

The sustainable last mile

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0.1 ABSTRACT

In this report, a proposal for a sustainable last mile is given. Inner city logistics brings many problems with it regarding livability in the city; polluting vans standing in the way on the road or the sidewalk and driving too fast because of high demands of the consumer and competitive nature of carriers. Unsustainable practices are being dealt with in regulations (in the Netherlands) such as the Zero Emission Stadslogistiek. The aim of the Zero Emission Urban Logistics is to reduce emissions of CO₂, NO_x and particulate matter due to urban traffic to 0%. In addition, parties want to reduce noise pollution.

More sustainable transport like cargo bikes or light electric vehicles could play a role in solving these problems on the relatively short term. However, because they typically have smaller capacity and have smaller ranges than the vans that are currently used they are not the default solution for consignment in the city; distribution centres nowadays typically lie too far away from the end consignee to effectively employ these type of vehicles.

The fact that distribution centres lie so far away from the city stems from more latent problem of the last mile; its inaccessible and un-communal nature.

In this project I propose 7 'design activities' in response of the aforementioned problems: cooperation, incentivisation, standardisation, decentralisation, integration (in the city), automation and consolidation.

Based on these design activities I proposed three types of urban consolidation centres that facilitate smaller types of transport while at the same time considering the aforementioned design activities.

0.1.1 Special thanks

I would like to thank Vanderlande for the opportunity they have given me to work together with them on a project I proposed to research, and it was nice to see their involvement in both the coaching and creative sessions I held with them. Special thanks go out to Odeke Lenior who has been my coach and contact within Vanderlande from the beginning, and Marc van Neerijnen, without whoms insights I would not have been able to put down the project I have.

I would also like to thank all the people that I have interviewed: Paul Buijs, Tom Kuijpers, Minze Walvius, Verena Vreedenveld and Annabelle Waldus.

Lastly, I would like to thank my coach Bart Bluemink and my chair Gerd Korteum for their involvement and investment in my project. Their input in the structure of the report has been vital for the story that I wanted to tell.

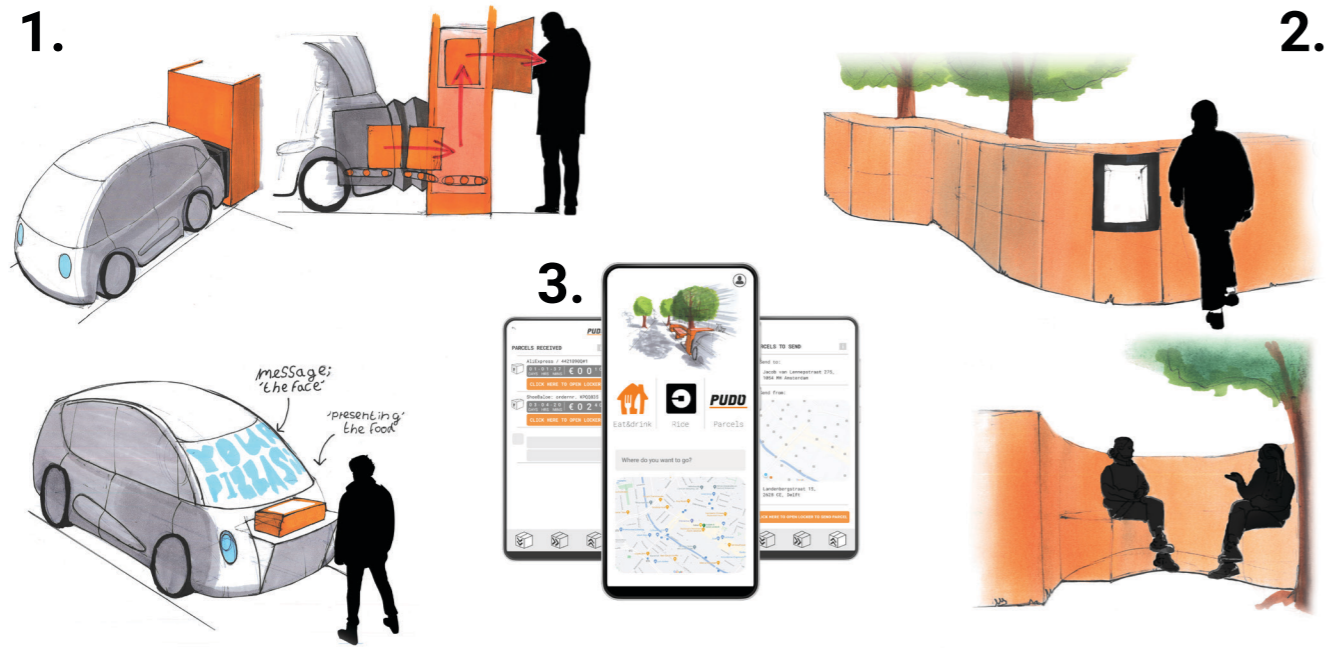
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0.2 INTRODUCTION



ACD project final result consisting of 1. Fleet of autonomous vehicles 2. Network of PUDOs, 3. Application for end user to interact with the system

This graduation project is a continuation of the project I have done for Vanderlande as part of the course Advanced Concept Design (ACD), where the goal was to find how Vanderlande could increase their portfolio in the last mile, escaping the walls of the warehouse where they currently operate. The following project description has been written by Vanderlande themselves.

"Vanderlande expressed their ambition with the following (preliminary) vision statement: Our passion for People-in-Transit drives us to create seamless and personalised travel experiences by orchestrating sustainable product-service ecosystems, guided by smart logistics. Based on this vision, Vanderlande has drawn up a long-term roadmap, illustrating several potential product-service ideas and concept sketches along a 20Y timeline. These ideas and concept sketches will be the starting point of the ACD-assignment as formulated below. Design a product-service ecosystem that creates value for travellers/ end-users in the future context of travelling / logistics across Europe. As this assignment is about creating concepts in a future context, Vanderlande challenged students to dream about it and propose products that go beyond our current imagination' (Vanderlande, 2021)".

The aimed final result of the project were three elaborated concepts as an inspiration and a manifestation of the product-service ideas, and outline sketches that were drawn up in a roadmap. The project outcomes will serve as 'inspirational concept cars' or 'demonstrators' and engage Vanderlande's stakeholders in the new strategic direction.

The specific direction I have chosen was Smart Logistics Interconnect (SLIM); "A smart logistics operational software to manage multimodal distribution and fulfilment services. SLIM offers the enabling logistics software platform to all modality providers and manages the entire logistics and fulfilment of the allied partners. The digital platform serves as a backbone and provides dynamic distribution planning, call-off and track & trace services for both providers and consumers, managing their personal baggage or parcel journeys. SLIM connects various logistics service providers (such as baggage handlers and parcel logistics services) to manage baggage or parcel journeys optimally across the distribution network. Providing joint End-to-End Distributing and Fulfilment Services, operated by various collaborating logistics partners. Although



Final solution proposal showing the three different types of urban consolidation centres

these services ask for software development and platform solutions, in this project I focused on developing new hardware solutions to facilitate collaborative distribution across the network and connected hubs. My design for this project consisted of three parts:

Autonomous vehicles which not only provide room for parcels but also for the transportation of humans. Consolidating personal- and goods- transport would save on driven kilometres in the city; pollution and congestion was one of the problems I identified resulting from the last mile.

Network of Pick Up and Drop Off points acting as parcel buffer and also further reducing the kilometres driven in the city; as will be explained in this report, PUDOs reduce delivery route lengths and failed delivery attempts. Furthermore, the PUDOs were designed to enhance the public space by incorporating greenery and places to dwell.

App to interact with the system, this app allowed the user to track their parcel and choose their preferred PUDO. It also acted as the interface of the PUDO when picking up your parcel.

Obviously, my graduation project has many similarities with the ACD project and can be seen as a continuation. However, more effort has been put into which problem of the last mile I want to solve; the research of the context, exploration of all the stakeholders, and identification of the problem as perceived by those stakeholders.

0.3 WHY THIS PROJECT?

The initial design brief is a very open question regarding the 'last mile problem.' This report aims to bring the problems in the last mile to the surface, so that Vanderlande can expand their portfolio in the last mile in a sustainable way.

0.3.1 Vanderlande's ambitions

It is in Vanderlande's interest to provide future proof innovations to their customers.

Currently, Vanderlande explores new product-service scenarios for future city logistics. In the past, the company has made a solid reputation by focusing on product-service solutions for B2B customers in the aviation and parcel delivery business. Today, Vanderlande shifted their focus to creating value for end-users in a B2B2C market.

The B2B world is much different from the B2B2C world, for it has more values to consider, namely those of the consumer. In the B2B context profit, efficiency, reliability, service, relationship building are important values. These are things in which Vanderlande excels already. In the B2B2C the same values are important, plus marketing for both business- and consumer- clients and consumer trends. One of the consumer trends that is becoming more and more prevalent is that sustainability is becoming an important value.

0.3.2 My ambitions

I want social-, economical- and ecological sustainability to be central to the design. What follows is an explanation what these types of sustainability mean and how are they of importance for this project:

Environmental sustainability:

Important values that come forward in my design are:

Resource efficiency: Accomplishing consignment of goods while using as little energy and resources as possible.

Climate change mitigation: Utilising transport modalities with little to no emission and, again, trying to optimise the consignment parcels to use as little as possible resources.

Waste reduction: Mitigate the need for packaging or single use parts.

Social sustainability:

Equity and inclusivity: This entails equal access to resources and services independent of people's background characteristics; openness and accessibility are important values for my design.

Quality of life: Negative implications of the last mile on end users and inhabitants should be mitigated as much as possible, therefore it is imperative to identify these negative implications.

Community engagement: This entails involving local communities in decision-making processes that affect their lives and environment. In this project this relates to the placement of touchpoints of last mile logistics in the city.

Economic sustainability

Responsible consumption and production: If possible, end users should be made aware of their consumer behaviour; making them realise what the implications of ordering products online are in their own city, and possibly in a larger context on the planet.

Diversification and innovation: This entails encouraging diverse economic activities and fostering innovation to create resilient economies that can adapt to changing conditions; the solutions will promote innovative approaches to delivery that consider sustainable transport modalities.

Long term planning: This entails developing economic strategies that consider the long-term impacts of decisions on both the economy and the environment; the solutions will be designed to make a lasting impactful change on the way that parcels are being consigned.

0.3.3 Ahead of the regulations

Another motivation for this project is to explore how to foster innovation that is ahead of regulation; which negative implications might the last mile have in the future, which might then result in regulations to mitigate those negative implications, and how might we overcome them before they happen? Usually the market innovates with little regard of bad implications it can have on people and planet, an example:

Social Media and Online Content

Innovation: The rise of social media platforms has transformed communication and content dissemination, enabling global connections and sharing of information.

Regulation Lag: The spread of misinformation, hate speech, and privacy breaches on social media platforms has highlighted the need for regulations that balance free speech with responsible content moderation. Striking this balance while safeguarding users' rights is an ongoing challenge.

There are lots of innovations making the last mile cheaper and more efficient, however the possible negative implications of them need to be identified and actions to mitigate them should be taken accordingly. That is why this report has a focus on problem finding and defining; it is obviously impossible to look into the future but I hope that I have been able to create valuable insights of how innovations and trends in the future might influence the future society and regulations, and how design can play a pivotal role in fostering a sustainable last mile.

ULaaDS future scenarios

To guide me in the envisioning of the future trends I have referenced the report of the Urban Logistics as an on-Demand Service report 'What's in store for last-mile logistics?' A provisional trend report based on a stakeholder perspective on trends shaping urban logistics in Western Europe between 2020 and 2035. I have also had several interviews with one of the authors of the report, Dr. Paul Buijs, to discuss how my prototypes would fit into these future scenarios. The report discusses the implications of innovation, regulation and market forces.

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 catalysts 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, 2021).

Zero emission zones 2025

From 1 January 2025, municipalities in the Netherlands may designate an urban area where no polluting vans and trucks are allowed to drive. With this, municipalities want to reduce CO2 emissions in cities. Those areas are zero-emission zones (ZE zone). The perimeter of a ZE zone is at least the city centre plus the surrounding neighbourhoods. You can only enter this area with your van or truck if it does not emit any harmful substances. Such as a car running on electricity or hydrogen (Rijksdienst voor Ondernemend Nederland, n.d.).

In facilitating these new, less polluting modalities Vanderlande could play a pivotal role; the role of the distribution and sortation centre is an important part of the logistical process that can influence which types of transport are best suited.

ZE- zones in the Netherlands



Typical high volume distribution centre. Lorries offload vast amounts of goods, for them to be sorted to smaller modalities such as vans or box trucks. The technology required for this sorting process is designed and supplied by Vanderlande.

0.4 VANDERLANDE

The company with whom I performed the project is Vanderlande (since 2017 the company is a subsidiary of Toyota Industries); they are leading in the industry of material handling and logistics automation which includes baggage handling in major airports (Schiphol is an example of this, but their baggage sorting systems are installed in many more terminals around the world), handling of goods in major flight terminals (parcels and the like) and parcel handling and sortation for the last mile. They have connections with large delivery companies such as DHL, GLS, DPD and more.

In short their capabilities are material handling, automation and warehousing. As will be further described, Vanderlande has lots of experience in the business to business (B2B) context, but will when expanding their portfolio to business to business to consumer (B2B2C), need to expand their capabilities.

I am very thankful for the opportunity that Vanderlande has given me, and the support that I have been given, especially from Odeke Lenoir and Marc van Neerijnen.

0.5 INITIAL DESIGN BRIEF

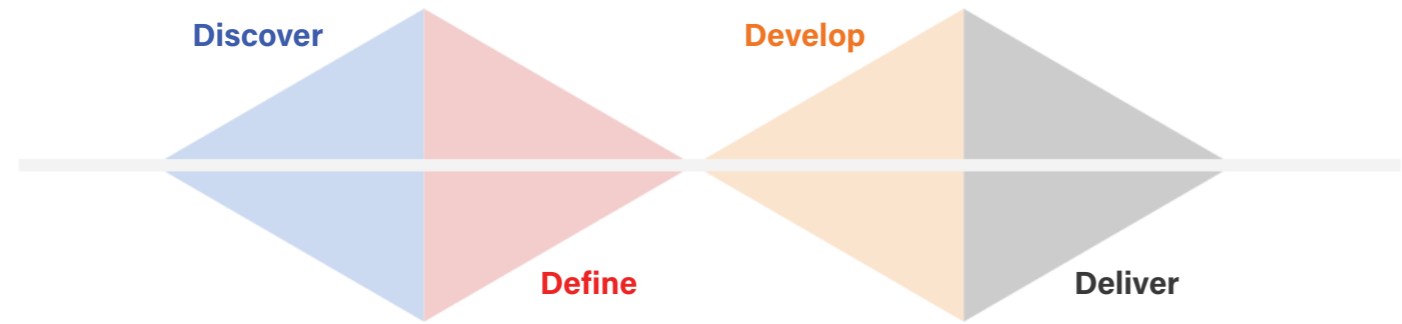
For my initial design brief when I started with the project all the way back in January 2023, I wrote the following:

"I will research different solution spaces for the first and last mile delivery problem to make it more socially, ecologically and economically sustainable. I will design two to three solutions to FLMD situated in urban areas (Rotterdam as a leading example) that are demonstrably (within the 20 week time frame) more sustainable (ecologically-, environmentally- and socially-)."

It soon appeared that this question would be too open and too vague, and does not really specify what the actual 'problem' is. That prompted me to do thorough research of the context, the stakeholders and what their perceived problems were in the last mile, to be able to distil what exact problem it was that I wanted to solve, and how it can be done in a sustainable way.



0.6 DESIGN PROCESS



Double diamond

For the sake of clarity for the readers of this report I have structured the design process according to the double diamond technique. Normally, I do not like force fitting a so-called 'design methodology' to my work because I believe that designing is a much more free process/activity than most models can describe. However, after relaying my report with my coaches it became apparent that more structure was necessary, and I must say that doing it actually does help to make the project more understandable. In my report you could interpret the double diamond as the applied design methodology. What follows is an explanation of each of the parts of the diamonds:

Introduction

The starting point, initial design brief and the reason why I do this project are explained in the introduction.

Discover:

The first diamond represents the "Discover" phase, which involves understanding the problem space and exploring possible directions. I gathered insights about the current context, data, and performed interviews with experts in the field of the last mile.

I created an understanding of the user needs, behaviours, and pain points.

I then synthesised the research findings to define the problem statement to clearly articulate the challenge that needs to be addressed, which resulted in a redefined problem statement:

'How can Vanderlande ensure that fewer vans enter the city? (ecological- and social- and to some extent economical- sustainability)

while at the same time making the 'last mile' more accessible and communal for the end user?' (social sustainability)

and service and cost stay comparable/improve for business clients?' (economic sustainability)

Define:

The second diamond represents the "Define" phase, which involves narrowing down the problem and defining a specific direction for innovation.

I researched a wide range of ideas and potential solutions, looked at case studies of the current and future context. I did this according to delving in to the ways that currently answer the subquestions of my design statement. The first part; *How can Vanderlande ensure that fewer vans enter the city?* is explored through the topics Government intervention, Alternative modalities, Consolidation and Out of home delivery. The second part; *while at the same time making the 'last mile' more accessible and communal for the end user?* is explored through the topics Accessibility and Community. The third part; *and service and cost stay comparable/improve for business clients?* is explored through the topics Service and Cost.

In this chapter I establish which design activities/principles the solutions should be designed. These were: Cooperation, standardisation, decentralisation, incentivisation, integration in the city, automation and consolidation.

Develop:

After the second diamond, there is an additional stage known as "Develop." This stage focuses on refining and iterating on the prototypes created during the "Define" phase. I focussed on the second part of the design challenge:

[..]. *while at the same time making the 'last mile' more accessible and communal for the end user?*

and service and cost stay comparable/improve for business clients?'

I had more interviews with experts in the field to gather feedback on my prototype designs and to gather insights. I also held several creative sessions to further explore the solution space and my prototypes.

I discuss solutions based on containerised transport, and defined the solution direction; bringing sortation and distribution closer to the end consignee to facilitate modalities other than vans for the consignment of parcels. The prototyped solutions include three types of microhubs, which are micro distribution centres located near or in city centres. The goal is to 'give the logistics a face,' this is done by creating openness, transparency and communality into the microhubs.

Deliver:

The final stage is the "Deliver" stage, which involves finalising the solution and bringing it to fruition. In this chapter I bring the refined solution to life by developing the final product/service solution based on the program of requirements.

I also explore how to continue the journey and how to expand on the design.

Reflection/conclusion

In the final chapter I reflect on the immense difficulties of this project, and I try to draw conclusions about how my design challenge fits my program of requirements and ultimately my final design.

1. Discover the context

Multi-headed solution space and the 'Wild West'

"Without any incentive, like a monetary- [...] or a regulatory one, carriers will keep on doing what they are doing..."

Minze Walvius, Advier 2023

The last mile system consists of many components and its economy is dependent on many different stakeholders whose views are mostly not aligned, be it because of lack of willingness or a lack of knowledge. This chapter explores the current context and exposes the issues arising from this misalignment of views in order to identify the pain points which inhibit a sustainable last mile.

Different stakeholders and their demands and current ways of working are explained, from e-retailer all the way to the end user.

Finally, the design challenge is restated to be more focussed and clear on what the intended solution might hold.

Chapter division:

Where does the project take place?

The hub and spoke model

Stakeholders and their needs and requirements

Carriers, E-retailers and Vanderlande

Municipality and its inhabitants

Conclusion and restatement of design challenge

1.1 EUROPEAN CITIES WHERE THE PROJECT TAKES PLACE

To limit my scope in solution space as vast as the last mile I will focus this project on the sustainable consignment of parcels in cities in Europe with a particular focus on the Netherlands. The reasons why European cities are an interesting design space are as follows:

The density of end consignees is highest in cities

High population density means lots of interaction between people and the last mile logistics (think of the sheer amount of delivery vehicles you see in the city every day), sustainability improvements could have big impacts on quality of life. This population density means also many ordered parcels per m². Furthermore, in the city many different carriers compete making it an interesting space to optimise for efficiency.

European cities have unique qualities

Most European cities have been inhabited over centuries and their streets, neighbourhoods and buildings reflect this heritage. The existing infrastructure partly determines how fast we can replace the building stock or retrofit the existing buildings or create new transport options. Achieving sustainability in these cases requires careful considerations (*Guideline 1*) (Europe Environment Agency, 2021).

Furthermore, mobility in these city centres is a pressing issue that many European cities' local governments are actively involved in. To foster cities that are made for people instead of for vehicles, many old city centres are made car-free, public transport plays a significant role, and in the Netherlands in particular, cycling is the main form of transport.

Not just bikes

The focus regarding the design space has mainly been on the Netherlands. In the Netherlands the bicycle as a form of personal transport is arguably the most common in the entirety of Europe. We know how to design public spaces that facilitate this human-level transport, that is sustainable in so many ways; no emissions, fewer embodied energy per bike in comparison to motorised vehicles, fewer chances of fatal accidents, the list goes on and on. People in the Netherlands are very fond of their bikes and they have good reason to.

Many initiatives in the logistics sector reflect this; DHL and PostNL increasingly deploy cargo bikes, Cycloon is a carrier consigning exclusively via bikes, Coolblue delivers on bikes whenever they can, but also other, smaller carriers increasingly spearhead their efforts to deliver with bicycles.

However, the bike is just one of the modalities that can make use of the infrastructure that is present in the Netherlands. Light electric vehicles (LEVs) are becoming more common as well, with notable proponents of them being Picnic and DHL.



Utrecht, a city in the Netherlands where logistic movements have shaped the city, its realisation has since become part of the city's heritage. The historical canals and wharfs, once the main route for goods to enter the city, are now mainly used for leisure.

dr. ir. P. (Paul) Buijs

Professor economics and business Rijks Universiteit Groningen

The subject of this interview was to discuss the design as it was at the time; a system where somehow transport got consolidated and consigning is done by small electric vehicles driving around the city to deliver parcels to a network of PUDOs. The idea at the time was to explore the scope of making PUDOs part of the social structure of a neighbourhood. We discussed things like openness but also key points that could make consolidation and smaller transport possible:

'I feel like, **agnostic** networks of parcel lockers, or providers of agnostic parcel locker networks already exist quite a lot. What might be more useful is to look at how you could expand to **consolidated** transport.

Yesterday, coincidentally I had a meeting in Groningen with PostNL, DHL and 'de Buren' (agnostic PUDO company in the Netherlands) about parcel pick up points. Placing parcel points inside is always allowed. Something to think about though is the fact that logistic points like this might cause annoyances for neighbours because of the movements of vans and trucks loading and offloading. Applications to build new parcel lockers seldomly get admitted.

Mechelen is a city in Belgium where an eco-zone has been proclaimed. Bpost has taken over all last mile in the city with 55 parcel points.

The social aspect also plays a role, think about the **openness** of the system.

You won't manage to make the transport of the last mile **white label**; cities already have dense enough networks in place where every courier can stand on their own feet. On the country side this is not the case though, there might be options there.

What could be useful for such an agnostic network of pick-up points is software that can **forecast parcel volumes**; something that will be more difficult when you need the sales volumes of several different parties; couriers are not inclined to share their sales volumes.

The issue for PostNL and DHL currently is that they want to use smaller transport, but that they do not have the proper **transfer points** to do so. This means the hand over from one vehicle to the other, or even from a vehicle to a locker. Maybe a network of these kind of points could be agnostic with parts that could click on to one another.

Vanderlande could be meaningful in the link between nationwide to hub to parcel point. The question is: how do you make sure you save on labour with transferring between these points?

The cost saving that can be achieved with utilising smaller vehicles can be significant. The larger the scale the bigger the difference.

Sorting parcels in transfer points to bikes sounds like a good idea. The bikes don't have to be white label however; some couriers value the **service they can offer on the door**.'



Verena Vredenveld (New Business Dev. Manager PostNL) & Annabelle Waldus (Digital Innovation Dev. PostNL)

What follows is a summary of a conversation with Verena Vredenveld and Annabelle Waldus about the current approach of PostNL and their initiatives such as 'agnostic lockers' and Stadslogistiek:

'Our new business development is **focussed on end users, mainly** through **digital logistical innovations**. Obviously we are also aware of the annoyances that delivery vans cause, and that municipalities are concerned with it as well. The municipality is also important concerning the placements of lockers, sometimes 5 different parties want to place a locker on the same place. The way PostNL sometimes distinguishes itself is by making **lockers in which room is offered to other couriers**, this is called 'horizontal cooperation'. This works by the courier reserving a spot in said locker for which they pay a small fee.

Stadslogistiek is something in place in some Dutch cities (Den Haag, Utrecht, Nijmegen, Leeuwarden and Amersfoort) it is a **B2B** courier of goods and waste removal service. PostNL has warehouses right near the city where the B2B goods from multiple different couriers and companies get bundled to be sent off to most of the business in the city. The transport used is an efficient light electric vehicle with room to accommodate up to three roll containers. **Here horizontal cooperation has been achieved.**

You could say that you optimise routes better by assigning certain couriers certain area's where only they may deliver; Groningen goes to PostNL and Friesland to DHL for example. Do not forget though that some companies value the **distinguishing experience** they can offer in the delivery proces.

Couriers do not want to concede parcel volumes. What can Vanderlande mean as a courier or provider of lockers? There are already many companies who make these type of parcel lockers.

If webshops do not contract PostNL, PostNL would have no work; **webshops are an important part in the chain.** Nowadays webshops close contracts with several different couriers.

There are chances to localise e-commerce, and how to make consuming more local. Think of things like **'ship from store'**, this is kind of similar to how Thuisbezorgd works. Again think about that here it is all about volume.

The meaning of a store is gradually changing when e-commerce is growing; stores become more of a place where to do up inspiration or fit your clothes for example. **In France, e-commerce companies offered room in brick and mortar stores as fitting rooms.**

What is super important for the consumer is obviously **convenience**, but maybe more important is **control**; where is my parcel? where can I pick it up? etc.'



1.2 HUB AND SPOKE MODEL AND INVOLVED COMPONENTS

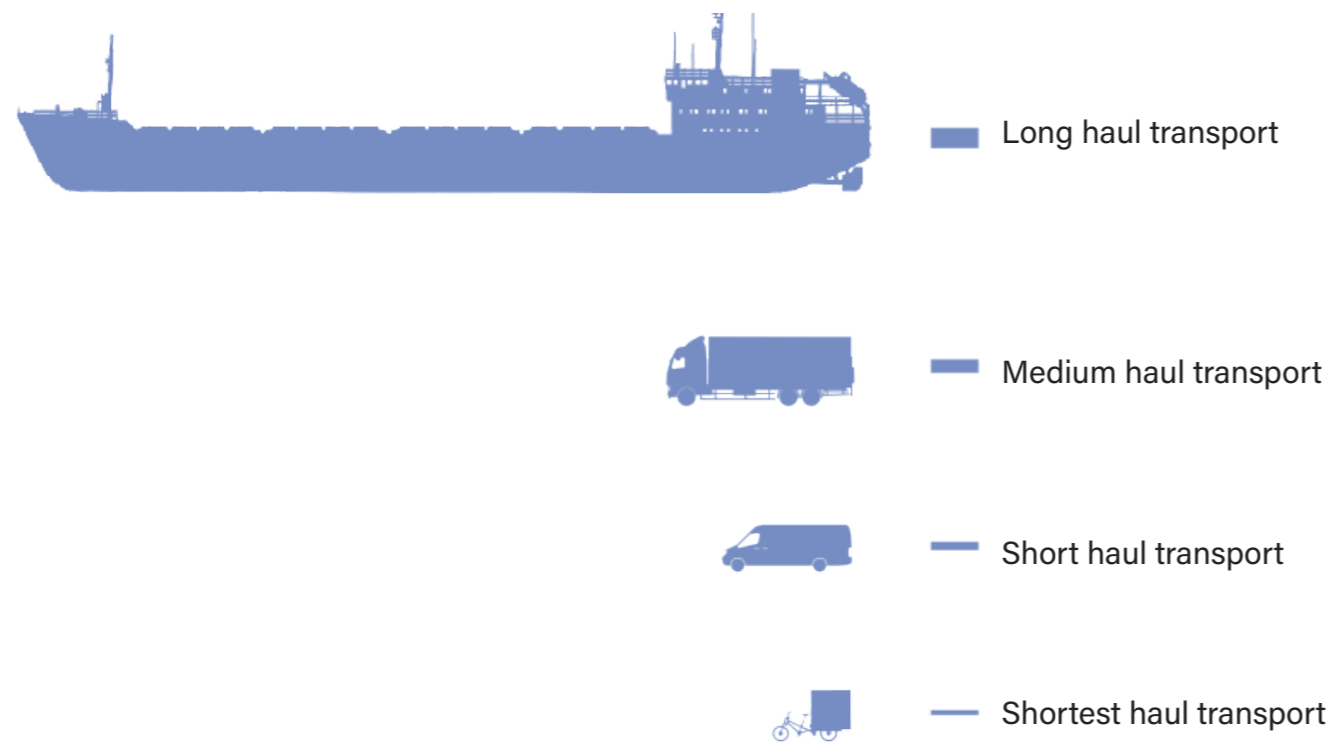
Although it is an oversimplified view of the last mile logistics, the hub and spoke model does give an insight to its general workings. The model describes a logistics and transportation strategy that involves centralising distribution and transportation activities around a central hub, which is then connected to various spokes representing different destinations. This model is often used in supply chain management to streamline transportation, reduce costs, and improve efficiency.

For an example of hub and spoke model logistics we can look at Amazon's delivery process, see 1.1 CASE STUDY AMAZON. It shows that the hub-and-spoke model is just an oversimplification of last mile logistics when we compare it to how it is done in the real world. Details such as parcel size, delivery area, delivery distance and other local factors can have great implications on the route that a parcel takes to its end consignee.

Hub: The central hub serves as a consolidation point where goods from various origins are gathered, sorted, and then redistributed to their respective destinations (spokes). Hubs are strategically located and equipped with efficient sorting and distribution facilities.

Spokes: The spokes represent the different destinations, such as cities or regions, to which the goods are ultimately delivered. These spokes are connected to the hub through various transportation routes.

As you move further into the hub and spoke model, the scale of transport modalities tends to scale down (*Guideline 2*) due to the nature of the distribution process:



The hub-and-spoke model benefits

Efficiency: Centralising operations at the hub allows for better coordination, optimization of routes, and consolidation of shipments, reducing the overall transportation costs.

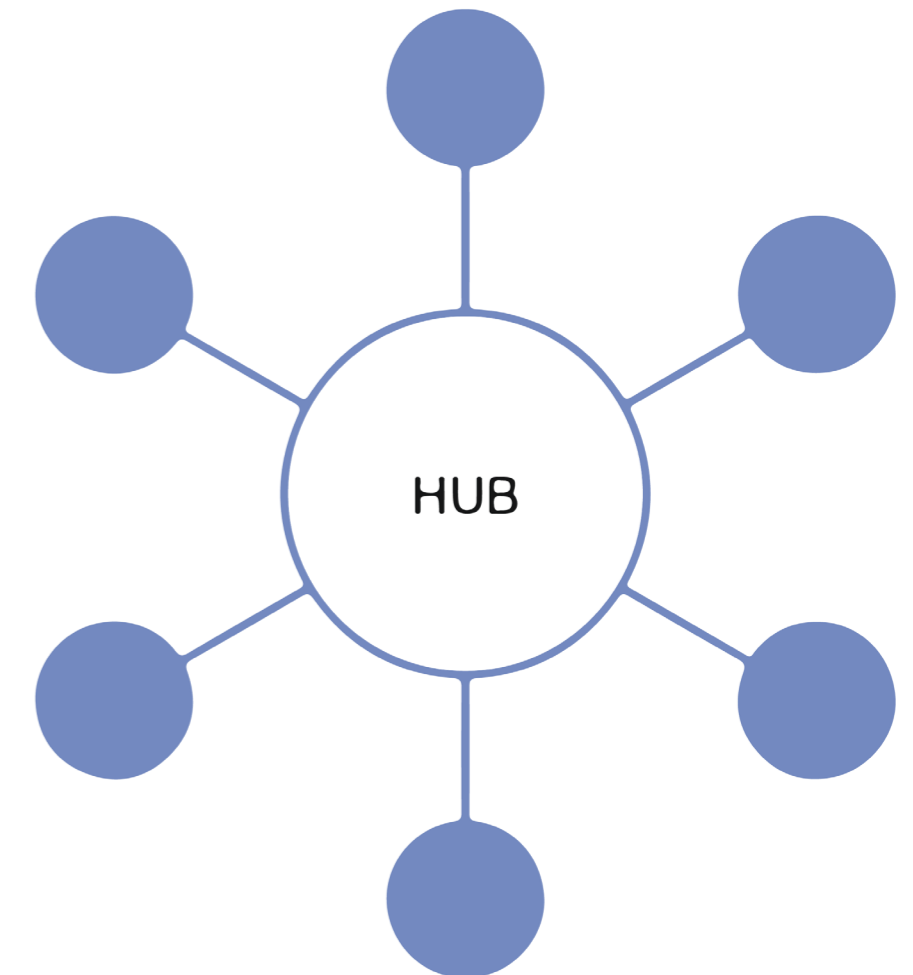
Flexibility: The model accommodates changes in transportation demand and can easily adjust distribution based on fluctuations in supply and demand.

Reduced Costs: By optimising routes and transportation modes, the model reduces the need for direct point-to-point connections and minimises empty return trips.

Improved Service Levels: The model enables faster and more reliable deliveries to spokes, as shipments are aggregated and routed more efficiently.

Resource Sharing: Shared resources at the hub, such as sorting facilities and equipment, increase operational efficiency and reduce duplication of efforts. A case study of Amazon's logistic process

While the hub-and-spoke model offers efficiency gains, it's important to note that the effectiveness of this model depends on factors like the location of the hub, transportation infrastructure, and the volume and distribution of shipments.



