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URBAN LOGISTICS AS AN ON-DEMAND SERVICE

Business and operating models in ULaaDS trials

ULaaDS D3.5: Final validated business/operating models

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Project abstract

ULaaDS sets out to offer a new approach to system innovation in urban logistics. Its vision is to develop sustainable and liveable cities through re-localisation of logistics activities and re-configuration of freight flows at different scales. Specifically, ULaaDS will use a combination of innovative technology solutions (vehicles, equipment and infrastructure), new schemes for horizontal collaboration (driven by the sharing economy) and policy measures and interventions as catalysers of a systemic change in urban and peri-urban service infrastructure. This aims to support cities in the path of integrating sustainable and cooperative logistics systems into their sustainable urban mobility plans (SUMPs). ULaaDS will deliver a novel framework to support urban logistics planning aligning industry, market and government needs, following an intensive multi-stakeholder collaboration process. This will create favourable conditions for the private sector to adopt sustainable principles for urban logistics, while enhancing cities' adaptive capacity to respond to rapidly changing needs. The project findings will be translated into open decision support tools and guidelines.

A consortium led by three municipalities (pilot cities) committed to zero emissions city logistics (Bremen, Mechelen, Groningen) has joined forces with logistics stakeholders, both established and newcomers, as well as leading academic institutions in EU to accelerate the deployment of novel, feasible, shared and ZE solutions addressing major upcoming challenges generated by the rising on-demand economy in future urban logistics. Since large-scale replication and transferability of results is one of the cornerstones of the project, ULaaDS also involves four satellite cities (Rome, Edinburgh, Alba Iulia and Bergen) which will also apply the novel toolkit created in ULaaDS, as well as the overall project methodology to co-create additional ULaaDS solutions relevant to their cities as well as outlines for potential research trials. ULaaDS is a project part of ETP ALICE Liaison program.

Keywords

Urban logistics, sustainability, business models, operating models.

Copyright statement

Executive summary

Business and operating models are essential to the success of new initiatives in on-demand and zero-emission urban freight transport. Therefore, ULaaDS has a strong focus on identifying successful, developing new, and continuously refining business and operating models related to the solutions and schemes trialled during the project. This process is reported in three separate deliverables: D3.1 “Benchmarking business/operating models and best practices”, D3.3 “Novel business/operating models and mapping to research trial sites” and D3.5 “Final validated business/operating models”, of which this is the third and final report.

The process of defining and pre-validating novel business and operating models for the ULaaDS solutions started off from the state-of-the-art with many examples of sustainable on-demand urban logistics solutions presented in deliverable D3.1, as well as the benchmark for business and operating models presented in the same deliverable. Deliverable 3.3 provided an update on the ULaaDS solutions trialled in the three lighthouse cities and mapped those solutions to the relevant business and operating models described in deliverable D3.1. Deliverable 3.5 builds on these earlier deliverables and reports on qualitative and quantitative data about the operating and business models gained during the ULaaDS research trials.

The research trials in the three lighthouse cities worked with ULaaDS solutions and schemes at different maturity levels, but all trials shed new light on the role of operating and business models. For some trials, there seems a clear path towards a self-sustaining business model for the solutions, while other trials suggest more technological development is needed for the solution to become commercially viable. Some trials with a potential business model are hampered by the lack of a sound operating model. While the research trials have brought us a step closer to the ultimate goal of sustainable, on-demand urban freight transport, they have also brought attention to two substantial challenges.

The first challenge emphasizes the importance of scaling the innovative solutions, as urban freight transport deeply influences the urban landscape, and to make a significant impact, scale is paramount. Achieving scale also frequently improves the financial feasibility of these solutions. Considering the considerable effort to implement the current research trials on a modest scale, it's important to note that the ULaaDS trials have laid a valuable foundation and roadmap for future scalability. The second challenge underscores the critical role of a supportive regulatory framework for the success of innovative on-demand and zero-emission urban freight transport business models. Simply placing the burden on the business model of the innovative solution is not enough. In fact, if existing urban freight transport activities are not discouraged, they may persist as a feasible and often more cost-effective alternative, thereby relegating the business models of innovative solutions to a secondary position at best. The ULaaDS trials have highlighted opportunities for policymakers and stakeholders to work in tandem to create conducive regulations that facilitate the transition from existing urban freight transport activities to more innovative, sustainable solutions.

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1. Introduction

This deliverable validates the relevant operating and business models of the ULaaDS solutions. The validation uses the benchmark and best practices described in D3.1 and the mapping of potential operating and business models described in D3.3 as foundation and is based on the research trials in the three Lighthouse cities Groningen, Mechelen, and Bremen. The document is divided in four main chapters, one for each lighthouse city, and a concluding chapter presenting important lessons learned across the lighthouse cities.

1.1 ULaaDS solutions and research trials

ULaaDS focuses on two categories of on-demand and sustainable urban freight solutions, namely (1) collaborative delivery models and (2) the integration of urban freight and passenger transport networks as shown in Table 1.1. Collaborative delivery models include logistics schemes based on encapsulating goods in standardised and modular containers (1), the integration of crowd-sourced delivery services (2), and the use of city-wide platforms for integrated management of urban freight transport (3). The integration of passenger and urban freight transport services includes logistics schemes based on location and infrastructure sharing (4), and vehicle capacity sharing (5). The solutions are tested in research trials across 3 lighthouse cities: Groningen, Mechelen, and Bremen.

Table 1.1 ULaaDS solution categories and logistics schemes

Solution	Scheme
1) Collaborative delivery models to enhance logistics efficiency and multimodal mobility in cities	1. Containerised urban last-mile delivery 2. Logistical network integration of crowd-sourced bike couriers 3. City-wide platform for integrated management of UFT
2) Effective integration of passenger and urban freight mobility services and networks	4. Location and infrastructure capacity sharing 5. Transport vehicle capacity sharing

ULaaDS pays close attention to the operating and business models of novel on-demand and sustainable urban freight solutions. In doing so, it explicitly considers—and actively involves—the local context and stakeholders of the lighthouse cities while developing, implementing, and testing the operating and business models of the ULaaDS solutions and schemes. Similarly, the context of satellite cities (Alba Iulia, Bergen, Edinburgh, and Rome) will be considered when assessing the scalability and transferability of the ULaaDS operating and business models. Many novel solutions in recent years have faced reluctant stakeholders, often because of concerns about the benefit to cost ratio, labour unions, a willingness to pay and many other operational constraints. Deep insight into operating and business models is therefore essential to the success of new initiatives in on-demand and zero-emission urban freight transport.

1.2 From Provisional to Validated Business and Operating Models

ULaaDS started with a provisional list of novel operating and business models for the two main solutions developed and trialled within the project: (1) collaborative delivery models to enhance logistics efficiency and multimodal mobility in cities and (2) effective integration of passenger and urban freight mobility services and networks. This provisional list served as a basis for further development in work package 3 (WP3), which focuses on the development and continuous improvement of the operating and business models of the ULaaDS solutions during the research trials. As a first step, WP3 identified an extensive list of best practices in on-demand and zero-emission urban freight transport and linked these to different business and operating models. This step is reported in ULaaDS deliverable D3.1. D3.1 was used as the ULaaDS trials were further getting shape. Deliverable D3.3 then mapped the solutions trialled in the three lighthouse cities to the relevant operating and business listed in D3.1. This mapping was done during the design of the research trials—based on available information up to March 2022—but prior to their actual start of the trials.

During the research trials, the operating and business models were refined based on first-hand experience with the technological aspects of the solutions as well as the response of the different stakeholders involved in the research trials. First-hand experience is gained during trial implementation and execution as part of ULaaDS work package 4 (WP4). The resulting insights are used as input for this deliverable (D3.5), presenting a final, validated version of the operating and business models. This validation also sheds light on the extent to which the operating and business models of the novel solutions are scalable within the lighthouse cities and transferrable to other (satellite) cities. Lastly, the validation process highlights the critical role of a supportive regulatory framework for the success of innovative on-demand and zero-emission urban freight transport business models.

2. Groningen trials

The two Groningen research trials focused on the implementation of a shared platform for zero-emission urban freight vehicles and the placement of parcel lockers on public transit hubs. Collectively, the Groningen trials addressed all ULaaDS solutions and schemes. The validation of the business and operating models underlying these solutions are presented in this chapter. In Groningen, the trials coincide with a relevant update in the regulatory framework, where the geographic extension of the time-window access restriction zone—an important step towards the zero-emission zone in 2025—took place during the trials.

2.1 Groningen trial 1

Trial 1 was aimed at developing, implementing, and promoting a platform for the on-demand supply of shops and delivery to consumers in Groningen. Specifically, the municipality of Groningen (GRO) and the Groningen City Club (GCC) worked towards a platform where local shopkeepers and entrepreneurs gain access to zero-emission vehicles for their inbound and outbound logistics processes. Table 2.1 shows how the trial addresses the two ULaaDS solutions across three schemes.

Table 2.1 ULaaDS solutions and schemes Groningen trial 1

Solution	Scheme
1) Collaborative delivery models to enhance logistics efficiency and multimodal mobility in cities	3. City-wide platform for integrated management of UFT
2) Effective integration of passenger and urban freight mobility services and networks	4. Location and infrastructure capacity sharing 5. Transport vehicle capacity sharing

2.1.1 Groningen trial 1 implementation

Trial 1 tests different vehicle types and their use by entrepreneurs with a different urban freight transport demand, with the explicit purpose of gaining insight into the operating and business model of the platform. The municipality of Groningen involved an established mobility solutions provider to manage the vehicles. The mobility solutions provider owns the vehicles used in the trial and initiated the development of an online portal through which users can reserve the vehicles. It also provided the quantitative data about the reservations, which was shared with the informed consent of both the shopkeepers involved in the trial and the mobility solutions provider. The Groningen City Club recruits the shopkeepers and entrepreneurs using the vehicles during the trial and communicates with all relevant stakeholders. The University of Groningen was involved in analysing the quantitative data provided by the mobility solutions provider as well as by conducting two rounds of interviews with the (potential) users of the system; one shorter interview prior to using it and one interview after some usage to discuss operating and business model implications.

2.1.2 Operating model validation Groningen trial 1

Three different vehicles are offered: a cargo bike (i.e., Urban Arrow L), a light electric freight vehicle (i.e., a Carver Cargo), and an electric van (i.e., Volkswagen ID. Buzz Cargo). The Urban Arrow L has a top speed of 25 km/h, a loading volume of 400 litre, a permissible total weight of 250 kilogram and a range of 40 kilometres. The Carver has a top speed of 45 km/h, a loading volume of 500 litre, a permissible total weight of 500 kilogram and a range of 100 kilometres. The ID. Buzz Cargo has a top speed of 145 km/h, a loading volume of 3,9 m^3, a permissible total weight of 650 kilogram and a range of 424 kilometres. The vehicles are shown in Figure 2.1.

Urban Arrow L | Carver Cargo | ID. Buzz Cargo

Figure 2.1 The three zero-emission vehicles that are part of the platform in Groningen Trial 1.

Each vehicle has a stationary location in—or close to—the city centre. Stationary means that entrepreneurs using it need to return the vehicle to the same location they picked it up, and that this location is always the same. Figure 2.2 shows the vehicle locations.

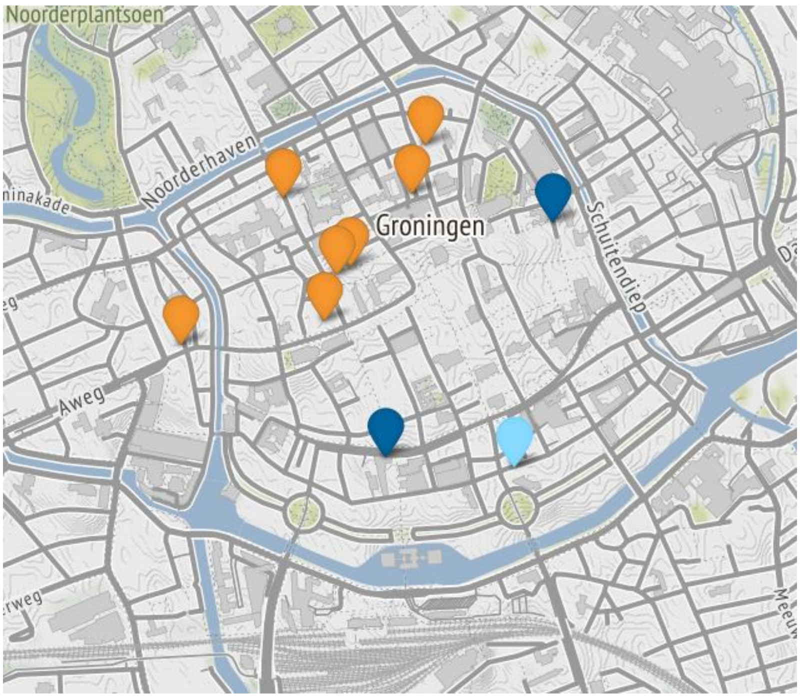


Figure 2.2 Location of the Carver and Urban Arrow L (in dark blue), the future location of the ID. Buzz (light blue) and entrepreneurs involved in stage 1 of trial 1 (orange).

The cargo bike is located in an underground bicycle parking lot at the East of the city centre and the light electric freight vehicle is located at an office location of the municipality of Groningen at the South side of the city centre. During the trial, the electric van has had different stationary locations. First, the van was located at the leasing company, which is located about 15 minutes by car or bike from the city centre, then at a parking garage at the East side of the city centre, adjacent to the cargo bike location, and as of June 2023 it will be located at a designated spot at the Herebinnensingel at the South side of the city centre. These locations have some operating and business model implications that will be discussed later. Figure 3.2 also shows the location of the seven shopkeepers that have been using the vehicle(s), including a wine merchant, a furniture and interior design shop, a cheese and luxury food shop, children's apparel boutique, an art gallery, a garden boutique, and a bookstore. Eight more shopkeepers have been actively involved in the trial but have not (yet) used one of the vehicles. Later parts of this deliverable explain reasons behind different use patterns in detail.

The online portal, through which users can reserve a vehicle, was developed for the purpose of the trial and based on a similar portal used for shared passenger mobility solutions of the same mobility solutions provider. It consisted of a mobile app to reserve a vehicle. For the ID. Buzz the app also served as key to open the van. During the trial, the users reserved the ID. Buzz using the portal, while organizing the use of the Carver through a private group chat. In principle, the Urban Arrow L could be used in a similar way, but due to some technical issues with the cargo bike in the beginning of the trial, and other considerations later in the trial, the cargo bike was not reserved at the moment of writing. A screenshot of the mobile app as part of the reservation portal is shown in Figure 2.3.

Figure 2.3 Screenshot of the mobile app as part of the reservation portal.

Between the moment the ID. Buzz became available, on the 14th of February 2023, and the 1st of May 2023 the electric van was reserved 52 times and had driven 6992 kilometers by six shopkeepers. The light electric freight vehicle was used way less: less then 200 kilometer in total, among three shopkeepers. The average trip involved using the vehicle for four hours and 80 kilometers. Quantitative and qualitative data analysis brought to light that shopkeepers reserve the vehicle for relatively large blocks of time. Throughout the pilot phase, the vehicles can be used free of charge, which incentivizes what we came to call "comfort use", for example, picking up the electric van the evening prior to the morning during which it was used for urban freight transport. For 42% of the reservations, the electric van was picked up the night before it was used, excluding the "comfort use" behavior on reservations where the vehicle was picked-up and returned on the same day.

