highlighted the most suitable locations for the micro consolidation centres.

In the final section, chapter 7, the solutions outlined in the general catalogue (chapter 4) were adapted to align with the urban context of Dublin and Zaragoza. This was achieved by considering also the most suitable locations for the micro consolidation centres outlined in chapter 6. In both cities, the concept of parcel lockers was proposed for installation at locations designated as "friendly or informal delivery pick-up points," such as local shops and markets. Such locations can be utilised as pick-up points by individuals who frequent them on a daily basis, thereby encouraging the use of this alternative to home delivery. Nevertheless, it should be noted that the measures set forth in this chapter are merely indicative and do not impose any obligations on the cities in question.

In conclusion, this deliverable presents local authorities with a theoretical framework of a general cargo-based design catalogue that can be replicated not only in Dublin and Zaragoza but also in other cities. Furthermore, it presents a theoretical analysis of potential locations for micro consolidation centres in both cities, based on a suitability assessment.

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