1. Distribution centres

This is where boat, train, plane or truck arrives and where 'the middle mile' ends. These are large centres, situated near airports, harbours or other logistically important locations, mostly outside of the city. Large couriers have their own centres, but some make use of others' (like in the case of Amazon, see 1.1 CASE STUDY AMAZON). From here parcels are sorted either to be distributed by vans to the local area or to be hauled in large volumes by trucks to the next type of hub in the system; the sorting centre.



2. Sorting centres

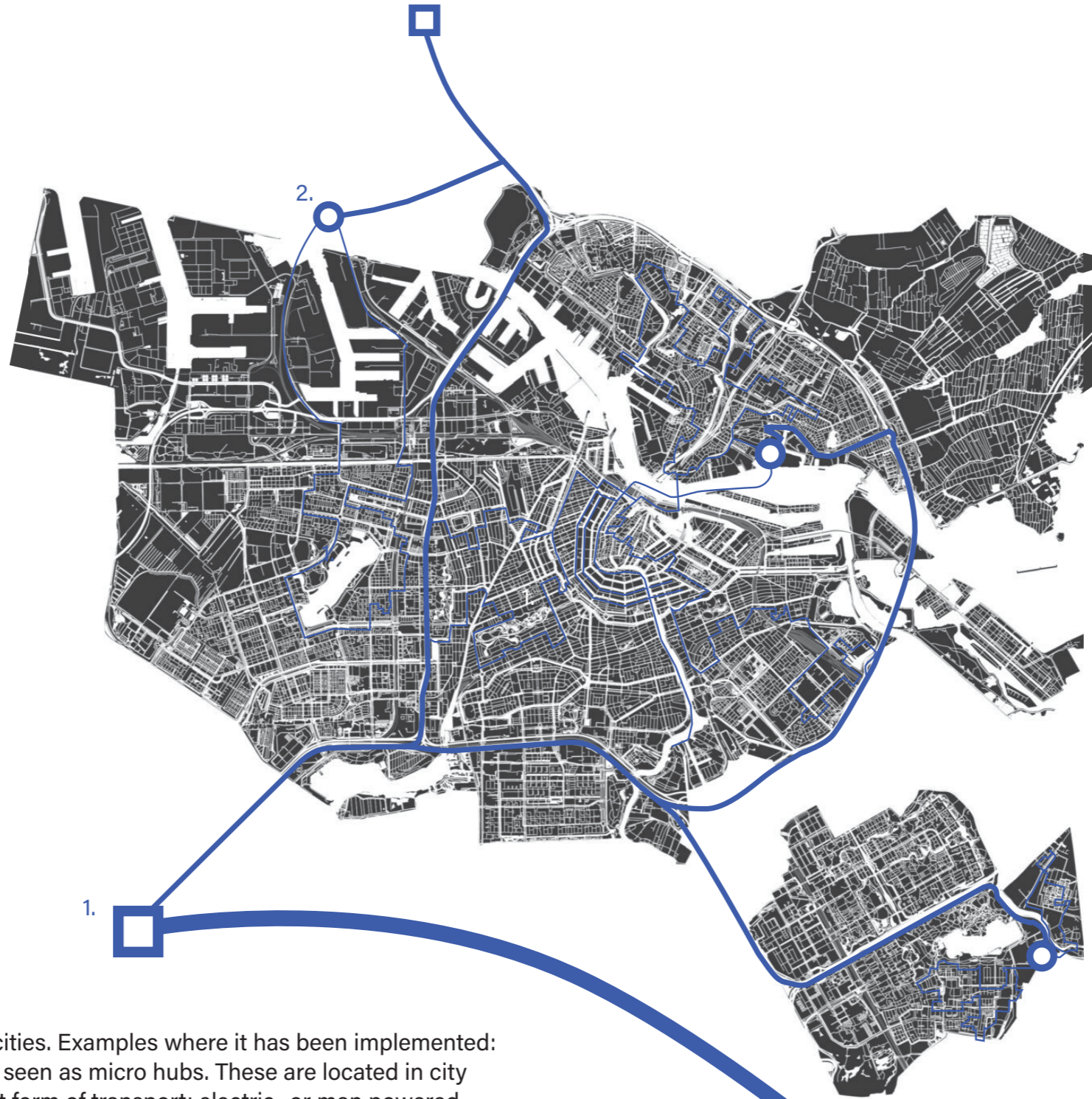
The next stop in the hub and spoke model, the larger trucks from distribution centre arrive here. It functions as transfer point to smaller types of transport like vans, compact electric vans or transport bikes.

Typically, carriers have their own sorting centres where exclusively their own parcel volumes are handled exclusively with some exceptions, in the Netherlands for example MyPup and Stadslogistiek.



3. Micro hubs

These are not yet implemented for parcels in most cities. Examples where it has been implemented: Gdansk Poland (GLS), Gorillas dark stores could be seen as micro hubs. These are located in city centres to accommodate the transfer to the smallest form of transport; electric- or man powered vehicles. For real life examples see 2.2 CASE STUDY NEAR CITY DISTRIBUTION.



4. Transport

Trucks, vans, small electric vans and cargo bikes; the transport of delivery generally, scales down the further you are in the hub and spoke model. However, transferral to the smallest and most efficient forms of transport is not facilitated yet for most carriers. Mostly, transport is carrier specific with vehicles having large visible logos. More and more however, transport is outsourced to sub-contractors in unbranded vehicles. 2.5% Of all emissions in Europe comes from vans.



5. OOH Delivery Points

Parcel lockers, PUDOs and parcel points make up Out of Home Delivery Points. These are mostly 'carrier specific', some are 'agnostic' and some are 'open' (see 1.2 CASE STUDY PARCEL LOCKERS). If all courier transport moved to parcel lockers, it would be possible to reduce CO2 emissions by up to 75% in relation to traditional courier delivery (Last Mile Experts, 2022).

6. Software

Routing software for the delivery vehicles used in the process is carrier specific because it is strongly dependant on sales volumes information. Carriers use forecasting of parcel flows to optimize their logistic processes.

7. The parcel

Electronics leads all the categories of e-commerce activity, slated to grow from 38% of retail sales to 45% of global retail sales in 2026 (Morgan Stanly, 2022). Other growing verticals: apparel and grocery. The most typical parcel size is 20x20x50cm, sizes might vary from something that fits in the palm of your hand to something that more than a metre in length.

Marc van Neerijnen

30-year employee at Vanderlande, currently researching the last mile

The subject of this conversation with Marc van Neerijnen was to find out how somebody who works for Vanderlande, and has been researching the last mile intensively for the last couple of years sees the problems and associated solution spaces concerning sustainability in the last mile. The proposed solution that was discussed consisted of a system of containerised transport, where consolidation of parcel flows was achieved in agnostic sorting centres. Each courier would have their own branded container which would be transported together with containers of other couriers on a LEV. The containers would then be placed on the street and act as a PUDO.

'One of the problems regarding the distribution centre is that **there isn't really more space**, and the size of your distribution centre is determined by the peak load, so if a lot of parcels come in and have to leave at once, you have a high peak load; you can **smooth that out** by not having to deliver everything at once at one time, you do that by building up a **buffer** in the distribution centre.

Having three different containers on one vehicle may be inconvenient because then you might see that if one of the companies does better and the other worse that you will end up with half-empty containers.

Carriers incur most costs on the last mile, so if that can somehow be unburdened without it meaning competing with them then it's really nice. Amazon, for example, only does their own last mile in very busy cities otherwise they outsource that. Otherwise, they have everything themselves; big distribution centres and freight trucks and so on.

Should Vanderlande start lobbying? Like Bpost did in Mechelen? Could be quite a good idea, to accomplish that it is important that everything is properly portrayed and so on.

When will the tipping point come? What makes people want a central system anyway? And who is the deciding stakeholder in this case, the municipality or the consumer?

Decisions concerning the overarching views of how the public space should look like is made by the government every five years and municipalities are constantly working on realising this vision in their own way.

One of the biggest problems Vanderlande has in this regard is communication; how do you make it clear that Vanderlande can add value when they take over a city's last mile?

The biggest hubs are all about volume!



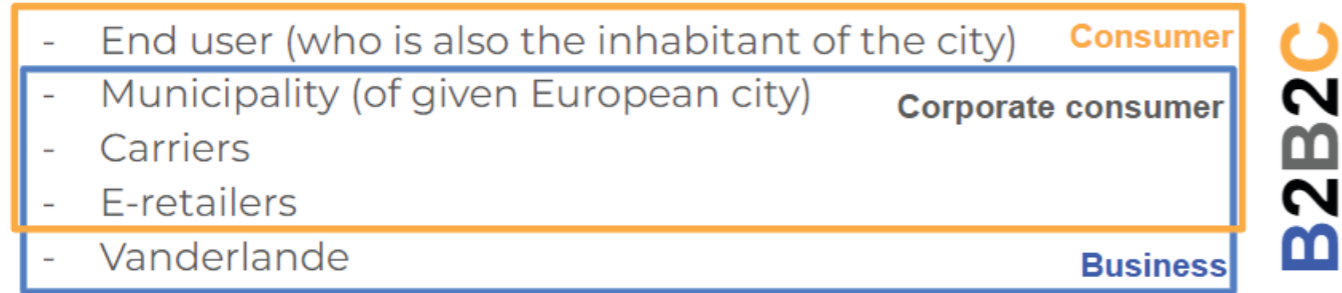
Vanderlande's current approach

Vanderlande's 'Innovate' department has a focus on speed and impact. It identifies and explores new ideas in a global ecosystem and determines the value of individual technologies. Through a systematic process, its drive is to make a seamless connection between today's technological 'push' and market 'pull'.

By working closely with knowledge institutions and start-up companies, Vanderlande is able to create innovative and sustainable solutions that improve the competitive positions of its customers. To accelerate these explorations Vanderlande utilises worldwide innovation labs, for example at the University of Eindhoven in The Netherlands. Vanderlande is a company coming from the industry of mechatronics and logistics that will enter the public space by playing a role in last mile delivery.

Understandably, the focus of many of Vanderlande's concepts is on technical design; after all, Vanderlande is a company employing mostly Engineers. Designing for public space requires a broader view than just the technical picture because all kinds of different factors in society play a role, think of latent needs of people considering public space and the requirements in cities of the future, these needs and requirements are elaborated in 7. Societal factors.

1.3 STAKEHOLDERS WISHES AND DEMANDS



Ordering of stakeholders in the project

The nature of the project being B2B2C means there are many different stakeholders to take into account.

Falling exclusively under the category of business stakeholder is Vanderlande themselves (and to some extent their suppliers) because internally their stake in the process entails their own corporate success through making products and services that last and are future proof.

They in turn have to maintain relations with their corporate consumers which include the carriers and e-retailers who employ the systems Vanderlande supplies them. Another interesting stakeholder that falls under this category is the municipality or local government (of European cities). They have a stake in the last mile because, as described, city logistics is becoming a more and more pressing issue for municipalities that are actively trying to foster a public space that remains sustainable by virtue of incentivisation, regulation, education etc.

The end user, which in this case concerns inhabitants of said European city, are the ones who live in these sustainable public spaces. These sustainable public spaces are shaped by a combination of the actions of the municipality, the actions of companies operating in the city (in this case the carriers, e-retailers and Vanderlande) and the behaviour of the inhabitants. Firstly, the B2B stakeholders and their demands are explained. Then, further explanation on the impact that the last mile has on public space is elaborated after which the remaining stakeholders (municipality and end users) and their demands are articulated.



Impression of the different stakeholders

1.3.1 Corporate consumers

Vanderlande is the reliable partner for the world's leading players in the parcel industry: UPS, DHL, FedEx and DPD. Together with these carriers they are working on the most advanced hubs to the smallest depots.

The carriers can be seen as the main 'users' of the system for they are the corporate consumers who are going to employ the solution, and they are the ones with whom cooperation must be brought about to create a sustainable last mile.

Cost savings

Carriers competing with each other in a 'race to the bottom' means that last mile services are being offered ever cheaper or even for free. Of course, it is in the interest of Vanderlande's corporate consumers that the solutions I propose are as cheap as possible as to keep their competitive position (*Guideline 3*). For the carriers the last mile is an expensive and inefficient process. 'Most carriers would like to be able to cut off or give the last mile out of hands because it is so expensive'

- Paul Buijs

So why would they venture into such a project if it only costs more money? What follows are some guidelines on how cost can be saved in the context of the last mile.

- consolidation
- more sustainable transport
- optimal use of loading per vehicle
- hands' are expensive > automation
- simply give (parts of) the last mile out of hands

More explanation on how to achieve these cost saving measures in chapter 2.

Service and competitive position

The service that carriers and e-retailers can provide to their customers is important because that is what determines their net promoter score (NPS) and thus their competitive position (*Guideline 4*).

For e-retailers it is important to ensure secure delivery of their goods, furthermore, sustainability is important for them. '[..] choices made in favour of sustainability, however, should not negatively impact the NPS of our customers. We know that the sustainable delivery options we provide, denoted by a 'green leaf' when choosing said delivery options, are chosen more often' - Large e-retailer NL.

In Chapter 1.4, the likes and dislikes describe the current experience end users have with the last mile, regarding service as well as other factors. Things that are important regarding the service that the B2B stakeholder group can offer to the end user are:

Price: important, however green choice can be sold more expensively.

Delivery time: not critical as long as it stays within limits

Interactive delivery management (IDM): one of the things with which carriers pride themselves is the control and trust they can offer to their customers through IDM which entails: Real-time Tracking and Communication, Delivery Preferences and Options, Delivery Rescheduling and Flexibility, Delivery Notifications and Alerts, Two-way Communication, etc.

Accessibility: regarding OOH delivery slipper distance or on route or receiving parcels at home. Home delivery is still the most popular delivery option, to stay competitive this option should remain.

Visibility: one of the things that came forward in conversations with experts is the fact that the visibility of the brand that carrier specific vehicles provide can be important for some carriers.

Accessibility and visibility could be further improved with 'brick and mortar' places where one can go for their needs around parcels (sending, receiving etc.).

1.3.2 The municipality, its inhabitants and the end users

As cities adapt to changing consumption patterns and technological advancements, the last mile impacts various aspects of public spaces. To satisfy customers' ever-rising desire to buy products online, without any intervention, the number of delivery vehicles in the top 100 cities globally will increase by 36% until 2030. Consequently, emissions from delivery traffic will increase by 32% and congestion will rise by over 21%, equalling an additional 11 minutes of commute time for each passenger every day (World Economic Forum, 2020).

Next to congestion there are several other obvious problems caused by the last mile:

Air Quality and Emissions: Delivery vehicles, particularly those powered by fossil fuels, emit pollutants that can degrade air quality and contribute to environmental pollution (*Guideline 5*). Poor air quality can have adverse effects on public health and the livability of urban areas.

Parking Demand: Delivery vehicles often need parking spaces for short durations to make deliveries. High demand for parking can lead to congestion in loading and unloading zones, making it challenging for other vehicles and pedestrians to navigate (*Guideline 6*).

Pedestrian Safety: Increased delivery activities can result in more interactions between pedestrians and delivery vehicles. Ensuring the safety of pedestrians while maintaining efficient delivery operations becomes crucial.

Curbside Management: Managing curbside space for deliveries, parking, and passenger drop-offs becomes complex. Balancing the needs of various users, including pedestrians, cyclists, public transit, and commercial vehicles, is a challenge.

Public spaces, such as sidewalks and plazas, may be encroached upon by parked delivery vehicles or delivery-related infrastructure, leading to a reduction in available space for pedestrians and recreational activities (*Guideline 7*).

Noise Pollution: Delivery activities involving loading and unloading of goods can generate noise that impacts the quality of public spaces, especially in residential areas (*Guideline 9*).

Visual Clutter: An increase in delivery vehicles and associated infrastructure, such as signage and loading zones, can contribute to visual clutter in urban areas, affecting the aesthetic appeal of public spaces (*Guideline 10*).

Distribution Centers and Warehouses: The location of distribution centres and warehouses, which are part of the last-mile network, can affect land use and urban planning. Poorly planned locations can disrupt the urban fabric and create conflicts with other land uses (*Guideline 11*).

The multitude of ways that logistics has an influence on the city is apparent to municipalities and that is why regulatory measures like window times and restrictions on types of transport have been instated. In other cases, investments are made for more sustainable transport, such is the case with DKTI. Through regulatory support, engaging with stakeholders, implementing pilot projects, funding etc. the municipality can push to achieve a more sustainable city with fewer heavy road vehicle (vans) movements.

The policy of municipalities differ per city, but the overall trend is that municipalities allow fewer polluting vehicles in the city, see the examples mentioned in 2.2 GOVERNMENT INTERVENTION. Another remarkable trend is that dark stores (which effectively are a type of micro distribution centre) are repelled from the city as well because of their unfriendly and inaccessible nature. This attitude towards fewer logistical movements logically stems from the municipalities' residents being annoyed with the way the last mile currently operates. Therefore, I made a compilation of the likes and dislikes that end users/inhabitants have of the last mile currently, this can be read in 1.4 CURRENT EXPERIENCE LIKES AND DISLIKES.

Unknown makes unloved

"The paradox of urban logistics in the future is that precisely to reduce the nuisance and emissions from logistics vehicle movements, logistics must be consciously fitted into the space in and around cities. This very space is becoming increasingly scarce as claims are made on it from multiple sectors. For urban planners, area developers and property developers, logistics is often a closing entry, whereby 'unknown makes unloved' " (Bram Kin, TNO, 2021).

The last mile being unknown is therefore problematic regarding the municipalities' and its residents' attitude towards it, and with it problematic for its effective integration in the city. This is a latent problem and concerns social sustainability aspects, while the more well known problems regarding traffic, congestion and pollution concern mostly environmental sustainability (and to some extent economical sustainability). In 0.6.3 MY AMBITIONS the applicable social sustainability components are briefly described. Here is some more elaboration on how they are of importance for the integration of last mile logistics into the city.

Equity and inclusivity (or more importantly Accessibility): This refers to accessibility to resources. According to Marco te Brömmelstroet, the chair of Urban Mobility Futures at the Amsterdam Institute for Social Science Research, accessibility is more important than mobility. An example of inaccessible resources is how supermarkets in America are 'few and far between' and have become 'megastores' that are located far from urban cores. Although they can have upsides like a great selection and efficient operation for the operator in question, they have replaced many of the small-town stores that would have been reachable by bike or by foot otherwise, therefore making them less accessible. These mega stores require large parking lots

because by car is usually the only way to reach them. These parking lots make their footprint even bigger, which means they need to be placed further apart, which again enforces the need for a motorised vehicle.

An example related to the last mile are how distribution centres are being repelled from the city (Walter Ploos van Amstel, 2022) and how post offices in the Netherlands have disappeared (RTL, 2011). Decentralisation in this design for the last mile means that distance that one must travel to interact with important touchpoints, for example pick up and drop off points, must be small enough to be travelled to with small efficient modalities, not only for the carrier but also for the end users. Ofcourse, the larger carriers already have service points in the city where one can go for their parcel needs, these are either in existing shops or standalone 'stores.' However, as can be found in the 'likes and dislikes', one of the perceived drawbacks is their carrier exclusivity and that they are still too far off route for most people.

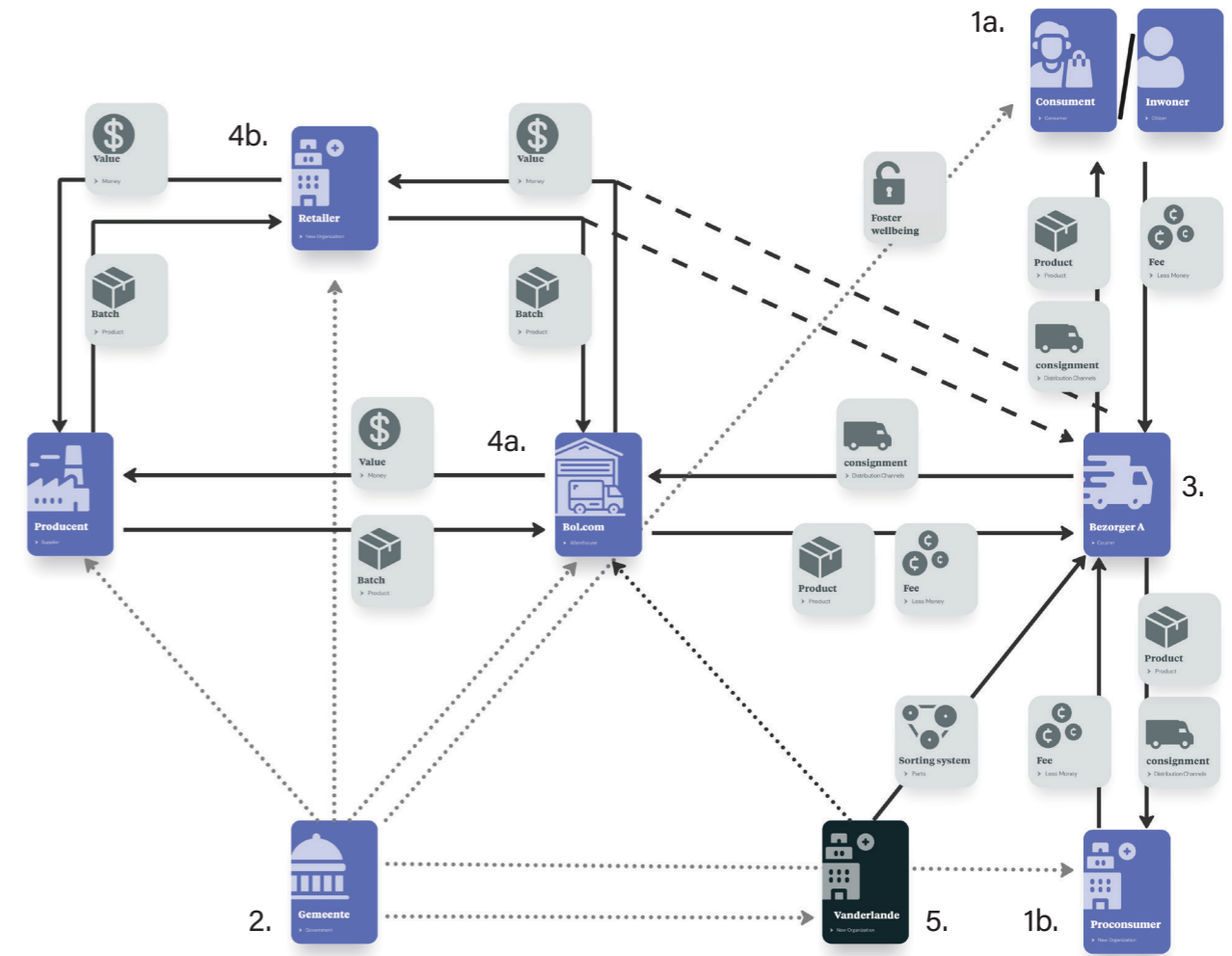
Accessibility also concerns the openness of the architecture that will be built for this design for the last mile. That is, a facade should express a certain 'openness' and where possible the building should be physically accessible to the public.

Community engagement: To enhance neighbourhood acceptance and to make logistics a more known entity for the end user and the municipality it might be important to let the community engage more with the last mile (*Guideline 12*).

An example of how to engage a community in the decision making of spatial planning is the project Advier is doing. Advier is a mobility design and advice company, they are doing a project where they let residents decide what to place on decommissioned parking spots as fewer and fewer people own cars in the neighbourhood. Residents can decide whether the won square metres become bicycle parking spots, room for plants, PUDO's or other neighbourhood enhancing features. This way the new features are very well tailored to the needs in the neighbourhood. Another example is how the placement of fietstrommels in Rotterdam is also initiated by requests made by the residents.

Quality of life: Dark stores are an example of a micro distribution centre located in the city centre and they can have negative implications on their neighbourhoods. Dark stores sometimes cause a nuisance in their area because trucks must unload there, but also because of their inaccessible look (facades mostly plastered with branding) (*Guideline 13*) and the delivery drivers that are loitering on the street for their next job (RTL, 2020). The street is very much part of the solution space for this design for the last mile. An example of a system that is designed to operate exclusively on the street is the collection of shared scooters that can be found in any major city nowadays. Although these scooters provide a great form of mobility other than cars or public transport, they do have some widespread disadvantages that relate to their ownership and usage model; because no one feels responsibility over the scooters they are handled with little care, meaning more costs in upkeep. Furthermore, the scooters litter the public space because people have little regard for neatly parking them, this is one of the major annoyances for people and municipalities and something on which the owning companies and municipalities are working together to resolve. Therefore, when designing for the public space, molestation sensitivity, loudness and possible nuisances should be kept in mind (*Guideline 14*).

On the next page a business model canvas of the current context is shown. The business model context shows the different monetary and goods flows between all stakeholders in a system.



- 1a. End user/inhabitant
- 1b. Professional consumers
- 2. Municipality
- 3. Carriers
- 4a. E-retailers
- 4b. Intermediary retailers
- 5. Vanderlande

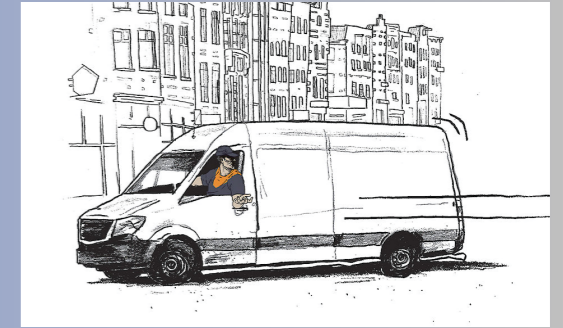
The arrows all represent a different flow of either goods, services, or remuneration. These types are indicated on the icons on the associated arrows and can include things such as:

- 1. Batch: large amount of goods usually delivered on pallets.
- 2. Value: large payment for batch of goods.
- 3. Product: singular product for end consignee.
- 4. Fee: small fee for singular product.
- 5. Dotted lines: they represent governance in different forms.

What can be seen is that carriers and e-retailers are central hubs to a lot of value flows. This emphasises their central role in the last mile business; from procurement, to offer to consignment.

The municipality governs every business stakeholder, for more explanation see 2.1 GOVERNMENT INTERVENTION, this is all with the goal to safeguard wellbeing for its inhabitants who are also the end user in this case.

1.4 CURRENT EXPERIENCE LIKES AND DISLIKES



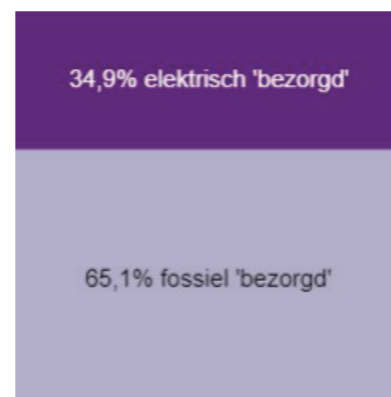
Like 1. Space for pedestrians and cyclists

As is described in 1.1 EUROPEAN CITIES European city centres can have unique qualities where pedestrians and cyclists are the ruling form of transport. Furthermore, as is described in 2.1 CASE STUDY MERWEDE, trends emerge of building more pedestrian focussed cities in the future.

As Marco te Brömmelstoet and Thalia Verkade describe in the book 'Movement – how to take back our streets and transform our lives' a less car focussed and more pedestrian and cyclist focussed city is a city that is safer, with happier and healthier inhabitants. Additionally, focusing on pedestrians and cyclists enhances the livability and attractiveness of cities. By creating vibrant, walkable streetscapes and dedicated cycling lanes, cities can foster a sense of community, social interaction, and economic activity. Pedestrian-friendly environments with amenities like parks, public spaces, and sidewalk cafes can contribute to a higher quality of life and a more enjoyable urban experience.

Reducing car dependency and promoting active transportation modes can help reduce greenhouse gas emissions, improve air quality, and mitigate the negative impacts of urbanization on the environment. Cities are increasingly recognizing the importance of sustainable development and are adopting policies that prioritize pedestrians and cyclists as part of their broader sustainability strategies (Parcu et al., n.d.).

Overall, the shift towards pedestrian and cyclist-focused cities is driven by the desire to create more sustainable, livable, and healthy urban environments. By using human level transport in the last mile, like cargo bikes or small EVs, the sector can attribute to this kind of urban environment while also saving costs (Last Mile Experts, 2022).

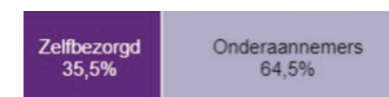


Above: Percentages of 'electric deliveries': 34,9% vs. 'fossil fuel deliveries': 65,1% in the Netherlands in 2022.

Credit: Autoriteit consument en markt



Above: Transport modalities carriers have in house (9.034 total) in the Netherlands in 2022 to energy type; fossil fuel: 3.839, electric: 4.091, other: 1.104
Credit: Autoriteit consument en markt



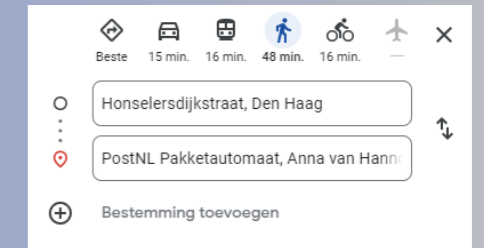
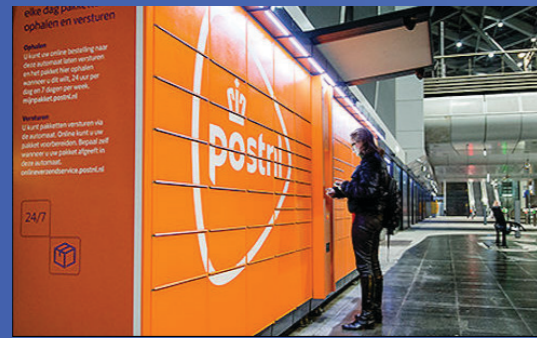
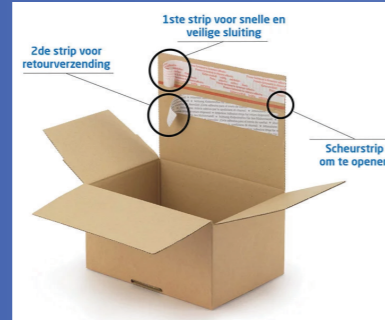
Above: Percentage of sub-contractors: 64,6% vs delivered by in house carrier: 35,5%
Credit: Autoriteit consument en markt

Disklike 1. Obnoxious vans

Diesel vans cause air pollution, traffic congestion and are often annoyingly in the way on the pavement or on the street. Freight transport and delivery services have been responsible for a third of all traffic volume in cities (Last Mile Experts, 2022). Especially when multiple vans are making frequent stops in a neighbourhood it can contribute to traffic congestion. This can result in slower traffic flow, longer commute times, and frustration for drivers who are trying to navigate through congested areas.

In 2022 about 65% of the deliveries have been handled by sub-contractors in the Netherlands (Autoriteit consument en markt, 2022). These sub-contractors usually work under poorer conditions than official carriers (Marieke de Ruiter & Volkskrant, 2021) and get paid per succesful stop. Because of the resulting haste with which delivery drivers operate (Marieke de Ruiter & Volkskrant, 2021), they sometimes cause accidents or dangerous situations.

Moreover, when delivery drivers cannot find a parking spot, usually because there is none, they will just park their van in the middle of the street with the warning lights on. Wrongly parked vans are a big annoyance for inhabitants, that is why more and more municipalities are regulating loading and offloading times and places. Although many carriers are starting to electrify their fleet, vans have been getting larger (Marieke de Ruiter & Volkskrant, 2021) meaning that particulate matter from the tyres is still an issue, as well as the threat they pose for pedestrians.



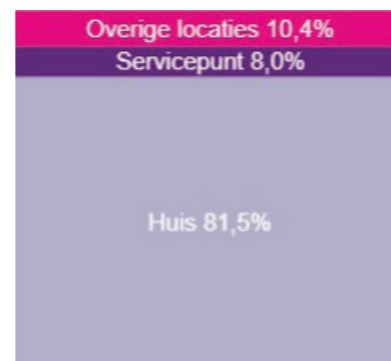
Like 2. Pleasant delivery

People like the convenience of home delivery and the associated price, which is not always more expensive than making use of PLs or SPs. Home delivery also allows for the delivery of fresh and extra large goods contrary to PLs since these usually do not offer cooled storage.

Considering parcel lockers, people like the time flexibility that they can offer if situated in a publicly accessible area. Also, PL deliveries are usually cheaper, and price, in combination with distance, is one of the most important factors for people to choose for PL, see 1.2 CASE STUDY PARCEL LOCKERS. Furthermore, people like it when they can pick up their parcel 'on route', for example when a pick up point is situated in publicly important areas like trainstations or supermarkets, or when the parcel can be sent directly to the place where people work.

Considering SPs, the lower price and closeness to it are likeable factors; an important distance to keep in mind when thinking of parcel lockers is the 'slipper distance' (about 350m), which is the maximum length that people ideally want to live away from a PL. Time flexibility plays a factor as well however mostly these service points are bound to opening hours which makes them less flexible.

People like that sending back parcels is sometimes facilitated (with for example return envelopes) and often free as well. In 2022 12,3% of the B2C parcels were returned (Consument Autoriteit, 2022) (Guideline 15). The offer at online shopping is usually greater than that of brick-and-mortar stores. Also, online shopping allows for consumer to consumer (C2C) transaction of goods.



Above: Percentages of HD: 81,5%, SP: 8% and other: 10,4% in the Netherlands in 2022.

Credit: Autoriteit consument en markt

Disklike 2. Akward pick-up and drop-off

Having to be at home to accept a parcel is not always convenient; this low time flexibility is because currently evening delivery scarcely an option. In addition, a quarter of parcels also arrived late. Bpost, DPD, GLS and UPS are the least punctual with 19 per cent of parcels not arriving at the door at the agreed time. PostNL and DHL do slightly better with 14 and 15 per cent respectively. Interestingly, other small delivery companies deliver 58 per cent of their parcels late (Radar & AvroTros, 2021). When the recipient is not home delivery has to be picked up at neighbours which is usually a reason for irritation because storing and attending parcels takes up unnecessary space and time. That is why parcel lockers (PL) and service points (SP) can be handy.