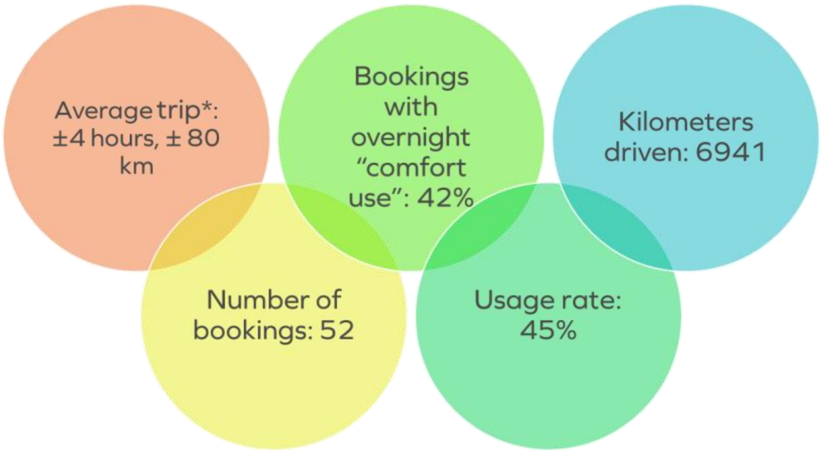


Figure 2.4 ULaaDS Groningen trial 1 in numbers.

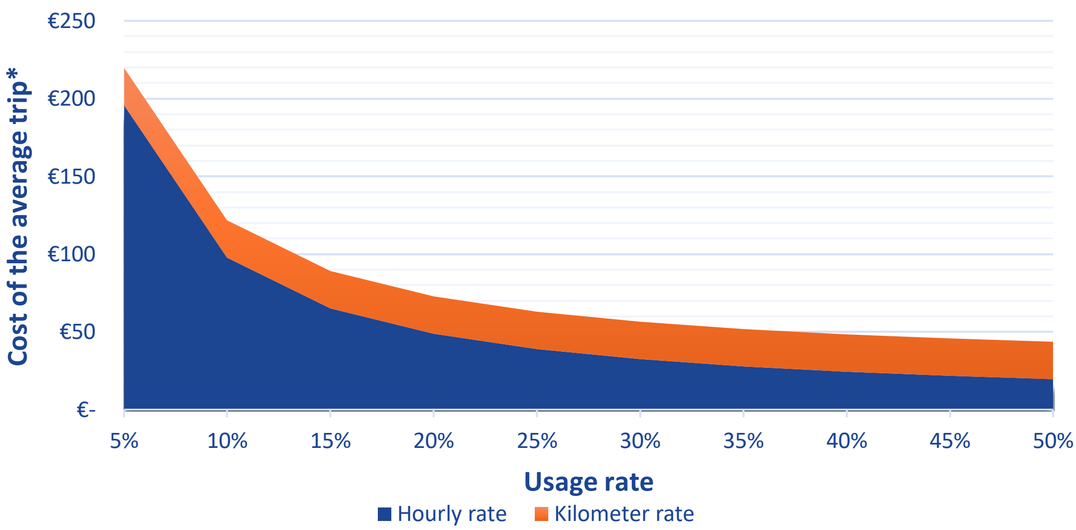
During the trial, shopkeepers use the vehicle(s) for different purposes and in different ways. The wine merchant used both the ID. Buzz and Carver actively for delivering wine from the shop in the city centre to its customers in and around the city but stopped using the vehicles after the physical shop closed and continued as an only web shop—now using a third-party logistics service provider for deliveries from a warehouse. The furniture and interior design shop only used the ID. Buzz. Furniture too big for the ID. Buzz is still delivered with their own diesel-powered, much larger van, while the relatively smaller deliveries are frequently performed with the ID. Buzz. Even these smaller deliveries are often too large for the smaller vehicle types in the trial, which explains not using the Carver or Urban Arrow L. The cheese and luxury food shop uses the ID. Buzz and Carver for picking up speciality food amongst artisanal cheese and dairy farms in the hinterland of the city. It also uses the ID. Buzz to supply a second branch of its shop in a nearby town. The children's apparel boutique occasionally used the ID. Buzz to replace deliveries otherwise performed by multiple trips with a private car. The art gallery uses the ID. Buzz for deliveries to consumers in and around Groningen. The other vehicles are considered too small for their typical products, such as painting canvases. The bookstore has occasionally used the Carver for book fairs in the city and is interested in using the ID. Buzz in the future. The Urban Arrow L is off less interest as they prefer a trolley for short distances. With the ULaaDS pilot in mind, the shopkeeper of the garden boutique got rid of a diesel van and invested in a self-owned light electric freight vehicle. The ID. Buzz is used for occasions where the light electric vehicle has insufficient volume or weight capacity, or requires a range beyond that of that vehicle, such as trips to specific suppliers in the South of the Netherlands. Other forms of transport, such as express delivery, are not an option because of high costs.

Generalizing the individual usage of the vehicle(s), a distinction can be made between ad hoc usage and planned usage. Ad hoc usage is mostly observed by shopkeepers with highly infrequent deliveries overall or with a delivery request at an unexpected moment, to an unexpected location or of an oddly sized product. Express delivery would, in these cases, either be more expensive and/or does not provide the opportunity to bundle that specific delivery with other deliveries to be made. Also, personal contact with the customer is perceived as valuable by most of the shopkeepers. Hence, explaining their preference for self-delivery over outsourcing delivery. Because of the unanticipated nature of these deliveries, shopkeepers value the availability of the vehicle(s). Occasionally or momentarily waiting for a vehicle may be an option but makes the platform considerably less valuable. Planned usage by contrast usually concerns recurring routes, with consolidated pickups or deliveries, at given times, and often for longer duration. Shopkeepers in these cases also value availability but can reserve the vehicle long ahead of use and may be able to change the timing of their use longer in advance. For planned use, (opportunity) cost seem a more important factor driving use of the platform. Because the use is recurring, shopkeepers carefully consider alternatives, such as selling or buying a vehicle of their own and compare the cost of using the shared platform with alternatives such as third-party logistics services.

A select group of shopkeepers uses the vehicle(s) in the platform intensively, generating important lessons for scaling up the solution. Therefore, in the remainder of the trial, the user group will be expanded by purposefully selecting new shopkeepers with planned usage that is synergetic to the current planned use or shopkeepers foreseeing ad hoc usage.

Several shopkeepers were involved in the trial from the beginning, and some still attend project meetings, but do not use the vehicle. Others use the vehicles less than anticipated. From their input during project meetings and interviews, a few key reasons can be distilled. First, is that the vehicles are not needed for business operations, for example, because a shop does not deliver to consumers and can be supplied by other means under the current public policy and regulations in Groningen. This holds true for all vehicles in the platform but are specifically brought forward in response to not using the electric van. The cargo bike and light electric freight vehicle were used less. At the beginning of the trial, the cargo bike was vandalized, and the battery was stolen. After the bad start, the cargo bike became available but opening the lock proved not trivial. The location was also considered far from ideal. Some shopkeepers could borrow another cargo bike from a neighbouring shop or had their own cargo bike already. As a result, the cargo bike added little (perceived) value. When looking at the light electric freight vehicle, some shopkeepers perceived its loading space as too small—albeit the weight capacity is only a little lower than the electric van and shopkeepers using it stress it is larger than anticipated. The garden boutique has its own light electric freight vehicle.

The trial yields another lesson learned about the operating model, namely the importance of the trade-off between cost and availability. The more a vehicle is used, the more the fixed costs can be shared amongst its users, ultimately lowering the price per use. However, increasing the usage rate directly implies reducing the availability rate. As a result, the probability of the vehicle being unavailable when users want to reserve it increases. This invokes a trade-off, where some of the shopkeepers indicated during their second interview that they favored availability (i.e., a high probability that the vehicle is available when needed) over price, whereas others indicated that price was the most dominant factor deciding interest in the vehicle. In general, the expectation is that this trade-off is stronger in a platform with one vehicle per vehicle type—such as in this trial—than in a platform with multiple similar vehicles. This expectation follows common probability theory logic, where the risk of unavailability is pooled across multiple vehicles, lowering the chance of all vehicles being unavailable at the same time, and resonates with earlier practical experiences of the mobility service provider in passenger car sharing platforms. Based on the business model analysis presented in the next sub-section, the general trade-off is depicted in Figure 2.5, showing that the cost impact is particularly high at usage rates below.



** Average trip is 4 hours and 80 kilometres*

Figure 2.5 The trade-off between usage rate and price per use.

2.1.3 Business model validation Groningen trial 1

For the purpose of the business model validation, we rely on all project meetings and the two rounds of interviews with shopkeepers as well as quantitative data about 52 trips between the 14th of February and the 1st of May retrieved via the portal. Collectively, information about the 52 trips and the qualitative data formed the foundation for developing three alternative pricing schemes for the ID. Buzz, considering three typical forms of use. These pricing schemes include one based on the kilometers driven alone, one on the hours used alone, and one combining both. The typical trips include a short duration delivery within the city, a medium duration and distance booking through the hinterlands, and a long-distance trip (e.g., to the South of the Netherlands). The rationale behind this validation process is that it is based on the most intensive vehicle use, and hence relies on the most robust data, and could easily be extrapolated to the other vehicle types.

Table 2.2 shows the fixed and variable cost of the ID. Buzz used during the trial. These costs are validated with the mobility service provider and presented in aggregated form for confidentiality reasons. The total fixed and variable cost components are, however, accurate.

Table 2.2 Fixed and variable cost of the ID. Buzz used in ULaaDS research trial 1.

Fixed cost component	Cost per month
Vehicle	
Investment*	
Financing	
Charging Infrastructure	€ 625,00
Additional cost	
Cleaning services	
Parking permit	
Sharing platform	
Insurance	
Waiver for time-window access restriction	€ 325,00
Commercial profit surcharge (25%)	€ 237,50
Total fixed cost per month	**€1.187,50**

Variable cost component		Cost per km
Maintenance		€ 0,06
Energy		
Estimated electricity consumption ID. Buzz (kWh/km)	0,30	
Electricity price (€/kWh)	€ 0,60	€ 0,18
Commercial profit surcharge (25%)		€ 0,06
Total variable cost per km		**€ 0,30**

** Considering depreciation and scrap value*

Using the cost parameter values from Table 3.2, it soon became apparent that a pricing scheme based on kilometres or hours alone would not yield good results. A model based only on pay-per-kilometre would be very unbeneficial for the mobility service provider in case a user decides to take the vehicle for a day, but only drives very few kilometres. In that case, the driven kilometres will be insufficient to cover all the cost. This holds in a similar vein for a pay-per-hour model sine users could decide on driving on many kilometres in relatively short time, which may result in the cost not being recouped via the hourly rate. From the user perspective the logic works the other way around: long distance trips become very expensive with a pricing scheme that is only based on distance while short, time-consuming trips become very expensive with a pricing scheme that is only based on the time vehicles are used.

Table 2.3 shows how a pricing scheme based on a combination of distance driven and time used in more detail. Specifically, the table retrospectively shows what the cost for using the vehicle would have been for a number of trips made during the trial. There are two costs shown, one that would break even—with a 25% profit margin—at 25% usage rate; and one at a 50% usage rate. The latter should be seen as a lower bound on the costs because the 50% usage rate is above the typical 20-30% rates seen in personal mobility services and would severely hamper availability of the vehicle. The costs for the trips shown in Table 2.3 were computed prior to the second round of interviews and discussed with the shopkeepers making those trips.

Table 2.3 Cost for using the ID. Buzz in trial 1 according to actual use cases.

ID	Trip start	Trip end	Distance (km)	Duration (hours)	Distance cost	Duration cost (25%)	Duration cost (50%)	Trip Fare (25%)	Trip Fare (50%)
24	17:21	22:19	116	4,97	€ 34,80	€ 48,62	€ 24,29	**€ 83,42**	**€ 59,09**
25	14:20	16:05	22	1,75	€ 6,60	€ 17,13	€ 8,56	**€ 23,73**	**€ 15,16**
28	16:21	17:22	49	1,02	€ 14,70	€ 9,95	€ 4,97	**€ 24,65**	**€ 19,67**
30	17:47	22:52	110	5,08	€ 33,00	€ 49,77	€ 24,86	**€ 82,77**	**€ 57,86**
33	8:58	12:27	91	3,48	€ 27,30	€ 34,10	€ 17,03	**€ 61,40**	**€ 44,33**
37	8:16	9:26	10	1,17	€ 3,00	€ 11,42	€ 5,70	**€ 14,42**	**€ 8,70**
41	18:13	18:33	6	0,33	€ 1,80	€ 3,26	€ 1,63	**€ 5,06**	**€ 3,43**
46	12:53	23:37	115	10,73	€ 34,50	€ 105,08	€ 52,49	**€ 139,58**	**€ 86,99**
49	13:22	17:49	18	4,45	€ 5,40	€ 43,57	€ 21,76	**€ 48,97**	**€ 27,16**
52	17:43	18:12	6	0,48	€ 1,80	€ 4,73	€ 2,36	**€ 6,53**	**€ 4,16**
51	8:39	17:00	105	8,35	€ 31,50	€ 81,75	€ 40,83	**€ 113,25**	**€ 72,33**

From the insights into potential pricing mechanisms for the shared vehicles, one can zoom out and explore the broader business model implications resulting from trial 1. Table 2.4 shows the business model canvas that was developed prior to the trial and discussed in detail in deliverable D3.3. Its mission statement is to pool zero-emission vehicles and freight flows of multiple local shopkeepers and entrepreneurs.

Table 2.4 Business model canvas for the shared zero-emission vehicle platform in Groningen Trial 1 from D3.3.

<table>
<tr><td colspan="5">Mission statement: To pool zero-emission vehicles and freight flows of multiple local shopkeepers and entrepreneurs</td></tr>
<tr><td rowspan="2">Key partnerships:
1. Vehicle provider
2. Platform provider
3. Local authorities</td><td>Key activities:
1. Provide an overview of where and when vehicles are available
2. Facilitate the reservation of vehicles</td><td rowspan="5">Value proposition:
1. To enable the use of shared, zero-emission vehicles
2. Familiarize local shopkeepers with the use of zero-emission vehicles
3. Ensure that local shopkeepers and entrepreneurs keep having access to the inner city.</td><td>Buy-in & support:
1. Local shopkeepers and entrepreneurs that need a vehicle for urban freight flows</td><td rowspan="2">Beneficiaries:
1. Local shopkeepers who keep having broad access to the city
2. Citizens and other people staying in the city benefit from improved efficiency (e.g., less vehicles, fewer buildings for logistics)
3. Platform/vehicle provider who will obtain a new business model</td></tr>
<tr><td>Key infrastructure and resources:
1. Zero-emission vehicles
2. Infrastructure for parking the vehicles
3. Platform for checking vehicle availability and booking</td><td>Deployment:
1. Find entity that provides the vehicles
2. Find entity that provides the platform
3. Identify locations for parking the vehicles</td></tr>
<tr><td colspan="2">Budget costs:
1. Cost involved with the use of the vehicles
2. Cost involved with developing the platform
3. Transaction cost involved with the reservation system</td><td colspan="2">Revenue streams:
1. Fee for using the vehicles
2. Membership fee for access to the platform
3. Advertisement</td></tr>
<tr><td colspan="2">Environmental costs:
1. Energy for operating the vehicles
2. Energy for infrastructure changes
3. Energy for operating platform</td><td colspan="2">Environmental benefits:
1. Reduced greenhouse gas emissions through the use of zero-emission, rather than traditional vehicles
2. Reduced greenhouse gas emissions from better utilization of vehicles</td></tr>
<tr><td colspan="2">Social risks:
1. Not all shopkeepers and entrepreneurs may benefit from the use of the shared vehicles and may lose access to the city as a result
2. To ensure business success, the vehicles must be located at the heart of the city, which may result in less space for other social activities.</td><td colspan="2">Social benefits:
1. A reduced number of vehicles operating in the city
2. More compliance with rules and regulations due to unlocking of up-to-date information directly to logistics providers</td></tr>
</table>

Table 2.5 presents the validated version of the business model. Trial 1 strongly reinforced the proposed value proposition, including familiarizing shopkeepers with zero-emission vehicles, enable shared use of those vehicles, and assist local shopkeepers and entrepreneurs in remaining access to the inner city. Accordingly, the mission statement narrowed somewhat in scope and no longer includes the sharing of freight flows. At least for the duration of the trial, the shared use of new types of vehicles proved sufficiently challenging and result in real value added for local shopkeepers involved in the trial.

Table 2.5 Validated business model canvas for a shared zero-emission vehicle platform.

<table>
<tr><td colspan="5">Mission statement: To enable the shared use of zero-emission urban freight vehicles by local shopkeepers and entrepreneurs</td></tr>
<tr><td rowspan="2">Key partnerships:
1. Mobility service provider
2. Local authorities
3. Collective representation for local shopkeepers and entrepreneurs</td><td>Key activities:
1. Provide an overview of where and when vehicles are available
2. Facilitate the reservation of vehicles</td><td rowspan="5">Value proposition:
1. To enable the use of shared, zero-emission vehicles
2. Familiarize local shopkeepers with the use of zero-emission vehicles
3. Ensure that local shopkeepers and entrepreneurs keep having access to the inner city.</td><td>Buy-in & support:
1. Local shopkeepers and entrepreneurs that need a vehicle for urban freight flows</td><td rowspan="2">Beneficiaries:
1. Local shopkeepers who keep having broad access to the city
2. Citizens and other people staying in the city benefit from improved efficiency of urban freight transport
3. Mobility service provider who will obtain a new business model</td></tr>
<tr><td>Key infrastructure and resources:
1. Zero-emission vehicles
2. Infrastructure for parking the vehicles
3. Platform for checking vehicle availability and booking</td><td>Deployment:
1. Find entity that provides the vehicles
2. Find entity that provides the platform
3. Identify locations for parking the vehicles</td></tr>
<tr><td colspan="2">Budget costs:
1. Fixed cost involved with the acquisition of the vehicles
2. Other fixed cost involved with the vehicles
2. Variable cost for using the vehicle</td><td colspan="2">Revenue streams:
1. Fee for using the vehicles
2. Membership fee for access to the platform
3. Advertisement</td></tr>
<tr><td colspan="2">Environmental costs:
1. Energy for operating the vehicles
2. Energy for infrastructure changes
3. Energy for operating platform</td><td colspan="2">Environmental benefits:
1. Reduced greenhouse gas emissions through the use of zero-emission, rather than traditional vehicles
2. Reduced greenhouse gas emissions from better utilization of vehicles</td></tr>
<tr><td colspan="2">Social risks:
1. The use of the shared zero-emission vehicles may increase cost for urban freight transport and result in shopkeepers losing access to the city
2. To ensure business success, the vehicles must be located at the heart of the city, which may result in less space for other social activities.</td><td colspan="2">Social benefits:
1. A reduced number of vehicles operating in the city
2. More compliance with rules and regulations due to unlocking of up-to-date information directly to logistics providers</td></tr>
</table>

The trial provided important lessons learned for the key partnerships involved in launching a shared zero-emission vehicle platform. Mobility service providers, such as the one involved in the trial, are often experienced with shared mobility platforms for passenger transport and can rely on that experience when setting up and rolling out a platform for urban freight transport. Local authorities not only play a key role in finding locations for the vehicle, including potential changes to the charging infrastructure, but also to in tuning the broader local regulatory framework. The more stringent regulation in Groningen, coinciding with the trial, seem to have been a positive influence for the interest in—and use of—the vehicles. A new key partnership identified during the trial is collective representation for the local shopkeepers and entrepreneurs. In Groningen, this representation was facilitated through the Groningen City Club, and could be replicated in other cities via special business districts or other existing infrastructures supporting local business activity. The key activities and infrastructure were, as anticipated, the vehicles themselves, the platform to check the status of the vehicles and to make reservations, and the parking infrastructure. Of these, the parking infrastructure proved most challenging and may prove a barrier to further scaling up solutions like these.

The main costs are involved with the solution were detailed in Table 3.2. The largest cost component concerns the fixed costs involved with acquiring the vehicles, including financing, followed by other fixed costs, such as for developing and operating the online platform and keeping the vehicle clean. There are also variable costs associated with the use of the vehicle, mainly consisting of energy cost and maintenance. The trial showed the potential for a positive business case, including a profit margin for the mobility service provider. It details a pricing scheme that would result in a single rate consisting of two elements: the hours used, and kilometres driven. Discussions with the trial user group suggested a membership fee would be another interesting revenue to explore. A challenge is that different users would value different things from a membership. Ad hoc users would mostly pay for ensured availability, while planned use benefits from a discounted price for longer use or for reserving ahead of time. In any case, the revenue from the membership could reduce the fee per use as indicated in the beginning of this sub-section. Advertisement was not considered during the trial, but could principally be another way of lowering the price per use.

The buy-in and support of local shopkeepers and entrepreneurs that use the shared zero-emission vehicles has proven crucial for the success of the platform. They are also the beneficiaries of the solution. Citizens and other people staying in the city benefit from the time-window access restriction, from 12 pm (noon) until the end of the day, while local shops are supported through the platform. The mobility service provider benefits from a new business model. In deploying the platform, the local authority was in the lead, both in finding the mobility service provider, offering the vehicles and platform, and identifying parking locations for the vehicles.

Generally, environmental cost and benefits relate to the replacement of diesel vehicles with electric vehicles. Furthermore, the trial showed that for some shopkeepers, the use of the shared zero-emission vehicles may result in costs higher than the alternatives, while the alternatives are no longer allowed due to regulatory changes. This may force local shops out of business and change the shopping landscape in the city centre. Another social risk is that the trials underscored the importance of vehicles being located in the city centre—especially the smaller vehicle types should be located in close proximity to the shopkeepers using them. Space in cities is already very scarce and any space used for shared vehicles cannot be used for other important functions in the city.

Against these risks, there are several benefits, such as the reduction of the number of different vehicles in the city and the fact that a platform for shared zero-emission vehicles supports local business activity throughout the rollout of more stringent regulations.

2.2 Groningen trial 2

Trial 2 was aimed at experimenting with the addition of logistics services to multi-modal mobility hubs. Specifically, the municipality of Groningen (GRO) and the public transport organisation of the provinces Groningen and Drenthe (OVB) worked towards placing a white label parcel locker system at the Park and Ride (P&R) location Hoogkerk, one of the main mobility hubs around the city of Groningen. Table 2.6 shows how the trial addresses ULaaDS Solution 2 by integrating the parcel locker system into the public transport system, while applying Scheme 4 by sharing its location with the available infrastructure capacity. ULaaDS Solution 1 and Scheme 3 are addressed by ensuring shopkeepers and entrepreneurs in the city can use the parcel locker system for reaching their customers.

Table 2.6 ULaaDS solutions and schemes Groningen trial 2

Solution	Scheme
1) Collaborative delivery models to enhance logistics efficiency and multimodal mobility in cities	3. City-wide platform for integrated management of UFT
2) Effective integration of passenger and urban freight mobility services and networks	4. Location and infrastructure capacity sharing

2.2.1 Groningen trial 2 implementation

The implementation of Groningen Trial 2 was not without challenges[1], which resulted in important learnings from an operating and business model perspective. Even more interestingly, learning from the implementation challenges, the municipality of Groningen expanded the scope of the trial by looking at parcel locker systems more broadly. Together with the ecosystem of local stakeholders, which was expanded because of the ULaaDS research trials, the municipality of Groningen decided to work towards an overarching policy framework for parcel locker placement in the city[2]. The policy framework focuses on parcel locker placement on public spaces while the underlying analysis also considers other forms of out of home e-commerce logistics services for consumers (e.g., in-shop pick-up/drop-off points and neighbourhood hubs). The implementation challenges and expanded scope of the trial positively influenced to the validation of the operating and business models as discussed in more detail below.

[1] Further details of the Groningen research trials are discussed in Deliverable D4.5.
[2] The process and resulting framework are discussed in Deliverable D6.6.

2.2.2 Operating model validation Groningen trial 2

When looking at all out of home e-commerce logistics service options for consumers in the municipality of Groningen, first, a distinction can be made between white-label and private-label options. White-label options (can) work with more than logistics service provider, while private-label options are dedicated to—and fully integrated with—the operations of a single logistics service provider. A second distinction can be made by looking at the type of facility being used. In Groningen, we see the use of in-shop pick-up/drop-off points, crowd-sourced neighbourhood hubs, and parcel locker systems.

In-shop pick-up/drop-off points are a manned solution, located in a shop with resulting opening and closing times, and can be accessed through infrastructure that is in place for the shop (e.g., parking lot). Shopkeepers receive the parcels for self-collection by consumers from the logistics service provider and accept parcels to be dropped off by consumers for returning them to the logistics service provider. A fee is agreed for handling each pick-up or drop-off. At the time of writing, PostNL operates 58 such points, all private label. The other logistics providers have a mix of dedicated and shared in-shop pick-up/drop-off points: DHL operates 38 such points in total, UPS 18, DPD 12, and GLS 8. The last logistics service provider active in the Netherlands, FedEx, operates no pick-up/drop-off points in Groningen.

Crowd-sourced neighbourhood hubs are a more novel phenomenon. This form of out of home delivery is operated by a resident, who receives parcels from one or more logistics service providers and is available for pickup by other residents in the neighbourhood. Similar to the in-shop pick-up/drop-off points, the operator receives a fee for every delivery handled. In Groningen, ViaTim and Homerr each operate four crowd-sourced neighbourhood hubs. In addition, Homerr operates nine in-shop pick-up/drop-off points, partially overlapping with the DPD points. All the ViaTim points are used by DHL, who drops of parcels for their consumers and picks up returned parcels, and some also by UPS or DPD. Homerr has its own operations but uses sub-contractors of the larger logistics service providers (e.g., UPS and DPD) to avoid additional delivery vans on the street.

Parcel locker systems are also a more recent phenomenon in Groningen. Other than the in-shop pick-up/drop-off points and crowd-sourced neighbourhood hubs, parcel lockers are available for picking up or dropping off parcels 24 hours per day. PostNL operates 11 private-label parcel locker systems, some in public spaces others inside retail shops. De Buren is a white-label operator, working with DHL DPD and UPS. It operates 4 such locker systems in public spaces in Groningen. DHL itself operates 2 private-label systems inside LIDL supermarkets.

From an operating model perspective, the out of home e-commerce logistics service options work similarly. Consumers either select out of home delivery when checking out their order at an online shop or their parcel is forwarded to an out of home delivery locations after a failed attended home delivery attempt. Instead of attended home delivery, a logistics service provider drops the parcels for self-collection off at the out of home delivery location. The consumer then picks the parcel up. At most locations, consumers can also drop off parcels for return. The logistics service providers differ in how they work with the out of home delivery locations. Some integrate home delivery and out of home delivery in the same routes, others have dedicated routes for home and out of home delivery. The same holds for returns, and combinations are seen as well—where some routes include parcels for both home and out of home delivery, while other routes are dedicated.

Looking at e-commerce delivery alone (i.e., not considering return flows), out of home delivery is often more efficient than home delivery from an operating model perspective. To show the operating model implications of out of home delivery, and in line with the expanded ULaaDS research trial 2 scope, we consider the inner-city of Groningen as a case study. This area is shown in Figure 2.6. On any given day, this area will see about 2000 parcel deliveries. According to their relative market share[3], one of the larger logistics service providers (i.e., PostNL or DHL) will serve about 700 addresses in an 8-hour working shift.

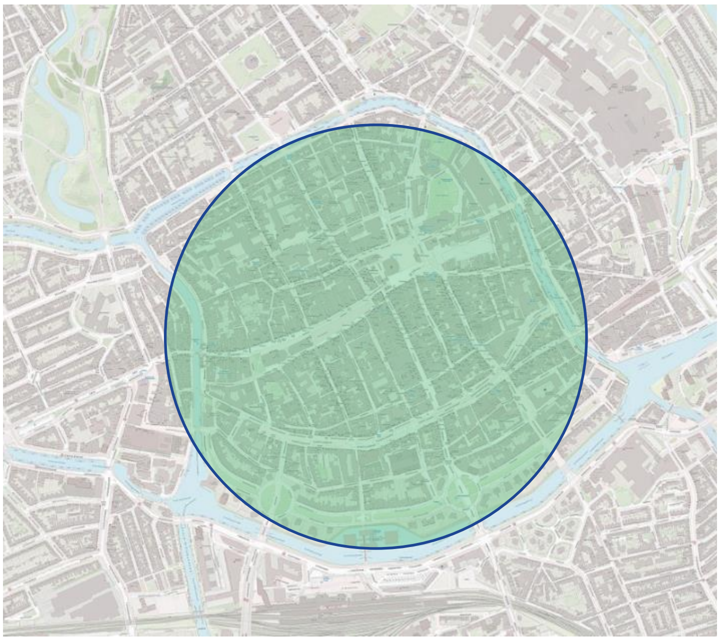


Figure 2.6 Delivery area considered during scenario analysis.

To show the operating model implications of out of home delivery, we analyse scenarios with different percentages of the 700 deliveries are operated via out of home locations. Specifically, we consider a range from 0% to 100% with increments of 5%. Both larger logistics service providers have around 5 out of home delivery locations in this area. The assumption is that all out of home deliveries will receive parcels in scenarios with out of home delivery, and that a stop at each of the 5 locations always results in a dwell time of exactly 20 minutes. Those 20 minutes are used for finding a parking location and for unloading all parcels for that location. Based on empirical observations in Groningen, the dwell time at home delivery addresses is 2,25 minutes on average.

We run the scenarios using a methodology developed and explained in detail in a scientific working paper by the authors of this deliverable[4], with input parameter values given in Table 2.7. This

[3] Authority for Consumers and Markets (2021) Post- en pakketmonitor 2021. https://www.acm.nl/system/files/documents/post-en-pakketmonitor-2021.pdf
[4] Niemeijer, R., Schurer, K., Peters, K. & Buijs, P. (2023) Delivering Pandora's Box: A Life Cycle Thinking Approach to the Environmental Impact of Last-Mile Logistics. Working paper.

methodology is based on route length approximation[5]. Other methodologies frequently used for analysing operating models are often based on vehicle route optimization[6], which is well suited to determine the best routes when exact customer addresses are known. Route length approximation, instead, is well suited for addressing more strategic, forward-looking questions, where the average number of deliveries can be determined, but the specific addresses not. The input values in Table 2.7 are based on the authors' empirical observations of e-commerce delivery operations in Groningen across various logistics service providers.

Table 2.7 Input parameter values for Niemeijer et al. (2023) methodology—these are constant across all scenarios.

Parameter	Value	Unit
Number of parcels	700	-
Size of delivery area	4	m_2
Average parcel size	0.02	m^3
Distance parcel depot to edge of delivery area	13.5	km
Courier shift duration	8	hours
Transhipment time at depot	20	min
Approximation constant	1.17	-
Effective volume capacity of the delivery van	5	m^3
Range capacity of the delivery van	400	km
Stop time per stop	2.25	min
Average cruising speed (depot to delivery route)	60	km/h
Average speed between stops (within delivery route)	10	km/h

In the scenario with 5% out of home delivery, there are 35 out of home deliveries spread across the 5 locations. The remaining 665 are attended home deliveries. In total, the logistics service provider makes 665 + 5 = 670 stops with a total dwell time of 1596,25 minutes—note this is slightly more than the 1575 minutes in case of 0% out of home delivery due to the relatively longer dwell time at the 5 out of home locations. In scenarios with 10% or more out of home deliveries, the logistics service provider reduces the total dwell time associated with the deliveries.