However, these are mostly exclusive per delivery company (Jasmijn Misseler & Trouw, 2020) which causes consumer frustration. Opening times of the store where the SP is situated limit its time flexibility. For store owners it is often seen more as a burden to have to deliver the extra service to be a SP, because users of the SP rarely stay around to shop at the store when they pick up or drop off a parcel.

Moreover, distance to these parcel points is one of the most important factors to opt for out of home delivery (Guideline 16).

In some cases where there are too few parcel lockers, parcels get crammed in with one another because there simply is not enough space. This can lead to confusion, parcels getting lost and it can infringe privacy of the consignee.



Like 3. White label

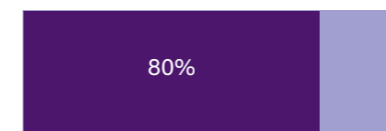
A 'white label' network of PUDOs, like the one in Mechelen, can offer even more flexibility and clarity for the end user. However, in an interview with an inhabitant of Mechelen, they said that they do not really see any of the postal vans in the city anyway. Furthermore, many different logistic operators do come in the city for other purposes like the supply of stores, or grocery vans like the ones from Picnic. The interviewed did say they use the parcel lockers from time to time and that they do offer convenience, they received parcels from other logistic operators as from GLS as well right at their door. They also said that Bpost delivers mail using a type of electric cargo bike.

Consolidated delivery does take place, however, usually not in a B2C context but rather in a B2B context, namely with initiatives like *StadsLogistiek* from PostNL see CASE STUDY NEAR CITY DISTRIBUTION. Consignees told that the clarity and consistency that a singular carrier can bring to the table is very pleasant.

Like 4. The world at your fingertips

The wide choice, competitive prices, and convenience offered by online commerce are transforming the retail industry at an accelerating rate (DHL, 2021). For consumers this means that almost nothing is out of reach anymore; from cheap specialised manufactures from the other side of the world to artisanal- or second-hand products in the area, logistics are in place to deliver whatever you want to your doorstep (or near it when considering parcel lockers).

With the dawn of flash delivery the timescale on which people expect your order is decreasing.



Above: Average vehicle occupancy in Den Haag in 2008.
Credit: DHV 2008

Dislike 3. Competing carriers

Different carriers often drive the same routes with vans whose capacity is often sub-optimally used, meaning more kilometres driven and more inconvenience and pollution. In addition, consumers want their parcels delivered at specific times to be able to accept their parcels at home which further reduces efficiency. Research in Den Haag showed that averagely 50% of the load capacity of the distribution vehicles that enter the city centre are filled with goods for the city centre and the average total load capacity of the vehicles is 80% (DHV, 2008).

This competition also means that there are few to no 'white label' pick up points, but rather pick up points exclusive per carrier. This means when ordering from different retailers using different carriers and opting for out of home delivery, your parcels likely end up at different locations around the city. This obviously negates the convenience of out of home delivery for the end user (*Guideline 17*).

Dislike 4. Asocial consumerism

Parcels are being sent to satisfy the demand of consumers for easier consumption. For sustainable design you need to also consider other, more latent needs of people.

Online shopping is gradually replacing the traditional brick and mortar stores. A decline in stores might mean a decline of purpose of the public space. In a society where everything can get delivered to you, is there still a need to go outside?

1.5 DESIGN CHALLENGE RESTATEMENT

The initial design challenge, which was too vague to answer, was:

"I will research different solution spaces for the first and last mile delivery problem to make it more socially, ecologically and economically sustainable. I will design two to three solutions to FLMD situated in urban areas (Rotterdam as a leading example) that are demonstrably (within the 20 week time frame) more sustainable (ecologically-, environmentally- and socially-)."

To break it down we need to find what are the first and last mile delivery problems? Concluding the research that I have done to analyse this it is described in the following five main themes:

Polluting and congesting vans: Most of the problems like congestion, pollution, regulation and cost stem from the transport modality used. Big, polluting vans in the city are the root of the problems, so reducing the amount of vans that go into the city is a way to tackle that problem.

Accessibility and community: The more latent problem of the last mile being that it is 'unknown and unloved' is something that relates to its accessibility and community; reasons why logistics is little considered in city planning are because distribution centres nowadays are inaccessible buildings where the community has not at all been engaged in.

Policy and future proof solutions: Regulations are forcing carriers, who are Vanderlande's clients, to use less polluting modalities. Vanderlande can play a role in providing future proof solutions that facilitate these more sustainable modalities.

Logistics and spatial planning: Policy and spatial planning are somewhat contradictory however, because to facilitate smaller, more sustainable transport it is necessary to integrate logistics better in the city. This design is therefore not only made to investigate how Vanderlande can expand their portfolio in the last mile in a sustainable way, but also an appeal towards municipalities/local governments to consider logistics as an important point for sustainability in the city.

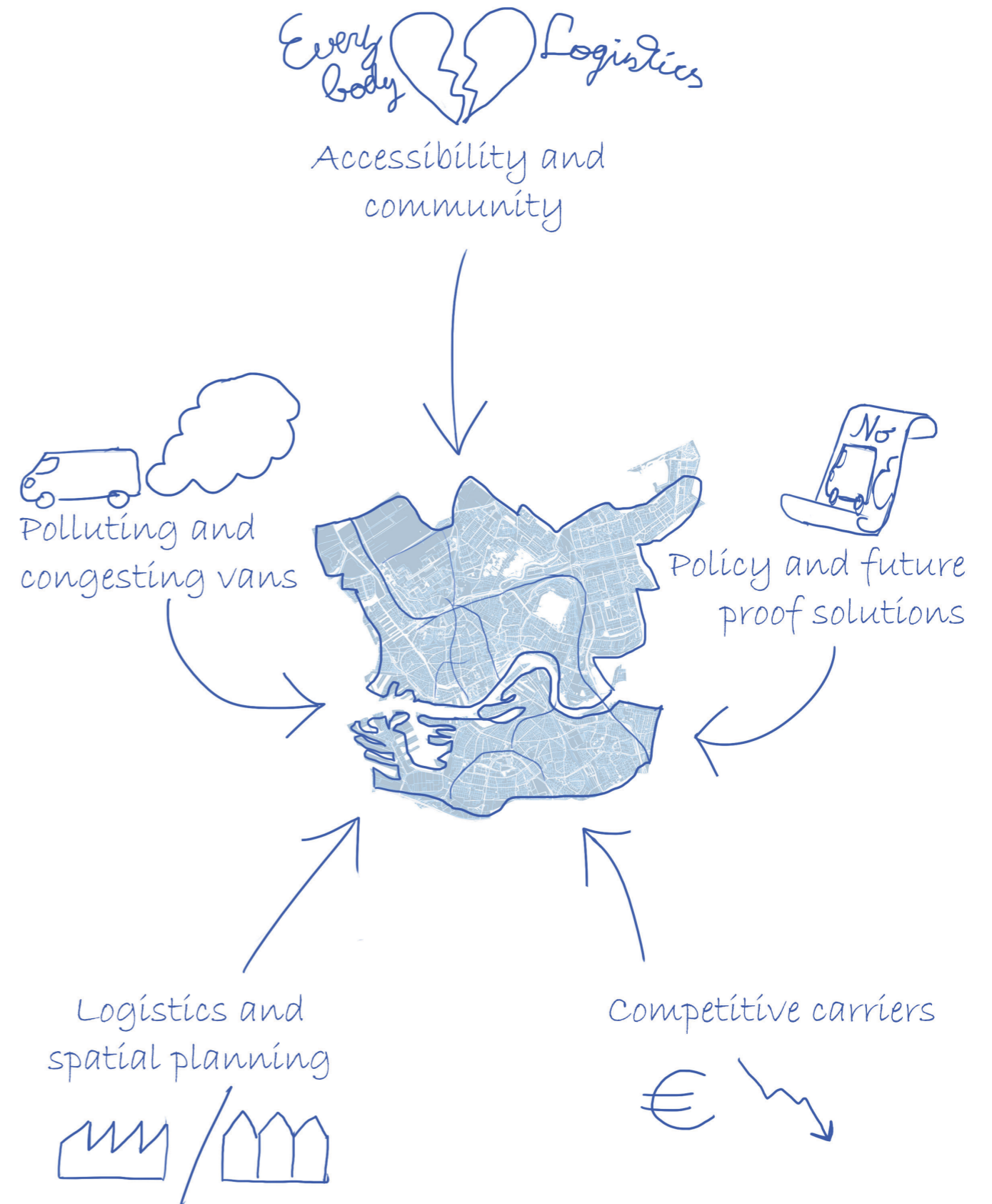
Competitive carriers: The 'race to the bottom' means that carriers offer their services for next to nothing. This means that, to maintain a competitive position, efficiency is imperative in the last mile. Furthermore, through the additional services that carriers offer they can distinguish themselves to gain a competitive advantage.

The design challenge has therefore been adjusted to address these main problems:

"How can Vanderlande ensure that fewer vans drive in the city? (ecological- and social- and to some extent economical- sustainability)

while at the same time making the 'last mile' more accessible and communal for the end user? (social sustainability)

and service and cost stay comparable/improve for business clients?" (economic sustainability)





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2. Define the context

Local governments acting up, good intentions abound

"We are definitely working on logistics, also looking at how logistics and passenger transport can be combined. We are also aware that it has to become an interplay between many different agencies and companies to arrive at an overarching solution."

Tom Kuijpers, Amsterdam Mobility Institute, 2023

In this chapter, trends and opportunities are identified concerning the sub-question of my design challenge:

How can Vanderlande ensure that fewer vans drive in the city for the consignment of parcels?

Multiple case studies have been performed outlining relevant factors concerning mobility, consolidation in the last mile, horizontal cooperation, and distribution. Some of the case studies concern already existing solutions, albeit in small numbers. Other case studies concern theoretical research to the effectiveness of certain operational models.

Amongst the theoretical case studies some important factors regarding possible placement of near city distribution and horizontal cooperation are discussed and I advise the reader, might they want to deepen their knowledge of these subjects, to further read into the discussed papers.

Furthermore, the conversations I had with experts in the field outline how they look- and work towards the future of the last mile. I spoke with Tom Kuijpers from the Amsterdam Mobility Institute and Minze Walvius from Advier, a mobility consultancy bureau.

Chapter division:

Government intervention

Incentives

Regulation

Consolidation

Cons

Pros

How?

Alternative modalities

Microhubs

Pros and Cons

Operational modes

Location problem

Data driven solutions

Out of home delivery options

2.1 GOVERNMENT INTERVENTION

European cities increasingly are enstating rules restricting logistics in the city; predetermined on- and offloading times, restrictions on types of transport, banning dark stores from the city centre (Amsterdam example), cities becoming car free (example inner cities Europe and Merwede Utrecht, Zero emission zones 2025).

Municipalities are obviously struggling with fostering sustainable city logistics. This results in policy that, to the impartial outsider, may seem inconsistent; logistics in inner cities is made more difficult by the fact that buildings like distribution- and fulfilment centres are being deterred further and further from the city centre, while at the same time these buildings are essential for the facilitation of the more sustainable transport that municipalities are demanding as well.

2.1.1 Incentivisation

Example successful incentivisation Rotterdam

The municipality of Rotterdam has invested in more sustainable transport modalities for the logistics- and agricultural sector. In October 2017, the grant scheme Demonstratieregeling klimaattechnologieën en innovaties in transport (DKTI transport) officially launched. Initially intended as an elaboration of the then Energy Agreement and the Fuel Vision, the DKTI transport has since become a permanent value within the implementation programme of the Climate Agreement from 2019.

The DKTI-transport focuses on accelerating the market introduction of means of transport using sustainable and innovative energy carriers, such as electricity, hydrogen and advanced biofuels. This takes place through product development and demonstration. The scheme also focuses on the further rollout of the fuelling- and charging infrastructure of the energy carriers. DHL Was one of the companies with whom DKTI did a project, they looked at the possibility of electrifying their entire fleet in the metropolitan region of Rotterdam. In the electric van segment, there were already relatively many small-scale trials taking place. But the challenges parties face in scaling up the fleet, was something which in practice was still hardly worked on. As a result, insufficient reliable and load-safe solutions were known yet. In this living lab, DKTI looked at convincing evidence.

"Through this project, we know a lot more about implementing electric freight transport. Never before has such a large fleet been switched on, so everything we are doing is new. DHL supports the investment in technology. We look forward to the tipping point when electric driving becomes the new normal, both in terms of vehicles and charging technology and network." - Ricky van Soest, operations field support Go Green specialist DHL.

This active involvement of local governments has had a great influence on logistics impact on the city streetscape. DKTI Has taken a cooperative role that was aligned with the business of DHL. The entirety of DHL's fleet in the region Rijnmond is now electrified, with the use of electric vans, LEVs and cargo bikes. These vehicles and the loading infrastructure they require are still in use.

Unsuccessful incentivisation

In stark contrast, Delft is a municipality which, has tried sustainable city logistic initiatives, namely Stadslogistiek Delft in two different forms, both of which have not been very successful.

"For several years, we had a logistics hub on Staalweg run by PostNL. With this, we were at



Above: DKTI Subsidized vehicles for DHL in Rotterdam

Below: Current vehicles DHL uses in Rotterdam



the forefront of the approach to urban logistics. Although research suggested otherwise, the market still seemed reluctant to use this new form of logistics. Partly because of the favourable conditions we could offer for the use of the Staalweg, this first variant of Stadslogistiek Delft continued to exist. With the sale of the Staalweg, it proved difficult to continue Stadslogistiek Delft at another location. PostNL focuses on regional hubs while we are looking for fine-meshed city logistics. This does not connect sufficiently. In consultation with PostNL, it was decided not to try to continue this first variant of Stadslogistiek Delft in a modified form." - Gemeente Delft, 2020

The second iteration of the Stadslogistiek project consisted of a cooperation with LessGo. To support the LessGo initiative, the Municipality of Delft acted as a launching customer and conducted a pilot with them. LessGo transported as many goods as possible to the city office using clean transportation through the hub, mainly using cargo bikes and electric vehicles for larger volumes. The Municipality of Delft relocated its delivery address to the hub's location and procured clean supply services from LessGo. They had agreed with LessGo to use this service for a year as part of a pilot. During this time, the municipality wanted to learn which goods flows were suitable, the volumes involved, the obstacles they could encounter and the total costs of the service. With this knowledge, they wanted to make a market inquiry to be able to continue the service structurally after the pilot with the best provider.

However, the bundled white label delivery of goods was an option for carriers rather than an obligation. This meant that new contracts for deliverers outside the scheme were still being allowed and renewed, meaning DHL could still enter the city in their vans. In a conversation that I had with Laurens van Tuinhout he stated that the municipality needed at least a year to establish the rule that no other delivery vehicle could enter the city.

Major carriers of parcels like DHL and GLS did not cooperate with the scheme, and with no structural changes to their practices the transport modalities in Delft are still very much traditional; large internal combustion engine vans. Especially in the ancient centre of Delft this can cause major congestion in the streets, see the image on the right.

In conclusion

What works best when incentivising innovation is seeking cooperation with the existing carriers, rather than trying to force a completely new logistic system. As has been apparent from my interviews with Paul Buijs, carriers already have their logistic processes optimised and are in volume and available assets the most dominant forces on the market. For effective action of local governments, extending or adding to the large carriers' processes is more effective than reworking- or setting up their own processes.

This is one of the reasons why the consolidated model of Stadslogistiek might not have worked. Other reasons might have to do with the way consolidation can throw a spanner in the works concerning efficiency and competitiveness. More about consolidation in 2.3 CONSOLIDATION.

Furthermore, investments in infrastructure, such as the loading infrastructure for electric vehicles, are an effective way to facilitate more sustainable transport in the long term; the infrastructure will be able to be used for a long time and is pivotal for electric vehicles to operate. When investments are made by local governments, the best thing is to kickstart innovation by investing in long lasting ways to facilitate more sustainable practices.



Integrating logistics in the city

There are still experiments running however to integrate logistics in the city. One example of a local government that takes a proactive role in this respect can be seen in Hamburg. There the local government is actively scouting potential locations for 'microhubs'; small fulfilment centres or depots that bring distribution closer to the end consignee.

The city has initiated trials of microhubs to address the challenges of last-mile deliveries. Under the direction of the Hamburg Ministry of Economy and Innovation (BWI), Hamburg Invest has been developing novel logistics solutions. Among these solutions, the identification of potential locations for microhubs in different quarters of Hamburg has been a key focus. The goal is to establish a comprehensive network of microhubs across the entire city, utilising both municipal and private sites (Invest Immobilien Hamburg, 2016). The 'Living Lab Hamburg' has envisioned the pilot implementation of these hubs and other implementations in the framework of MOVE21 (Move21, 2018). More on the details of how the microhubs operate in 2.3 CASE STUDY HAMBURG.



Potential hub location as identified by the Living Lab in Hamburg.



Inside a hub in Hamburg, fresh goods are stored for local stores and restaurants

2.2.2 Regulation

Regulatory measures regarding restrictions on vehicle movements and loading times have been mentioned already in this report. These can be seen as obvious regulatory measures, however they are more symptom management than actually addressing the root of the problem; the lack of integration of logistics in the city in a sustainable way.

Segregating logistics from the city

Corporate land is being chased out of the city, with major consequences for business activity. "By 2040, over 500 hectares of business sites will disappear from Amsterdam," says Bart Stek of real estate company Colliers in an interview with local newspaper het Parool. 350 Hectares alone are evaporating in the port area and Noord, where the municipality wants to build between 40,000 and 70,000 homes. "That will cause big problems," he says. For how will we get our Internet orders home, how will the restaurants, cafés and shops we love so much still be delivered? And where will we have to work in the future?

Bart Stek: "Warehouses, logistics and small factories are being squeezed out of the city, but the city actually needs these companies." Municipal politicians look for solutions a long way away in the region of Amsterdam. There, 800 hectares of industrial land are said to be ready. But this includes 280 hectares in Flevoland and almost 160 hectares in North Holland.

Bart Stek: "That is no use to a parcel company, online supermarket or catering delivery company. You can't just drop them off in the region; that creates all sorts of new problems. Employees would have to travel longer to work and delivery vans would have to drive further back and forth. What does that mean for accessibility and the environment?" Moreover, the long distance to the cities makes the deployment of clean, electric transport more difficult. That is why fulfilment centres nowadays are 'boxes near the highway'; they are cheaply built with a large footprint, they are efficiently operating centres that accommodate large volumes of parcels. The transport modalities these hubs can support are, depending on their average distance to end consignees (but typically tens of kms) ICE vehicles or large electric vans.

The municipality makes the zoning laws and therefore also decides where logistical centres can be placed. By moving logistical centres further away from the city, it becomes more difficult to effectively integrate sustainable ways of delivery, like LEVs, whose range and capacity are smaller than those of the large combustion powered vehicles widely used today.

Typical distribution centre in the Netherlands; large, not very nice to look at and located near the motorway.



2.2 ALTERNATIVE MODALITIES

Darkstores example

An example of logistic hubs that are very centrally placed in the city are darkstores. They are practically small fulfilment centres where groceries are kept for flash delivery distribution. The shops are called darkstores because they often have taped windows, meaning you cannot enter them. Companies such as Getir, Zapp and Gorillas are popular exploiters of these types of darkstores.

“They are located in locations intended for retail: shops where customers can walk in and out and select products. Darkstores with flash delivery do not meet the requirements of the zoning plan: the retail spaces are not publicly accessible: they are distribution centres for flash delivery.” - Municipality of Amsterdam, 2022

The flash delivery from a residential area causes a lot of inconvenience, according to the municipality. “These centres are more frequently supplied and constantly visited by flash deliverers, leading to traffic nuisance, noise nuisance, bicycle parking nuisance and rubbish nuisance. In addition, the businesses are also open outside the usual shopping hours.” - Municipality of Amsterdam, 2022

Their inaccessibility has therefore been their downfall; municipalities did not find them suitable for the zoning plans of the city. Again the interplay between government and logistics becomes apparent.



Gorillas dark store in Amsterdam, nowadays dark stores are prohibited in the centre.



Bicycle depot for courier service Thuisbezorgd in the centre of Rotterdam. Couriers wait outside here for their next job and take a bike from the depot.



Chariot employed by DHL



LEV Employed by PostNL for Stadslogistiek in Den Haag



Typical PostNL transport modalities



Cycloon bicycle setup



DHL Parcel boat in Amsterdam canals

Cities in Europe are more and more becoming car free. An example of a district that is a frontrunner in that respect is Nieuw Merwede in Utrecht, see 2.1 CASE STUDY MERWEDE. For the logistics concept in Merwede, the owners foresee three basic work packages, which are needed to provide residents and businesses with their logistics needs from the completion of the first homes: parcel walls, service shops and the provision of light electric vehicles (Gemeente Utrecht, 2023).

Carriers are already working with a plethora of different human powered vehicles for consignment. Take the chariot of DHL, the LEVs and several different parcel bikes employed by PostNL, and the bike-and-trailer combination that Cycloon employs.

Smaller vehicles like (electrically supported) freight bikes/micro cars have several advantages, (also referring to the likes and dislikes that end user have with the current system):

Less in the way on the roads and sidewalks

Fewer emissions (CO₂, NO_x, particulate matter from the tyres)

Traffic is less of an issue; smaller vehicles suffer less- and have less impact on- traffic because they can manoeuvre through it

This smaller transport does have some downsides as well:

Smaller range (w. manpower especially, also for electric vehicles a pressing issue) (DKTI overhead, 2017).

Smaller load capacity meaning they can carry fewer items.

To overcome these downsides and to facilitate smaller transport it is therefore important that the routes from fulfilment centre to end consignee are made shorter. This would mean bringing the end consignee closer to the fulfilment centre (e.g. through the use of out of home delivery) or bring the fulfilment centre closer to the end consignee (e.g. through urban consolidation centres).

Transport needs to be tailored to location

The same type of transport cannot be applied everywhere. Arnhem, for example, has different problems from The Hague. Consider the hills they have there, which means electric bikes have a shorter range.

Cities like Amsterdam, with its many canals, are actually thinking more about using waterborne transport, an example being the DHL parcel boat.

Tom Kuijpers

Program Developer Smart Urban Mobility Research & Valorization AMS Institute

The question of how to develop our cities to meet our current and future needs is a recurring one. This was the subject of the conversation with Program Developer Smart Urban Mobility Research & Valorization of the Amsterdam Institute for Advanced Metropolitan Solutions, Tom Kuijpers. Their smarthubs project was discussed as well as the role that the municipality could take in the last mile:

We are definitely working on logistics, also looking at how logistics and passenger transport can be combined. We are also aware that it has to become an interplay between many different agencies and companies to arrive at an overarching solution.

Not all transport needs to be by road, also look at how transport by water or air can become part of your scope.

Hubs can start playing a role in daily mobility or even energy supply. They are mainly going to exist to give people the option of not having to have a car themselves. SMARTHUBS is a project they are working on.

As for ownership, who becomes the 'white label' owner: that is a tricky business. The municipality does currently not think of these kind of things.

Amsterdam would have to do its own tendering for, say, PUDOs in the city. There has been a pilot in the 9 streets in terms of a white label consolidated trash removal service.

Although the municipality of Amsterdam was initially very enthusiastic about it, according to Tom Kuijpers it is not feasible to work with autonomous vehicles on a large scale: 'in a low-traffic area it could work but as soon as you're on Leidseplein (busy area with many pedestrians), for example, an autonomous vehicle doesn't work well and safely enough! Smaller robots might be able to work: 'autonomous vehicles on a smaller, more human scale could work on cycle paths for example, but as soon as they get busy car traffic it quickly becomes dangerous!'

What is also interesting is a dynamic policy: for example, a parking space could change function by part of the day; morning and night a parking space and afternoon a place for terraces.



Possible future scenario: 'Good intentions abound'

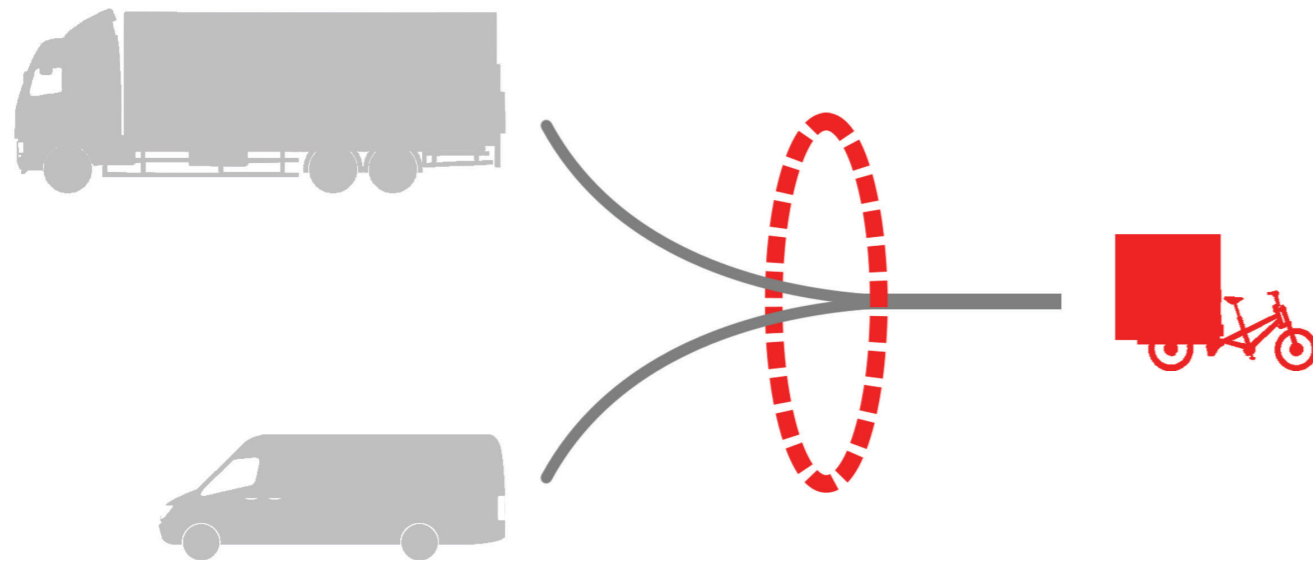
"Municipalities lead the transition to sustainable last-mile logistics in the Good Intentions Abound scenario and take firm direction with mostly mitigation measures. Mitigation plans must be prepared and approved in advance for new developments involving significant logistics flows. Local governments manage a system of urban hubs where parcels are cross-docked from large to small transport. And governments actively acquire logistics real estate for last-mile storage and distribution.

As a result, transport is completely zero emission. But apart from compulsory cooperation at hubs, cooperation in supply chains and in logistics facilities is scarce, so the transition to sustainability is only partially made. Where possible, operators operate from their own distribution centres and use their own fleets. Little to no data is exchanged between logistics players, nor between private parties and the government.

Innovation also gets off to a slow start. Where regulation has led to innovation in transport, many of the established players have been unable to meet new requirements. At the same time, the strict policy ensures that the share of new entrants is among the lowest of all scenarios."

ULaADS, What's in store for last-mile logistics, Plazier, Paul; Rauws, Ward; Buijs, Paul

2.3 CONSOLIDATED LOGISTICS



According to Vaillancourt (2016), consolidation is “generally understood in the business literature as combining certain activities or materials that have common attributes.” Consolidation in the last mile of logistics refers to the practice of combining multiple shipments from different sources into a single delivery vehicle or route before reaching their final destinations. This can refer to the following activities:

Multi flow consolidation: Multiple goods flows, such as from multiple different carriers, transported in the same vehicle.

Time consolidation: Buffering goods that need to go to the same location so they can be transported in the same vehicle.

Transshipment: Transfer of goods flows from one vehicle to another, for example to modalities that are best suited for the last mile in urban areas such as cargo bikes.

Consolidating goods from several retailers in one shipment for a transport service provider creates the potential to increase resource utilisation by raising trucks’ fill rates (Hagberg et al., 2022). Wehner (2020), in discussing the importance of utilising capacity, has argued that because “distribution in the last mile is exceptionally energy-intensive due to low fill rates, the use of private vehicles and the vast number of stops, that leg of supply chains shows exceptional potential for improving energy efficiency.”

With the ZE-zones in prospect ‘white label’ urban consolidation centres (UCCs) are one of the solutions that are put forward by local governments, as was the case with Delft Stadslogistiek. “There are now relatively poorly loaded deliveries especially from small in-house carriers. For some of those deliveries, after the introduction of zero emission zones in compacted cities, it will become more attractive to deliver via a professional carrier that bundles loads and can invest in zero-emission vehicles” - Bram Kin, TNO, 2023.

However there are also several reasons why consolidation (of parcel flows from several different carriers) might be undesirable by the carriers in question.

2.3.1 Arguments against consolidation

Already optimised last mile

In a process that is cost optimised as much as the last mile delivery process, there is little room to incorporate extra steps, which consolidation might well entail; the building and exploiting of consolidation centres, procuring and operating different transport modalities etc. is something that according to Dr. Paul Buijs carriers would rather like to save on.

“Goods flows towards cities are often planned in such a way that there are a lot of optimizations in the planning so that vehicles enter the city as fully loaded and as efficiently as possible. This is also why many carriers do not feel the need to transfer goods at hubs for bundled transport.” - Veronique Mienis, logistiek.nl, 2023

However, literature and experience teaches that this statement is not fully true. In the time that I have spent on my thesis I have paid attention to delivery vehicles in Rotterdam and Delft, and although some delivery vehicles seem efficiently packed, some are not. There are definitely efficiency gains to be had in optimising loading capacity through consolidating travel; either by having multiple carriers in the same vehicle or better transshipment to (smaller) modalities to more efficiently utilise load capacity. These processes could all take place in consolidation centres, more about them in 2.3 CONSOLIDATION.

Sharing data

From my conversations with Dr. Paul Buijs, I concluded that carriers do not want to share their sales information with each other. Giving your competitors a peek into the kitchen might well have a negative impact on your competitive position.

“There, in my view, is also the crux that bundling initiatives on white label hubs do not get off the ground or fail prematurely because sharing data is complex. It’s technology on the one hand and influencing the behaviour of people who are used to otherwise. If you want to bring this about, we still need to look at a control tower-like solution.” - Veronique Mienis, logistiek.nl, 2023.

Sales volumes

Furthermore, in my conversation with Verena Vreedeveld and Annabelle Waldus, we concluded that carriers do not want to sacrifice sales volumes. As Verena Vreedenveld said: ‘couriers do not want to concede parcel volumes.’ When transport is combined how can be ensured that said transport is able to deal with the capacity of the associated carriers. Moreover, who operates the said transport if it carries goods from multiple large carriers such as PostNL and DHL?



2.3.2 The 'pros' of consolidation

Reduced Delivery Vehicles

Consolidation of loads and collaboration in transport planning are amongst the most effective strategies for reducing urban freight related traffic (Browne et al., 2005a, Browne et al., 2005b; Macharis & Melo, 2011). This helps decrease traffic congestion, minimise emissions, and alleviate the overall environmental impact of delivery operations.

Lower Costs

Besides the external benefits, these strategies also reduce the use of transport resources such as personnel, trucks, and fuel (Anand et al., 2021). Consolidation allows for economies of scale, as delivery routes are optimised to accommodate multiple deliveries.

Optimised Routes

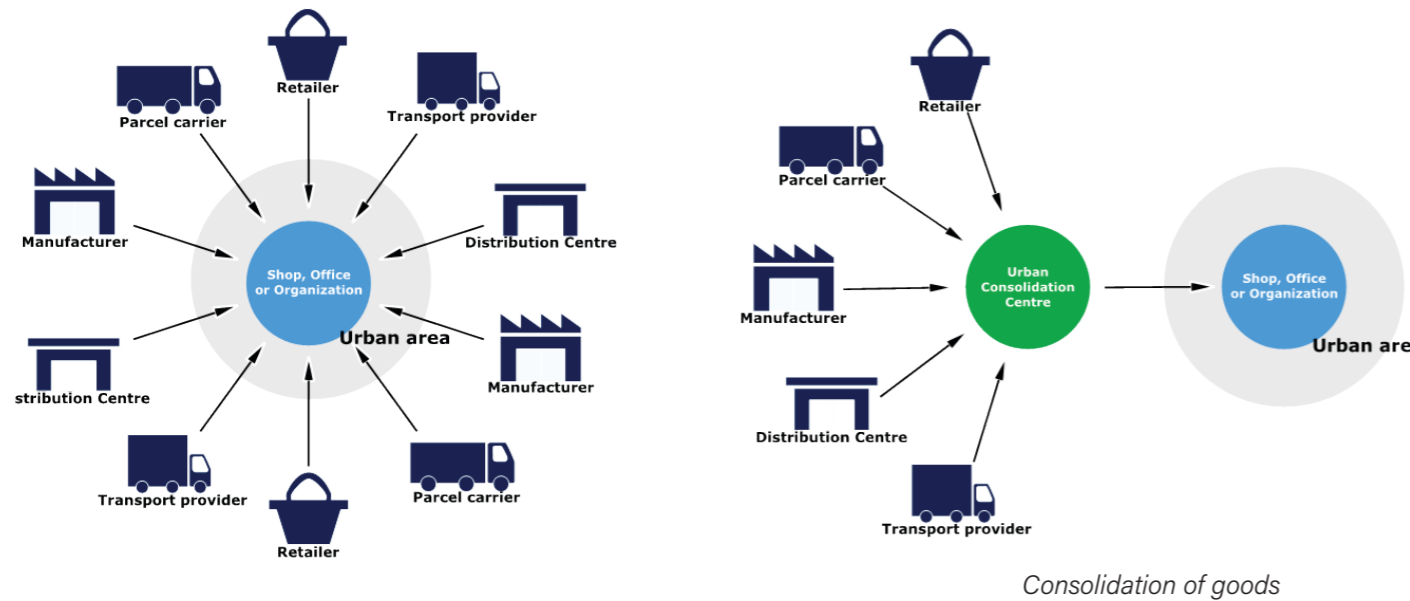
Consolidation enables the creation of efficient delivery routes that minimise the distance travelled and the time spent on the road. This results in faster deliveries, reduced mileage, and improved route planning.