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[5] Beardwood, J., Halton, J.H., Hammersley, J.M. (1959). The shortest path through many points. In: Mathematical Proceedings of the Cambridge Philosophical Society, vol. 55, p. 299–327. Cambridge University Press. Daganzo, C.F. (2005). Logistics systems analysis. Springer Science & Business Media.

[6] Enthoven, D.L., Jargalsaikhan, B., Roodbergen, K.J., uit het Broek, M.A., Schrotenboer, A.H. (2020). The two-echelon vehicle routing problem with covering options: City logistics with cargo bikes and parcel lockers. Computers and Operational Research, 118, 104919.

Table 2.8 shows how higher percentages of out of home delivery increases decrease the number of stops and positively affect the total route length that is driven. In the scenario with 5% out of home deliveries, we already saw that the total dwell time at delivery stops is somewhat higher than in the scenario without out of home delivery. The delivery routes, on the other hand, are faced with 35 less home delivery addresses, which reduces total approximated route length to 190,41 km and the time of the delivery routes to 35,15 hours. Note that given the input parameter values in Table 2.7, each delivery vehicle has sufficient volume capacity for 250 home deliveries, yet the available working time prohibits that number of stops. Instead, on average, a delivery vehicle makes about 155 stops in a scenario without home delivery. As the percentage of out of home delivery increases, the total dwell time reduces, which results in a better utilization of the delivery vans' volume capacities. Accordingly, the number of trips needed to perform all deliveries decreases, which further improves the total route length involved with the deliveries.

Table 2.8 Operating model implications of out of home delivery in Groningen.

Adoption rate out of home	Number of stops	Total working hours	Total km	Vans needed	Trips per van	Parcels per van	Volume per van
0%	700	36,18	195,55	4,52	1,00	154,80	3,10
5%	670	35,15	190,41	4,39	1,00	152,51	3,19
10%	635	32,19	177,87	4,02	1,00	157,84	3,48
15%	600	29,36	165,79	3,67	1,00	163,47	3,81
20%	565	26,57	153,79	3,32	1,00	170,09	4,21
25%	530	24,03	142,66	3,00	1,00	176,42	4,66
30%	495	21,71	134,86	2,71	1,03	176,68	*
35%	460	19,67	132,84	2,46	1,14	164,47	*
40%	425	17,69	130,89	2,21	1,26	151,98	*
45%	390	15,90	128,97	1,99	1,41	139,28	*
50%	355	14,23	126,76	1,78	1,57	126,90	*
55%	320	12,69	124,71	1,59	1,77	114,16	*
60%	285	11,20	122,22	1,40	2,00	101,83	*
65%	250	9,89	119,75	1,24	2,27	89,29	*
70%	215	8,68	117,04	1,09	2,58	76,80	*
75%	180	7,58	114,17	0,95	2,95	64,27	*
80%	145	6,56	110,97	0,82	3,42	51,76	*
85%	110	5,65	107,31	0,71	3,97	39,28	*
90%	75	4,80	103,03	0,60	4,67	26,78	*
95%	40	3,97	97,55	0,50	5,65	14,29	*
100%	5	2,85	87,98	0,36	7,87	1,79	*

* At this adoption rate, the full effective capacity of the van is used on its first trip

2.2.3 Business model validation Groningen trial 2

The initial scope of the ULaaDS trial 2 was the placement of a parcel locker at one public transit hub in Groningen, where there was a strong preference for a white-label system so that all logistics service providers and local entrepreneurs could principally use it. The resulting business model canvas presented and discussed in deliverable D3.3 is provided in Table 2.9. The mission statement for these white-label parcel locker system at public transit hubs is to reduce the dependence on cars and vans for last-mile and first-mile logistics.

Table 2.9 Business model canvas for parcel lockers at public transit hubs in Groningen Trial 2 from D3.3

<table>
<tr><td colspan="5">Mission statement: To reduce dependence on cars and vans for last-mile and first-mile logistics</td></tr>
<tr><td rowspan="2">Key partnerships:
1. Public transport authority
2. Logistics service providers
3. Other suppliers such as local shopkeepers and entrepreneurs</td><td>Key activities:
1. Accept goods from logistics service providers and other suppliers (e.g., local shopkeepers)
2. Accept return parcels from commuters
3. Enable pick up of goods</td><td rowspan="5">Value proposition:
1. To provide pick up and drop off services for parcels for commuters
2. To provide an additional delivery method to local shops
3. To reduce the need for going to/from the city by car or van</td><td>Buy-in & support:
1. Local authority for finding appropriate location and providing permit for locker placement</td><td rowspan="2">Beneficiaries:
1. Commuters and other customers
2. Local shopkeepers
3. Logistic service providers</td></tr>
<tr><td>Key infrastructure and resources:
1. Parcel locker
2. Public space with access to power
3. Digital infrastructure to alert suppliers and commuters when parcel is available and for accessing locker box</td><td>Deployment:
1. Install parcel locker
2. Offer easy integration into delivery processes of third-party logistics providers and suppliers</td></tr>
<tr><td colspan="2">Budget costs:
1. Investment cost of installing locker system
2. Operational cost (e.g., power and transaction costs) and maintenance</td><td colspan="2">Revenue streams:
1. Fee per parcel
2. Membership fee for third-party users
3. Revenue from advertisement on locker system</td></tr>
<tr><td colspan="2">Environmental costs:
1. Energy use of manufacturing and operating the locker system
2. Greenhouse gas emission from logistics service providers and suppliers traveling to parcel locker in polluting vehicle as well as from consumers that otherwise would not have travelled to the public transit hub.</td><td colspan="2">Environmental benefits:
1. Reduced greenhouse gas emissions involved with transport by logistics service provider
2. Reduced greenhouse gas emissions involved with travel into and out of the city by local shopkeepers and entrepreneurs</td></tr>
<tr><td colspan="2">Social risks:
1. Reduced service for attended home delivery because easy alternative exists (e.g., logistics service provider not willing to make second attempt at home delivery)
2. Increased number of trips (in polluting vehicles due to heavy parcels) to the public transport hubs for pick-up or drop-off matters only</td><td colspan="2">Social benefits:
1. Alternative for attended home delivery for customers
2. Less vehicles in the city</td></tr>
</table>

As the scope got broader throughout the execution of the trial, a few important lessons emerged for the business model of parcel lockers at public transit hubs. Indeed, the municipality of Groningen now considers parcel lockers from a more integral perspective—as one of the out of home delivery options among several (i.e., in-shop pick-up/drop-off points, neighbourhood hubs and parcel lockers) and in conjunction with other societal, environmental, and economic goals. This shift in perspective was the result of stakeholder engagement and culminated in the second stakeholder forum in Groningen, where the trial was discussed with various logistics service providers as well as local shopkeepers and civil servants from several departments of the local authority.

The forum yielded important insight into the business logic of these various stakeholders. The perspectives of the different stakeholder group converged around a desire to end up with a dense network of out of home delivery options. From a public perspective, this would yield in relatively short distances that consumers need to travel when picking up a parcel—increasing the likeliness of consumers traveling to the out of home delivery location by bike or on foot[7]. For logistics service providers, a dense network increases the service offering to consumers, and increases the likeliness that a consumer will select out of home delivery. The previous sub-section explained how an increase in out of home deliveries improves the operational efficiency of a logistics service provider. Stakeholder views on how to achieve a dense network diverged in some respects. The logistics service providers see parcel lockers on public spaces as a solution when other out of home delivery locations are not at hand. They also described a general preference for private-label solutions, citing issues with accountability when a parcel gets lost and hampering inter-organizational information technology as main arguments against white-label solutions. From a public perspective, it would be possible to realize a dense network with less locations if all out of home delivery locations where shared among all logistics service providers. Given the scarcity of public spaces, the public authority is cautious in providing public spaces for parcel lockers.

The challenge is to incorporate the converging and diverging stakeholder views into the more general policy framework for parcel locker placement in public spaces. In line with the extended business model canvas logic, parcel locker placement in public spaces should provide business value as well as societal and/or environmental value[8]. A complicating factor is that out of home delivery—including parcel lockers—offers a clear path to business value while creating societal and/or environmental value is much more complicated. Business, societal, and environmental value, in fact, are often trading off. That is, the carbon emission and other nuisances of consumers travelling to and from out of home delivery locations easily outweigh the societal and environmental benefits from out of home delivery resulting from more efficient delivery routes[8] while the business value from more efficient delivery routes remains.

When logistics service providers request the use of public spaces for parcel lockers, there is an opportunity to negotiate and explicitly trade off the different extended business model aspects. The consensus during the forum was that a local authority can set requirements when parcel lockers are to be placed in public spaces. Local authorities could be pro-active by pre-determining the locations deemed suitable for parcel lockers, for example, because of the accessibility of the location, the available infrastructure, the ability to cope with potential nuisances, the density of the overall out of home delivery network in that area, the potential societal function other services could play, et cetera. In return, the local authority may need to contribute in kind or even in cash, by facilitating the location free of charge and/or paying a fee to a white-label parcel locker system provider. These lessons learned are reflected in the validated business model canvas, presented in Table 2.10.

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[7] Niemeijer & Buijs (2023). A Greener Last Mile: Analyzing the Carbon Emission Impact of Pickup Points in Last-Mile Parcel Deliver. Available at SSRN: https://ssrn.com/abstract=4169737

[8] Dobber & Buijs (2023). Policy Approaches for Placing Parcel Lockers in Public Space, in conference proceedings of the 9th International Physical Internet Conference.

Table 2.10 Validated business model canvas for parcel lockers on public transit hubs.

<table>
<tr><td colspan="5">Mission statement: To complement the existing out of home delivery network and mitigate the negative externalities of e-commerce delivery</td></tr>
<tr><td rowspan="2">Key partnerships:
1. Public (transport) authority
2. Logistics service providers
3. Other suppliers such as local shopkeepers and entrepreneurs</td><td>Key activities:
1. Accept goods from logistics service providers and other suppliers (e.g., local shopkeepers)
2. Accept return parcels from commuters
3. Enable pick up of goods</td><td rowspan="5">Value proposition:
1. To provide parcel pick up and drop off services for commuters and residents at areas that were hitherto under-served
2. To provide an additional delivery method to local shops
3. To reduce the need for going to/from the city by car or van</td><td>Buy-in & support:
1. Local authority for finding appropriate location and providing permit for locker placement</td><td rowspan="2">Beneficiaries:
1. Logistic service providers
2. Commuters and residents
3. Local shopkeepers</td></tr>
<tr><td>Key infrastructure and resources:
1. Parcel locker
2. Public space with access to power
3. Digital infrastructure to alert suppliers and commuters when parcel is available and for accessing locker box</td><td>Deployment:
1. Install parcel locker
2. Offer easy integration into delivery processes of third-party logistics providers and suppliers</td></tr>
<tr><td colspan="2">Budget costs:
1. Investment cost of installing locker system
2. Operational cost (e.g., power and transaction costs) and maintenance</td><td colspan="2">Revenue streams:
1. Operational cost benefits for logistics service provider
2. Fee per parcel
3. Revenue from advertisement on locker system</td></tr>
<tr><td colspan="2">Environmental costs:
1. Greenhouse gas emission from suppliers and consumers traveling to the parcel locker that otherwise would not have travelled to the public transit hub
2. Energy use of manufacturing and operating the locker system</td><td colspan="2">Environmental benefits:
1. Reduced greenhouse gas emissions involved with transport by logistics service provider
2. Reduced greenhouse gas emissions involved with travel into and out of the city by local shopkeepers and entrepreneurs</td></tr>
<tr><td colspan="2">Social risks:
1. Reduced service for attended home delivery because easy alternative exists (e.g., logistics service provider not willing to make second attempt at home delivery)
2. Increased number of trips (in polluting vehicles due to heavy parcels) to the public transport hubs for picking up or dropping off a parcel only</td><td colspan="2">Social benefits:
1. Alternative for attended home delivery for customers
2. Less vehicles in the city</td></tr>
</table>

The updated version of the business model canvas in Table 3.10 does not deviate from the on in Table 3.9 in many respects. Reflecting the broader scope and lessons learned, the mission statement relates explicitly to the existing network of out of home delivery locations—including in-shop pick-up/drop-off points, neighbourhood hubs, and parcel lockers—and aims at reducing the negative externalities involved with e-commerce delivery broadly. This is also reflected in the value proposition, the first part of which now includes the role these parcel lockers can play for local residents, and not only to commuters. Public transit hubs may be located in areas with relatively few out of home delivery locations, and hence form an opportunity to enhance the existing network.

Key activities, infrastructure and resources remain unchanged and are further detailed in the previous sub-section explaining the operating model. The key partnerships in the original canvas are validated but changed somewhat in the role of the different stakeholders in those partnerships. The public authority can play a more pro-active role when parcel lockers are to be placed on public spaces, such as public transit hubs, and actively liaise with the various logistics service providers and parcel locker system providers. Other suppliers, shopkeepers, and entrepreneurs play a somewhat different role than anticipated in that they mainly want to have a say in what locations are suitable and how the operating model favours the in-shop pick-up/drop-off point operators.

Buy-in of the local public authority is required to ensure a permit for using the parcel locker in public spaces. In terms of deployment, the parcel locker needs to be installed and should operate well with the systems and operations of logistics service providers. Shopkeepers do not seem particularly keen on using parcel lockers for their inbound and outbound logistics operations and rather benefit when parcel locker placement results in increased traffic to their shop or shopping centre. An important lesson from the trial was that revenue streams depend on the specific solution and perspective. A key source of "revenue" is actually the reduced operational costs for logistics service providers, which are weighed into the business decision when the parcel locker is private-label and fully integrated with the logistics service provider's operations. In case of a white-label solution, the third-party provider receives a fee per parcel handled from the logistics service provider and could potentially use the locker for advertisement.

The main budget costs in the original business model canvas are validated during the trial. When the parcel locker is located on private land—and often a private-label solution—the investment and operational cost are born by the logistics service provider, but for white-label solutions on public spaces the expectation may be that a public authority makes investments to prepare the location (e.g., installing the foundation and electricity) and contributes to the operational cost. The research trial in Groningen and peripheral studies (Dobber & Buijs, 2023; Niemeijer & Buijs, 2023), highlight the potential societal and environmental cost of parcel lockers on public spaces. While they can contribute to more sustainable e-commerce deliveries (i.e., reduced vehicle movements and emissions), there is a considerable risk that the societal and environmental cost outweigh the societal and environmental benefits—while a parcel locker provides an easy path to improved business value, especially when local authorities contribute to the investment and operational costs. This makes logistics service providers potentially also the main beneficiaries from parcel locker placement on public transit hubs, followed by commuters and residents that prior to placement had no other out of home delivery options nearby.

3. Mechelen trials

The primary focus of the two research trials in Mechelen was on setting up collaborative management for urban freight transport and the piloting of a shared autonomous vehicle. These trials addressed both ULaaDS solutions across two schemes. The validation of the business and operational models that underpin these solutions is detailed in this chapter. The trials aligned with larger trends in Mechelen. The city is experiencing a growing population, an influx of entrepreneurs and employers, and increased numbers of visitors and tourists. Additionally, the city has committed to reducing urban logistics emissions to zero by 2030, as outlined in a covenant signed in 2020. These trials contribute to this broader objective, demonstrating Mechelen's proactive approach to sustainable urban mobility.