Enhanced Sustainability

Fewer (large) delivery vehicles on the road mean reduced carbon emissions and a smaller environmental footprint. Consolidation aligns with sustainability goals by promoting resource efficiency and responsible logistics practices.

Reduced Traffic Congestion

Consolidation allows for fewer and smaller delivery vehicles entering the city and making stops at individual locations help decrease traffic congestion. This benefits both the environment and urban mobility.



2.3.3 Urban consolidation centres

With the introduction of zero-emission zones from 1 January 2025, an important role will be played by urban consolidation centres (UCCs) (logistiek.nl, 2023). According to a recent statement by Buck Consultants International (BCI), the Netherlands now has at least 300 city distribution hubs located near cities' edges. Most of these consist of single-user city hubs, for a single tenant or owner/user, and in particular parcel delivery companies such as PostNL and DHL Parcel, and also single market segments such as retail, hospitality, construction and facility-based office products (logistiek.nl, 2023).

Generally, a UCC is situated at the periphery of the city so that big trucks from shippers can easily access the UCC and deliver goods. Later, small, often environmentally friendly, modalities are used to deliver goods to their recipients in the city.

In my conversation with Dr. Paul Buijs I found out that nowadays the transfer from larger modalities to smaller modalities is badly facilitated and automated; the contents of the larger modality are usually 'dumped on a table' and sorted out manually to fit in the smaller modality. Automating these kinds of things is something that happens in a UCC. Furthermore, these activities fit exactly within Vanderlande's line of work and could be a meaningful addition to a sustainable last mile.

So UCCs are an answer to facilitate modalities other than (polluting) vans. However larger modalities, as we have seen in the hub and spoke model, will always be necessary to transport the larger volumes of parcels to the hubs.

Viability problem

In Europe, UCCs have been adopted by many countries, but the expected benefits of UCCs were rarely realised. Research by various scholars (Balm, Browne, Leonardi, & Quak, 2014; Behrends, Lindholm, & Woxenius, 2008; Browne et al., 2005; Marcucci & Danielis, 2008; Melo, 2010; Olsson & Woxenius, 2014; Patier & Browne, 2010; Tsamboulas & Kapros, 2003; van Duin, Quak, Munuzuri & Eds., 2008; Van Duin, Quak, & Muñuzuri, 2010; Verlinde, 2015; Wolpert & Reuter, 2012) suggests that most of these UCCs depended on full government subsidies for their operation. When funding was



Small distribution centre from DHL in Amsterdam Oost near the city, the perfect location for a UCC

reduced or discontinued, these UCCs struggled to sustain themselves and eventually had to close. Some attempted to adapt their business models to achieve financial independence (Quak & Tavasszy, 2011). However, public support, often in the form of regulatory measures favouring alternative approaches, remained crucial, and ultimately, only a few UCCs managed to remain operational (Hagberg et al., 2022).

"For operators, multi-user city hubs are often by no means a goldmine" - Christiaan van Luijk, 2023. Late 2022, for instance, operator Lessgo, with branches in Alphen aan den Rijn, Rotterdam and The Hague, went bankrupt (Logistiek.nl, 2023). This begs the question, 'who will operate these hubs?' If exploiting these hubs is not profitable, might an organisation like the local government take this up instead of a commercial enterprise? After all, infrastructure is a cost item for local governments already, under which white label hubs might be considered to fall. More about the potential business models behind these UCCs in 4.1.4 MULTIPLE CARRIER CONSOLIDATION.

Location problem

Finding the most suitable locations for logistic facilities in the city, like a UCC, depot or hub is a complex problem. This is something that Novotná et al. have been researching. For a case study on the location problem see 2.2 CASE STUDY NEAR CITY DISTRIBUTION. The five criteria used by Novotná et al. were: **Sum of distance from sorting centre** (i.e. vicinity to the consignees), **Reach area of the microhub**, **Cargo bike availability**, **Cycle distance** and **Costs**.

Furthermore, there is obviously the aspect of public acceptance; to ensure that nearby residents do not oppose the newly built logistical infrastructure things like noise pollution, littering and loitering should be considered.

To conclude, finding the right location is a very difficult question and one I am not going to be able to answer in the scope of this project (however there is much literature available on the guidelines and parties more suited to solve this problem, like for instance the local government as in Hamburg). Finding the right location is essential for the success of UCCs, microhubs, depots and the like.

Separating goods flows

When consolidating goods flows from several carriers it could be important to distinguish these parcel flows. This so that each individual parcel can still be traced back to its original carrier. This does require that contents can securely be communicated, for

example through technologies such as blockchain. This approach ensures clear identification of each provider's belongings while maintaining a certain level of privacy (e.g., information regarding sales volumes).

While containerization could potentially be a part of this approach, it's important to note that the project does not aim to fully containerize the last mile, as this isn't aligned with Vanderlande's core business. There are already smaller companies like Rytle and Velove that specialise in fully containerized last-mile solutions. These companies make containers that are weather- and tamper proof and are easily clicked onto transport modalities also provided by these companies.

Achieving a fully containerized last mile would require a significant overhaul of the entire logistics chain, which is a complex and extensive endeavour beyond the scope of this graduation project. For a case study on Rytle and how they operate, please see 2.4 CASE STUDY HORIZONTAL COOPERATION. However, this project does explore standardisation to better facilitate goods flows from several companies to mix. The possibility of organising parcels from various carriers for example, could perhaps utilise racks, to facilitate the separation of logistic flows within a fulfilment centre.

2.4 OUT OF HOME DELIVERY



Mechelen is a city whose centre has been designated an 'ecozone' where parcel lockers and consolidated delivery should result in fewer logistic kilometres driven. An initial phase of the project, 20 parcel vending machines were installed. Later it became 50, and now it has grown into a successful, implemented network. With a parcel machine nearby, you can easily collect parcels on foot or by bike. Moreover, the parcel machines are always open. So you choose when to pick up or send your parcel.

According to the 'Last Mile Experts,' a team of consultants on last mile logistics, a dense network of automated parcel machines (APMs) and pick up and drop off points (PUDOs) operated in an efficient manner is currently the most effective and efficient way to reduce the environmental impact of e-commerce logistics. If all courier transport moved to parcel lockers, like it has been attempted in Mechelen, see the image above, it would be possible to reduce CO2 emissions by up to 75% in relation to traditional courier delivery (Last Mile Experts, 2022). For a more detailed case study on how out of home (OOH) delivery works, please read the 1.2 CASE STUDY PARCEL LOCKERS.

OOH Delivery may well address the sustainability aspect of my project brief, and although it can help reduce the driven kilometres for the consignment of parcels, it does not address the main problem I want to solve; 'How can Vanderlande ensure fewer vans enter the city?'

Furthermore, as is shown in the 1.2 CASE STUDY PARCEL LOCKERS, the market for APMs and PUDOs is a competitive one, and one that not is very much in line with Vanderlande's line of business. Therefore APMs and PUDOs will not be taken into scope as such, however, the concept of OOH delivery is still interesting in other forms when combined with UCCs for example.

2.5 ACCESSIBILITY

The second part of the design challenge reads;

[..]. while at the same time making the 'last mile' more accessible and communal for the end user [..]

This addresses the conflict between the need to integrate logistics in the city and the overarching trend in city planning and policy to limit logistics' (negative) influence. It raises the question, how can last mile logistics be made more accessible, and what does accessibility mean in this context?

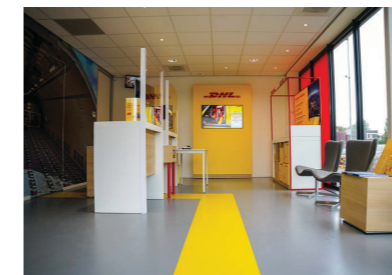


Pumpstation acting as service point for multiple carriers.

Decentralisation

This has been briefly discussed in 1.3 STAKEHOLDERS, accessibility is more important than mobility. It refers mainly to making touchpoints with customers take place in smaller and more dispersed facilities contrary to consolidating facilities into large efficient ones (for example small neighbourhood supermarkets vs megastores). The kind of touchpoints in this case are service points where one can retrieve or send their parcel, or go to for other parcel related queries.

One of the dislikes of consumers was not having service points of their specific carrier close by, that is why consolidated hubs with mixed service points are valuable for the accessibility of the carriers by the end users.



DHL Service point with open accesible character

Open for everyone

This concerns openness of the touchpoints. Where possible the public should be able to enter the touchpoints to create an open and approachable character of last mile logistics. An open plan and as much as possible visibility through the entirety of the facility, no taped windows etc. can all be important to enhance neighbourhood acceptance, in contrary to how darkstores work. Generally the touchpoints should look like a kiosk and integrate functions benefiting the public space as well.

Minze Walvius

Founder of ADVIER, Public Speaker

Advier is a creative and innovative agency with a mission: They move people towards a more sustainable society. They do this as consultants and (re)designers of services, systems and organisations. Advier works on breakthroughs towards a Sustainable & Smart Society based on clear insights, tangible impact, connecting people, locations and innovative initiatives. The conversation with Minze Walvius, founder of Advier was about which drivers could possibly make the last mile more sustainable:

'About consumerism and delivery, how Wehkamp can afford same day delivery: Wehkamp charges interest if you choose spread payment, they have enough money to send your package. Really they are creditors without people knowing it which is why I say you need to light Wehkamp on fire.

Money rules when talking business to business: In London, cooperation was brought about very quickly during the Olympics because loading and unloading was being charged; it could only be done at certain places and certain times, and it cost a lot of money. As a result, within two weeks DHL designed a bus that used side-loading, this bus carried parcels from different carriers.

Fundings only have not been able to bring about fundamental change: Fundings are nice, but once the funding is runs out, the project is finished. What works quickest is when companies get obliged or restricted certain things. That is in most cases the best catalyst for innovation.

A nice example of predictive modeling; Gorillas can stock just enough products because they build up information on the consumer behaviour of their users. I can remember a company in Japan that based on social media data could predict how busy certain public transport would be, and could suggest diversions to people to spread the load.

About how Mechelen could create their 'ecozone: In Mechelen, it was realised because an alderman simply said: we are going to tender the whole last mile, Bpost picked this up. From now on, Bpost has exclusive rights to the last mile in Mechelen.

Waste collection is easily consolidated, why? Because there is no branding involved, no service except to get the waste out of the city as quickly and efficiently as possible.

About what Vanderlande's competencies are and what that could mean for this project: Vanderlande operates in a world where space and staff are expensive, which is the space in which they comfortably design. So design for automisation.

You have to think about demographics: Who do you design for? People now might not care for ecologically responsible last mile delivery, and might not want to pay extra for it, but I assume that more and more people will do so in the future.'



Possible future scenario: 'Thriving, individually'

"After an emphasis on restrictive measures in the early 2020s, local authorities focus on facilitative measures to stimulate innovation and cooperation in last-mile logistics. These early restrictions on mode use and inner-city access have triggered a mix of innovations in transport modes and business models. The logistics sector has expanded rapidly, and consumer preferences have changed: for instance, the majority of residents now prefer delivery at unattended pick-up points. Developing such unattended pick-up points is also essential for logistics providers to process the growing volumes of parcels. For B2B-deliveries, door-to-door remains the standard as consolidation is difficult to organize. A similar result of early restrictions, the last-mile transport fleet is almost completely zero emission and includes a mix of (e-)cargo bikes, LEV's, and fuel cell vehicles for large deliveries. Also, automation in the form of autonomous mail carts following mailmen is part of the fleet. Micro hubs support a further increase of capacity and efficiency. The growth of e-commerce creates room for a wide range of new operators including big tech companies, start-ups and community initiatives, which together account for a quarter of the deliveries. Taken altogether, the mix of innovations and the increase in number of logistics providers is sufficient to keep up with the growing demand and increase delivery capacity within the constraints of crowded inner-city areas. However, cooperation between private actors is rare. Most private operators choose to operate independently. In an attempt to create synergies, the local authorities set up publicly funded initiatives. Where operators do work together, this is done to increase efficiency and reduce costs, but enhancing sustainability is not a motive. This shows in resource cooperation, where operators deliver parcels through joint parcel lockers, but work with their own distribution centres and vehicle fleet. Also, data sharing across logistics operators does not take place, as data is seen as a major asset for creating competitive advantage. Sharing data with local authorities is however considered somewhat more acceptable..."

ULaaDS, What's in store for last-mile logistics, Plazier, Paul; Rauws, Ward; Buijs, Paul

2.6 COMMUNITY

One reason for utilising community engagement in the urban planning process is related to decreasing boundary critique, and especially preventing later conflicts. The current literature on community operational research recognizes that the use of transparent processes enabling dialogue between participants, accepted as fair by the stakeholder groups, has been shown to make a significant difference in people's acceptance, even when they might disagree with the outcome of the decision (Konsti-Laakso et al., 2016).

This can be about the importance of citizen/end user having co-determination in the placement of touchpoints as well as UCCs or other parts of the logistical system that could be part of the solution that I propose. This is especially important concerning parts that are being placed on the street since it will affect people's lives the most.

What follows are some examples of projects that use co-determination as their core strategy for urban planning design.

Bewegend bos

Advier is doing a project in Dordrecht where they are repurposing parking spots to more useful functions like parcel lockers, shared mobility options but mostly greenery. Central to the project is that inhabitants of the neighbourhood decide what they want to place on repurposed parking spots. A microhub could be one of the options that people place there.

Because of the close cooperation with the inhabitants, acceptance has easily been found. According to het AD, inhabitants would not want to revert their streets back to the old ways of having multiple parked cars instead of the newly placed greenery.



Above: *Bewegend bos Dordrecht*
Below: *Fietstrommel Rotterdam*

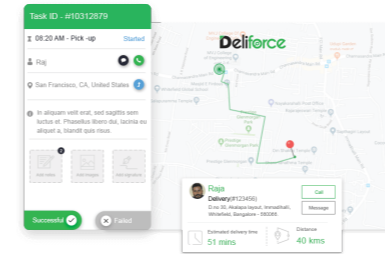
Fietstrommels

In Rotterdam you can request a bicycle drum to be placed on the pavement near your house. The placement of these fietstrommels is something that is done exclusively on request of the inhabitants. When a request is placed, the municipality will firstly assess the situation; amount of bicycles parked, space available etc. to see if building a fietstrommel would be viable. After that construction plans will start.



2.7 SERVICE

Service should not deteriorate when my design is implemented. Important parts regarding service are:



IDM Software

Interactive Delivery Management (IDM); Real-time Tracking and Communication, Delivery Preferences and Options, Delivery Rescheduling and Flexibility, Delivery Notifications and Alerts, Two-way Communication, etc.

Customers expect a low cost or free delivery, but if a choice is 'green' there is a bit more flexibility

Home delivery is still the most popular option because it requires no effort from the consignee at all, so this possibility should keep existing or otherwise it will not be competitive.

No limiting factors on the type of goods; the smaller modalities should be able to ship the same types of goods that vans can, so in size and weight should be similar to standardised parcel size/weight the van can carry.

Well trained/behaved personnel; as mentioned some carriers pride themselves with the service they can offer at the door, and in a way it is understandable that this interaction is a part of the process that carriers want to keep control over.

The solutions that I design should allow for pick up and drop off by any customer. For all of the solutions, the IDM software should have possibilities to communicate things like 'pick up your package yourself between then and then, otherwise it will be sent to your home address' (picking it up yourself obviously saves on delivery cost because you take work away from the carrier).

Furthermore, the one of the things that has come forward in my research about the likes and dislikes of the last mile as experienced by the consumer is the fact that people value the possibility to interact with someone when picking up/sending parcels, especially when it concerns particularly difficult deliveries.

2.8 COST FOR THE CARRIER

Nowadays the delivery process is optimised on cost efficiency so much, that employees actually suffer from it; see the sub-contractors not being able to take breaks, not having proper insurance coverage and having to work with great haste because they get paid per successful stop. However, the general sentiment from the experts I've talked to is still that the last mile is too expensive. This has to do with transportation; van maintenance, fuel, but also hourly wages, for example. This is something where smaller modalities like bikes can play a pivotal role because these smaller modalities:

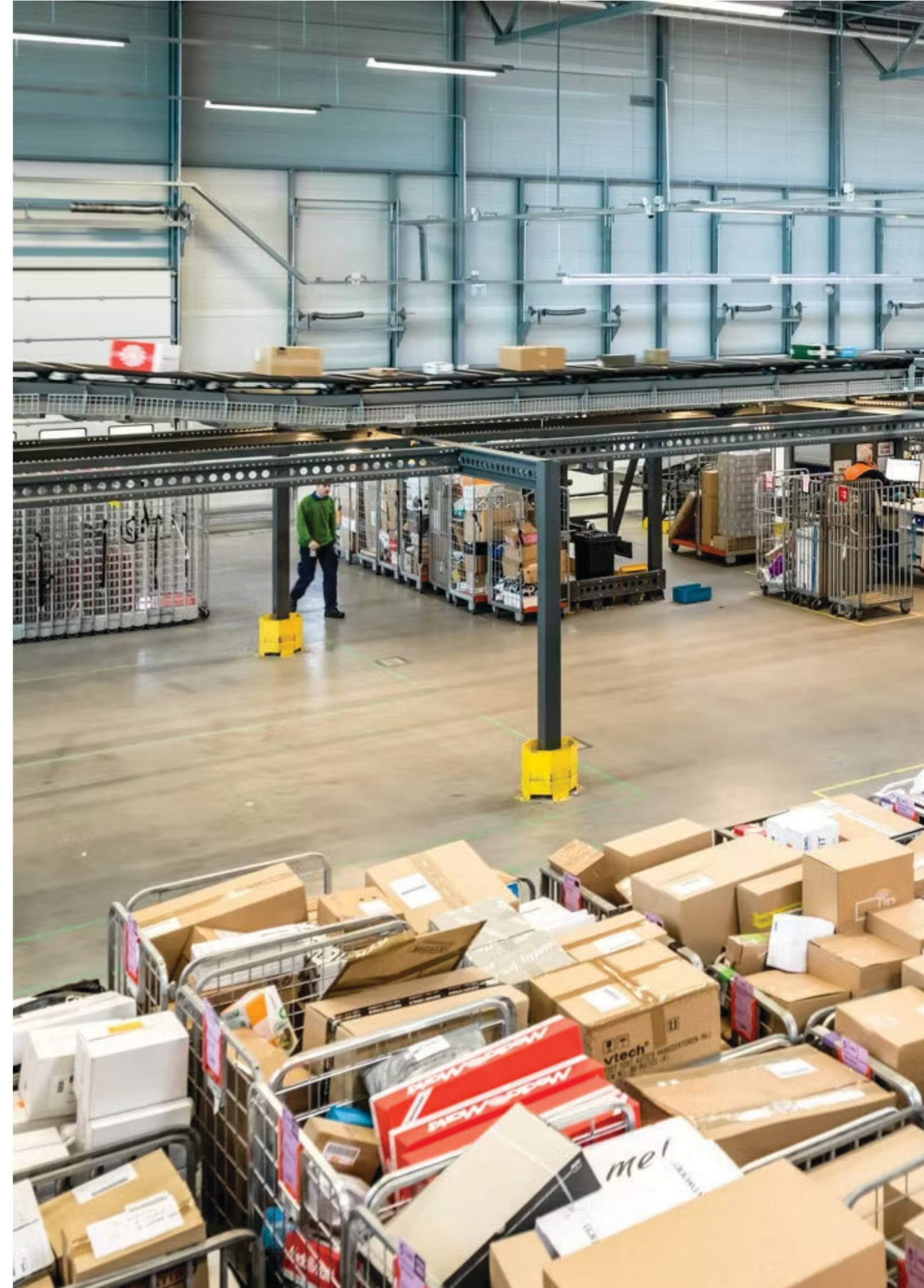
are cheaper to operate; no fuel cost, purchasing is cheaper (although switching to/investing in- an entirely new fleet could be a big initial investment).

Because (bikes especially) do not experience the perils of traffic, they in principle could operate quicker

Whether or not the system will operate more efficiently is something I can only make a very rough estimation about, comparing the costs of the new fleet and buildings compared to running costs of the current system. For an accurate estimation there are entire companies that can calculate it. The fiercely competitive market makes it very difficult to introduce significant changes to it. The fact that in Rotterdam DHL now employs (smaller-) electric modalities is because of the investments of the DKTI; (Rijksoverheid 2017)

That is why I write this report to appeal to the municipality as well; with their investment as an incentive, transitions can be kickstarted. Investments that the municipality could help with include:

The building cost of the infrastructure, for the selection of the right location Vanderlande, carriers and the municipality could operate together.
fleet of smaller modalities



2.9 CONCLUSION AND DEFINING DESIGN ACTIVITIES

To conclude this chapter in which I defined the ways that Vanderlande can ensure that fewer vans drive in the city while at the same time making the 'last mile' more accessible and communal for the end user and service and cost stay comparable/improve for business clients, I will translate the learnings into activities that are part of the design strategy for this project moving forward.

Incentivisation can help in kickstarting innovation if done right; investments should be long term, like investments in infrastructure, and from there on companies should be allowed to make operations as efficient as possible themselves.

Regulations force carriers to rethink their ways of operating, an important thing that needs to change is the transport modality; these need to be less polluting and have less of an impact on public space. This change will furthermore benefit a sustainable city.

The alternate modalities that fall under this category are for example electrically- or human powered such as LEVs or cargo bikes, the former requiring sufficient **loading infrastructure** to efficiently operate, as seen in the example from DKTI. Typically, these vehicles have smaller ranges and capacities which means **decentralisation** of operations is in order. This means that distribution/consolidation/fulfilment centres should take a more prevalent role in spatial development, but also that spatial planning should take a more prevalent role in logistics. This means that things like accessibility and openness can become important factors for the design of logistical flows.

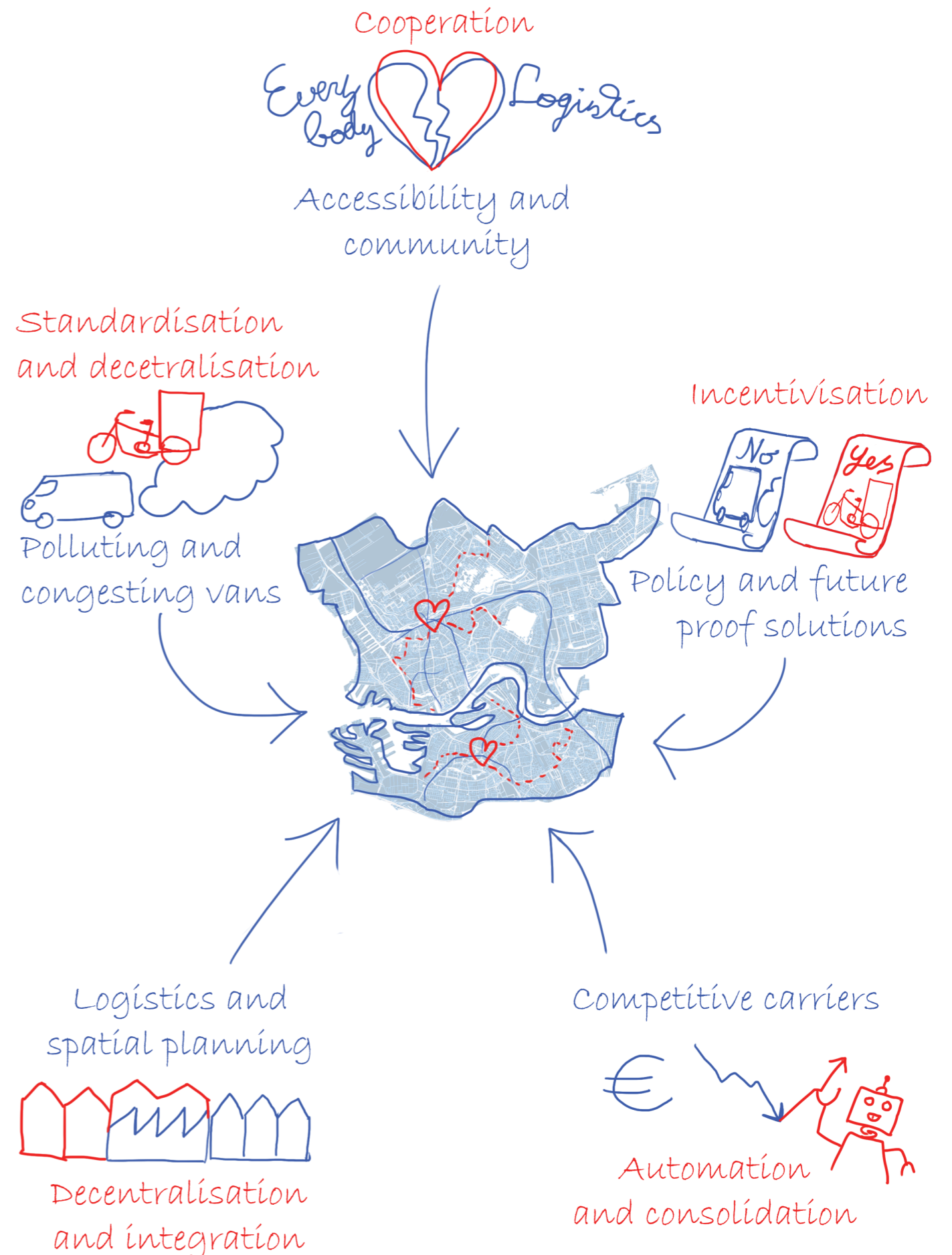
Decentralised operations could take place in UCCs where goods flows get consolidated into the more sustainable transport modalities. **Consolidation** is in order to more efficiently utilise the transport and prevent half empty vehicles, and thus also save cost. **Automation**, which is Vanderlande's core business, is another important way to save on costs. However, to efficiently automate this consolidation, **standardisation** might be in order.

Cooperation with district councils and inhabitants could improve neighbourhood acceptance of these UCCs. Therefore, facilitating **co-creation** might be of importance.

This design is not only made to investigate how Vanderlande can expand their portfolio in the last mile in a sustainable way, but also an appeal towards municipalities/local governments to consider the **integration** of logistics as an important point for sustainability in the city.

To summarise, the following processes are important to achieve my design goal (How can Vanderlande ensure that fewer vans drive in the city while at the same time making the 'last mile' more accessible and communal for the end user and service and cost stay comparable/improve for business clients?)

- **Standardisation**
- **Loading infrastructure**
- **Consolidation**
- **Automation**
- **Decentralisation**
- **Integration**
- **Cooperation**
- **Incentivisation**



3. Future approach

Developing the design activities

'Nowadays, the distribution centre is where the automating of sorting and ordering parcels stops, however more efficiency could be reached if there is a point further in the chain where this is done.'

- Paul Buijs, Rijks Universiteit Groningen

Now that we know the activities that are important for the design strategy we need to look into these activities to translate them into strategy proposals.

I will look at how standardisation can be accomplished through some sort of containerisation, using standardised racks throughout the parcel journey.

Automation plays an important role in the optimisation of the last mile process, I establish the important interfaces and processes.

Then, I propose three different types of urban consolidation centres that play a pivotal role in decentralisation of distribution in the last mile and with it the facilitation of smaller transport modalities.

Then I look at the activities that regard the interplay between logistics and public space as well as governmental actions. I explore what role Vanderlande can play in these fields, and possible partnerships and platforms that might be of interest. I also compiled a list of guidelines regarding logistics and public space.

Finally, an overview of the strategy proposal is given in which all the parts and their relations are explained.

Chapter division

- Standardisation
- Automation
- Consolidation
 - Multi flow consolidation
 - Transshipment
- Decentralisation
- Public space and governmental action
- Integration
- Co-creation
- Incentivisation
- City Logistics Innovation Campus
- Guidelines
- Strategy proposal

3.1 STANDARDISATION

In my conversation with Marc van Neerijnen we discussed that to create efficient and effective interfaces between different points in the parcel journey (i.e. from distribution centre, to transport, to UCC, to smaller transport modality), it is useful to apply standardised measurements (i.e. for loading bays of vehicles, bundling of goods for transport and storage etc.). This is one of the benefits a containerised transport journey can offer, however, as discussed, full containerisation is difficult and does not fit the DNA of Vanderlande.

So instead of creating weather- and tamper proof containers that click onto specially designed vehicles, a much easier and accessible solution is to use standardised racks, similar to how racks are used in the supermarket fulfilment industry. These racks roll into their respective storage or vehicle, can easily be interacted with by automated sorting robots and are a cheap solution to consolidate parcels into bundles. This does, however, require some alignment between the measurements of the vehicle designs; that of the larger and the smaller modalities, and it requires alignment between the measurements of the vehicles and the storage space designs if they are to be optimally packed into these vehicles.

An example of a company that applies these types of racks in combination with small transport modalities is Fulpra, see image below. Their bicycles can accommodate at least two racks, adding up to 3000 litres of storage space.

These carts could be used throughout the entire parcel journey for easy bundled transport; starting from the distribution centre, parcels get loaded into racks before being rolled into box trucks, to then later be transferred into smaller modalities that can enter the city. If necessary, a robot can move parcels from one rack to another whilst in storage.



Fulpra bikes are made to carry specially designed racks. The bikes have a load capacity of 3000L / 350kg



Amazon robotics are made to move around specially designed racks in the fulfilment centre

3.2 AUTOMATION



Vanderlande order picking robot

Vanderlande's ADAPTO robot moving goods around shelving units

These racks can facilitate the design of interfaces with automation; unified sizes throughout the parcel journey make it easier to design automated processes. Automation often relies on sophisticated software and control systems, and Vanderlande can develop these to manage and optimise automated processes. These processes include:

Parcel Sorting: The sorting of parcels in distribution centres, ensuring that packages are directed to the correct destinations efficiently.

Order picking: Automation solutions for e-commerce operations, such as the picking and packing of online orders.

Vehicle loading: The loading and possibly unloading of box trucks, for example, with racks of parcels so they are optimally loaded and according to the 'last in first out' principle.

Managing parcel flows: When multiple different carriers their parcel flows are consolidated in a single centre the need arises to securely handle information like sales volumes and keeping track which parcels are from which carrier.

The image on the bottom left shows an example of Amazon Robotics robots moving racks around a distribution centre. In Amazon's workflow, there is a lot of interplay between the automated and manual processes; for example at order picking, lights in the racks indicate which item the worker needs to pick. Other processes like making shipments ready for loading into a vehicle are usually also not automated yet. This is a good example to show that human interaction might remain important so long as not every process is automated.



3.3 CONSOLIDATION

3.3.1 Multi flow consolidation

Standardised racks can help in separating the parcel flows from several carriers when they are handled in a single facility. According to Marc van Neerijnen, a 30 year employee of Vanderlande, particularly focussing on last mile delivery since the last few years, the 'last mile' is something that most couriers would like to cut costs on or even outsource. This is what a multi user consolidation scheme could resolve; the 'last mile' or rather 'last yard' is taken care of in consolidated facilities where one carrier is responsible for the infrastructure and upkeep cost.

At the same time some couriers do pride themselves with the service that they can offer in the last yard, for example in the form of well-behaved employees, timely delivery and care with which they handle the parcel. Furthermore, branding of a courier on one of their delivery vehicles increases the brand's visibility, which I found out in my conversation with Verena Vreedevel and Annabelle Waldus might be something couriers do not want to compromise on.

To establish a multi carrier flow consolidation scheme it is important to think of the business model; Who hitchhikes with whom, who bears responsibility and how are profits shared? To address these questions, I worked out several business models in collaboration with Vanderlande.



In practice parcels sometimes get randomly stacked inside vans

3.3.2 Transshipment

This refers to the transshipment of goods flows from one vehicle to another. Smaller, more focussed transport, preferably electric or human powered can solve issues regarding efficiency, hindrance, and pollution because they have lower weight, require less fuel or energy consumption and can navigate through congested urban areas more easily, resulting in reduced transportation costs and environmental impact. According to Butrina et al. (2018) cargo bikes have some competitive advantages over delivery trucks. This type of light electric freight vehicle (LEFV) has more choices to manoeuvre through a city using the road, bike lane, sidewalks, and accessing pedestrian-only areas to find the quickest or shortest route to the destination.