3.1 Mechelen trial 1

Trial 1 included several elements aimed at enhancing logistics efficiency by the development of a collaborative urban freight transport model, as indicated in Table 3.1. UPS, bpost (BPO) and EcoKoeriers (ECO) work together with the city of Mechelen (MEC) towards streamlining business-to-business (B2B) logistics, building on prior advancements in B2C and C2B logistics in Mechelen. Specifically, the trial setup involved ECO picking up parcels from local shopkeepers and delivering them to bpost's existing microhubs, with BPO then sorting and transferring the parcels to UPS or its own delivery services for final delivery to consumers. Due to a small volumes per shop for each individual logistics service provider, picking up parcels at local shops is inefficient—both from an economic and sustainability perspective.

Table 3.1 ULaaDS solution and scheme Mechelen Trial 1

Solution	Scheme
1) Collaborative delivery models to enhance logistics efficiency and multimodal mobility in cities	3. City-wide platform for integrated management of UFT

3.1.1 Mechelen trial 1 implementation

Trial 1 in Mechelen did not reach the implementation stage. Mechelen initially envisioned separate solutions for bpost and UPS, where bpost established additional microhusbs and UPS would rent a box in a city hub and both would operate their cargo bike routes from those facilities. However, due to concerns raised by unions about the safety of the bike couriers and their exposure to weather conditions, UPS had to rethink their approach. ECOkoeriers sought to position themselves as a key partner for first and last-mile deliveries, providing bike courier services and warehousing activities, but had to re-evaluate their approach after Dropper's bankruptcy.

Eventually, a joint trial between the three companies was proposed to optimize logistics in the inner city through sustainable measures, facilitated under the framework of the ULaaDS project. The initial version of the trial had ECOkoeriers, a local bike courier service, providing consolidated pick-ups from inner-city merchants using UPS and bpost for parcel delivery, driving the parcels to bpost's microhub for sorting and onward delivery. However, due to hesitancy and lack of formal agreement from the partners, especially UPS, the trial was redefined. In the second version, UPS objected to having their parcels sorted at a bpost hub. It was proposed that ECOkoeriers would pick up and transport parcels from both UPS and bpost using cargo bikes and then drop them off at respective pick-up/drop-off points. The forum held to discuss the joint trial showed lack of interest from retailers, and concrete input was lacking. A third version of the trial attempted to establish agreements between bpost and ECOkoeriers and UPS and ECOkoeriers, however, issues with subcontractors led to further complications. The lack of progress and extended time taken in defining the trial led UPS to prefer ceasing its efforts, with bpost making a similar statement, ultimately stalling the process.

3.1.2 Operating model validation Mechelen trial 1

The envisioned primary role of ECOkoeriers would be as an intermediary service provider, acting as a bridge between larger delivery companies such as UPS and BPO, and local businesses. The operating model would involve ECOkoeriers picking up parcels from merchants, consolidating these pickups, and then delivering them to a central location where they would be sorted and prepared for delivery. As these pickups have been identified as a loss-making activity for the larger delivery companies, ECOkoerier's involvement would present an opportunity to streamline this process and make it more efficient. Potentially, this could not only save costs for the larger delivery companies, but it could also potentially reduce traffic and emissions in the city center, contributing to the sustainability goals of the city of Mechelen. Given the local nature of ECOkoerier's operations, they would be well-positioned to understand and cater to the specific needs of Mechelen's businesses and consumers. This local knowledge and flexibility could also provide additional benefits in terms of service quality and responsiveness.

The success of this intermediary model is contingent on the seamless alignment of operational processes between three independent entities—ECOkoeriers, UPS, and BPO—while also negotiating mutually beneficial business agreements. It is essential to clearly outline the cost components for each transport leg to ensure fair distribution of benefits and responsibilities. The trial demonstrated the complexity of this endeavor, as parcel delivery companies are often highly protective of their brand recognition and fiercely competitive over market shares, making collaboration with a third-party, white-label service provider challenging. Additionally, the intricacy of the operating model increases due to the frequent use of subcontractors by larger delivery companies. Therefore, negotiations and agreements need to not only involve the primary delivery companies but also their subcontracted operations.

3.1.3 Business model validation Mechelen trial 1

Table 3.2 shows the business model canvas that was developed prior to the trial and discussed in detail in deliverable D3.3. The mission statement for the trial was to offer local retailers an option for sustainable urban freight transport, particularly for their outgoing parcels. Important elements of the value proposition include facilitating the sharing of vehicles and hub facilities across multiple providers, and in doing so, providing a service for picking up urban freight that is both cost effective and sustainable.

Table 3.2 Business model canvas for collaborative management of urban freight transport in Mechelen Trial 1 from D3.3.

<table>
<tr><td colspan="5">Mission statement: To offer local retailers an option for sustainable urban freight transport</td></tr>
<tr><td rowspan="2">Key partnerships:
1. Logistics providers with potential resources to be shared.
2. Local authorities.</td><td>Key activities:
1. Picking up freight at local retailers.
2. Transporting consolidated shipments to micro hub or urban consolidation centre.
3. Transporting goods from micro hub or urban consolidation centre further into the supply chain.
4. Facilitate information flows between different actors in the network.</td><td rowspan="5">Value proposition:
1. To facilitate the sharing of vehicles and hub facilities across multiple providers.
2. To provide a cost effective and sustainable service for picking up urban freight.</td><td>Buy-in & support:
1. Local retailers for using the shared service.</td><td rowspan="2">Beneficiaries:
1. Local retailers gain from a sustainable urban freight transport solution.
2. Logistics service providers gain from more efficient operations.
3. Citizens and other people staying in the city benefit from improved efficiency (e.g., less vehicles, fewer buildings for logistics)</td></tr>
<tr><td>Key infrastructure and resources:
1. Micro hubs and urban consolidation centres.
2. Cargo bikes & other last-mile vehicles.
3. Vans and trucks for transport further in supply chain.
4. Information system accessible to logistics providers and retailers.</td><td>Deployment:
1. Agreements about different roles of logistics service providers.
2. Identify locations of micro hubs and consolidation centres to be used.
3. Agree on tariff structure for retailers and between logistics service providers.
4. Design information sharing scheme.</td></tr>
<tr><td colspan="2">Budget costs:
1. Fixed and variable cost of the micro hubs and consolidation centres.
2. Cost of operating the cargo bikes, other last-mile vehicles and transport further in the supply chain.
3. Transaction cost of information sharing.</td><td colspan="2">Revenue streams:
1. Fee from local retailers using the service.
2. Tariff structure among logistics service providers involved.</td></tr>
<tr><td colspan="2">Environmental costs:
1. Energy for operating micro hubs and consolidation centres.
2. Energy for operating cargo bikes and other vehicles.</td><td colspan="2">Environmental benefits:
1. Reduced greenhouse gas emissions from better utilization of existing logistics resources.</td></tr>
<tr><td colspan="2">Social risks:
1. Weaker market position for logistics providers that are not active on the platform.
2. More traffic around micro hubs or urban consolidation centres.</td><td colspan="2">Social benefits:
1. Better matching of vehicle size to city context.
2. A reduced number of vehicles operating in the city, potentially leading to reduced congestion and less parking required.
3. Reduced real estate pressure.</td></tr>
</table>

Although the trial did not reach implementation stage important learnings for the business model of collaborative, zero-emission urban freight transport solutions can be derived from the trial design and preparation stages. The main lessons learned are reflected in Table 3.3, presenting the validated business model canvas collaborative management of urban freight transport. Prior to the trial, the value proposition was built on two key elements. Firstly, from the perspective of enhancing city liveability, the envisioned solution aimed to foster the sharing of vehicles and hub facilities among different providers operating in the city. This approach was expected to yield significant environmental and societal benefits by reducing traffic congestion and emissions. Secondly, from a commercial standpoint, the value proposition emphasized the potential efficiency gains through the consolidation of pickups at local shops. The expectation was that this consolidation would offer a more cost-effective alternative to each delivery company conducting separate pickups, thus generating tangible financial benefits.

Ultimately, the trial highlighted that the cost of implementing the solution exceeded the perceived value it offered. Despite the positive intentions and aspirations behind the value proposition, the reality of the operational and competitive landscape rendered it insufficient to work around several implementation hurdles, including safety concerns, subcontractor complications, resistance from competitors, and lack of interest from retailers, counter the value proposition.

Table 3.3 Validated business model canvas for collaborative management of urban freight transport.

<table>
<tr><td colspan="5">Mission statement: To offer local retailers an option for sustainable urban freight transport</td></tr>
<tr><td rowspan="2">Key partnerships:
1. Logistics providers with potential resources to be shared.
2. Local authorities.</td><td>Key activities:
1. Picking up freight at local retailers.
2. Transporting consolidated shipments to micro hub.
3. Transporting goods from micro hub or urban consolidation centre further into the supply chain.
4. Facilitate information flows between different actors in the network.</td><td rowspan="5">Value proposition:
1. To facilitate the sharing of vehicles and hub facilities across multiple providers.
2. To provide a cost effective and sustainable service for picking up urban freight.</td><td>Buy-in & support:
1. Local retailers for using the shared service.</td><td rowspan="2">Beneficiaries:
1. Local retailers gain from a sustainable urban freight transport solution.
2. Logistics service providers gain from more efficient operations.
3. Citizens and other people staying in the city benefit from improved efficiency (e.g., less vehicles, fewer buildings for logistics)</td></tr>
<tr><td>Key infrastructure and resources:
1. Micro hubs and urban consolidation centres.
2. Cargo bikes & other last-mile vehicles.
3. Vans and trucks for transport further in supply chain.
4. Information system accessible to logistics providers and retailers.</td><td>Deployment:
1. Agreements about different roles of logistics service providers.
2. Identify locations of micro hubs and consolidation centres to be used.
3. Agree on tariff structure for retailers and between logistics service providers.</td></tr>
<tr><td colspan="2">Budget costs:
1. Fixed and variable cost of the micro hubs and consolidation centres.
2. Cost of operating the cargo bikes, other last-mile vehicles and transport further in the supply chain.</td><td colspan="2">Revenue streams:
1. Fee from local retailers using the service.
2. Tariff structure among logistics service providers involved.</td></tr>
<tr><td colspan="2">Environmental costs:
1. Energy for operating micro hubs and consolidation centres.
2. Energy for operating cargo bikes and other vehicles.</td><td colspan="2">Environmental benefits:
1. Reduced greenhouse gas emissions from better utilization of existing logistics resources.</td></tr>
<tr><td colspan="2">Social risks:
1. Little interest from logistics providers.
2. Little interest from customers.</td><td colspan="2">Social benefits:
1. Better matching of vehicle size to city context.
2. A reduced number of vehicles operating in the city, potentially leading to reduced congestion and less parking required.
3. Reduced real estate pressure.</td></tr>
</table>

Key activities within the collaborative management of urban freight transport include picking up freight at local retailers by cargo bikes, transporting pickups from multiple local retailers to a micro hubs, and delivering the goods from the hub to further destinations in the supply chain. The key resources, including vehicles, hubs, and information systems to execute these activities were in place, but the trial encountered significant implementation hurdles, such as safety concerns, subcontractor complications, and lack of interest from retailers, leading to challenges in executing these key activities effectively. The trial also demonstrated the need for changing operational processes to optimize efficiency, ensuring interoperability between the operations and information systems of the logistics service providers involved. Partnerships among logistics service providers and between logistics service providers and the local authority are crucial for the success of collaborative urban freight transport. However, the trial revealed that the lack of consensus, cooperation, and formal agreements hindered the establishment of strong partnerships and impeded the smooth operation of the integrated management system.

The cost difference would result from changes in the operations from each individual delivery company picking up goods from the local shops to a joint pickup by one party. The expectation was that there would be no extra operational cost per se because the solution relied on existing micro hubs and consolidation centres, while there might be costs involved with information sharing because of added transactions. These transaction costs do not come forward as a cost component. Instead, compared to the initial situation, a new, neutral organization got involved in the process. The idea was that this would reduce resistance between the other two, fiercely competing, delivery companies. Yet, the new organization's business model for the solution is fully dependent on the pick-ups alone and cannot leverage profits further in the supply chains to effectively subsidize pick-ups. At relatively low volumes, the organization still needs a business model that could lead to profitability, which may even add to the cost of picking up goods at local shops. The anticipated environmental costs were negligible because of the use of cargo bikes and existing hub infrastructure. The anticipated risks of a weaker market position for logistics providers that are not active on the platform and increased traffic around the micro hubs did not materialize. Instead, a key social risk appeared a lack of interest in the solution from potential users, but at the service provider side as on the customer side.

The trial highlighted the importance of engaging and securing buy-in from all relevant stakeholders, including local shopkeepers, logistics service providers, and the local authority. While involving stakeholders from the early stages of the trial, addressing their concerns, and fostering a sense of ownership and shared responsibility are crucial for success, the trial also underscores the challenges involved in establishing formal agreements. Because not many local shops are willing to pay a fee for shared pick-ups, the key revenue flows involve cost re-allocations among the logistics providers involved. In setting up the trial, however, the logistics service providers could not formalize a tariff structure among themselves that fits with the role they play in the operation. Deployment also got challenged by the selection of a micro hub, which initially was a micro hub operated by one of the larger delivery companies. Throughout the trial preparations, one aspect remained unquestioned: the envisioned environmental and social benefits that motivated the initiation of the project. These benefits included reduced greenhouse gas emissions through the optimized utilization of existing logistics resources and better matching of vehicle size to the city context. Moreover, the potential for social advantages, such as a decreased number of vehicles operating in the city, which could alleviate congestion and reduce the demand for parking spaces, were recognized.

3.2 Mechelen trial 2

Trial 2 was aimed at experimenting with the use an autonomous vehicle, the focus is on the effective integration of passenger and urban freight mobility services (Solution 2) by means of shared vehicle use (Scheme 5) as indicated in Table 3.4. Specifically, VIL and the city of Mechelen (MEC) agreed to test the concept of cargo-hitching – the combination of freight and public transport – using an autonomous shuttle.

Table 3.4 ULaaDS solution and scheme Mechelen trial 2

Solution	Scheme
2) Effective integration of passenger and urban freight mobility services and networks	5. Transport vehicle capacity sharing

3.2.1 Mechelen trial 2 implementation

During the trial preparation research, five potential scenarios for implementing autonomous shuttles in Mechelen were proposed to stakeholders, including policy makers, technology providers, academic experts, and business representatives. The chosen scenario involved cargo-hitching with an autonomous vehicle at a business park.

The preparations for the trial began in 2021 with a feasibility study and creation of a tender for subcontracting the vehicle service deployment. An external company, Easy Mile, was subcontracted to operate the autonomous shuttle for the trial. After concluding the tender procedure, the process to obtain a permit were initiate. The process took five months to complete and there were some complications during this stage. Both regional (Flanders) and national (Belgium) governmental departments were reluctant to assume the responsibility of granting the permit. The national department of transport initially considered this to be a regional task, since the trials would be performed on regional roads. The regional government, however, was hesitant to accept this role. The situation was resolved when the national Minister of Transport personally granted the permit based on a positive risk assessment and required documentation for the vehicle.

The testing started in June 2022, initially focusing on passenger transport alone, and later a locker system was installed to validate the cargo-hitching scheme for transporting people and packages. Each of these two phases lasted for about a month. The focus in this deliverable is on the cargo-hitching part of the solution as tested in the second phase.

3.2.2 Operating model validation Mechelen trial 2

The business park “Mechelen-Noord” was selected for a route has a length of a little over 2 kilometres, consisting of six stops, and operated on weekdays from 11 am till 6 pm. To facilitate cargo hitching, the main stop was located near a parking spot with an existing bpost parcel locker, and—in the second month of testing—a parcel locker was installed on-board the autonomous vehicle and integrated into the daily operations of bpost. The route was operated by an electric autonomous vehicle owned by Easy Mile, with a capacity of 9 people after installing the on-board parcel locker. The locker system had three small and three medium-sized compartments.

Using the autonomous vehicle for passenger transport required users to open a website, showing a map of the route as well as the real-time location of the vehicle, and clicking on the stop from which they would like to depart. Looking at the overall process, the on-board parcel locker functions as any regular parcel locker, in this case one of bpost. A consumer can hence simply choose the on-board parcel locker from the delivery options during checkout, and the parcel will be delivered in that locker.

From an operating model perspective, the trial revealed challenges for both the logistics service provider delivering into an on-board locker as well as for consumers picking it up. For the logistics service provider, it is easier to deliver into a stationary parcel locker system or, in the case of a business park, hand a parcel off at the reception desk of an office building. The on-board locker has a very low capacity and, because it is on board an autonomous vehicle, is harder to locate. The latter also holds for consumers. If a consumer was anyway using the shuttle service for mobility purposes, collecting a parcel would not result in additional waiting time. If, however, the consumer simply wants to collect the parcel, having the locker on board a moving vehicle involves additional steps, such as knowing where the vehicle is and when it will arrive at a particular stop.

3.2.3 Business model validation Mechelen trial 2

Table 3.5 shows the business model canvas that was developed prior to the trial and discussed in detail in deliverable D3.3. The aim of the research trial 2 in Mechelen was not to directly deploy a full-scale operational combining passenger and urban freight transport service with autonomous vehicles. Rather, the aim was to explore how an autonomous vehicle can be used for both passenger and urban freight transport, with a focus on parcel collection and delivery services. This is reflected in the exploratory mission statement for the trialled solution.

3.5 Business model canvas for integrating passenger and urban freight transport using an autonomous vehicle in Mechelen Trial from D3.3.

Mission statement: To explore a service that combines passenger and urban freight transport by means of an autonomous vehicle				
Key partnerships: 1. Company or campus that wants to adopt an autonomous vehicle on-site. 2. Manufacturers and/or operator(s) of the autonomous vehicle and parcel locker.	**Key activities:** 1. Identify an area and route where the autonomous vehicle can be tested. 2. Program route and schedule of the vehicle. 3. Enable loading and unloading of the passengers and goods from the vehicle.	**Value proposition:** 1. To provide a service for passenger transport. 2. To provide a service for urban freight transport.	**Buy-in & support:** 1. Legislators writing rules and regulations or consider statutory exemptions for autonomous vehicles. 2. Passengers need to accept goods in vehicle. 3. Stakeholders offering goods for transportation.	**Beneficiaries:** 1. Company using the autonomous vehicle for passenger transport. 2. Local authority. 3. Company or campus on which autonomous vehicle operates.
	Key infrastructure and resources: 1. Autonomous vehicle. 2. Solution for transporting urban freight on autonomous vehicle. 3. Restricted area on which autonomous vehicle is allowed to drive without driver.		**Deployment:** 1. Form an alliance of actors (e.g., logistics service provider, autonomous vehicle manufacturer/operator) to deploy the service. 2. Determine on the use of one or more parcel lockers in relation to the service.	
Budget costs: 1. Operational cost of operating the autonomous vehicle and for preparing its trajectory. 2. Operational costs involved with loading and unloading the vehicle.			**Revenue streams:** 1. External funding explicitly geared towards trials with autonomous vehicles.	
Environmental costs: 1. Energy use for manufacturing the autonomous vehicle. 2. Energy use for operating the autonomous vehicle. 3. Energy involved with making Infrastructure changes.			**Environmental benefits:** 1. Reduced greenhouse gas emissions.	
Social risks: 1. Safety of other road users where autonomous vehicle operates.			**Social benefits:** 1. More flexible parcel delivery by additional service option.	

The trial was successful in that it provided an opportunity to explore the solution in-depth and gaining insight into the extent to which integrating passenger and urban freight transport in an autonomous vehicle provides value. The main lessons learned are reflected in Table 3.6, presenting a validated business model canvas for this solution. Notably, the did not confirm the initial value propositions. The fundamental premise of the solution was that separately, an autonomous passenger transport service and an autonomously mobile parcel locker have a challenging business case, but that combined they would have a clearer path towards commercial success. By combining two services in one, fewer vehicles might be required to provide the same level of service, saving on fuel, and maintenance. Passengers could send or receive parcels directly from the autonomous vehicle, reducing the need to travel or wait for deliveries at home. And, by offering additional services, such as parcel delivery, there could be opportunities for extra revenue streams beyond passenger fares. Key elements of this value proposition were to provide services for passenger transport and urban freight transport in one combined solution.

3.6 Validated business model canvas for integrating passenger and urban freight transport using an autonomous vehicle.

Mission statement: To explore a service that combines passenger and urban freight transport by means of an autonomous vehicle				
Key partnerships: 1. Provider and/or operator(s) of the autonomous vehicle 2. Logistics provider 3. Partnerships between local and national government for permit 4. Campus or industrial area that wants to adopt an autonomous vehicle on-site	**Key activities:** 1. Identify an area and route where the autonomous vehicle can be tested. 2. Program route and schedule of the vehicle. 3. Enable loading and unloading of the passengers and goods from the vehicle	**Value proposition:**	**Buy-in & support:** 1. Legislators writing rules and regulations or consider statutory exemptions for autonomous vehicles 2. Passengers need to accept goods in vehicle 3. Logistics provider	**Beneficiaries:** 1. Local government. 2. National government
	Key infrastructure and resources: 1. Autonomous vehicle. 2. On-board parcel locker system. 3. Area on which autonomous vehicle is allowed to drive without driver.		**Deployment:** 1. Form an alliance of actors (e.g., logistics service provider, autonomous vehicle provider) to deploy the service. 2. Determine the route and operate the vehicle.	
Budget costs: 1. Cost of operating the autonomous vehicle and for preparing/maintaining the necessary infrastructure. 2. Operational costs involved with loading and unloading the vehicle.			**Revenue streams:** 1. External funding explicitly geared towards trials with autonomous vehicles.	
Environmental costs: 1. Energy use for operating the autonomous vehicle.			**Environmental benefits:** 1. Emission reduction from using electric vehicle compared to internal combustion engine alternative.	
Social risks: 1. Safety of other road users where autonomous vehicle operates. 2. Perceived safety of passengers.			**Social benefits:**	

These initial value propositions didn’t prove to be viable during the trial. Autonomous vehicles rely on advanced technologies, including machine learning algorithms, sensors, and mapping technologies. These systems need to function flawlessly for safe and efficient operations. However, difficulties can arise in maintaining consistent service levels across diverse and changing urban environments. Factors like weather conditions, roadworks, and other unpredictables can significantly impact the system's performance. These complications make the development of routes that can accommodate individual passenger pick-up and drop-off points a significant challenge. Adding an on-board parcel locker presents additional hurdles. Customers need to be aware of the vehicle’s route and potentially uncertain time schedule for the collection and return of parcels. The trial suggests that, instead of creating synergies, the combination of passenger transport and the collection and return of parcels seems to exacerbate the challenges that each individual service faces. Other value propositions, such as using the autonomous vehicle to supply static parcel lockers, were explored but not deemed viable in the current socio-technological context.

The key activities explained in D3.3 were validated in the trial, and involve identifying a suitable route, creating a schedule, and organizing for the loading and unloading of both passengers and goods. In the trial, the parcel locker was integrated into the vehicle and existing operations of the delivery company. Other infrastructure and resources include the autonomous vehicle itself and the area on which the route is operated. The latter proved a more critical resource than anticipated, as the smooth functioning of the vehicle required changes to the road and surrounding fauna. Another important lesson was the need for close cooperation between different levels of government to enable a permit for the operations. Partnership with the provider of the vehicle served as a catalyst for this cooperation while the logistics provider took the processes involved with the on-board parcel locker on. The partnership with a campus or industrial zone proved mainly important in early stages of the trial and for stakeholder engagement.

In line with remarks about the value proposition, the envisioned beneficiaries perceived little benefit from the solution in its current state. That does not mean the trial should be seen as a failure. It yielded valuable insights that can guide the next steps in exploring the business model, whether that means revising the service offerings, targeting a different market, or reconsidering the operating model. The trial also provide valuable insights for local and national governments for autonomous transport more generally. In the present stage, local and national governments are hence key beneficiaries of tests with new autonomous transport solutions.

The initial environmental and societal costs and benefits have been explored in the trial. Safety of other road users was an important focus point during the trial, and the trial suggest such safety can be guaranteed. A novel insight was that this partially seems to come at the expense of perceived safety of passengers inside the vehicle, who noticed sudden stops and manoeuvres of the autonomous vehicle to avoid unsafe situations for other road users. No social benefits emerged during the trial. Insight was gained in the energy use of operating the vehicle—emissions involved with vehicle manufacturing and infrastructure were left outside the scope of the trial. While potentially, the solution could reduce the overall number of vehicles needed for separate delivery and passenger services, and thereby potentially emissions, no data was collected supporting such benefits. The stakeholders mainly stressed the environmental benefits of having an electric vehicle, instead of one with an internal combustion engine.

4. Bremen trials

The primary focus of the two research trials in Bremen is on scaling up containerised urban freight transport and to explore systems for combining passenger transport with urban freight transport. The trials align with Bremen's urban sustainability plan and address both ULaaDS solutions across three schemes. The validation of the business and operational models that underpin these solutions is detailed in this chapter.

4.1 Bremen trial 1

In Trial 1, the city of Bremen (BRE) and Rytle (RYT) continued their ongoing collaboration by operating two new micro hubs—in addition to the existing one. The existing micro hub, located on the Jakobikirchhof in the inner city, has been operational since 2019. In May 2022 a second container was located back-to-back with the first hub. Another new microhub opened in July 2021 in Viertel. Both locations were used for the trialling of containerized last-mile logistics in a B2B setting, addressing ULaaDS Solution 1 and Scheme 1, as indicated in Table 4.1.

Table 4.1 ULaaDS solution and scheme Bremen trial 1

Solution	Scheme
1) Collaborative delivery models to enhance logistics efficiency and multimodal mobility in cities	1. Containerised urban last-mile delivery

4.1.1 Bremen trial 1 implementation

After important learnings from using containerised logistics in the courier express freight sector in Bremen, research trial 1 focused deliberately on applying the concept to general cargo in a B2B setting. To this end, the location Jakobikirchhof was not only used for parcel deliveries, but also for much larger B2B deliveries to shops in the inner city. Several locations were considered for new micro hubs, and finally the decision was made to locate a second hub at the original location at the Jakobikirchhof, and a new one in the city district Viertel. The two micro hubs at the Jakobikirchhof operate on public space using a special permit; the new one in Viertel is located on a commercial car park. To that end, three parking spots were rented long term for the micro hub. By the end of March 2023, the financing of the parking spots ended, and the micro hub operations seized—at least temporarily.

The B2B focus resulted in new partners supplying the goods, including a logistics service provider from a nearby freight village and another party supplying pharmacies and medical devices. The logistics service provider handled shipments with an average size above 60 kilograms, the party supplying pharmacies and medical devices has much smaller shipments providing for an interesting contrast.

4.1.2 Operating model validation Bremen trial 1

One of the key novelties of trial 1 in Bremen is that it wants to facilitate the use of small-sized, zero-emission vehicles in the last-mile delivery of general cargo. Cargo bikes and other smaller, zero-emission vehicles have been proven effective and efficient in the express freight and parcel delivery sectors, which face time-critical and small-sized deliveries. General cargo, by contrast, can be much more voluminous and heavier. Indeed, the typical shipment weight of above 60 kilograms in the research trial yielded interesting new challenges for the operating model.

Project partner Rytle provided important resources and infrastructure for the trial. Specifically, its e-cargo bikes were used for the last mile. The MovR3 is the latest generation of Rytle's e-cargo bikes. It is equipped with full suspension, can carry larger volumes and shipments with a total weight of up to 370 kilograms. Furthermore, Rytle provides its standardised loading units, called RYTLE BOX and RYTLE HUB. The RYTLE HUB has space for 9 RYTLE BOXes, which in case of parcel delivery can be pre-sorted before the RYTLE HUB is moved to a central location from where the Rytle bikes are starting their delivery routes—loading the pre-sorted RYTLE BOXes on the vehicle in one go.

The goods for delivery during the trial were provided by a logistics service provider. Only deliveries in the inner city were transported via a micro hub. The logistics service provider also serves many other customers outside the inner city, and the broader region. Making use of the option to pre-sort the RYTLE BOXes, placing them in the RYTLE HUB on-site at the freight village, and transporting the full RYTLE HUB to the micro hub location would require considerable changes to the operational planning of the logistics service provider. That is, shipments for the inner city would need to be removed from one or more existing routes operated by heavy freight trucks, and handled via the Rytle equipment at the logistics service provider's facility.

Instead, the logistics service provider opted to group inner city shipments in one truck route and include a transhipment at the micro hub location as part of the route of one 7,5t truck. At the micro hub location, shipments are unloaded from the truck, and loaded either directly onto an available e-cargo bike or loaded into the RYTLE HUB. Those shipments will be loaded onto a cargo bike later, after completing previous trips. Because of the more voluminous and heavier shipments, routes of the Rytle e-cargo bikes in the trial typically involve one or a few stops. This makes that a micro hub location close to the delivery locations becomes even more important. Otherwise, the vehicles would frequently spend a relatively large distance traveling between the micro hub and delivery locations.

4.1.3 Business model validation Bremen trial 1

Table 4.3 shows the business model canvas that was developed prior to the trial and discussed in detail in deliverable D3.3. The mission of the trialled solution was to facilitate the use of small-sized, zero-emission vehicles in the last-mile delivery of general cargo.

Table 4.2 Business model canvas for containerised urban last-mile delivery in Bremen Trial 1 from D3.3.

<table>
<tr><td colspan="5">Mission statement: To facilitate the use of small-sized, zero-emission vehicles in the last-mile delivery of general cargo</td></tr>
<tr><td rowspan="2">Key partnerships:
1. Manufacturer of standardized loading units and containers.
2. Manufacturer of cargo bikes.
3. Suppliers delivering goods for delivery via the containerised urban last mile.</td><td>Key activities:
1. Load goods into standardized loading units at the warehouse.
2. Load loading units into container.
3. Transport container with loading units towards delivery area.
4. Position container at location near delivery area.
5. Operate last-mile delivery routes.</td><td rowspan="5">Value proposition:
1. To enable the integration of smaller zero-emission vehicles into urban last-mile delivery network.
2. To provide efficient transhipment for last-mile delivery.
3. To optimise vehicle capacity utilisation.</td><td>Buy-in & support:
1. Local authority for finding appropriate location and providing permits for transhipment points, as well as appropriate road infrastructure for cargo-bikes.
2. Courier willingness to operate cargo-bikes.</td><td rowspan="2">Beneficiaries:
1. Carrier/suppliers by enabling more cost-effective transport.
2. City visitors and residents by more sustainable last-mile delivery process.
3. Local authorities and all stakeholders due to reduced environmental, safety- and health-related costs.</td></tr>
<tr><td>Key infrastructure and resources:
1. Warehouse location.
2. Transhipment location.
3. Standardized loading units.
4. Containers.
5. Truck/van and driver for transporting containers.
6. Cargo bikes and couriers for last-mile deliveries.</td><td>Deployment:
1. Changes to operational processes to enable integration of loading units and containers.
2. Planning of feeder routes towards city and last-mile routes.</td></tr>
<tr><td colspan="2">Budget costs:
1. Total cost of ownership (manufacturing/acquisition, operational, maintenance, etc.) involved with the standardized loading units.
2. Total cost of ownership involved with containers.
3. Total cost of ownership involved with cargo bikes, including wages of couriers operating the bikes.</td><td colspan="2">Revenue streams:
1. Last-mile delivery fee for user of the solution.
2. End-receiver of goods willing to pay more for sustainable last-mile delivery, and/or willing to wait so that last-mile delivery efficiency can be improved.</td></tr>
<tr><td colspan="2">Environmental costs:
1. Energy use involved with the manufacturing of the standardized loading units, containers, and vehicles.
2. Energy use of cargo bikes and the vehicle transporting the container from the warehouse to the transhipment location.
3. Energy use of the warehouse.</td><td colspan="2">Environmental benefits:
1. Reduced total greenhouse emissions involved with last-mile delivery due to consolidation on-route to transhipment point.
2. Reduced greenhouse gas emissions and noise pollution in last-mile delivery route by enabling the use of smaller zero-emission vehicles.</td></tr>
<tr><td colspan="2">Social risks:
1. Use of parking space for container if that would otherwise be dedicated to public usage (e.g., café terraces).
2. Low paid work for material handlers.
3. Attracting additional freight flows from/to the transhipment point due to smaller-sized vehicles.</td><td colspan="2">Social benefits:
1. Smaller (zero-emission) vehicles in city centre and streets
2. (Low skilled) jobs for citizens in the area.
3. Safer streets due to reduced number of large freight vehicles.</td></tr>
</table>

Table 4.3 provides a validated business model canvas for urban last-mile delivery of general cargo with small-sized, zero-emission vehicles, and includes important learnings from trial 1 in Bremen. The mission statement was validated in that the trial has proven that the solution makes the use of cargo bikes for general cargo bikes feasible. In terms of the value proposition, the solution provides a means to find and exploit suitable locations for transhipment of general cargo, from larger trucks to smaller, zero-emission vehicles. In turn, this transhipment can help reduce the number of large trucks entering the inner city. Especially in older European cities, several urban areas are not designed for urban freight transport, and hence benefit from delivery via smaller vehicles.