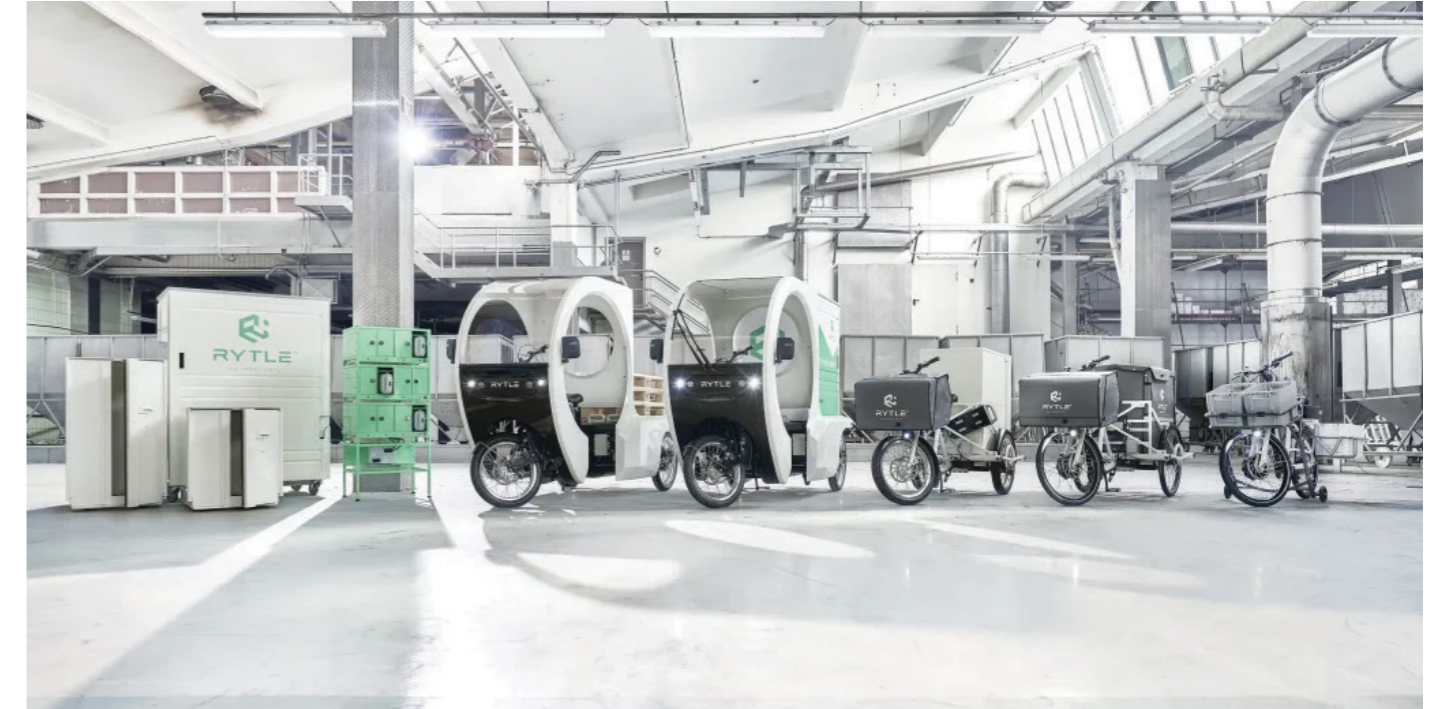
As mentioned, the design of this smaller transport needs some alignment considering the dimensions of their storage bay, with the design of storage spaces, considering standardised racks will be used throughout the entire parcel journey. However, Vanderlande will likely not be the company to design these vehicles. The design of the vehicles could be made ground up by for example Vanderlande's parent company Toyota, or cooperation with existing companies in the LEFV market, such as Rytle (see image below) or Velove could be



LEFV Made by Velove, employed by DHL

established to align dimensions of the storage bays and storage racks to create a kind of industry standard.

In my conversations with Paul Buijs we discussed that this transshipment is currently an inefficient process that requires better facilitation. That is why this transshipment will need to be facilitated in decentralised urban consolidation centres for example.



Rytle portfolio

3.4 DECENTRALISATION

This refers to the decentralisation of distribution operations in order to bring distribution closer to the end consignee. In my strategy I envision logistical buildings similar to the project in Hamburg, see 2.4 CASE STUDY HAMBURG, being an integral part of the solution. Different size districts require different sizes of consolidation centres, meaning the properties can range in size. The numbers are based on existing hubs performances and estimations made together with Marc van Neerijnen:

Parking spot size (approx 15m²): little room for automation or consolidation operations, mostly operating as a depot (120 - 150 items per day).

Storefront sized (approx 150m²): room for automation, possibly consolidation, operating as fulfilment centre, room for interaction with end user like a PUDO (2000 items a day)

Supermarket sized (350+m²): fully automated and consolidated fulfilment centre with facilities for end end users like return logistics, PUDOs and human interaction; possibly incorporating other functions such as 'work from home' offices (5000 items per day).

In short, the following should be considered when finding locations for these hubs:

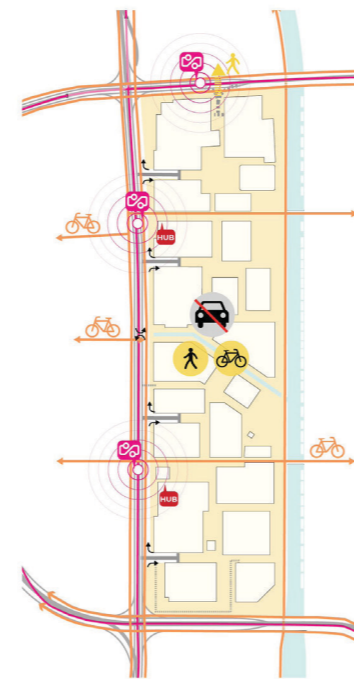
1. It is close to the main road for easy access by (box-) truck.
2. Preferably (just) outside of a ZE-zone, so that the supply of the hubs does not get hampered.
3. Will it be placed on municipal or private ground? See 2.4 CASE STUDY HAMBURG for how this can affect the business model of the hub.
4. All the things mentioned in the facility location problem are of importance. In short these are: sum of distance from sorting centre, Reach area of the microhub, Cargo bike availability, Cycle distance, Costs

Approach

A large transport modality like a truck supplies the hub. Some sort of approach is provided at the hub, again, preferably near main peripheral roads to prevent the larger modalities from needing to enter the denser urban areas.

Unloading

The (larger) modalities that supply the hub with goods flows should be able to load and unload somewhere. This can be done outside on a parking lot such as is done at supermarkets, or, in an effort to cause fewer nuisance in the neighbourhood (as has been the complaint with darkstores) indoors like the image below. The disadvantage of the latter being that it would require more indoor space.



Above: mobility strategy Merwede

Left: Neighbourhood logistics proposal for Toronto, Canada by Sidewalk Labs (2019)

Specially reserved parking spot for box trucks for small Albert Heijn supermarket in Rotterdam



Sorting

In the hub parcels get sorted into bundles for easy pick up by smaller modalities, be it through containerisation or otherwise. The size of parcels bundled in a container is elaborated in 4.1.3 STANDARDISATION.

Buffer

The hub acts as a buffer for the sorted bundles meaning ample storage should be provided. Assuming a parcel bike or LEV can carry around 200 FXME parcels per trip it would mean that per day about ten modalities come by the transfer point to pick up and distribute parcels either to lockers or home delivery.



Above: Getir bikes encroach the streets.

Below: Fulpra bike loading



Vehicle parking/charging

The smaller modalities that will be used for the 'final yard' can be stored on the premises, because these modalities will likely have some component of electrical propulsion loading infrastructure could be provided on the premises. Again it is important that visual clutter is kept to a minimum, to prevent situations like the image on the left, storage of these vehicles inside would be ideal.

Loading

Loading in the goods flows to the smaller modalities is facilitated on the premises, this process could be automated or at least require the least possible manual labour. Again, the standardised racks can play a role here.

To conclude, there will be more and smaller hubs (so one per district instead of one per couple of cities) to facilitate smaller transport modalities. However, in addition to purely logistical requirements, there are also requirements and guidelines regarding the integration of these properties in the urban fabric, which will be discussed in the next chapter.

3.5 PUBLIC SPACE, GOVERNMENT ACTIONS AND PARTNERSHIPS

The last few design activities; 'integration urban landscape, cooperation and incentivisation,' are (currently) mostly outside of Vanderlande's scope because they concern policy and public space design. These things fall under the scope of local governments, property developers and urban planners. However, Vanderlande has a stake in the logistic processes that take place in the properties that will be developed, therefore they should at least in some way be involved in the process of developing sustainable logistic properties. Public acceptance of this kind of property development is largely dependent on how well logistics is integrated into the urban landscape and people's possibility to have a say in the associated urban planning, as has been explained in 2.6 COMMUNITY THROUGH CO-CREATION. Furthermore, incentivisation is important to kickstart innovation in this area. There are several organisations and platforms that Vanderlande could enter to join the discussion of logistics and public space, which will be covered in this chapter.



Intospace concept mixing a distribution centre with housing, greenery and a football pitch

3.5.1 Integration urban landscape

The importance of an open and accessible character of logistics for its public acceptance have been discussed in this report. However there is more to integrating logistics into the urban landscape.

A distribution centre generally is a big box that is unappealing to the eye and does not serve any function other than sorting and distributing goods flows, meaning there is a lot of associated traffic. The classic distribution centre therefore does not fit in well in urban landscapes and it is understandable that "Warehouses, logistics and small factories are being squeezed out of the city" (Bart Stek in Het Parool, 2022). If logistical operations are being brought closer to the city, or the other way round; the city encroaches further outwards, then these logistics operations should be designed with the urban landscape in mind. This is also true the other way round; the urban landscape should be designed with logistic operations in mind.

The image above shows a concept of design platform IntoSpace that tries to make logistics part of spatial plans and better fit into the landscape and urban environment. By mixing and stacking functions such as logistic, housing and energy, the design platform tried to find an answer to this spatial task. They call this 'logistic real estate out of the box' (IntoSpace).

The question remains however, how Vanderlande ties into the story. Their practices mainly focus on what happens inside the property and less so the overall architectural design. What

might be useful however, is exploring how mixing different functions in one building influences the logistical processes. How does it affect available space, approach routes, logistical flows inside the building, and how do they interplay with the other functions in the building? Intospace might be an organisation that Vanderlande could start this dialogue with.

3.5.2 Co-creation

The concept of co-creation has been explained in 2.6 COMMUNITY THROUGH CO-CREATION. Organising co-creation for public design is a large endeavour that requires managing multiple stakeholders in a project. It could significantly improve public acceptance, however, fall beyond the purview of Vanderlande's core competencies. Consequently, it is conceivable that the responsibility for its elucidation and resolution may be better entrusted to entities with more pertinent expertise, such as Advier (from the 'bewegend bos' example), local governments and other relevant stakeholders

3.5.3 Incentivisation

Whether Vanderlande can actually fix the issue of proper investment is doubtful, mainly because it's a matter of the municipality's finances. However, there's a potential role for Vanderlande related to the earlier points of cooperation and integration. Vanderlande could consider taking on an advisory or collaborative role, working alongside local governments and other organisations like the Zero Emissie Stadslogistiek initiative or the City Logistics Innovation Campus, which offers opportunities for partnerships.

3.5.4 City Logistics Innovation Campus (CLIC)

Another organisation/platform that Vanderlande could consider talking to, to more actively participate in the design challenge that addresses the interplay between quality of life and logistics is the city, is the City Logistics Innovation Campus (CLIC). The City Logistics Innovation Campus is a fully operational city logistics hub, innovation centre and complete campus in one. CLIC is an ecosystem for parties 'developing the city logistics of tomorrow' (City Logistics Innovation Campus, 2023). Parties that have a place somewhere in the city logistics chain or are otherwise involved in innovation in city logistics.

CLIC ensures that established companies can focus on innovation. They do this by facilitating those companies, for example by offering shared services, such as charging facilities, security, catering, extended stay or park management, but also a knowledge desk, meeting facilities or even a shared fleet of electric vehicles.

CLIC serves as a hub for innovation and discussion in urban logistics, providing a place where stakeholders can come together to tackle relevant challenges. Vanderlande teaming up with such initiatives could lead to productive outcomes, fostering the exchange of knowledge and practical solutions that align with the broader goals of improving urban logistics. These collaborations might be a key factor in enhancing the effectiveness of urban logistics operations at the municipal level.



A living lab for city logistics. That is what the City Logistics Innovation Campus should be. It is located near the A9 near Badhoevedorp.

dr. ir. P. (Paul) Buijs

Professor economics and business Rijks Universiteit Groningen

With Paul Buijs I conversed about the concept of containerised transport, micro hubs and the role of the municipality as a 'white label' carrier:

'Who will own the transfer points/city hubs? Will the municipality be the owner? Rytte, does almost the same as your project, they have clients all through Europe, even here in Groningen, however they are just a small company unlike Vanderlande. They might not even make a profit yet with the scale they are working on.

I just came back from Paris, one of the things that was discussed was the exploitation of distribution centres and other parts of the last mile. The conclusion was that municipalities lack the money, expertise and willingness to do so. They do exploit public transport but logistics in the last mile just does not make enough money, the investments involved in automating are simply too large. I do not think there is a suitable 'white label' party that can do it, we simply do not know. I think the bottom line is that a private party should pick it up.

Nowadays, the distribution centre is where the automating of sorting and ordering parcels stops, however more efficiency could be reached if there is a point further in the chain where this is done.

When you look at how containerisation goes in practice, you see that nowadays the delivery driver somehow does not trust the container and still opens it up to look at its entire contents. I do think however this is a matter of getting used to, as soon as you can really assume with certainty that the containers are correctly filled according to the 'first-in-first-out' principle this might change, and then people will understand. Things that could help with this understanding could be 'augmented reality'.

To implement your idea of containerisation you must be able to earn back your investments. On which scale is it viable? Try to make a back of the envelope calculation. You can find information about sales volumes in reports of the ACM. It is important to than be able to make an estimation of the number of parcels per container, per bicycle, per van, per microhub etc.

I must say I am sceptical about the chances of a 'white label' last mile and even more sceptical about the municipality taking that role. The government should not be doing those things. What I am very positive about is the effect that smaller transport could have on sustainability. I have seen it having positive influence on neighbourhoods as well.

In conclusion, horizontal cooperation might be difficult, considering containerised transport think especially of the vertical cooperation; how does the container pass hands from distribution centre to microhub to bicycle? Think of packing technology and the like.'

Unnamed delivery contract negotiator large e-retailer in the Netherlands

For privacy and publication reasons, the identity and name of the e-retailer with whom I spoke are kept secret. The person I spoke is the main contract negotiator concerning carriers for one of the largest e-retail companies in the Netherlands. We spoke about the role of e-retailers in the last mile talked about the concept of containerised delivery in combination with microhubs:

'The role of our company is to be a platform for our partners (sellers); we connect the supply of our partners with the demand of our customers. What is important for us concerning the choice of carrier are a few things:

- We should be able to guarantee that the parcel actually gets delivered.
- Price is important.
- Speed of delivery, although we that that becomes less and less important the more sustainability becomes important for our customers.
- Sustainability of the transport; we see a trend in people wanting to make the sustainable choice of delivery.

The trend of the costumer towards sustainable delivery means that 'same day delivery' becomes less popular; 'same day delivery' is inherently less sustainable than when consignment is allowed to follow a less rushed path. We are actually asking ourselves if 'same day delivery' is something that we should still offer because of this trend and the associated sustainability aspects, but also the added stress it puts on the [last mile] network.

Choices made in favour of sustainability, however, should not negatively impact the NPS (Net Promotor Score) of our customers. We know that the sustainable delivery options we provide, denoted by a 'green leaf' when choosing said delivery options, are chosen more often. However, we are very aware that we should not do any 'greenwashing'; the ease of following the system and choosing the green leaf should mean something. We might consider trying to make the 'green leaf' the standard for delivery options.

We communicate sustainably aspects with our carriers, they rapport about their CO2 and energy goals, though they obviously do not give a full analysis of their company. We do also keep track of their sustainability goals by for example checking track and trace data on our parcels. We want to be a frontrunner in sustainable delivery.

Concerning things like IDM (interactive delivery management), track and trace data and costumer service, we value our own more than that of the carrier; we are big enough to have a good costumer service and when you order a parcel from us, we will email to let you know it has arrived as well as our carriers. We are looking into consolidating this so that we can take over all communication with the costumer.

In the interest of the consumer and to deliver them a seamless delivery experience we have started to do some first mile logistics. This entails that we take care of the collection of products ordered from our partners. How this used to go was that they themselves had to send their parcels from a service point to the end consignee.

As e-retailer we are not the design side of the last mile, however I do see that some initiatives that

I like. For example, Hubakee is an initiative in Amsterdam where they try to consolidate delivery. What I also like a lot are pick up points, I heard that they can be very effective in making the last mile more sustainable. We likely will not enter that market because it is very capitally intensive, however we do already cooperate with Budbee and Albert Heijn; their lockers located in the supermarkets are a delivery option you can choose when ordering with us, this option is then also denoted with the 'green leaf'.

3.6 STRATEGY PROPOSALS

The first of the proposed design activities to facilitate smaller, more sustainable transport modalities concerns standardisation of parcel transport. This has implications on the entire transport journey; from the sorting and storage solutions, to the loading bays of the transport modalities, to consolidation between carriers. This would mean several different industries need to work together to implement this standardisation; Vanderlande themselves, the vehicle manufacturers and the carriers. Although this is quite a challenge to accomplish, there are platforms like CLIC to which Vanderlande could bring their expertise to, to try and accomplish such a project jointly with numerous other players in the logistical market. Furthermore, Vanderlande could build on their relation with their parent company Toyota regarding the development of a range of transport modalities with standardised loading bays.

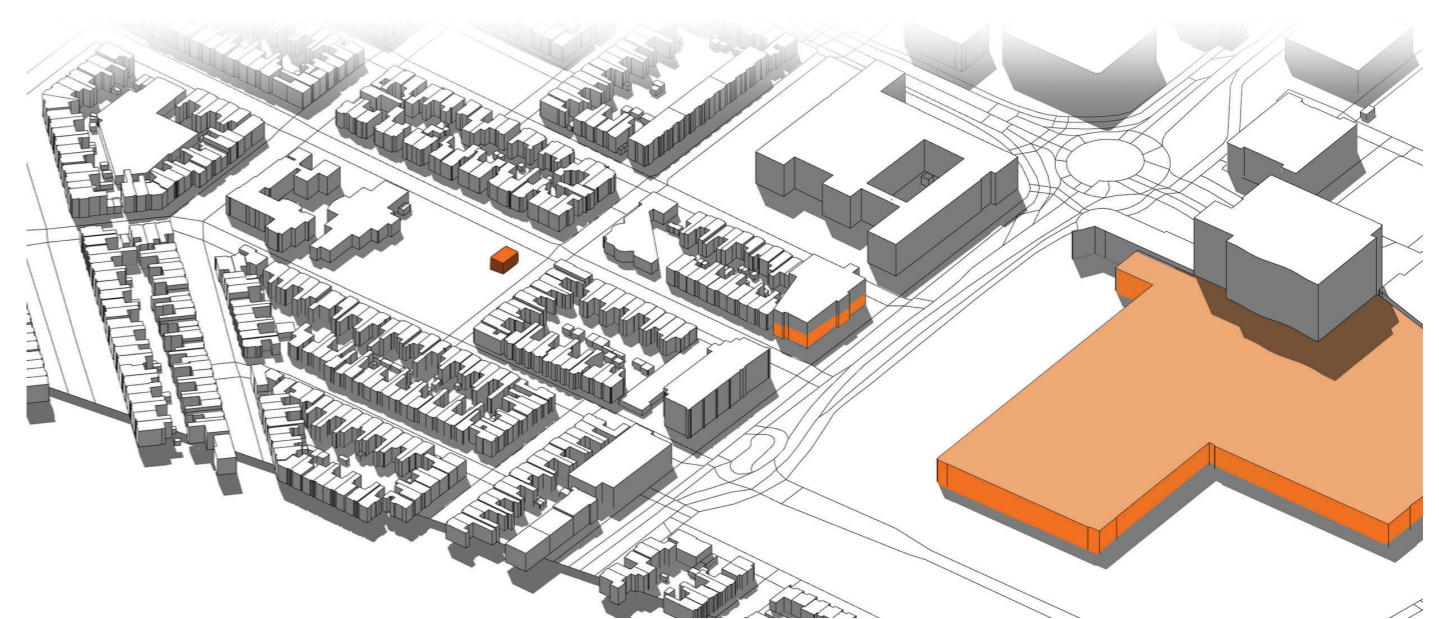
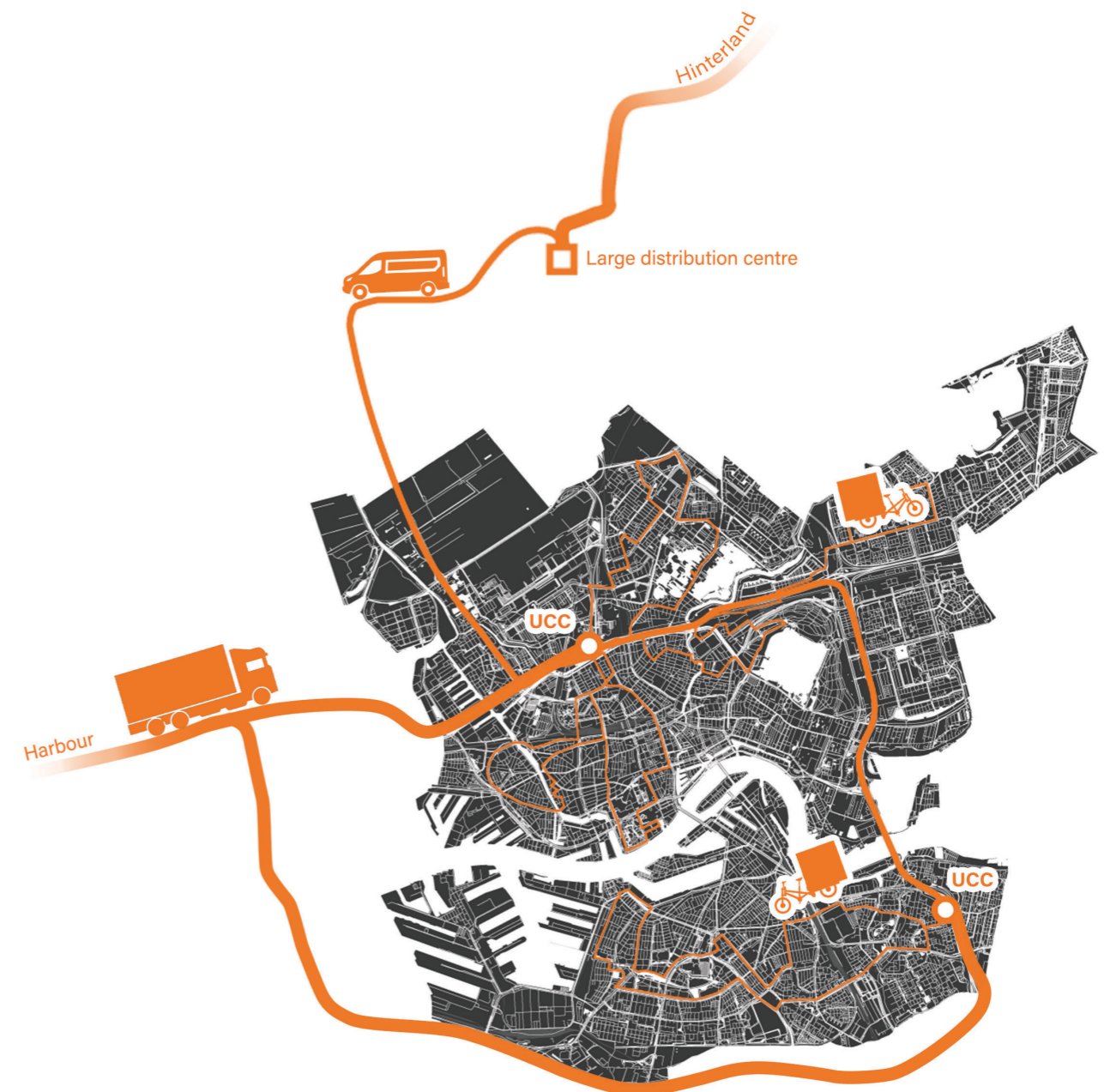
The first step is to envision the possibilities of such a standardised transport journey. What implication does it have on logistical flows exactly, how can it be implemented and what business models support the scheme, the latter is especially important considering consolidation between several carriers.

Decentralisation is another activity that facilitates smaller, more sustainable transport. This also has implications on the transport journey by bringing the last hub of the hub-and-spoke model closer to the end consignees. I propose three different types of hubs that fulfil this role, but depending on their size can fulfil other, more public space related roles as well. For these hubs it is important to visualise how they can operate, how logistical flows work, how they can have as little negative impacts on public space while still being practical and which processes will be automated.

Automation of the processes inside the hubs and in the interfaces between the hubs and the transport modalities could optimise the last mile by saving on labour cost and most in line with Vanderlande's core business.

Concluding, the following can be developed to answer the design question that was formulated in chapter 1; (How can Vanderlande ensure that fewer vans drive in the city while at the same time making the 'last mile' more accessible and communal for the end user and service and cost stay comparable/improve for business clients?), whilst keeping in mind the activities formulated in chapter 3; Standardisation, Consolidation, Automation, Decentralisation, Integration, Cooperation and Incentivisation:

- **Explore the three types of hubs;** their functions, integration in the city and employability
- **Standardised transport journey;** interfaces and types of transport
- **Business models;** regarding consolidation schemes or otherwise



4. Solution strategy

Designs and business models

'One size does not fit all.'

- Ruud Görtz, Vanderlande

As Ruud Görtz, senior UX designer at Vanderlande, said during the creative session that I held regarding the multitude of possible touchpoints and transport modalities in the last mile: 'one size does not fit all.'

In this chapter the solution strategy that follows from the design activities defined in chapter 2 and 3 is visualised. The prime objective of this chapter is to create an insight in how, in a relatively short term, with relatively few resources, city logistics can be transformed into something that is interconnected and part of the city and its inhabitants.

Firstly, the system in its entirety will be explained and how the standardised racks/containers can play a crucial role in consolidation. Then, consolidation schemes between carriers are defined in terms of goods- and monetary flows using the tools provided by the business model canvas. Then, the urban consolidation centres (UCCs) that are located near the city's edge and how they operate are explained in more detail.

Each UCC is then evaluated on guidelines based on the research performed in the 1st and 2nd chapter.

Finally, I will conclude the entire project and the resulting concepts.

Chapter division

- 4.1 Overview of the system
 - 4.1.1 UCC locations
 - 4.2.2 Consumer interaction
 - 4.1.3 Standardisation
 - 4.2.4 Multiple carrier
- 4.2 Evaluation matrix
- 4.3 Microhub/depot
 - 4.3.1 Placement of the hubs
 - 4.3.2 Possible different operating modes
 - 4.3.3 Evaluation
- 4.4 Midsized hub
 - 4.1.1 Integration in the city
 - 4.4.2 Operating mode
 - 4.4.3 Evaluation
- 4.5 Large hub
 - 4.5.1 Evaluation
- 4.6 Conclusion
- 4.7 Recommendations
- 4.8 Reflection

4.1 OVERVIEW OF THE SYSTEM



The solution directions I propose consist of the three types of UCC mentioned in 3.4 DECENTRALISATION. Details regarding their placement and operating modes, as well as their evaluation in the context of the last mile will be described in this chapter. The image above shows an overview of the general location of the hubs and their size relative to each other.

The most important thing to keep in mind regarding the proposed solution directions is that they do not represent a definitive answer to my design question:

How can Vanderlande ensure that fewer vans drive in the city, while at the same time making the 'last mile' more accessible and communal for the end user and service and cost stay comparable/improve for business clients?

The design directions more so represent a point of discussion, a starting point, for multiple organisations within the last mile to work together in creating a last mile that considers all the implications it has on society. Referring back to my research, these include the polluting and congesting vans, the policies that will be instituted to counteract them, the competitiveness of the carriers and the high demands of consumers resulting in a race to the bottom which in turn results in unsustainable practices. But also the more latent implications that logistics has on the city, regarding proper fitting of logistic practices in the urban context, spatial planning, accessibility and the sense of community that logistics can foster. Furthermore, the experience of the consumer is central to many decisions made in the designs.

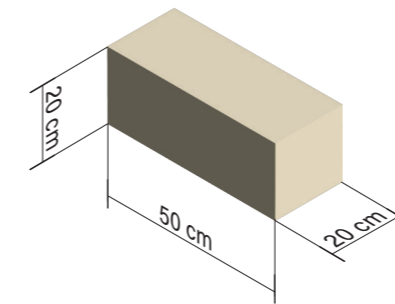
4.1.1 Locations of the UCCs

The placement of the hubs is mostly in the periphery of the city near main roads so that the box trucks that supply the hubs do not need to enter the city. The last yard from hub to end consignee is accomplished with LEVs or electric bikes. The placement of these hubs is therefore vital for their effectiveness in preventing heavy vehicles from entering the city.

The UCCs could be placed on municipal ground, for example a parking space as is the case with the smallest hub, in existing building stock as will likely be the case with the mid-sized hub, or atop of a shopping centre or supermarket as is the case with the large hub. For the former, arranging parking spaces is a matter of co-determination with municipal organisations. For the latter two, developing the properties will likely be a cooperative effort with property developers whose primary focus initially is not the development of solely logistical properties.

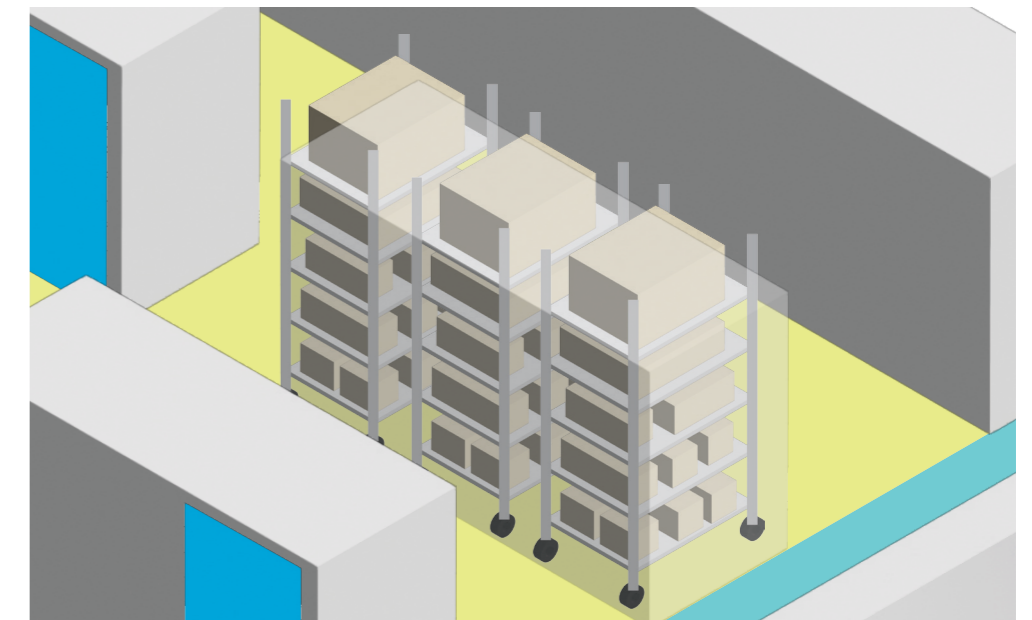
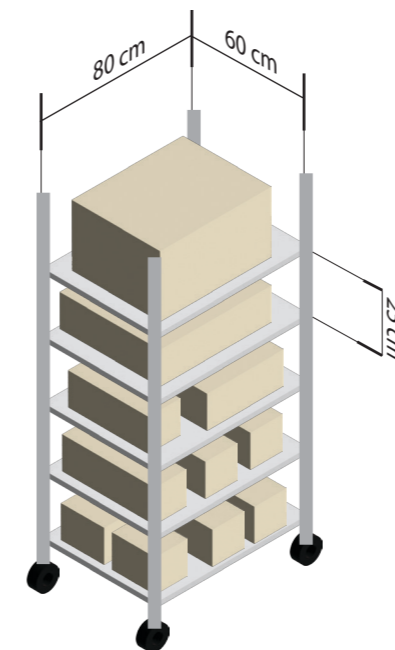
An example of an organisation that has been concerned with identifying suitable locations for UCCs is the Hamburg Ministry of Economy and Innovation (BWI) see 2.4 CASE STUDY HAMBURG. I also recommend the reader to read the paper of Novotná et al. for an explanation on the facility location problem.

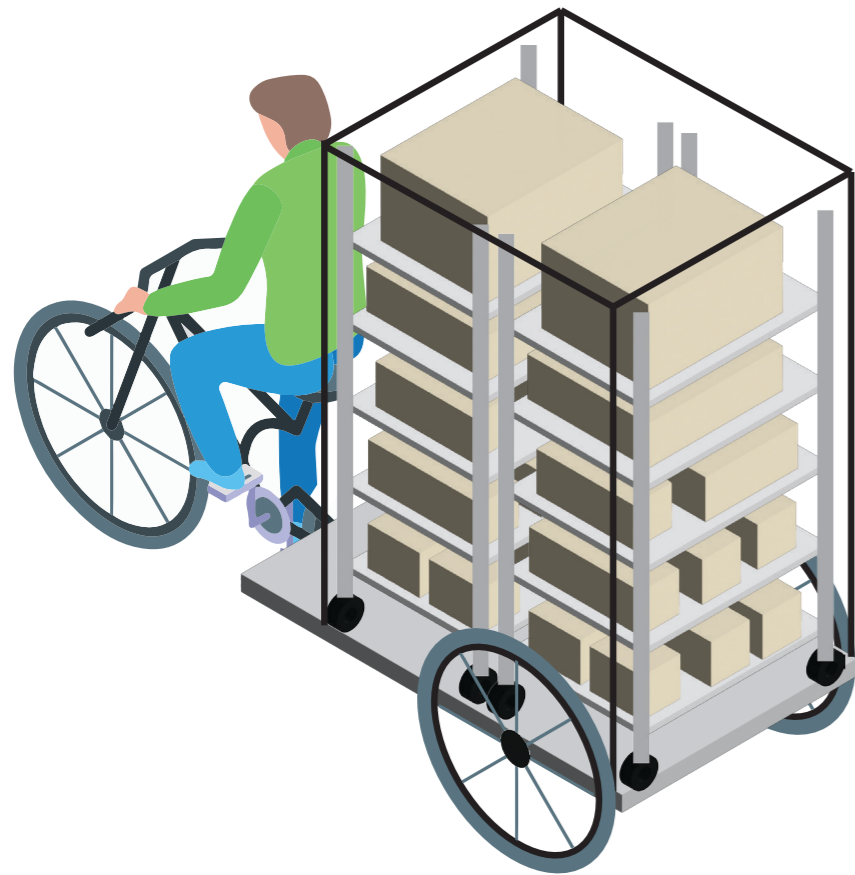
4.1.2 Standardisation



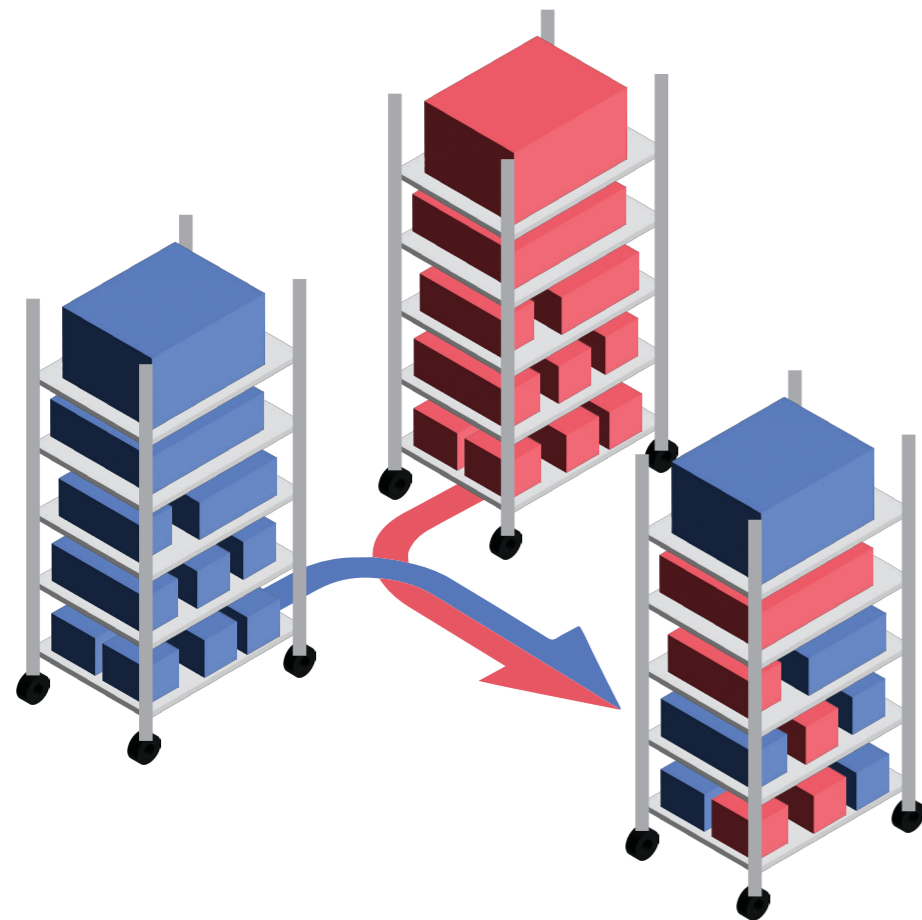
As discussed, standardised racks will play an important role in the smooth interfacing between the types of transport, storage and between carriers. Therefore I have created a rough outline of the dimensions of said racks. The sizes are based on the average parcel size, this average parcel size has been found through conversations with experts and people working in the field and are 20x20x50 cm.