An important learning from the trial is that for general cargo, pre-loading standardized loading units was deemed infeasible from an operating model perspective. This considerably affects the notion of containerized urban last-mile logistics, in that the container effectively becomes a stationary micro hub facility. That also changes the key partnerships, where the local authority plays an important role in identifying micro hub locations—potentially providing permits for use when located on public space. Other members of the partnership involve the logistics service provider(s) transporting goods via the micro hub location and the last-mile delivery service provider operating the smaller-sized, zero-emission vehicles on the last mile. Key activities simplified to include loading of goods at the logistics service provider’s warehouse, transhipping those goods at the micro hub location, and delivering the goods with the smaller-sized, zero-emission vehicles. Key resources and infrastructure include the location for the micro hub, the truck(s) and/or van(s) used to transport the goods to the hub, the hub facility itself, and the last-mile delivery vehicles.

Table 4.3 Validated business model canvas for urban last-mile delivery of general cargo with small-sized, zero-emission vehicles.

<table>
<tr><td colspan="5">Mission statement: To facilitate the use of small-sized, zero-emission vehicles in the last-mile delivery of general cargo</td></tr>
<tr><td rowspan="2">Key partnerships:
1. Local authority for identifying micro hub location and providing permit for use
2. Logistics service provider(s) for delivery via the micro hub
3. Last-mile delivery service provider</td><td>Key activities:
1. Load goods into truck at the logistics service provider's warehouse
2. Tranship goods from truck directly onto last-mile delivery vehicle or into micro hub
3. Operate last-mile delivery routes</td><td rowspan="5">Value proposition:
1. To reduce the number of large trucks delivering in the inner city
2. To provide an efficient location for transhipment for last-mile delivery.</td><td>Buy-in & support:
1. Local authority for finding appropriate location and providing permits for transhipment points
2. Courier willingness to operate cargo-bikes.
3. Logistics service providers willing to use the micro hub location</td><td rowspan="2">Beneficiaries:
1. City visitors and residents by more sustainable last-mile delivery process.</td></tr>
<tr><td>Key infrastructure and resources:
1. Transhipment location and hub
2. Truck/van and driver for transporting goods.
3. Last-mile delivery vehicle(s)</td><td>Deployment:
1. Changes to operational processes to facilitate transhipment
2. Planning of feeder routes towards city and last-mile routes</td></tr>
<tr><td colspan="2">Budget costs:
1. Total cost of ownership (manufacturing/acquisition, operational, maintenance, etc.) involved with the hub facility.
2. Total cost of ownership involved with last-mile delivery vehicles.
3. Transhipment costs</td><td colspan="2">Revenue streams:
1. Logistics service provider renting different equipment involved with the containerized last-mile solution.</td></tr>
<tr><td colspan="2">Environmental costs:
1. Energy use involved with the manufacturing of the micro hub and last-mile delivery vehicles.
2. Energy use of cargo bikes and the vehicle transporting the container from the warehouse to the transhipment location.
3. Energy use of the truck and warehouse location.</td><td colspan="2">Environmental benefits:
1. Reduced greenhouse gas emissions and noise pollution in last-mile delivery route by enabling the use of smaller zero-emission vehicles.</td></tr>
<tr><td colspan="2">Social risks:
N/A</td><td colspan="2">Social benefits:
1. Smaller (zero-emission) vehicles in city centre and streets
2. (Low skilled) jobs for citizens in the area.
3. Safer streets due to reduced number of large freight vehicles.</td></tr>
</table>

The implemented solution requires buy-in from the local authority in finding appropriate locations for the micro hub locations—and providing the necessary permits for placing the hubs on public spaces. A need for buy-in of couriers operating cargo bikes proved relatively easy as there are many couriers and companies willing to operate such vehicles. The trial revealed that in the current situation, buy-in of the logistics service provider may be most important. That is, deployment of the solution requires changes to operational processes of the logistics service provider to facilitate transhipment at the micro hub, and the planning of feeder routes towards city and last-mile routes. In the current setup and context, these changes decrease operational efficiency and hence result in a cost increase. Costs include the total cost of ownership involved with the hub facility and last-mile delivery vehicles as well as the cost involved with the operating time needed for transhipment (i.e., from unloading the goods from the truck to loading them onto the last-mile delivery vehicle or into the hub). Because the city is principally still reachable by truck, a logistics service provider needs to perceive societal and/or environmental benefit as outweighing these downsides. City visitors and residents are the main beneficiaries as last-mile delivery of general cargo involves smaller-sized vehicles that have a lower impact on the urban space and the environment.

Although a life cycle assessment of the solution was outside the scope of the trial, the manufacturing of the micro hub and last-mile delivery vehicles involve carbon emissions, and it is unlikely that those emissions were offset by any considerable improvements in last-mile efficiency during the trial. Such efficiency improvements were anticipated at the outset of the trial. By contrast, some of the anticipated social risk did not materialize. Specifically, there seems sufficient public space for micro depots that at the moment would not be easily used for other public services (e.g., café terraces), nor does the hub attract unwanted additional movements because of the smaller-sized last-mile delivery vehicles. Indeed, the solution provides social benefits in that it helps reduce the number of larger trucks entering the city. This may result in better use of urban spaces in the inner city and improve road safety. The solution also provides job opportunities for local residents.

4.2 Bremen Trial 2

Trial 2 targets the effective integration of passenger and urban freight mobility services. The first part of Trial 2 focuses on the transport of goods by individual citizens (e.g., transporting shopping or furniture items), referred to as private micro-logistics, with the aim to reduce car trips by familiarising users with cargo bikes without a need to buy one themselves. As a second part of Trial 2, the city of Bremen and VIA Technologies Europe (VIA) are to test a cargo-hitching scheme, where freight transport is combined with on-demand mobility. Table 4.4 shows how the two parts of this trail together address ULaaDS solution 2 and Schemes 4 and 5.

Table 4.4 ULaaDS solution and scheme Bremen Trial 2

Solution	Scheme
2) Effective integration of passenger and urban freight mobility services and networks	4. Location and infrastructure capacity sharing 5. Transport vehicle capacity sharing

4.2.1 Bremen trial 2 implementation

The first part of trial 2 in Bremen sought to add cargo bikes to the (existing) ADFC scheme—called Fietje—providing access to cargo bike for private micro-logistics to more Bremen residents. Specifically, four new cargo bikes were added, bringing the new total at 14 cargo bikes. The implementation involved finding “hosts”, typically small local stores or coffee bars, that would provide a location to park the bike and help taking care of it. The idea was to expand especially into neighbourhoods other than the densely populated ones in central Bremen. The second part of trial 2 involved a digital pilot of an urban on-demand cargo-hitching service in Bremen. The digital pilot explored using a fleet of vehicles for both an on-demand passenger transport service as well as for the transport of small cargo. This was done using VIAs simulation and modelling technology as well as by leveraging its vast operating experience with logistics pilots across the world, with the purpose of understanding the potential impact of a cargo-hitching scheme.

4.2.2 Operating model validation Bremen trial 2

The operating model of the Fietje bikes is straightforward. First-time users of the scheme must register via the website, before selecting a location to pick up the bike, a pick-up date and return date. Returning users can simply log in using the username and password created during registration. A cargo bike can be booked for a minimum of one day—the cargo bike can be returned earlier if possible—up to three days at a time. A booking confirmation with code with be send by email and should be showed together with an ID-card at the pick-up location. The cargo bikes have a maximum loading capacity of 80 kg. ADFC is responsible for finding “hosts” willing to act as location for a bike and with whom they can take care of the maintenance and other functionalities of the cargo bikes.

Deciding on a suitable operating model was in fact a key aspect of the digital cargo-hitching pilot, especially in relation to the transport of cargo. Passenger transport with VIA is arranged via an app, where travellers can input the start and end location of their trip, either days in advance, as part of recurring patterns, or just minutes before departure. Requests for passenger transport are then linked to a fleet of vehicles to meet the request in an on-demand manner. The question is how the transport of goods could be integrated effectively into the operational processes involved with meeting passenger demand. Various variants were considered, and two selected for further exploration. First, goods from local businesses within a residential zone for consumers in that zone are integrated with passenger transport. Second, small-sized and time sensitive shipment from business to business are integrated with passenger transport.

To determine the potential impact of these variants, four scenarios were analysed and compared. Scenario 1 is a passenger-only scenario, which serves as a baseline of the traditional operating model of VIA in regard to an on-demand passenger service. Scenario 2 is a cargo-only scenario, to understand how the resources that would be needed to fulfil demand for cargo delivery when not integrated with demand passenger transport. Scenarios 3 and 4 integrate demand for passenger and cargo transport, and hence are the cargo-hitching scenarios. Scenario 3 sketches a situation where all demand for cargo would be integrated while scenario 4 takes an incremental approach to explore what cargo demand volumes best match the full demand for passenger transport in terms of operational efficiency and environmental performance. The business-to-consumer variant was simulated, applying all four scenarios to a residential area in Bremen, using carefully selected input data from a reference city matching the local context.

Results from the digital pilot resulted in several important insights for the cargo-hitching operating model. Meeting full demand for passenger transport (i.e., 100 boardings per day) requires operating two vehicles, resulting in an average utilization of between 2.1-2.6 passengers per vehicle per hour, an average waiting time of 10-14 min before boarding, and a walking distance of 50-100 meters to board the vehicle. Meeting full demand for cargo transport (i.e., 200 packages per day) requires operating four vehicles, with similar utilization rates, a waiting time between 13-17 minutes, and pick up at the origin location. Integrating full demand for both passengers and cargo in this context would result in the need for 5 vehicles—one less than the sum of both. Interestingly, when incrementally adding cargo demand to the cargo-hitching system, an optimum is reach at 52 packages per day, which could effectively be integrated in the two vehicles needed for passenger transport anyway. As a result, operating cost could be reduced by 13% and a CO_2 emission reduction of 12 ton. These benefits would come at the expense of additional waiting time for passengers, to about 24-28 minutes.

4.2.3 Business model validation Bremen trial 2

Table 4.5 shows the business model canvas that was developed prior to the trial and discussed in detail in deliverable D3.3. It focuses on the ULaaDS solution where private citizens in Bremen can reserve and use a cargo bike for their household logistics. The mission statement was to provide a sustainable alternative for household logistics that would otherwise include the use of a car. Easy access to cargo bikes for household logistics at convenient locations is the main value proposition.

Table 4.5 Business model canvas for community driven cargo bike platform in Bremen Trial 2 from D3.3

<table>
<tr><td colspan="5">Mission statement: To provide a sustainable alternative for household logistics that would otherwise include the use of a private car</td></tr>
<tr><td rowspan="2">Key partnerships:
1. Individuals or small companies that are willing to act as temporary "renting station"
2. External funding bodies or donating organizations or individuals.</td><td>Key activities:
1. Identify suitable "renting stations" for the cargo bikes.
2. Design, implement and operate a website through which cargo bikes can be reserved.
3. Maintain cargo bikes.
4. Move cargo bikes from one "renting station" to the next.</td><td rowspan="5">Value proposition:
1. To provide easy access to cargo bikes for household logistics at convenient locations.</td><td>Buy-in & support:
1. Members for using the cargo bikes
2. Local authorities for stimulation use.</td><td rowspan="2">Beneficiaries:
1. City visitors and its residents by less unsustainable vehicles in the city.
2. Citizens can rent cargo bike for own needs (weight and load issues) with no need to possess a car or similar.</td></tr>
<tr><td>Key infrastructure and resources:
1. Cargo bikes.
2. Website through which cargo bikes can be reserved.</td><td>Deployment:
1. Integrate cargo bike system into existing scheme
3. Notify potential users about the existence of the cargo bike rental system.</td></tr>
<tr><td colspan="2">Budget costs:
1. Investment in cargo bikes.
2. Maintenance costs for keeping cargo bikes operational.
3. Cost for hosting and maintaining website for reservation</td><td colspan="2">Revenue streams:
1. Donations and/or external funding.</td></tr>
<tr><td colspan="2">Environmental costs:
1. Energy use for manufacturing the cargo bikes.
2. Energy for hosting the website</td><td colspan="2">Environmental benefits:
1. Reduced greenhouse gas emissions involved with transport due to use of cargo bikes instead of polluting vehicles.</td></tr>
<tr><td colspan="2">Social risks:
1. Temporary parking in public space when in use.
2. Lack of use, because availability of cargo bikes is limited, locations are inconvenient, or the initiative is not sufficiently known.</td><td colspan="2">Social benefits:
1. Smaller (zero-emission) vehicles in city centre and streets.
2. Increased visibility for cycling and active travel.</td></tr>
</table>

The research trial in Bremen provided important insights into the business model of community-driven cargo bike platforms, as shown in the validated business model canvas in Table 4.6. The fact that ADFC is a not-for-profit association has severe implications for the business model, especially in relation to partnerships, infrastructure and resources, budget, and revenue streams. Key activities for the platform are to acquire cargo bikes, identify suitable locations to station the cargo bikes, facilitate the website through which users can reserve the cargo bikes, and to maintain them. Cargo bikes can be reserved and used for free, although there is an option to give donations. As a result, the cargo bikes are usually acquired via external funding or donations, and key partnerships involve local shopkeepers willing to "host" a cargo bike and external funding bodies and donors.

Buy-in of local authorities to stimulate use amongst its citizens is key, as is the support from the users of the cargo bikes is important. An important lesson from the trial is that the latter involves being somewhat flexible in terms of use, not expecting a cargo bike to always be available on the location of first choice when looking on the website for a reservation. This has critical implications for the budget and revenue streams too. Because it's a community-driven platform, with the goal to provide as many people as possible the opportunity to try out a cargo bike, a deliberate choice was made not to charge a user fee. The logic is that charging a fee may start a vicious circle where flexible users become demanding customers, always expecting availability of cargo bikes, which in turn would increase costs to facilitate quick maintenance or spare bikes, which would increase user fees, which would make customers even more demanding, and so forth. Hence, the budget for investing in the cargo bikes and website as well as for operating expenses related to maintenance is limited and should match what is available from external funding and donations as revenue stream.