These racks are then the driving dimension for the storage system as well as the transport modalities. Automated systems like the ADAPTO are made to seamlessly work together with these racks. For example, to move parcels from one rack to the other for consolidation.





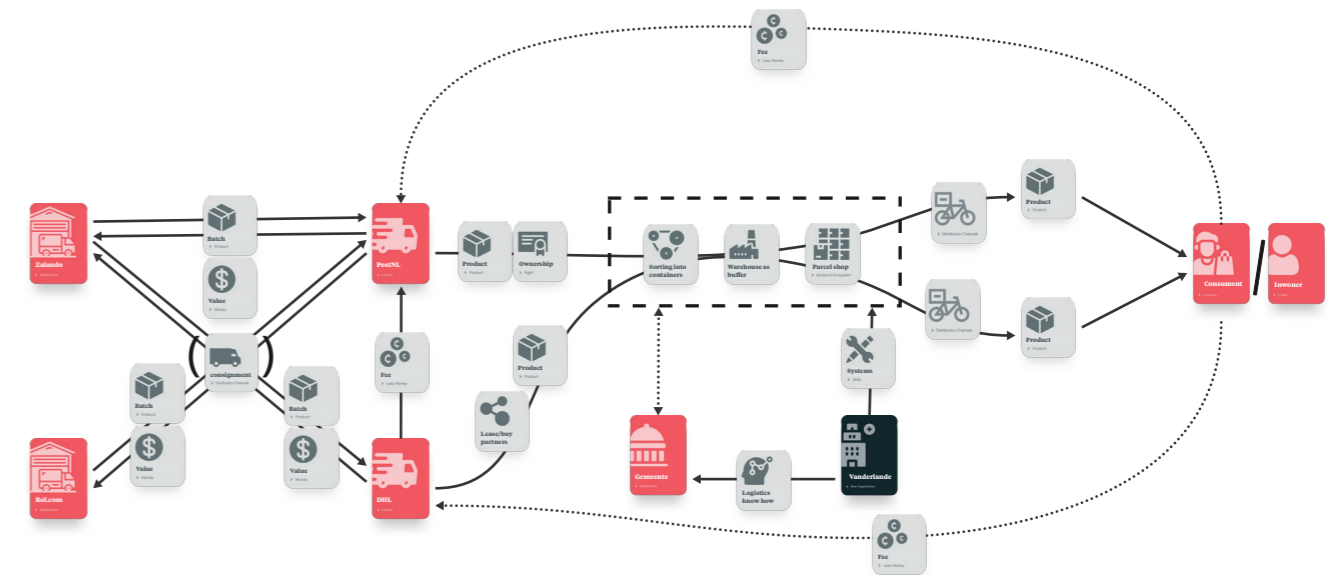
Example of racks being loaded into a bike specially made to accommodate them



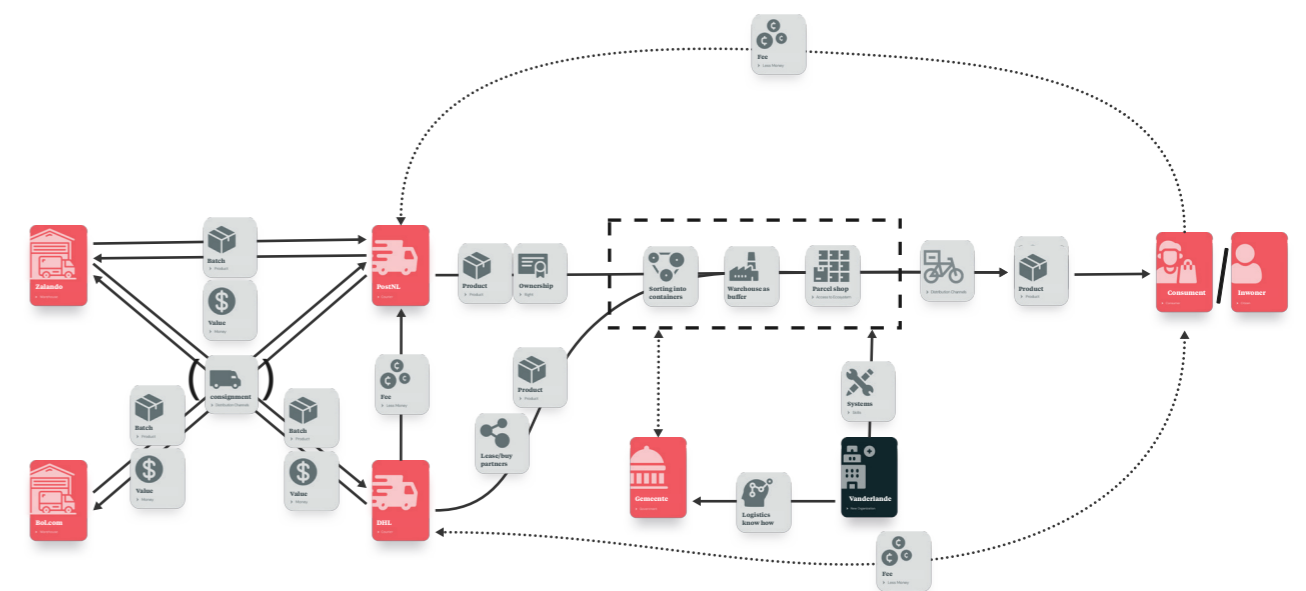
Parcels in racks from different carriers get combined into a new rack to ensure the new rack entails the shortest possible delivery route

4.1.3 Multiple carrier consolidation

Another part that could positively influence consumers' experience with the last mile is the fact that these hubs accommodate multiple carriers; the clarity of a one stop shop instead of carrier specific SPs scattered around the city is one of the things I found in the 1.4 CURRENT EXPERIENCE. However, to operate a hub with a multiple carrier consolidation scheme, economical and logistical implications like ownership, responsibility and consignment need to be considered. According to Paul Buijs, a fully agnostic network will be very difficult to realise, that is why hybrid solutions are proposed. Below are two different consolidation schemes with PostNL and DHL as examples of carriers working together. The most left part of the diagrams show the relation between carriers and the e-retailers.



Option 1. PostNL operates the hub, DHL rents space within it, and the last yard is done by delivery drivers respectively. This means that vehicles from both carriers are used.

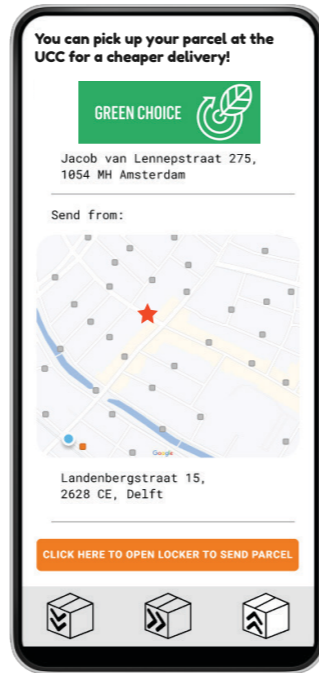


Option 2. PostNL operates the hub, DHL rents space within it, last yard is also shared. This means PostNL delivers packages from DHL.

4.1.4 Consumer interaction

The UCCs also allow for a better interface with the client, both physical and digital; the hubs will allow for clients to enter and pick up parcels before they are sent to end consignment. Interactive delivery management apps will offer clients this choice. Especially for the largest hub that will be placed atop a point of interest, namely some sort of large supermarket or mall, this option to pick up your parcel is very attractive. Furthermore, automated parcel machines (APMs) will be located facing outwards of the UCC. These will allow consumers to pick up their parcel 24/7. Stimulating people to pick up their parcels themselves could, again, reduce the amount of vehicle movements in the city. Creating better interfaces for the client is one of the unique selling points (USP) of the system, and one that can benefit the net promoter score (NPS) of the carrier as well.

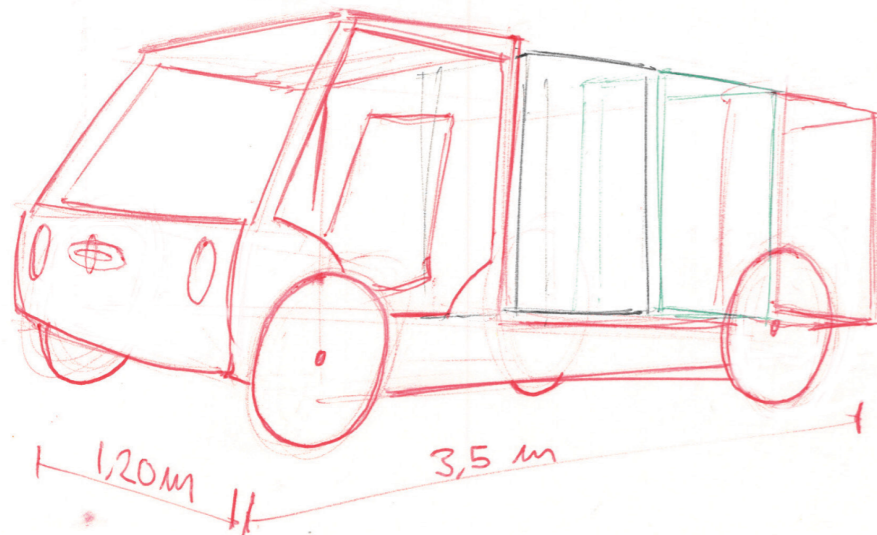
The option for home delivery (HD) will obviously always exist; it remains the most chosen option (Autoriteit Consumentenmarkt, 2022). However, consignment will not be done by vans but rather by LEVs or by bikes similar to the ones created by Fulpra for example. This can reduce the negative experience that people have with last mile logistics associated with the presence of vans in the city, see 1.4 CURRENT EXPERIENCE. This is the second USP of the system that can again positively influence the NPS of the carrier.



IDM Software showing client the possibility to pick up their parcel themselves from the nearby UCC, this will entail lower cost for the consumer



Early design of a storefront UCC with APM located in the facade, the APM is accessible 24/7



Early design of a LEV carrying racks from multiple different carriers

4.2 EVALUATION MATRIX

Based on the literature review I created guidelines for the design of the UCCs. These consider the built environment, consumer interaction, competitiveness and impact on the street. For the full list of guidelines see Appendix 1.4 GUIDELINES.

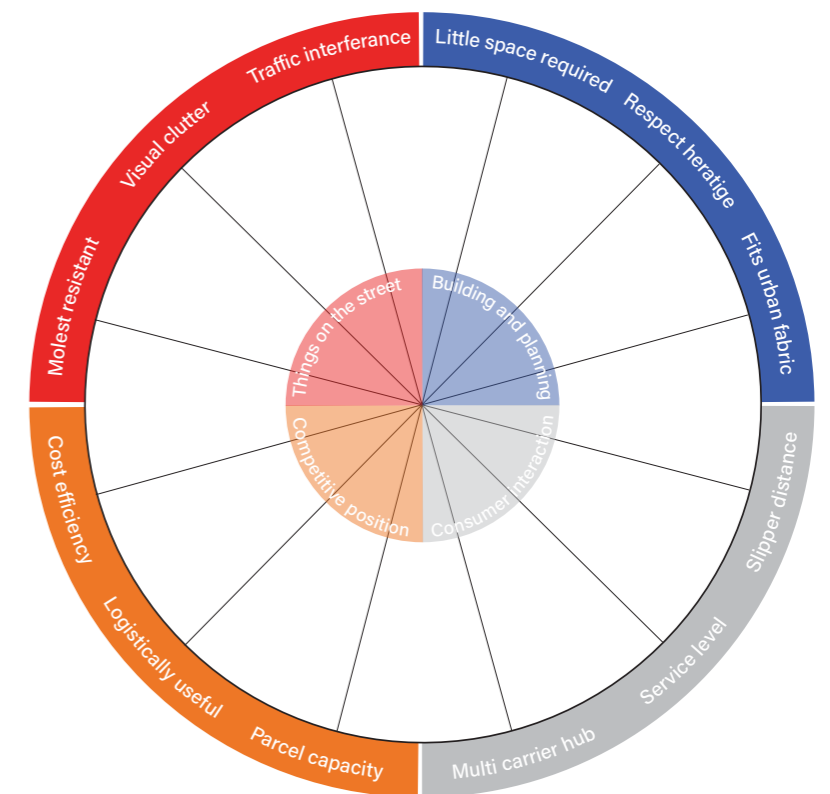
Concerning the built environment I look at the amount of space needed, whereby fewer space results in a higher score. Furthermore, I look at how well the existing building stock's heritage is respected and how well the UCC can fit within the urban fabric. For the latter an important factor is the UCCs flexibility; can it be adjusted to suit the urban context it is in?

Consumer interaction concerns the added benefits the UCC can offer for the consumer and are beneficial for the carrier as well. For example, a multi carrier hub provides a one stop shop for consumers UCC where they can make use of the services of multiple carriers. On the other hand the consolidation scheme this multi carrier hub entails can mean a cost saving for the carriers. Service level entails the possibility of the UCC to offer any additional services such as the ability to pick up or post parcels for return, speak to an employee, send and receive odd parcel sizes, buy postage stamps etc. Slipper distance refers to the closeness of the hubs to consumers; either their homes or near points of interest.

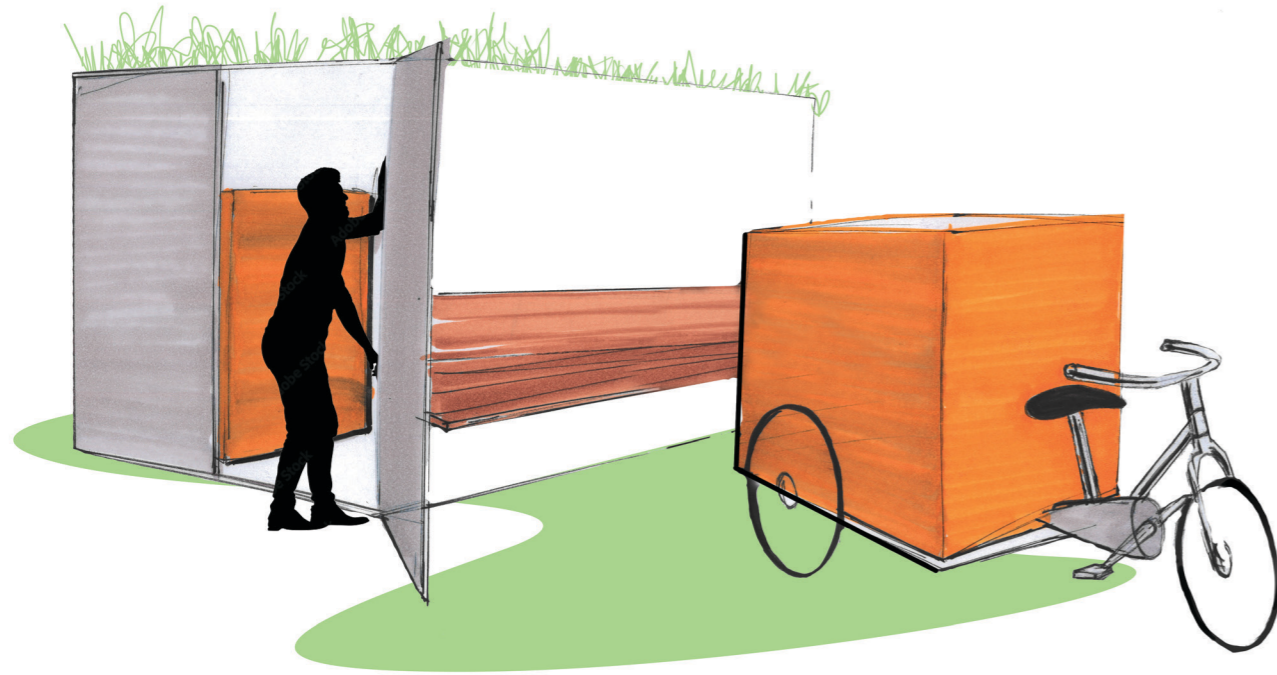
Competitive position refers to things like cost efficiency of the UCC, the logistical usefulness and parcel capacity. Although these terms seem to be somewhat easily quantifiable, keep in mind that I can only make estimated guesses based on assumptions made together with Marc van Neerrijnen, and that discrepancies can arise depending on how the hubs will eventually be applied in practice.

Impact on the street refers to how little interference the UCC causes on traffic, how little visual clutter it causes in the form of, for example, vehicles on the street and how well the items that are put on the street are resistant to molestation. The latter also concerns the safety of the goods that are transported in the UCC.

Based on these guidelines I created an evaluation matrix to evaluate the concepts. The evaluation was done in cooperation with Marc van Neerrijnen and Tom Kuijpers.



4.3 MICROHUB / DEPOT

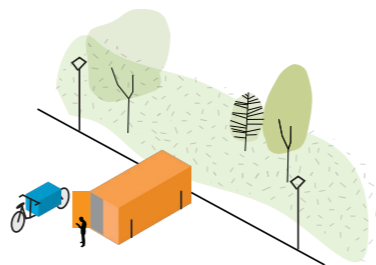
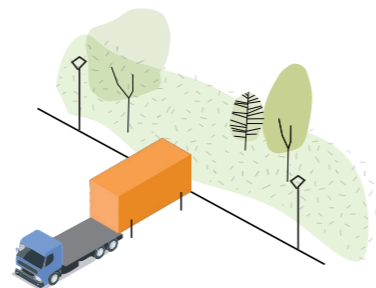


These localised, movable depots, strategically positioned near urban areas, play a pivotal role in streamlining and optimising the final leg of the delivery process. By decentralising operations and bringing goods closer to the end consumers, micro hubs offer a range of added benefits that contribute to improved efficiency and reduced costs. They are small enough to fit on a parking spot for easy placement in the city, for example they can be carried around on the back of lorry or small truck and placed on a vacant parking spot.

4.3.1 Placement of the hubs

The image on the right shows how a lorry carries around a single micro depot. A space near a main road that does not require the lorry to drive through dense urban cores is appointed for the location of the micro hub/depot. In the facility location problem in 2.3 CASE STUDY NEAR CITY DISTRIBUTION it is described which things are all of importance, which can also be found in 3.4 DECENTRALISATION. In short these are: Sum of distance from sorting centre, Reach area of the microhub, Cargo bike availability, Cycle distance, Costs. As they fit on a parking spot, the ideal location is one or two parking spots near main roads in- or near the city that are especially reserved for these logistical activities, for example, somewhere near a park.

When the box truck arrives at the location the hub is lowered into place, after which smaller modalities fulfil the last leg of the last mile. The depot could have multiple different forms of operation that influence the way they are situated within the last mile ecosystem.



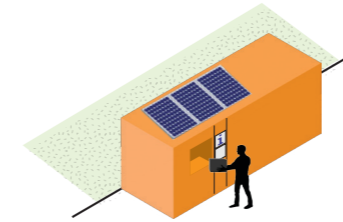
Microhub placement through a box truck

4.3.2 Possible different operating modes

1. Movable PUDO with integrated screen

The microdepot could operate effectively as a pick up and drop off location (PUDO) that is temporarily placed near urban areas. Consumers will themselves be responsible for the pickup and drop off of their parcel.

With some integrated electronics the PUDO can be more than just a parcel locker; return logistics could be facilitated, in hub sorting and arrangement etc. Interaction with consumers can be done via a screen, however, when electronics are integrated in the PUDO it does require it to have some sort of power supply like solar panels. This makes this an expensive option.

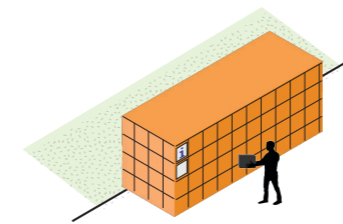


Microhub acting as PUDO with integrated screen, solar panels are present to power it

2. Parasitic PUDO

Instead of incorporating electronics in the PUDO, it could also operate parasitically which could make the PUDO substantially cheaper. However, the capacity of the locker, which is important for the courier, especially in a scheme where the PUDO is used by several different carriers, should still be able to be communicated.

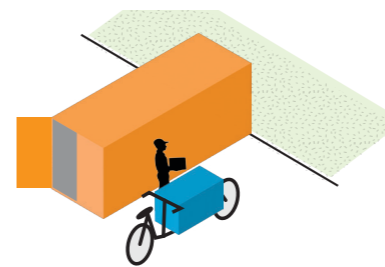
This should by far be the cheapest option, though for both of these PUDO type microhubs distance to the urban core is paramount for their success since, as I found out in 1.2 CASE STUDY PARCEL LOCKERS, end users like to travel as little as possible for their parcel.



Microhub acting as PUDO without integrated screen

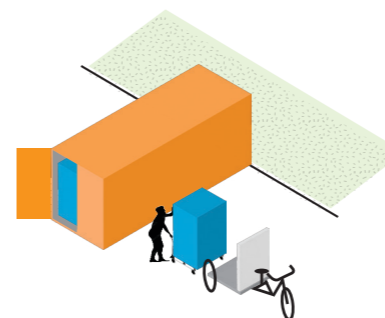
3. Depot for carriers

What the microhub can also function as is a depot that brings bundles of parcels closer to the end consignee, allowing for smaller modalities to pick up parcels for further consignment.



4. Agnostic micro depot with standardised racks

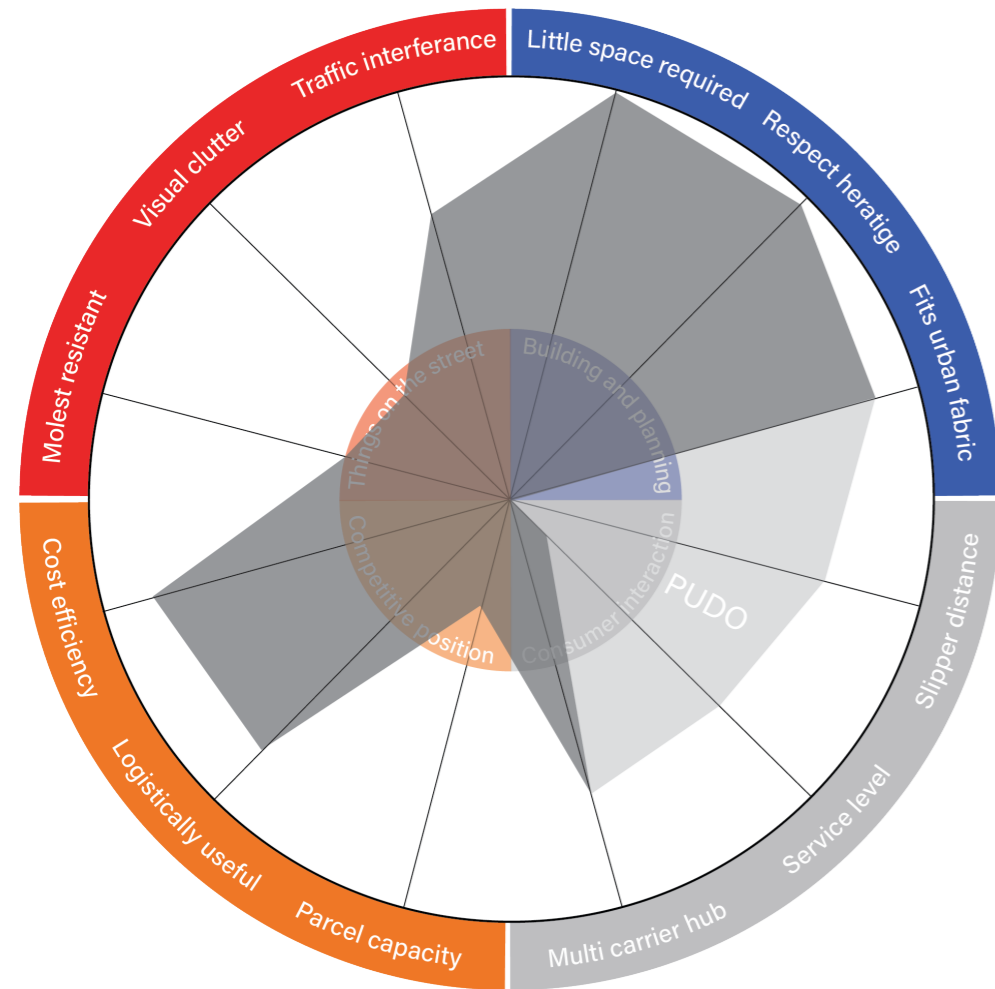
When standardisation is applied to the last mile system it allows for parcel flows of different couriers to more easily mix usage in these kinds of micro depots. Each different courier can then come by and pick up their own racks.



Microhub acting as depot for carriers

4.4 SUPERMARKET SIZED UCC

4.3.3 Evaluation Microhub/Depot



Depending on the operating mode, either purely as a depot or as a movable microhub with pick up and drop off capabilities, the scores differ on the consumer interaction aspects. The flexibility that the small size offers; the fact it can be placed in a parking spot wherever it is needed, means that it has potential to be placed close to end consumers. This flexibility also is the reason why it scores high on the 'Building and planning' category and why it is deemed reasonably logistically useful. Service levels are not ideal since it is bound to the capabilities of the automatic interface. This will likely mean extraordinarily sized parcels cannot be handled, furthermore, there is little to no possibility for personal interaction when something goes wrong or when consumers need to ask questions.

The capacity is obviously low because of its small size. Because these hubs will be dispersed around the city they are hard to monitor on safety. There is some scope for multi carrier consolidation, but their small size does not allow for much. Their presence on the street might also cause visual clutter.

This concept of micro hub is best described as a fulfilment centre disguised in a storefront, that has a much smaller footprint and handles smaller volumes of parcels than a traditional centre would. It has an area of about 150-200 m² which would allow for two to five thousand parcels a day to be handled*.



Street view of the mid-sized UCC showing the open facade and APM

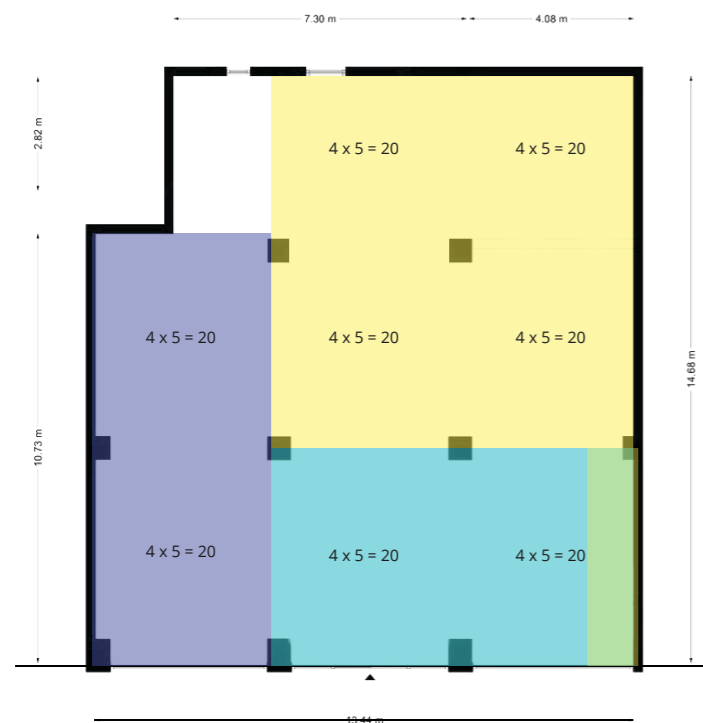
The hubs are small enough to be built into existing building stock of for example a store or supermarket. Again the facility location problem applies, in addition to the fact that existing building stock varies in shape, size and accessibility. This means that at each different location the hubs will have to be designed slightly differently. However, a couple of guidelines are important to attain an approachable and accessible character which is important for its integration in the neighbourhood; as described in 2.2.2 REGULATION for darkstores, the lack of accessibility and approachability has been their demise in many a city.

In short the guidelines that I applied entail that the UCC buildings should have a certain level of accessibility both visually and physically (see Appendix 1.4 GUIDELINES). That is why I designed the mid-sized UCC to be on ground level with an open facade. Furthermore, the logistics processes can be observed by anyone because of the open plan of the hub, making it very transparent and known to people how parcel delivery is being established.

As can be seen, the hub is accessible by anyone and there is a counter inside where consumers can interact with employees for their parcels needs, such as return logistics, sending and receiving odd parcel sizes, buying postage stamps etc. There is a parcel locker located inside with an automated parcel machine (APM) facing outwards connected to it. The APM is open 24/7 for maximum accessibility.



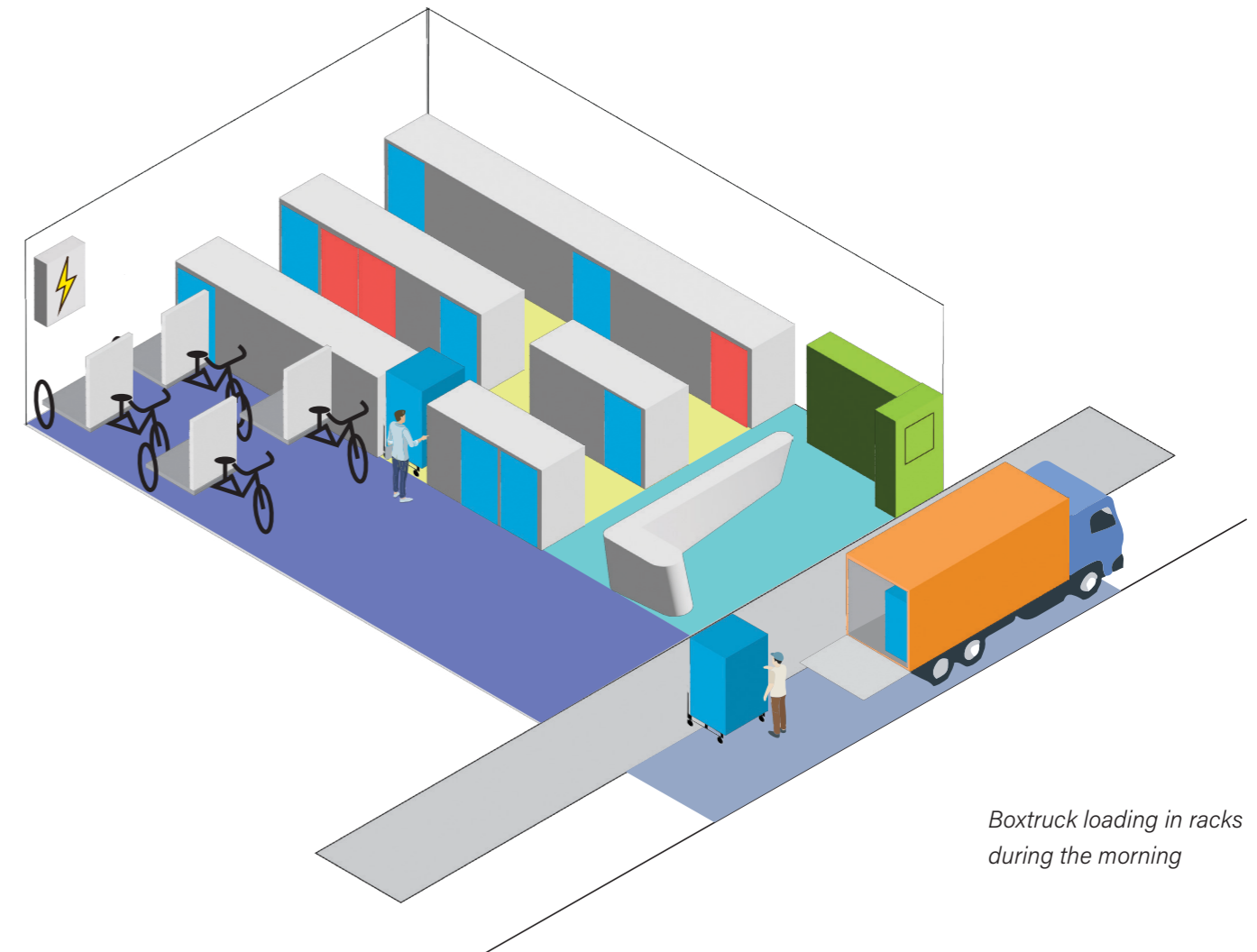
Above: Inside view of the mid-sized hub showing a parcel locker and service point where odd sized parcels and other parcel related inquiries can be done



Left: Plan of the mid-sized hub with an area of about 160m²

4.4.1 Operating mode

The operating mode of the mid sized UCC will be explained by looking at the different stages that it goes through during the day; loading in, consignment and inactive.



Boxtruck loading in racks during the morning

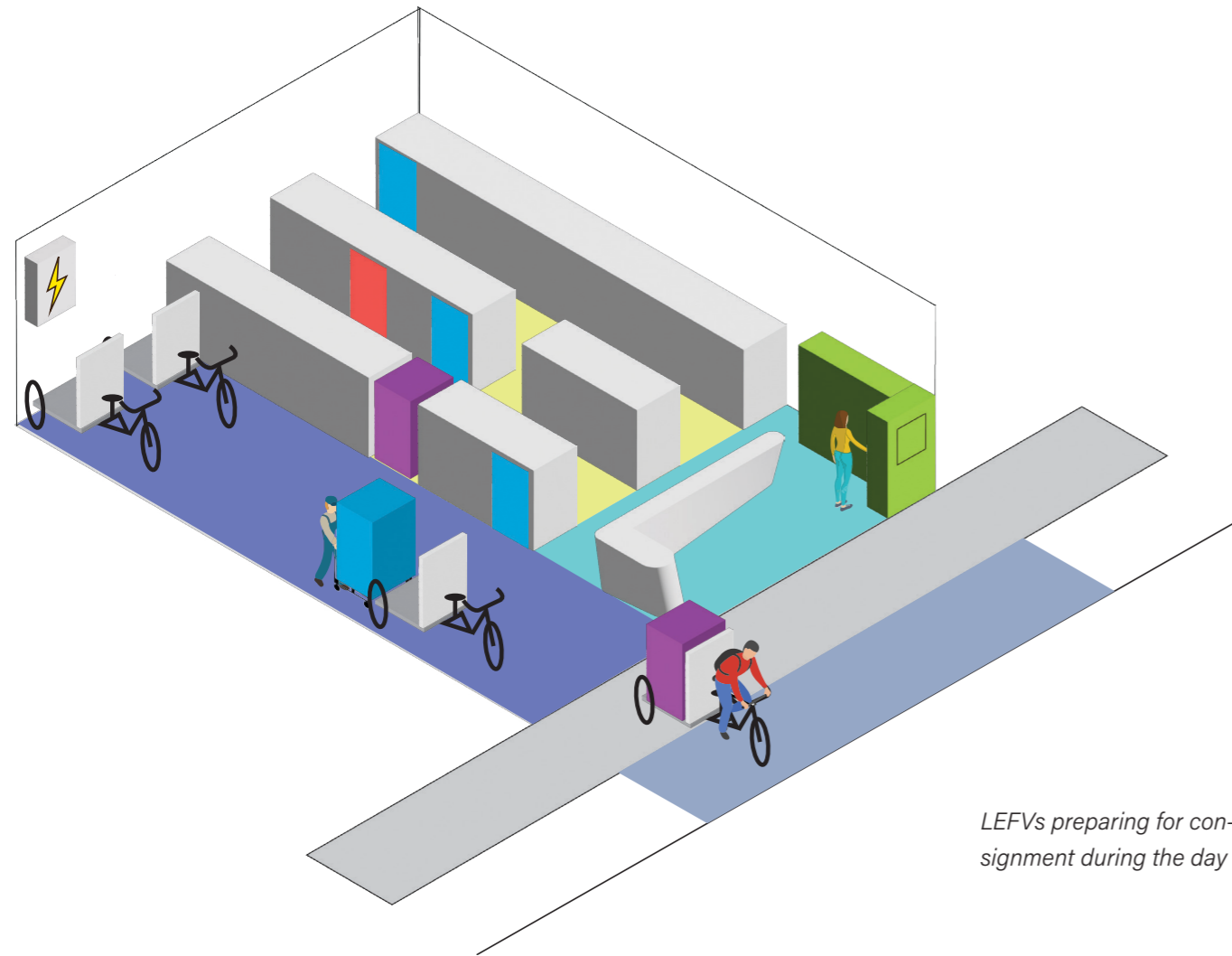
10:00 - 12:00 Loading in

In the morning the distribution centre is being loaded in by the (box) trucks from organisations that are affiliated with the UCC. This could include the carrier that exploits the hub, carriers that are subletting space in the hub or e-retailers directly.

The best time for loading the hub is outside of rush hours so as to not cause extra unnecessary congestion. The box trucks themselves are full preloaded racks, the racks are stored inside. Several box trucks might arrive belonging to several different carriers, until the centre is at full capacity. The UCC allows one truck per time to be unloaded, for which a 'parking spot' in front of the facility is reserved.

Preferably the centre was emptied out as far as possible the previous day to accommodate as many new racks of parcels. Workers roll the newly delivered racks inside and to the entrance of the storage area. There the ADAPTO-like robot rolls them to a free position within the storage area.

The smaller transport modalities that are used for the last yard are stored inside overnight to charge up or refuel.



LEFVs preparing for consignment during the day

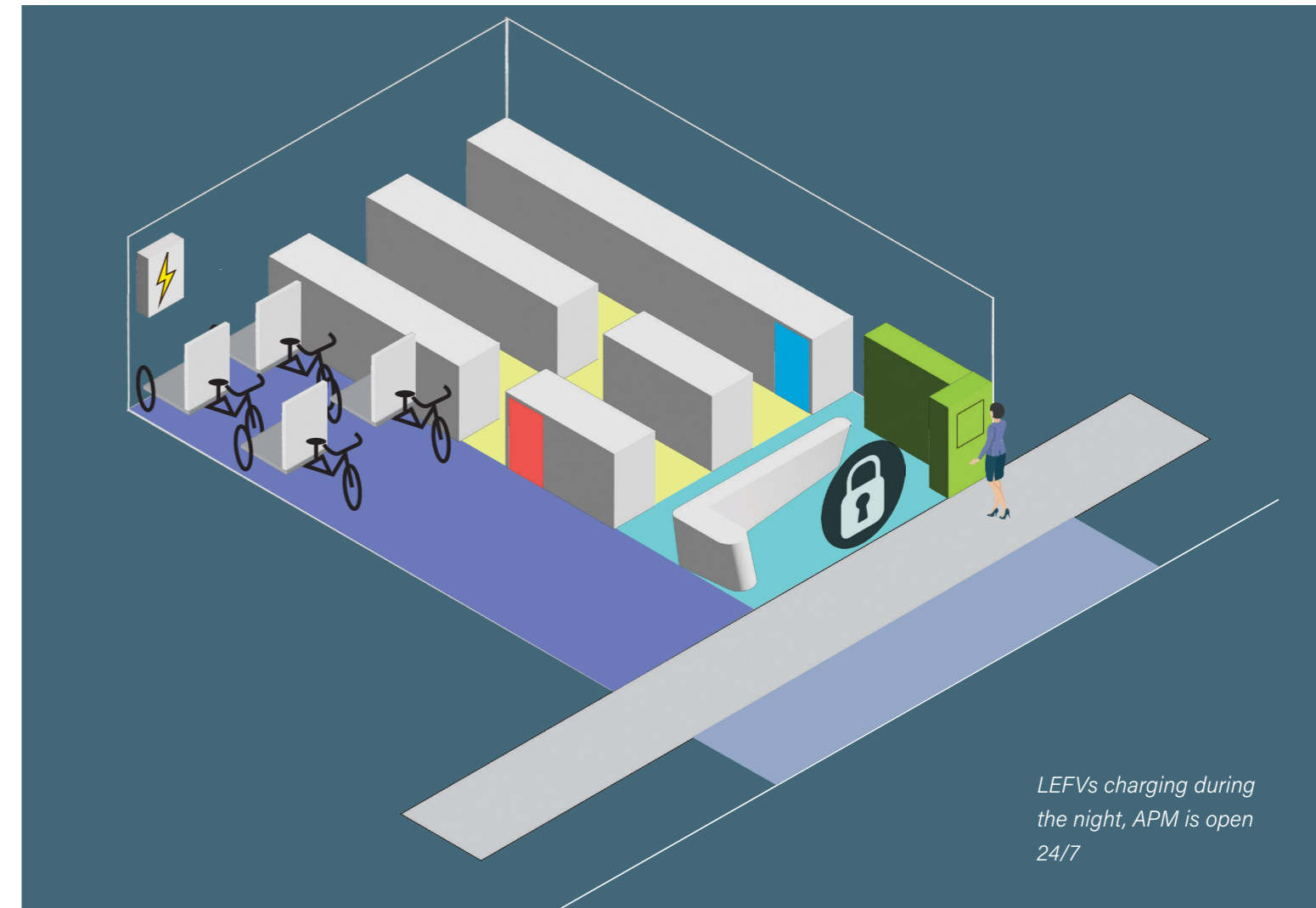
Day: Distribution

During the day distribution takes place through the use of the smaller modalities that have been stored inside the premises. The ADAPTO like system has evaluated the end locations of the parcels that are bundled in the racks and has displaced and swapped parcels from one rack to another accordingly. Racks now have the most optimal packing they can have to form the shortest route possible based on the end locations of all the parcels present in the system.

Workers load in the racks that the ADAPTO system presents to them at the entrance of the storage system. There are two ways in which this system can operate to establish a consolidated scheme between multiple carriers:

1. Each carrier delivers their own racks, parcel flows are kept separate.
2. Parcel flows of different carriers are combined into one rack based on their end destination, one carrier delivers these combined racks.

More information on the consolidation scheme and the economical implications can be found in 4.6 CONSOLIDATION.

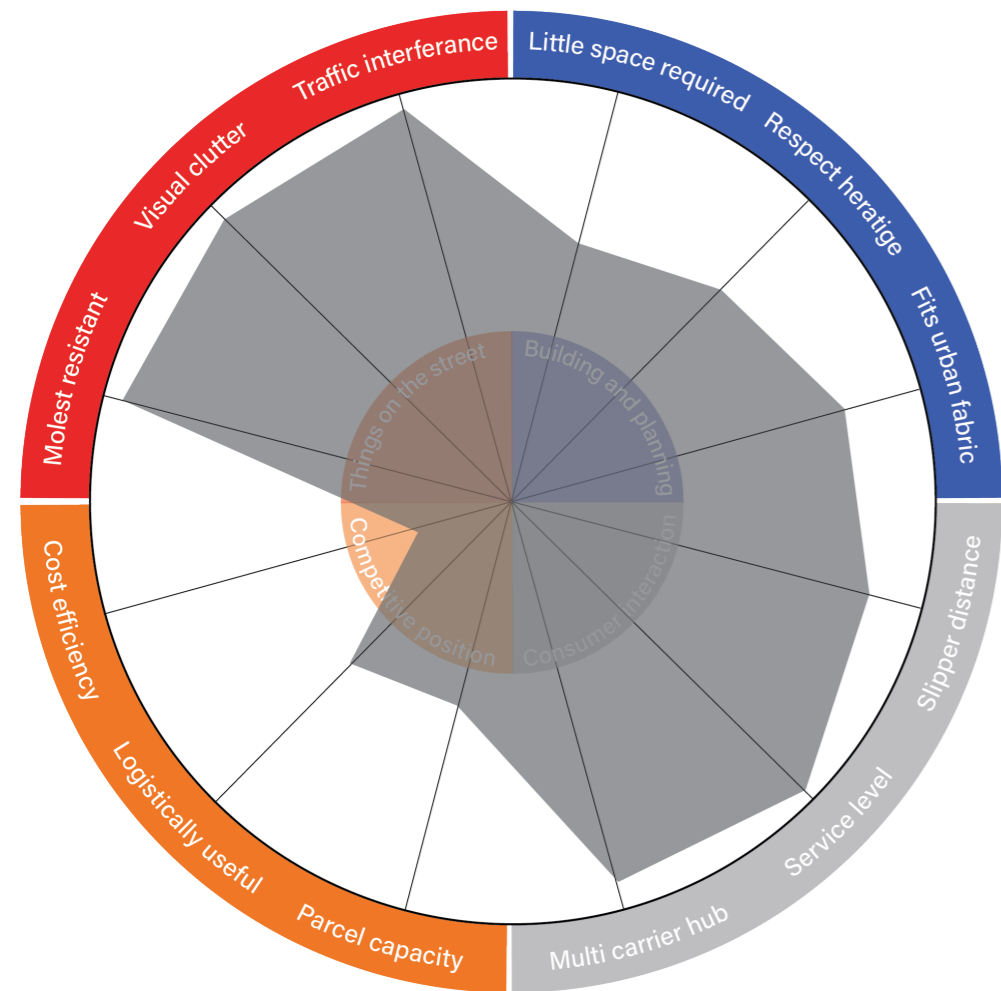


LEFVs charging during the night, APM is open 24/7

Night time: APM is accesible

In the night, the eclectic bicycles are stored inside the hub to charge. Any parcels that are still left in the hub can be picked up at the interface of the APM that faces towards the street.

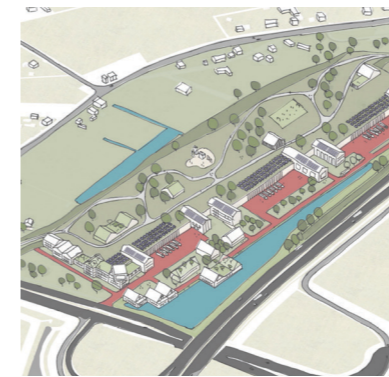
4.4.2 Evaluation supermarket sized UCC



The mid-sized hub scores best on the categories of 'Things on the street' and 'Consumer interaction.' The fact that the LEVs and bikes are stored inside means there is very little visual clutter, and the fact that for loading there is a space reserved in front of the hub means there is little traffic interference. The open facade and the fact that it can be located in existing building stock means that it fits urban fabric well and can be situated close to the end consumer. The ability to speak to employee, the ability to send and receive odd-sized parcels and the 24/7 accessible APM mean that service levels are high. There is enough space to facilitate the processes for a multiple carrier consolidation scheme.

Existing building stock of the type that is required, especially ones close to the city are more expensive though, which means that cost efficiency will likely be low. The capacity per hub can be low to average compared to traditional urban consolidation centres.

4.5 LARGE MIXED FUNCTION UCC



Above: Intospace concept showing how distribution centres can be part of the landscape

Below: Intospace concept shows integration in urban landscape

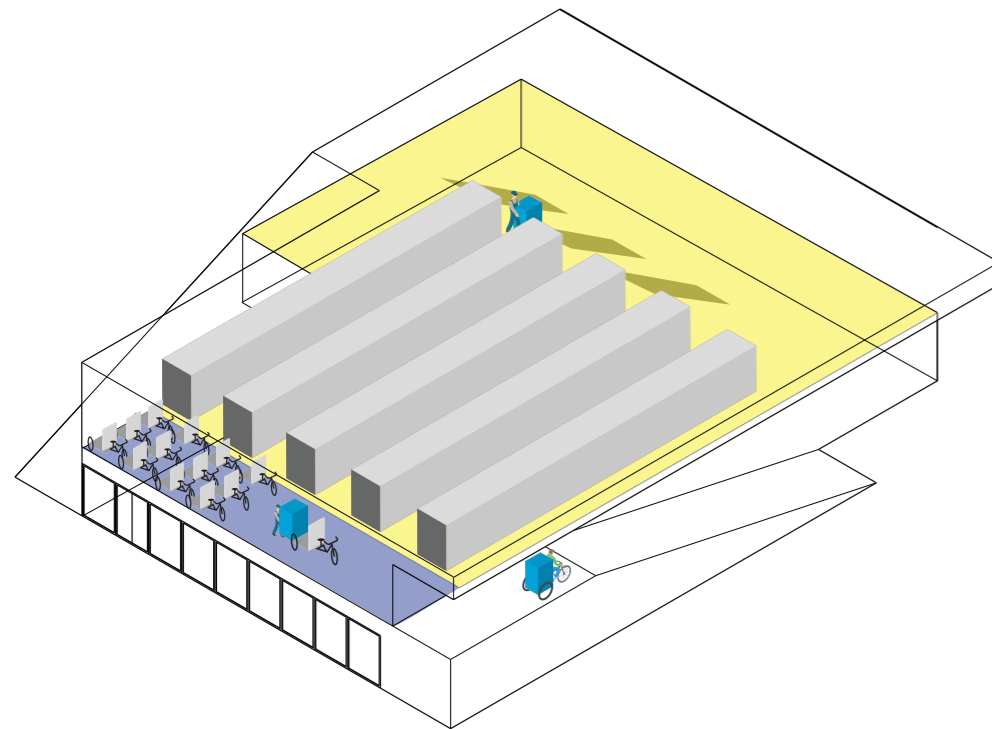


The largest of the hubs focuses, like is the case with the concepts from the design agency Intospace, most on the mixing of logistics- and other functions in the same building. The images on the left show concepts made by the design agency; "In urban areas, logistic real estate can offer a unique opportunity for creating affordable housing opportunities, space for recreational facilities, a place for nature to thrive, an expansion for social areas and so much more." Intospace concepts show how logistic centres can be part of the landscape. Instead of taking unwanted space, logistic developments are leveraged to create much more value. Instead of these buildings sticking out of the flat landscape of The Netherlands, this concept creates exciting landscapes by forming geographical adaptations to blend within the landscape.

My concept mostly builds on these existing concepts from Intospace; the logistics centre will be located for example atop of a large supermarket or shopping centre. The closeness to such a point of interest allows for a service point where clients can go for all their parcel needs.

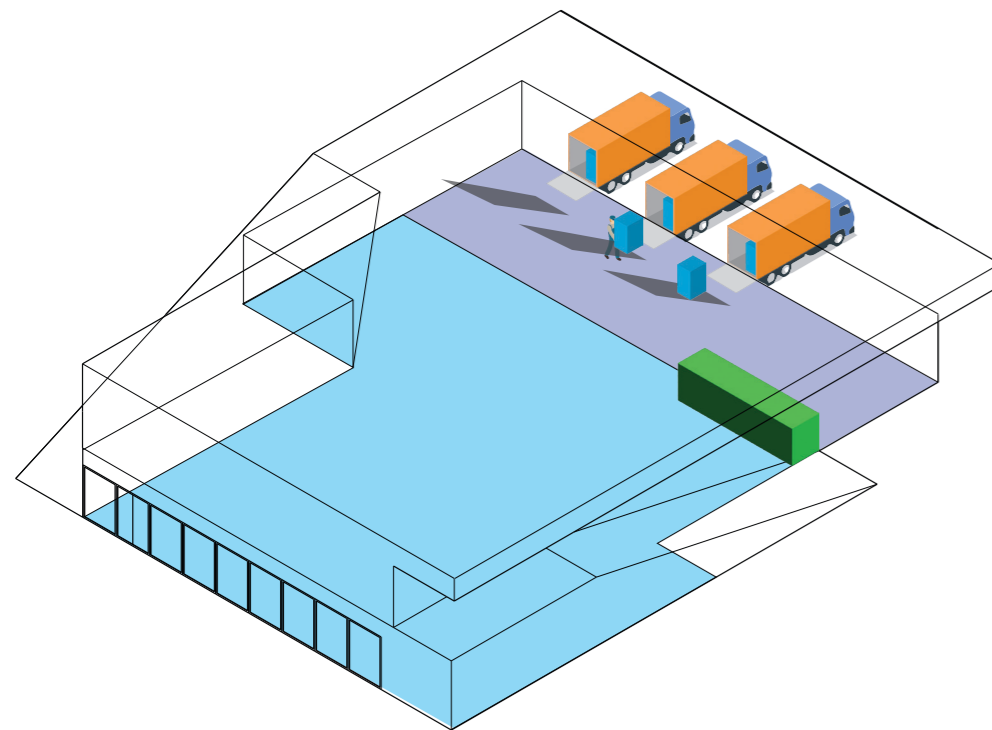
This concept is to show the ability for logistic centres to be more than a big box next to the highway; with a broad view and multiple branches working together, logistic buildings can be integrated into the city- or landscape. My concept incorporates a green roof that is accessible from ground level, effectively creating a park on top.

4.5.1 Evaluation Large Hub



The distribution centre is on the top floor, the LEFVs are loaded in directly next to the storage, with a ramp they get down to ground level

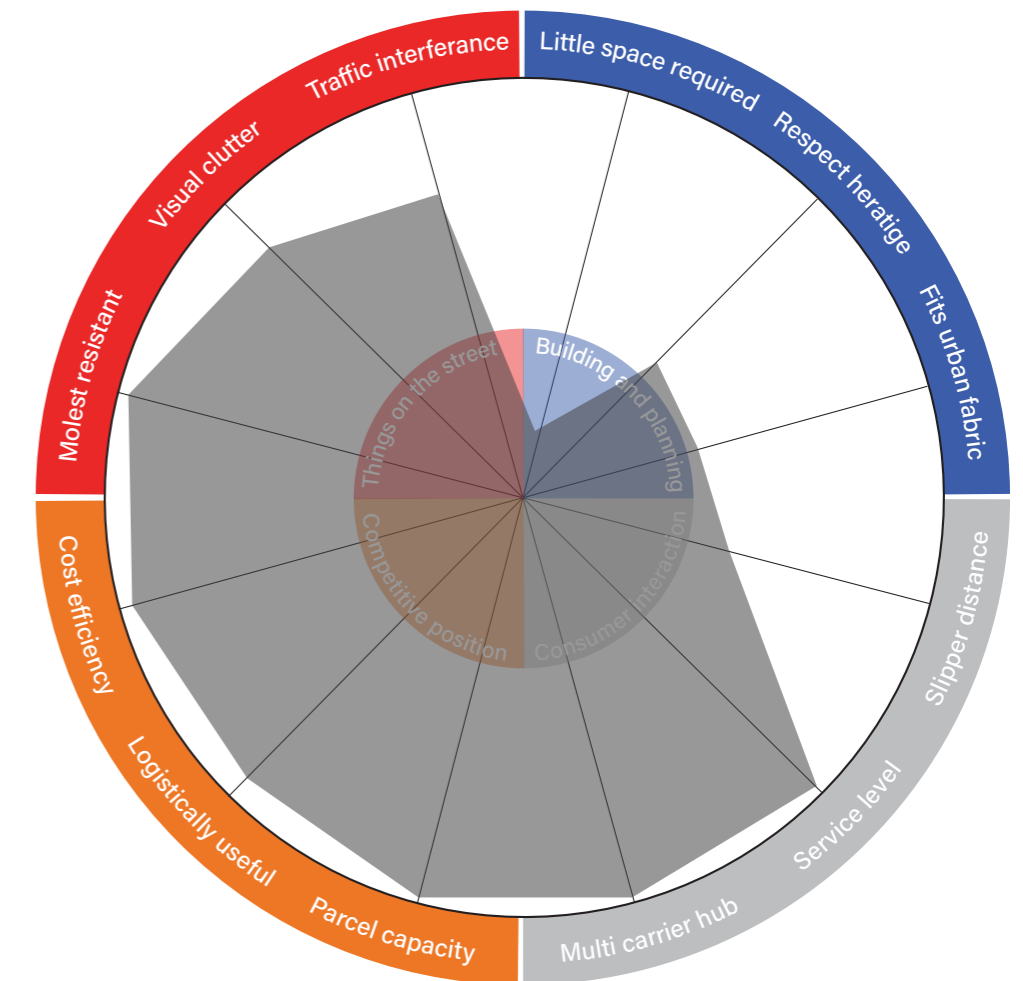
- Storage/consolidation space racks
- Storage/charging space for the LEFVs



The lower floor of the hub encompasses a space for trucks to dock and shutes leading parcel flows up to the upper floor. For trucks it is impractical to drive up in the building, from the store on the ground floor a service point is accesible



- Store space with service point attached to it
- Docking space for the boxtrucks + shutes upstairs



The emphasis of this hub is mostly on service and efficiency. The large size means the hub can handle large amounts of parcels, is logistically very useful and can be operated in a cost efficient manner. Also there is enough room to accommodate multiple carrier consolidation schemes. Visual clutter is somewhat in order because it mixes in with the landscape with its greenery.

Due to its large size, it is more difficult to fit into a dense urban context. This is why it will likely be located further outside the city.

4.6 CONCLUDING THE PROJECT

Confidently proposing a 'solution' for the myriad of problems that arise from logistics in the city would be hubris. As I discussed in my conversations with Tom Kuijpers from the Amsterdam Mobility Institute, there are too many steps, too many different parties and too many implications to consider. However I did willingly choose this project because I wanted, together with Vanderlande, to look at how logistics could change to make cities more sustainable to live in. In this project I explore the problem areas between livable cities and logistics, and with my proposed solutions I try to paint a clear picture for everybody involved in the planning and practice of logistics in the city what these problems are and how we can think of ways of solving them.

Because of my discussions with Tom Kuijpers (AMS), but also with Marc van Neerijnen (Vanderlande) and Paul Buijs (Rijks Universiteit Groningen) I gravitated towards attainable solutions. Solutions that would not require a complete overhaul of the logistic system, but rather extend the practices that exist today to create a 'last mile' that is more accessible, decentralised, better automated and better integrated into the city. I assumed the use of vehicles, mechatronics and automations processes that could be used the coming ten years. But also looked at regulatory and societal demands that would still be true in scope of at least two decades.

The importance of Vanderlande in this project, and the proposed solution directions I came up with can not be understated. As I discussed with Minze Walvius (Advier), Vanderlande is a company that works best in tight spaces where labour cost is high. Because of their competencies of automation and the insights I gained in conversations with Paul Buijs about consolidation, led to the decision to make consolidation in multiple different ways central to the designs. Consolidation in space and time through standardisation and automation, by creating racks in which management of parcel flows is more efficiently achieved than with the practices used today. But also consolidation between carriers, for which it has been important to identify the business models of the last mile, and how this scheme of cooperation would fit in to it.

The best way to see the UCCs is as a friendly way to bring logistics closer to the city, to allow more friendly types of transport. For the carriers this is important because they will have to adjust to the changing regulations (zero emission zones 2025) and urban planning, where distribution/consolidation/fulfilment centres are not often enough in the scope of spatial development. This design is therefore not only made to investigate how Vanderlande can expand their portfolio in the last mile in a sustainable way, but also an appeal towards municipalities/local governments, carriers and every other important player in the industry to work together to create sustainable cities through sustainable last mile practices.

4.7 RECCOMENDATIONS

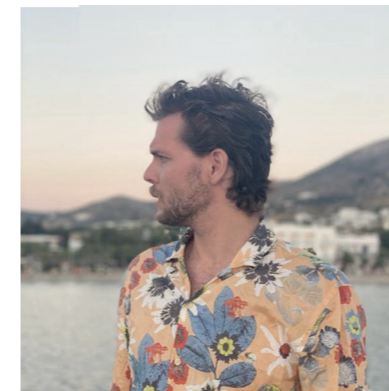
For Vanderlande I recommend to consider pursuing cooperation with local governments. There are programs from the Dutch government such as 'Zero-Emissie Stadslogistiek' of which Vanderlande could become a partner, or the platform City Logistics Innovation Campus in Amsterdam, the fully operational city logistics hub, innovation centre and complete campus in one where city logistic strategies are created and tested.

It is important that Vanderlande mixes itself in the dialogue about future of logistics in the city because, as I found in my research, issues related to it will become more and more pressing. This can be done by joining the aforementioned platforms and think tanks on the subject matter. Because Vanderlande operates on a global scale they should not limit themselves to the Netherlands as I have done in my research.

Another concrete step Vanderlande could take is to look at automation and proper integration of logistic flows between storage and different kinds of vehicles, light and non polluting vehicles in particular. With Vanderlande being the daughter company of Toyota, there are opportunities to do so. Vanderlande could choose to be an innovative leader in the facilitation of smaller, less polluting transport for consignment.



4.8 REFLECTION



The project scope I took was wide to begin with, and through researching and speaking with experts in the field I have let my scope widen even more. This resulted in a project that, although it was very interesting, also was a lot of work. Most of the work was in distilling clear concepts and rationale in the immensely pluriform nature of city logistics. To create a comprehensive problem statement I noticed that could not leave out a broad scale factors including the negative implications of vans, the inconvenient aspects of current distribution centres, the competitive nature of the carriers, policy and aspects regarding liveability in the city.

Through the involved coaching of my mentor Bart Bluemink and Gerd Korteum I was led to rethink the structuring of my report and therefore my way of looking at the story I wanted to tell. This resulted in a complete rework of my report, which was a lot of work, but I am very happy I did it and that my coaches told me so. Because of it I am now confident that I have told the story I wanted to tell, and that I have made clear what I wanted to make clear.



REFERENCES

- CNBC, & Frank Holland. (2020). *Amazon is delivering nearly two-thirds of its own packages*. <https://www.cnbc.com/2020/08/13/amazon-is-delivering-nearly-two-thirds-of-its-own-packages.html>
- Daniela, P. (2021). The Five Attribute Performance Assessment (FAPA) model to evaluate the performance of an urban consolidation centre. *Research in Transportation Economics*, 90. <https://doi.org/10.1016/j.retrec.2021.101065>
- Europe of Cities, & Nicolaie Moldovan. (2022). *Top 5 Pedestrian City Initiatives in Europe — Europe of Cities*. <https://www.europeofcities.com/blog/top-5-pedestrian-city-initiatives>
- Five ways we can systemically transform last-mile logistics | by Bax & Company | Medium*. (n.d.). Retrieved June 16, 2023, from <https://baxcompany.medium.com/five-ways-we-can-systemically-transform-last-mile-logistics-7fa199569ef8>
- Gemeente Groningen. (n.d.). *Ruimte voor zero-emissie stadslogistiek*.
- Gemeente Utrecht. (2020). *Merwede | gemeente Utrecht*. <https://www.utrecht.nl/wonen-en-leven/bouwprojecten-en-stedelijke-ontwikkeling/bouwprojecten/merwedekanaalzone/projecten-in-de-merwedekanaalzone/merwede/#c444980>
- Gevaers, R., Van de Voorde, E., & Vanelslender, T. (2014). Cost Modelling and Simulation of Last-mile Characteristics in an Innovative B2C Supply Chain Environment with Implications on Urban Areas and Cities. *Procedia - Social and Behavioral Sciences*, 125, 398–411. <https://doi.org/10.1016/J.SBSPRO.2014.01.1483>
- Invest Immobilien Hamburg. (2016). *Micro hubs*. <https://invest-immobilien.hamburg/en/commercial-real-estate-and-land/micro-hubs>
- Jasmijn Misseler, & Trouw. (2020, March 19). *Winkeliers worden gek van alle pakketjes: de dozen van Zalando en Bol.com reiken tot aan het plafond*. <https://www.trouw.nl/economie/winkeliers-worden-gek-van-alle-pakketjes-de-dozen-van-zalando-en-bol-com-reiken-tot-aan-het-plafond~b32bacb9/>
- Kosicki, M. A. (2020). *Parcel Lockers-A Solution to the Last Mile Problem? A Behavioural Analysis of Dutch Consumer Preferences*.
- Last Mile Experts. (2022). *GREEN LAST MILE EUROPE REPORT 2022*.
- Marcucci, E., & Danielis, R. (2008). The potential demand for a urban freight consolidation centre. *Transportation*, 35(2), 269–284. <https://doi.org/10.1007/S11116-007-9147-3/TABLES/7>
- Marieke de Ruiters, & Volkskrant. (2021). *12ft | De prijs van gratis bezorging*. Rapportage PostNL. <https://12ft.io/proxy?q=https%3A%2F%2Fwww.volkskrant.nl%2Fkijkverder%2Fv%2F2021%2Fde-prijs-van-gratis-bezorging%7Ev449789%2F>
- Morgan Stanly. (2022). *Global Ecommerce Growth Forecast 2022 | Morgan Stanley*. <https://www.morganstanley.com/ideas/global-ecommerce-growth-forecast-2022>
- Mourad, A., Puchinger, J., & Chu, C. (2019). A survey of models and algorithms for optimizing shared mobility. *Transportation Research Part B: Methodological*, 123, 323–346. <https://doi.org/10.1016/J.TRB.2019.02.003>
- Move21. (2018). *HAMBURG - Move21*. <https://move21.eu/city/hamb/>
- Novotná, M., Švadlenka, L., Jovčić, S., & Simić, V. (2022). Micro-hub location selection for sustainable last-mile delivery. *PLoS ONE*, 17(7 July). <https://doi.org/10.1371/journal.pone.0270926>
- Parcu, P. L., Brennan, T. J., & Glass, V. (n.d.). *Topics in Regulatory Economics and Policy The Postal and Delivery Contribution in Hard Times*.
- Radar, & AvroTros. (2021). *Eén op de zes pakketjes op verkeerde dag geleverd - Radar - het consumentenprogramma van AVROTROS*. <https://radar.avrotros.nl/nieuws/item/een-op-de-zes-pakketjes-op-verkeerde-dag-geleverd/>
- Rijksoverheid. (2017). *DKTI Uitgelicht*.
- Rosenberg, L. N., Balouka, N., Herer, Y. T., Dani, E., Gasparin, P., Dobers, K., Rüdiger, D., Pättiniemi, P., Portheine, P., & van Uden, S. (2021). Introducing the Shared Micro-Depot Network for Last-Mile Logistics. *Sustainability 2021, Vol. 13, Page 2067, 13(4)*, 2067. <https://doi.org/10.3390/SU13042067>
- RTL. (2011). *Nederland heeft geen postkantoren meer | RTL Nieuws*. <https://www.rtlnieuws.nl/nieuws/artikel/3060801/nederland-heeft-geen-postkantoren-meer>
- Savelsbergh, M., & Van Woensel, T. (2016). City logistics: Challenges and opportunities. *Transportation Science*, 50(2), 579–590. <https://doi.org/10.1287/TRSC.2016.0675>
- SupplyChainBrain. (2022). *Consumers Want Greener Delivery Options — But Retailers Have to Explain Them | SupplyChainBrain*. <https://www.supplychainbrain.com/blogs/1-think-tank/post/35182-consumers-want-greener-delivery-options-but-retailers-have-to-explain-them>
- Van Duin, J. H. R., Wiegman, B. W., Van Arem, B., & Van Amstel, Y. (2020). From home delivery to parcel lockers: a case study in Amsterdam. *Transportation Research Procedia*, 46, 37–44. <https://doi.org/10.1016/J.TRPRO.2020.03.161>
- Walter Ploos. (2020). *Stadshubs: een bestaand idee krijgt nieuwe invulling. Omgevingsvisie Amsterdam 2050*.
- Walter Ploos van Amstel. (2020). *Merwede-wijk in Utrecht wordt autovrij. Hoe moet dat dan met de logistiek? - De Laatste Meter*. <https://www.delaatstemeter.nl/slimme-laatste-meters/merwede-wijk-in-utrecht-wordt-autovrij-hoe-moet-dat-met-logistiek/>
- Washington Post, & Steven Pearlstein. (2018). *Is the post office making or losing money delivering Amazon packages? - The Washington Post*. <https://www.washingtonpost.com/news/wonk/wp/2018/04/04/is-the-post-office-making-or-losing-money-delivering-amazon-packages/>
- World Economic Forum. (2020). *The Future of the Last-Mile Ecosystem Transition Roadmaps for Public-and Private-Sector Players*. www.weforum.org

1. Case studies related to exploring the context



Warehouse of Red je pakketje, a startup (2016) that tried to be the Netherlands' first fully electric carrier. Sadly because of the increased cost of extra staff and delivery vans and the lack of new growth capital it went bankrupt (RTL, 2022).