While cargo bikes have zero tailpipe emissions, their manufacturing does involve carbon emissions. Such emissions may be as much as 750 kg of CO_2 considering the full life cycle, of which a considerable part could be recouped via recycling. In light of those numbers, the environmental impact of hosting the website is neglectable. The environmental benefits include the avoided carbon emissions involved with car trips no longer done because of the cargo bike use. At the present number of cargo bike, the social cost of parking cargo bikes is small, especially in light of the public space needed for parking cars as an alternative. The platform is quite successful in its user rates and has proven an excellent way for people to try out a cargo bike and maybe buy one privately in case it is perceived as useful.

Table 4.6 Validated business model canvas for community driven cargo bike platform

Mission statement: To provide a sustainable alternative for household logistics that would otherwise include the use of a private car				
Key partnerships: 1. Individuals or small companies that are willing to act as temporary location. 2. External funding bodies or donors (organizations/ individuals).	**Key activities:** 1. Acquire cargo bikes. 2. Identify locations for the cargo bikes. 2. Design, implement and operate a website through which cargo bikes can be reserved. 4. Maintain cargo bikes.	**Value proposition:** 1. To provide easy access to cargo bikes for household logistics at convenient locations.	**Buy-in & support:** 1. Users of the cargo bikes. 2. Local authorities for stimulation use.	**Beneficiaries:** 1. City visitors and its residents by less unsustainable vehicles in the city. 2. Citizens can rent cargo bike for own needs (weight and load issues) with no need to possess a car or similar.
	Key infrastructure and resources: 1. Cargo bikes. 2. Website through which cargo bikes can be reserved.		**Deployment:** 1. Integrate cargo bike system into existing scheme 3. Notify potential users about the existence of the cargo bike rental system.	
Budget costs: 1. Acquisition of cargo bikes. 2. Maintenance costs for keeping cargo bikes operational. 3. Cost for hosting and maintaining website for reservation			**Revenue streams:** 1. Donations and/or external funding.	
Environmental costs: 1. Energy use for manufacturing the cargo bikes.			**Environmental benefits:** 1. Reduced greenhouse gas emissions involved with transport due to use of cargo bikes instead of polluting vehicles.	
Social risks: 1. Temporary parking in public space when in use.			**Social benefits:** 1. Smaller (zero-emission) vehicles in city centre and streets. 2. Easy way to try out cargo bike use.	

Table 4.7 shows the initial business model canvas for integrating passenger and urban freight transport. Its mission statement is to reduce congestion and emission in busy areas and offer cost-effective transport of passengers and urban freight. The main value propositions are to provide a valuable cargo transport service by optimizing vehicle use through integration with on-demand passenger transport services. This initial business model envisioned using public transportation.

Table 4.7 Business model canvas for integrating passenger and urban freight transport from D3.1

Mission statement: To reduce congestion and emission in busy areas and offer cost-effective transport of passengers and urban freight				
Key partnerships: 1. Passenger transport authority or company 2. Logistics providers involved with first and last mile	**Key activities:** 1. Schedule the integrated passenger and urban freight transportation services 2. Pick up, transport, and drop off parcels 3. Load, transport, and unload roll carriers or bags with parcels	**Value proposition:** 1. To provide a service for urban freight transport using passenger vehicles 2. Optimize load and vehicle usage	**Buy-in & support:** 1. Legislators writing rules and regulations or consider statutory exemptions for integrating urban freight transport in passenger vehicles 2. Passengers need to accept goods in vehicle	**Beneficiaries:** 1. Logistics service providers gain from cost-effective transportation of parcels to less busy areas of the city or its surroundings 2. Citizens and other people staying in the city benefit from improved efficiency (e.g., less vehicles) in busy areas of the city
	Key infrastructure and resources: 1. Decision support for planning the operations 2. Mobile app to guide drivers to passenger and parcel pick-up and drop-off locations 3. Passenger vehicles that enable transport of multiple parcels at once 4. Roll containers or bags for parcels		**Deployment:** 1. Form an alliance of actors (e.g., logistics service provider, public transport authority, collection point operator) to initiate the service 2. Identify areas where service will run 3. Identify public transport lines on which goods will be transported	
Budget costs: 1. Developing decision support and app that helps drivers pick up and drop off passengers and parcels 2. Transportation costs, or costs for detours needed to pick up and drop off parcels. 3. Designing or retrofitting vehicles that can carry both parcels and passengers			**Revenue streams:** 1. Fee per parcel transported 2. Cost saving from optimised routes and optimisation of vehicle capacity	
Environmental costs: 1. Greenhouse gas emissions involved with detours to pick up and drop off parcels 2. Greenhouse gas involved with first and last mile, depending on the vehicle used			**Environmental benefits:** 1. Reduced greenhouse gas emissions from better utilization of existing vehicles	
Social risks: 1. Passengers are exposed to potential dangers with parcels, such as dangerous goods (low probability). 2. Increased traffic due to inefficient transport of individual parcels by individual vehicles			**Social benefits:** 1. Additional income or work for drivers 2. A reduced number of vehicles operating in the city 3. More public transport services in less busy areas of the city due to increased cost-effectiveness	

Instead of public transportation, the second part of Bremen trial 2 considered using on-demand passenger transport services as a basis for the integration of cargo. The digital pilot provided novel insights that are used to update the business model canvas, as shown in Table 4.8. Key activities include the scheduling of transportation services, integrating demand for passenger transport with that for urban freight transport, as well as the physical pickup, transport, and drop off of passengers and parcels. Especially for parcels this may involve some walking between the vehicle and pickup and/or drop off location.

Table 4.8 Updated business model canvas for a platform providing on-demand passenger and urban freight transport services

<table>
<tr><td colspan="5">Mission statement: To reduce congestion and emission in busy areas and offer cost-effective transport of passengers and urban freight</td></tr>
<tr><td rowspan="2">Key partnerships:
1. Service provider executing the transport trips</td><td>Key activities:
1. Schedule the integrated passenger and urban freight transportation services
2. Pickup, transport, and drop off passengers
3. Pickup, transport, and drop off parcels</td><td rowspan="5">Value proposition:
1. To provide a service for urban freight transport using passenger vehicles
2. Optimize load and vehicle usage</td><td>Buy-in & support:
1. Legislators writing rules and regulations or consider statutory exemptions for integrating urban freight transport in passenger vehicles.
2. Drivers' willingness to pick up and drop off parcels.
3. Passengers need to accept goods in vehicle and slightly longer response times.</td><td rowspan="2">Beneficiaries:
1. Transport service provider gains from cost-effective transportation of parcels.
2. Citizens and other people staying in the city benefit from improved efficiency (e.g., less vehicles) in busy areas of the city</td></tr>
<tr><td>Key infrastructure and resources:
1. Decision support for scheduling the integrated services
2. Mobile app to guide drivers to passenger and parcel pick-up and drop-off locations
3. Vehicles that enable transport of passengers and parcels.</td><td>Deployment:
1. Identify areas where service will run
2. Identify transport service provider
3. Deploy app and attract users (passengers and local shops).</td></tr>
<tr><td colspan="2">Budget costs:
1. Development and operation of scheduling algorithms and app
2. Operating cost of transport service provider</td><td colspan="2">Revenue streams:
1. Fee per parcel transported
2. Fee per passenger</td></tr>
<tr><td colspan="2">Environmental costs:
1. Greenhouse gas emissions involved with detours to pick up and drop off parcels</td><td colspan="2">Environmental benefits:
1. Reduced greenhouse gas emissions from better utilization of existing vehicles
2. Less vehicles needed</td></tr>
<tr><td colspan="2">Social risks:
1. Passengers are exposed to potential dangers with parcels, such as dangerous goods (low probability).</td><td colspan="2">Social benefits:
1. A reduced number of vehicles operating in the city
2. Possibility to lower the fee for passenger transport</td></tr>
</table>

The key partnership is with the service provider operating the actual trips, and provide important infrastructure and resources related to the vehicles. Other infrastructure involves the algorithms to schedule integrated passenger and cargo services as well as the mobile app that enable the drivers to execute operations as planned. Critical buy-in and support comes from local and national legislators who may need to change regulations obstructing the joint transport of passengers and cargo, as well as from the drivers that need to pick up and drop off parcels and passengers that need to accept goods in the vehicle and slightly longer response times. Deploying the service includes the identification of a suitable area where the service can be run, based on detailed estimates of the potential user base. From there, a transport service provider with sufficient vehicle and driver capacity can be contracted, after which the app can be deployed, and users can be attracted. Users include both passengers and local shops providing cargo. When executed well, the transport service provider gains from more cost-effective transport while citizens and other people staying in the city benefit from less vehicles operating in busy parts of a city.

The budget needs to include room for the development and operation of the algorithms used for scheduling rides and app as well as the costs charged by the transport service provider. Against that are the revenues from parcel and passenger fees. Environmental relate to potential detours that are needed to integrate passenger and parcel pickup and delivery. At least in the digital pilot setting, these detours are outweighed by the benefits of enhanced efficiency in terms of carbon emissions, resulting in lower overall emissions compared to a setting where parcels and passengers would be transported separately. In terms of social risks and benefits, a platform providing on-demand passenger and cargo transport should consider the potentially dangerous content of parcels that are now transported together with passengers. There are potential social benefits associated with less vehicles driving around the city and a lower fee for transporting passengers via an on-demand service which may complement local public transport options.

5. Cross-trial learnings

Throughout the trial preparations and execution in Bremen, Mechelen, and Groningen, several learnings emerged. Among these, the critical need for a supportive regulatory framework was paramount for the success of innovative business models. A prime example of this broader phenomenon can be observed in the city of Groningen. The city is long known for its progressive mobility strategy, for example, via its 1977 “traffic circulation plan”, pushing cars largely out of the city centre and regulating the flow of cars on infrastructure that remains accessible for cars. In 2014, Groningen signed the Green Deal city logistics, a covenant in which several parties commit to zero-emission city logistics by 2025. This Green Deal formed the foundation for the Dutch climate accord, which includes the goal of zero-emission city logistics in 40 larger and medium-sized cities in the Netherlands. Groningen gave more body to its Green Deal in 2021 in its Sustainable Urban Logistics Plan, called “room for zero-emission city logistics”, in which it outlines specific actions towards zero-emission urban freight transport. This included the geographical extension of the already existing time-access restriction zone—a zone that will become a zero-emission zone by 2025. As a result, many new shops and entrepreneurs need to adhere to the time window between 5am and 12pm (i.e., noon) when entering the city with a freight vehicle or need to apply for a waiver allowing access outside the time window. All zero-emission freight vehicles are eligible for such a waiver, and can receive it at a strongly discounted value.

The moment the time-access restriction zone extension came into effect coincided with the launch of the platform in research trial 1. Some shopkeepers—that were previously located outside the zone—were hence simultaneously confronted with the challenge of the time-access restriction and the shared vehicles becoming available. The empirical data gathered during the trial strongly suggests this improved willingness to explore using the shared vehicles. Another lesson learned during the Groningen trials is that local shopkeepers appreciate—and indeed often need—an in-depth introduction and support when exploring a novel solution. For the shared zero-emission vehicles, the mobility service provider and the Groningen City Club prepared a launch introducing in detail how the vehicles work, followed up by constant support from the mobility service provider for the many small questions arising during the first (few) time(s) of use. Without it, all the small things would have likely hampered shopkeepers from trying a shared vehicle.

The trials also revealed—an often implicit—expectation from private businesses that public spaces could be utilized at no cost, or even that public funds should be allocated to prepare these spaces if a novel solution they provide contributes to improved sustainability. In Bremen, the local public authority took the initiative to identify suitable locations for micro-hubs, integral to supporting the efficient distribution of goods in the city as part of trial 1. In a bid to facilitate the trial, the authority provided valuable land for one micro hub at no cost and rented parking spaces for another. However, once the authority ceased covering the rental cost, operations at the rented micro-hub came to a halt. This outcome illustrates a critical challenge: While private businesses are eager to contribute to sustainability and adopt innovative solutions, they also anticipate support from public authorities, often in the form of resources or subsidies.

Private businesses often expect the public authority to bear the cost of the spaces required for the sustainable solutions in urban freight transport, viewing this support as a necessary contribution to their efforts. This raises several important questions about the long-term viability and scalability of such solutions. If public subsidies or resources are required for these initiatives to survive, how sustainable are they in the long run? Linking back to the first learning, it is crucial that novel sustainable urban freight transport solutions have sound operating and business models, yet it's equally important that public authorities support the required transitions with a conducive regulatory framework. This is especially pertinent considering that the typically higher costs of sustainable solutions compared to traditional methods might hinder businesses from fully embracing them. The trials therefore not only serve as inspiration for the development of new solutions be private business but also as a call to action for policymakers and other stakeholders. They illustrate the need to work in tandem to create regulations that encourage the transition from existing urban freight transport activities towards more innovative, sustainable solutions.

Conclusions

ULaaDS has a strong focus on identifying successful, developing new, and continuously refining operating and business models for on-demand and zero-emission solutions for urban freight transport. The evolution of important insights in business and operating model is document in three separate deliverables: D3.1 “Benchmarking business/operating models and best practices”, D3.3 “Novel business/operating models and mapping to research trial sites” and D3.5 “Final validated business/operating models”. This deliverable (D3.5) concludes the work in this regard, and provides value lessons about the operating and business models of the solutions trialled in the three lighthouse cities. In doing so, it made use of the state-of-the art on business models relevant for the ULaaDS solutions prior to the trials (D3.3), which in turn was based on example solutions and operating models as described in deliverable D3.1.

The solutions trialled in the lighthouse cities included many elements presented in D3.1 and D3.3. The implemented ULaaDS solutions focus on novel vehicle technology—using smaller, zero-emission, and even autonomous vehicles—and collaborative models to use vehicles, facilities, and infrastructure more efficiently. The varying levels of maturity among the different trials provided unique insights into the role and effectiveness of the proposed operating and business models. While some trials illustrated a clear path to sustainable business models, others suggested a greater need for technological advancement to achieve commercial success.

Two key challenges were highlighted during this process. The first was the importance of scalability in urban freight transport, which is crucial not only to make a substantial impact on the urban landscape but also to improve the financial feasibility of these models. The second challenge emphasizes the need for a supportive regulatory framework. Business models alone cannot carry the burden of transformation; policy support is necessary to discourage existing transport activities and enable the transition to more sustainable solutions. The ULaaDS trials have thus underscored the importance of policy makers and stakeholders working together to facilitate this transition.

In conclusion, this final deliverable (D3.5) encapsulates the crucial learnings from the ULaaDS project. It highlights the importance of continued innovation in operating and business models, the need for scalable solutions, and the critical role of regulatory support for sustainable urban freight transport. These findings provide valuable insights for future developments in the field of on-demand and zero-emission urban freight transport.

Acronyms

Acronym	Meaning
AI	Artificial Intelligence
AV	Autonomous Vehicles
D	Deliverable
EC	European Commission
GA	Grant Agreement
ICT	Information and Communication Technology
LF	Load Factor
LSP	Logistics Service Provider
O	Objective
ODD	On-demand Delivery
P	Product
PPP	Public Private Partnership
PM	Person Month
SUMP	Sustainable Urban Mobility Plan
SULP	Sustainable Urban Logistics Plan
T	Task
UC	Use Case
UCC	Urban Consolidation centre
UFT	Urban Freight Transport
ULaaDS	Urban Logistics as an on-Demand Service
WBS	Work Breakdown Structure
WP	Work Package
VUR	Vehicle Utilisation Rate
ZEV	Zero Emission Vehicle

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