1.1 CASE STUDY AMAZON

Let us now look at a case study of how a large logistics operator can work if that company establishes the entire logistic chain from first- to last mile. For this we take a look at how Amazon can keep up their two-day delivery promise by utilising other carriers' capacity.

Amazon's approach to delivery is interesting in that it reaches simplicity for the end consignee through complexity in their delivery process. About a quarter of their deliveries is handled directly by the seller as most products on Amazon are listed there by a third party which can send packages through (other) existing carriers (CNBC & Frank Holland, 2020). The other three-quarter fall under Amazon's fulfilment, this is divided into three categories: small sortable, large sortable and large non sortable, the first category being the largest in sales volume. Small sortable items are less than 30x40x15cm in size and roughly 11kg in weight. Large sortable is anything above that to a limit of 27kg in weight.

The small sortable items are easiest to automate a sorting process for. For example, in their fulfilment centres, Amazon is robotising shelves that drive towards the workers for easier picking, saving human labour.

For the stocking of the fulfilment centres predictive modelling is used to determine which products need to be in stock, for example ice scrapers in cold areas and parasols in warmer areas, however the modelling goes far deeper and has far less obvious implications on what needs to be in stock.

After the fulfilment centre the parcel goes to the sortation centre to be sorted by zip codes and get put on pallets to be shipped further towards their end destination. For smaller distances this is done by ground transport but for larger distances this can be done for example by air freight; Amazon leases 70 aircrafts from other companies.

An airplane from Amazon takes off usually in the morning, contrary to other carriers in the USA that depart at night. That is because Amazon has a promise of two-day delivery instead of the one-day delivery that the other carriers apply. This means that Amazon can



DHL Express Americas Hub in Cincinnati. Credit: Wendover Productions



Amazon air started in 2014 with 20 aircrafts leased from other airlines. Now they lease at least 70 aircraft. They also now bought their own planes.



The \$2 that USPS charges Amazon per package is about half that of what other carriers would charge. The USPS services every address in America.

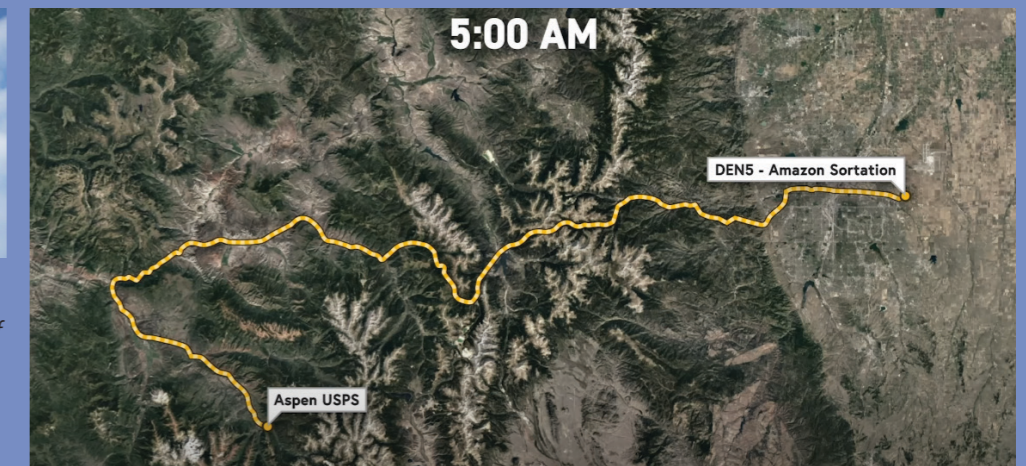


About 20% of packages of Amazon are delivered by UPS.

use DHL's hub of the Americas during daytime (they lease it), because DHL operates it only at night.

For areas where they have typically small delivery volumes (like in Aspen) they do not have their own distribution centres but make use of for example the USPS (Washington Post & Steven Pearlstein, 2018) who typically charge only \$2 per package. For the most rural places in America the parcels are sent by UPS about 20% of Amazon's total parcel volume (Washington Post & Steven Pearlstein, 2018).

The core of Amazon's business is logistics, and they are constantly expanding their systems and fleet. Instead of utilizing delivery capacity of other companies they might in the future be able to offer their own delivery capacity to others making them a company that straddles the line between e-retailer and carrier.



Mountainous route from Denver sortation centre to Aspen, carried out by the USPS. Credit: Wendover Productions

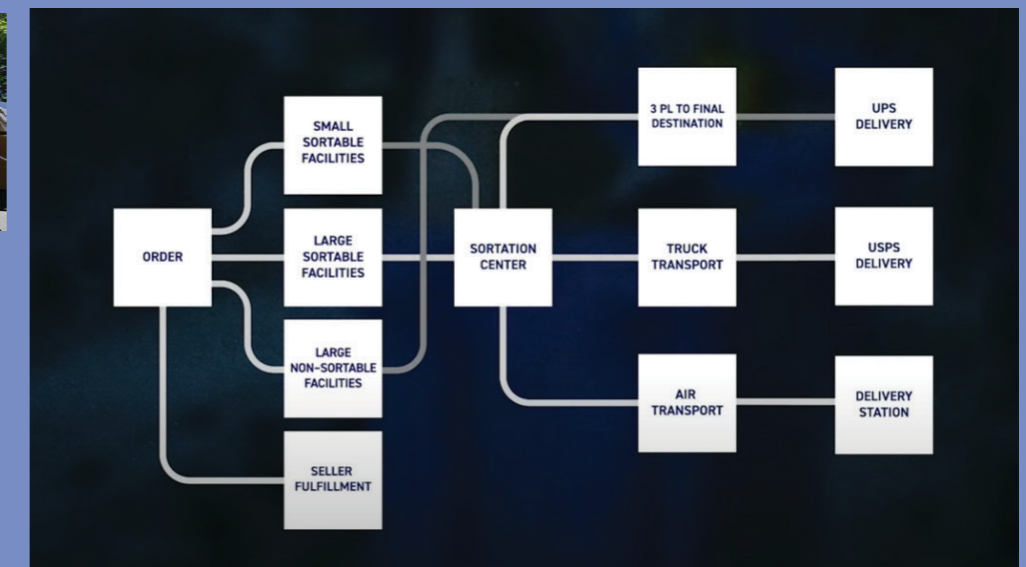


Diagram of the possible ways a parcel is delivered when ordering from Amazon. Credit: Wendover Productions

1.2 THE ADVANTAGE OF PARCEL LOCKERS

A dense network of APMs (and /or PUDOs) operated in an efficient manner is currently the most effective and efficient way to reduce the environmental impact of e-commerce logistics (Last Mile Experts, 2022). If all courier transport moved to parcel lockers, it would be possible to reduce CO2 emissions by up to 75% in relation to traditional courier delivery (Last Mile Experts, 2022).

Below is a chart which describes the added value of parcel lockers and OOH Delivery Points in general, namely that it guarantees first time delivery, allows for more optimised routes for the deliverer (given the lockers are placed on easily accessible locations) and results in fewer driven kilometres.

According to the four large delivery companies in the Netherlands, the consumer prefers home delivery given the current market shares for delivery options. Market entrants that try to build a network of alternative pick-up options experience this lack of collaboration, which also makes the realization of a denser parcel lockers network more difficult.

Lockers or PUDOs can be 'carrier specific,' meaning that they are owned- and used by only one company. Some are 'agnostic,' meaning that multiple carriers are integrated in the system, and some are 'open,' meaning that different parcel locker owners can cooperate, and that different e-com players can cooperate and integrate with it and different logistics carriers can work with it. This can be seen as a B2B sharing economy model.



In the Netherlands there are 400 PostNL parcel lockers currently. By 2024, this number should be increased to 1,500.

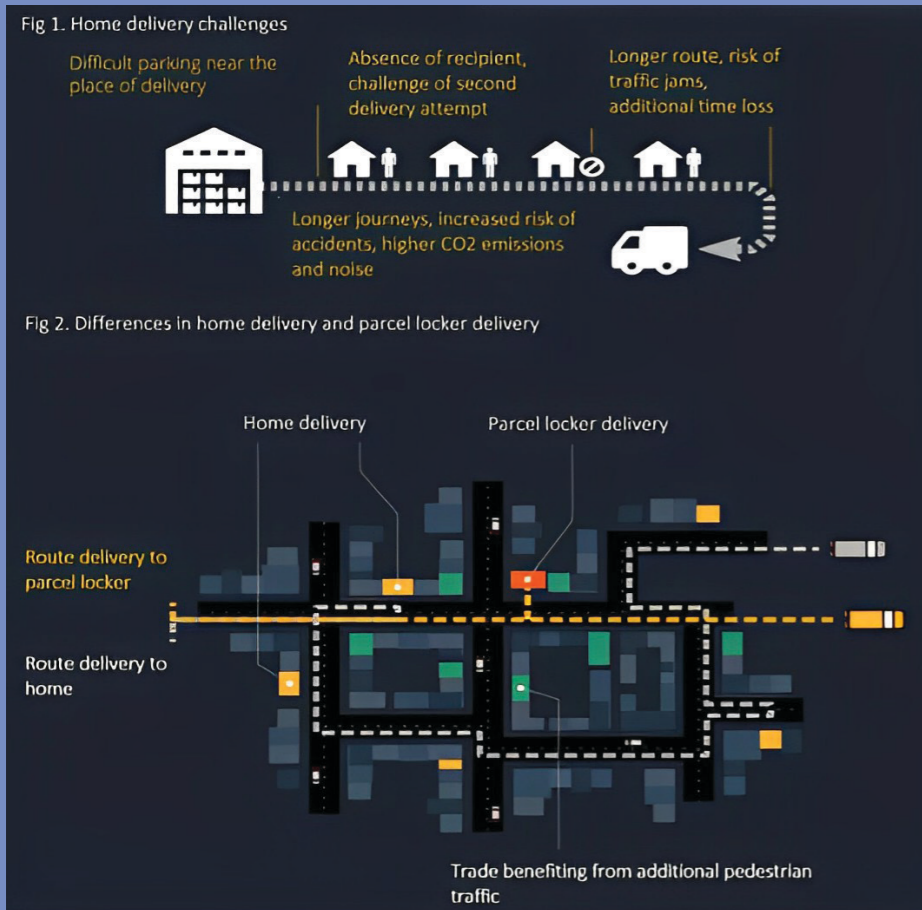
Part of the reason lockers are admitted to PostNL by local authorities is that they propose their lockers to allow for shared use; other delivery companies can make use of the lockers for a small rental fee.

To rent a space in a locker as a carrier other than PostNL you have to reserve said space, though if the locker is already full with PostNL's own parcels no reservation can be made. This makes them not fully 'open' but rather 'agnostic.'



When a parcel locker is placed inside a building, opening times of said building dictate the accessibility of the parcel locker. This is something that proves to stand in the way of a parcel locker's acceptance.

However in some cases, lockers placed inside could increase their acceptance, if it allows people to pick up their parcel 'on route,' for example at the place where they work, at trainstations or at local grocery stores.



Left: Diagram showing how OOH delivery points negate failed first-time deliveries and will reduce driven kilometers of a delivery vehicle.

Credits: TOR Consulting

Below we see a matrix showing the market shares for home delivery (HD), service points (SP) and parcel lockers (PL) concerning pick up of parcels in a few different scenarios. These scenarios are based on two stated choice experiments conducted among 343 respondents residing in the Netherlands. Based on certain factors it was research which delivery option the respondent would choose; home delivery (HD), pick-up at a service point (SP) and pick-up at a parcel locker (PL). The factors that were varied were delivery price, delivery moment, distance of the pick-up points and opening hours of the pick-up points.

Scenario one mimics the current situation, in which deliveries are often free and parcel lockers are not very established in the Netherlands (about 2.5km away from consumers' houses). Scenario two looks at a situation where parcel lockers are placed at 500m from each consumer's home. Scenario three looks at a situation in which e-retailers collectively increase the prices of home delivery. In scenario four a situation is assumed where the last mile sector cooperates more optimally, with HD a more premium option, and an abundance of PL and SPs. The final scenario is a combination of scenario two and three. Currently home delivery accounts for 50% of the chosen delivery options, service points 43% and parcel lockers 7%. According to the four large delivery companies in the Netherlands, the consumer prefers home delivery given the current market shares for delivery options. Market entrants that try to build a network of alternative pick-up options experience this lack of collaboration, which also makes the realization of a denser parcel lockers network more difficult.

Scenario	1.Reference	2.PLs at bus stops	3.Price collaboration	4.Optimal coordination	5.PLs and Price collaboration of e-retailers
Attributes					
HD Price	€0	€0	€2	€4	€2
SP Price	€0	€0	€0	€0	€0
PL Price	€0	€0	€0	€0	€0
HD Delivery moment	Weekdays: 9h-18h	Weekdays: 9h-18h	Weekdays: 9h-18h	Weekdays: 9h-18h; 18h-22h; Weekend: 9h-18h; 18h-22h	Weekdays: 9h-18h
SP Opening hours	Mon - Sat: 8h-22h; Sun: 10h-20h	Mon - Sat: 8h-22h; Sun: 10h-20h	Mon - Sat: 8h-22h; Sun: 10h-20h	Mon - Sat: 8h-22h; Sun: 10h-20h	Mon - Sat: 8h-22h; Sun: 10h-20h
PL opening hours	24/7	24/7	24/7	24/7	24/7
SP Distance	1 km	1 km	1 km	0.75 km	1 km
PL Distance	2.5 km	0.5 km	2.5 km	0.5 km	0.5 km
Market Shares, for the above chosen attribute values, for the median scoring person					
HD	50%	25%	27%	12%	11%
SP	43%	21%	62%	30%	25%
PL	7%	54%	11%	58%	64%

What can be seen is that for the consumer the distance to the parcel locker is crucial for them to be used as much as possible. Looking at scenario 2, when parcel lockers are placed at 500 metre distance, the market share of PLs increases to more than 50% for the median scoring person. Furthermore, increasing HD price can have great effect to moving consumers to PLs and SPs.

1.3 REAL LIFE EXAMPLES PARCEL LOCKERS

The locker market consists of many different players nowadays, each trying to distinguish themselves from one another by unique selling points. Some examples include:



C Solution/Posta Panduri: Parcel locker producer from Romania. Make lockers for extreme temperatures that keep products in locker between 15 - 25 degrees.



bloq-it: young dynamic startup with a much more holistic view at lockers. Supporting clients in how to setup their network of lockers to make it more 'plug and play' or 'turnkey'. Also focussing on second life lockers.



Myflexbox: Biggest open agnostic network in Austria. With couriers like DHL, DPD, UPS and GLS connected to their locker network. They already have e-commerce partners as well. They say it is because of their software that they have managed to do this.



Swipbox: locker producer, but they also deliver software that scouts out potential locations for new lockers using different data sets like google streetview, geological data etc.



Kern: Polish company; Poland is a real 'locker land'. Since recently now also working together with Orlen

1.4 GUIDELINES BASED ON RESEARCH

1. Solutions should respect heritage of existing building stock
2. Solution should logically integrate in the hub and spoke model
3. " as cheap as possible for carriers to remain competitive position
4. " remain similar service level for end consumers
5. Where possible, the use of ICE vehicles should be avoided
6. Loading and unloading minimally interferes with traffic
7. Solution should occupy minimal curbside real estate
9. Noise pollution should be kept at a minimum
10. Visual clutter in the street image should be considered
11. Proper planning of logistical locations regarding urban fabric
12. Community should be engaged in the planning
13. Facades should be open and accessible
14. Molest sensitivity should be kept in mind
15. Return logistics should be facilitated
16. Pick up locations are on 'slipper distance' from consumer
17. Pick up points should not be limited to one carrier



KEBA: lockers that can be placed without foundation or preparation (or power connection). Screen operated or 'parasitic'-app operated lockers. Parasitic means that they use the hardware on your phone to operate the software to interact with the system. This means that they do not require power to be operated and can be placed anywhere.

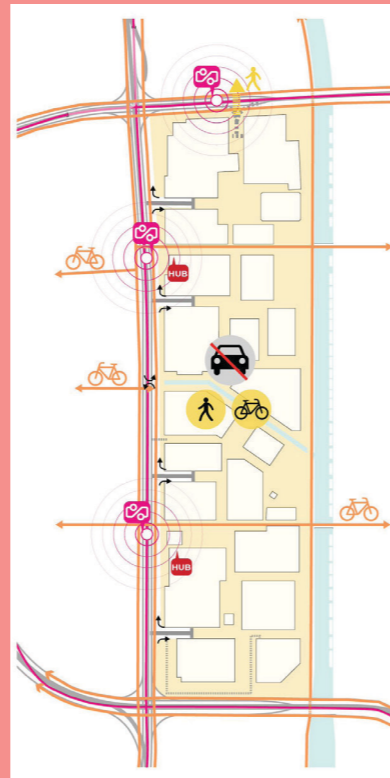
2.1 CASE STUDY NIEUW MERWEDE

An example of how neighbourhoods of the future might be shaped is Nieuw Merwede in Utrecht. The previous page shows the plan of the area showing where its mobility hubs and important logistical points are located.

1. Mobility in the area

Merwede is set to become a pedestrian area, welcoming cyclists and light electric vehicles. Accessible by car only up to the parking garages on the neighbourhood's outskirts, Merwede will be entirely car-free, providing ample space for cyclists, pedestrians, and green areas. An exception is made for electric vehicles with a width of up to 1.30 meters, allowing small delivery vehicles like Picnic to operate within Merwede, along with deliveries via cargo bikes. Essential services, such as Keramiekmobach and Stedin, will remain accessible. Furthermore, certain vehicles, like grocery delivery trucks or maintenance and emergency vehicles, can enter the area with a permit (Gemeente Utrecht, 2020).

Residents will primarily use bicycles and walking for transportation, supplemented by shared mobility and public transportation. New bike and pedestrian routes will connect Merwede to the city via the Merwedekanaal. Various shared mobility hubs in the neighbourhood will offer electric shared cars and other forms of shared mobility. The high-quality public transport lane on the Europalaan will be enhanced to facilitate quick and efficient transportation to and from the city.



Above: Mobility strategy of the area showing the mobility hubs and access routes

Credit: LOLA Architecten



Left: Impression of how mobility inside the area will look like.

Credit: LOLA Architecten

2. Mobility out of the area

In total, there will be 1,800 parking spaces available in the parking garages at the edge of Merwede, with approximately 1,500 allocated for private use, including 50 spaces for people with disabilities. The remaining spaces will cater to 250 shared cars, delivery vans, and light electric freight vehicles for neighbourhood use. To ensure the smooth functioning of shared mobility, a Mobility Company (Mobiliteitsbedrijf) will be established in collaboration with project developers. The Mobility Company will manage (bike) parking garages in Merwede and operate service centres where residents can access various neighbourhood-related services. Through a dedicated app, residents will be able to book all forms of shared mobility within Merwede, and the service centres will provide support and assistance as needed. Parking and distribution facilities, such as city logistics hubs, will be located in the Merwedekanaal zone close to the city boulevards. The municipality will make provisions for delivery in the residential areas with cargo bikes. Enforcement can be done without cumbersome measures such as bollards with electronic license plate enforcement in the pedestrian zones (Walter Ploos van Amstel, 2020).

3. Logistics towards the area

There will be high-quality logistics solutions for larger freight vehicles. There will be centralised and indoor mobility hubs from which deliveries are made to residents and entrepreneurs in the neighbourhood. Parcel delivery will take place in parcel walls in the mobility hubs or at the front door with delivery robots, cargo bikes and light electric vehicles.

Utrecht demonstrates in the Merwede neighbourhood that public and private professionals can work together to smartly organise provisioning for a vital residential area where the public space invites healthy exercise, relaxation, and meetings with neighbours. The approach in Utrecht is inspiration for other municipalities. After all, those municipalities are responsible for passing on these supply conditions to the project developers who start working in the neighbourhoods (Walter Ploos van Amstel, 2020).

2.2 CASE STUDY NEAR CITY DISTRIBUTION

1. Mobihubs

MobiHubs represent a visionary and innovative approach to urban mobility solutions, aimed at addressing the challenges of increasing traffic congestion and environmental concerns in modern cities. These hubs serve as multi-functional centres strategically located within urban areas, offering integrated transportation services, seamless connectivity, and sustainable mobility options. By consolidating various transport modes, such as electric buses, shared bicycles, and e-scooters, MobiHubs aim to provide commuters with convenient and efficient mobility choices, reducing reliance on individual car usage and promoting a greener urban landscape.

With a strong focus on sustainability, MobiHubs incorporate smart technologies, such as real-time traffic management systems, electric vehicle charging infrastructure, and data-driven route optimization, to create a harmonious and interconnected urban mobility ecosystem. By encouraging a shift towards cleaner and greener transport options, MobiHubs play a pivotal role in fostering a more liveable and eco-friendlier cityscape, while also offering added amenities like parcel lockers, retail spaces, and seamless integration with public transit systems. As cities continue to embrace the concept of smart urban mobility, MobiHubs stand at the forefront of this transformative movement, promising a more efficient, sustainable, and enjoyable commuting experience for residents and visitors alike.

These MobiHubs can offer a scope for more integration of logistical services, such as accommodating microhubs and the like. More logistical focussed centres, located somewhat further from the city centre, have also been trailed in Amsterdam under the name of 'City Hub'.



Left: A mobihub can have multiple functions but some are essential. To install a mobihub for example, it is necessary to have at least some car sharing parkingspots and a bicycle storage. The hub should be near a public transport stop and easily accessible for everyone.

Credit: Mobihubs.eu

2. Cityhubs

In 1990, the concept of urban hubs was first introduced in a Coopers & Lybrand report, proposing a solution for handling non-perishable, dirty, cumbersome, voluminous, or feather-light goods in urban logistics. Despite initial optimism, sceptics expressed doubts that such an idea would ever prove viable due to excessive costs and complexity. Over the course of thirty years and the establishment of nearly 400 urban hubs across Europe, substantial amounts of subsidies and research funds have been squandered with limited success to show for it (Walter Ploos, 2020). The pursuit of these hubs has proven challenging, highlighting the need for more innovative approaches to tackle the intricacies of urban logistics efficiently.

What went wrong according to Walter Ploos van Amstel, Lecturer City logistics Hogeschool van Amsterdam, is that many initiatives focused on already well-organised retail distribution. Large flows such as construction, waste, facility purchasing, and hospitality remained out of the picture. Shippers and receivers did not want it; too expensive and cumbersome. The total chain from origin, through the hub to delivery in the city was not well thought out. The revenue model for city logistics providers was not solid and dependent on government support. Finally, the local government changed the playing field every four years. The city hubs could not create value in the chain.

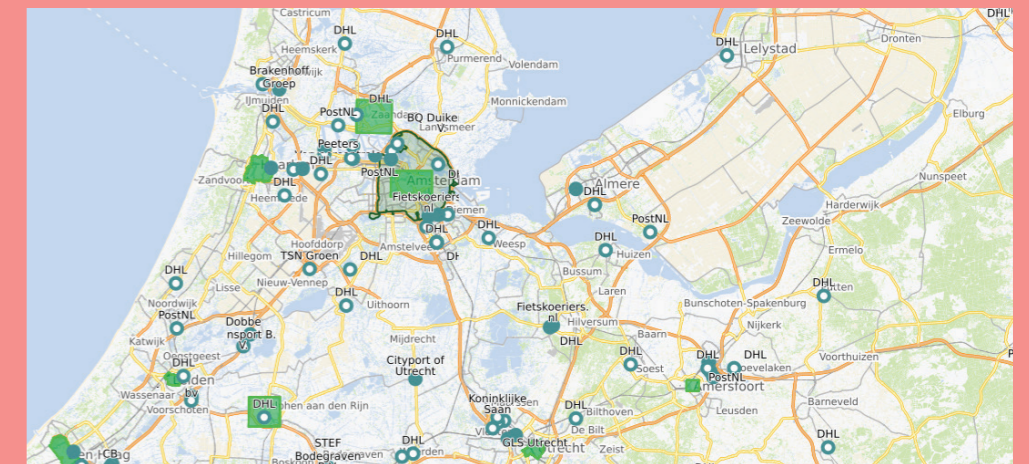
"In the future, the city hubs will be 'white label', and scale will be a critical factor for success. If an entrepreneur lacks sufficient scale independently, they will collaborate with other businesses to create it collectively. These city hubs will be meticulously planned, not just for the present but also for the forthcoming weeks. Transaction and planning data within the supply chain will be paperless and seamless. The shared urban vehicles will be lightweight electric and connected to the intelligent traffic systems in the city. Intelligent and collaborative electric charging will be implemented. Standardized loading carriers, such as containerization, will be the norm within the supply chain. The city hubs will add value throughout the production, processing, 3D printing, installation, return, and inventory-holding processes" – Walter Ploos van Amstel.



Above: CityHub, a logistical centre located near the city centre. It is an initiative of PostNL for B2B delivery and associated trash pick up. At CityHub, an average of 90 rides depart daily, including 60 during the day and 30 in the evening, with short routes with 100 to 200 delivery addresses. One of the added benefits that the initiative offers is that the supply trucks also immediately take with them any associated trash flows.

Right: Transport Logistiek Nederland has mapped all the cityhubs in the Netherlands. The map now shows around 300 city hubs that bundle shipments and offer zero emission transport for the 'last mile'. In addition to city hubs, the TLN map includes environmental and zero emission zones, postcode areas, shopping areas and business parks.

Credit: TLN



2.2 CASE STUDY NEAR CITY DISTRIBUTION

3. Hubs moving away from the city centre

Corporate land is being chased out of the city, with major consequences for business activity. “Until 2040, over 500 hectares of business sites will disappear from Amsterdam,” says Bart Stek of real estate company Colliers in the Parool. 350 Hectares alone are evaporating in the port area and Noord, where the municipality wants to build between 40,000 and 70,000 homes. “That will cause big problems,” he says. For how will we get our Internet orders home, how will the restaurants, cafés and shops we love so much still be delivered? And where will we have to work in the future?

Bart Stek: “Warehouses, logistics and small factories are being squeezed out of the city, but the city actually needs these companies.” Municipal politicians look for solutions a long way away in the region of Amsterdam. There, 800 hectares of industrial land are said to be ready. But this conveniently includes the 280 hectares in Flevoland and almost 160 hectares in North Holland.

Bart Stek: “That is no use to a parcel company, online supermarket or catering delivery company. You can’t just drop them off in the region; that creates all sorts of new problems. Employees would have to travel longer to work and delivery vans would have to drive further back and forth. What does that mean for accessibility and the environment?” Moreover, the long distance to the cities makes the deployment of clean, electric transport more difficult.

The construction of homes in new districts in Amsterdam threatens to come at the expense of businesses (het Parool, December 2019). If the municipality does not intervene, craft businesses, manufacturing and repair shops will disappear from the city.

That is what new Business Strategy of alderman Victor Everhardt (Economic Affairs) warns for. A shortage threatens as early as 2025. If the issuance of new plots continues at the current pace, all space for these types of businesses will be exhausted in six years.

By 2040, the municipality fears a shortage of at least 150 hectares of business premises in Amsterdam, 230 football fields. Displacement is lurking, writes Everhardt, because these types of businesses ‘are less able to cough up the rapidly rising rents than offices and the hospitality industry.’

4. Microhubs

In their study, Rosenberg et al. aimed to explore the benefits and potentials of auxiliary businesses within a shared Micro depot (MD) network. They found that consolidating resources at one location through auxiliary businesses allows for making the most out of limited resources, leading to increased value in urban spaces and providing residents with convenient services that might be otherwise challenging to access.

The concept of auxiliary businesses in a shared MD network also serves as an innovation hub for companies, encouraging them to experiment with new models, supported by local authorities (Rosenberg et al., 2021). The shared component of the MD network is the underlying construct, contributing to potential cost reductions and improved outcomes for both businesses and end customers. Effective cooperation among business partners is a critical aspect of these models’ success, ensuring benefits for all stakeholders (Rosenberg et al., 2021).

The research presented a comprehensive assessment framework based on three pillars: environmental, economic, and social aspects. This framework allows for the evaluation of the network’s sustainability in the long run. By consolidating deliveries within shared MD networks, the need for multiple delivery trips is reduced, leading to decreased fuel consumption, greenhouse gas emissions, and traffic noise, contributing to environmental sustainability (Rosenberg et al., 2021).

Public acceptance and stakeholder involvement are essential factors for the successful implementation of shared MD networks. The planning phase should engage all relevant stakeholders to foster acceptance and address potential concerns.

Recognizing that establishing shared MD networks involves costs, the study of Rosenberg et al. emphasizes the role of the local authority in providing initial incentives, either through financial support or regulatory policies. Their involvement can facilitate the creation of sustainable shared MD networks that benefit both businesses and the community.

2.2 CASE STUDY NEAR CITY DISTRIBUTION

5. Real life examples of microhubs

Real life examples of microhubs include those of DHL. They introduced its new city hub for the use of cargo bikes in Frankfurt's city centre. After successful tests, including in Frankfurt, DHL is now launching its central hub for inner-city express delivery on the corner of Klapperfeldstraße and Heiligkreuzgasse. "Together with our cooperation partners, we are pleased to present our pioneering City Hub concept today. From our DHL Express City Hub, four cargo bikes will now permanently take over delivery tours in the city centre. In this way, we are helping to protect the environment by reducing CO2 emissions on the one hand and promoting the flow of traffic in the city centre on the other. Our customers benefit from this new last-mile service as well as from greater flexibility and time savings," says Markus Reckling, Managing Director of DHL Express Germany.

A project in Berlin, called KoMoDo, has five of Germany's biggest parcel service providers, DHL, UPS, GLS, Hermes and DPD, working under one roof to test the collaborative use of a micro depot in combination with last-mile delivery via cargo bikes. Each operator has access to its own 14m2 container at the depot, provided and managed by the Berlin port and warehouse company BEHALA. "Our packages are delivered to the hub by conventional trucks, then distributed in busy city districts using the Cubicycle, an e-cargo bike that can carry a specialized container with a load of up to 125k," says Marc Rüffer, head of operations at DHL Parcel. "While the micro depot has been provided by the Senate of Berlin and is collectively used by the companies involved, each player still coordinates deliveries on its own," adds Michael Peuker, project manager of new mobility at Hermes. "What's unique about the project is that for the first time all major parcel delivery services in Germany are taking part." (Rytle Company, 2018).



6. Facility location problem

Finding the most suitable locations for these microhubs is a complex problem that not only requires public acceptance but also requires to find the logistically most optimal location. This is something that Novotná et al. have been researching. This paper solves the micro-hub location selection for sustainable LMD using the multi-criteria decision-making (MCDM) techniques. The five criteria used were: Sum of distance from sorting centre, Reach area of the microhub, Cargo bike availability, Cycle distance and Costs.

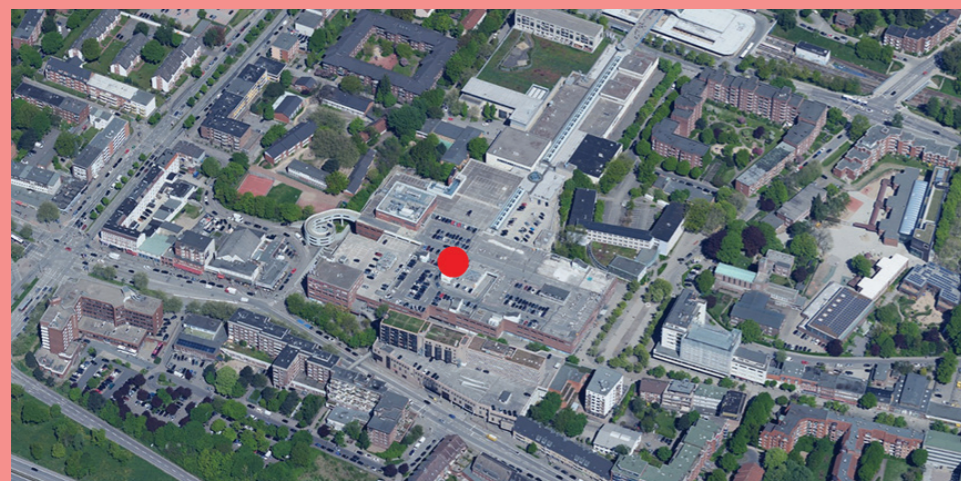
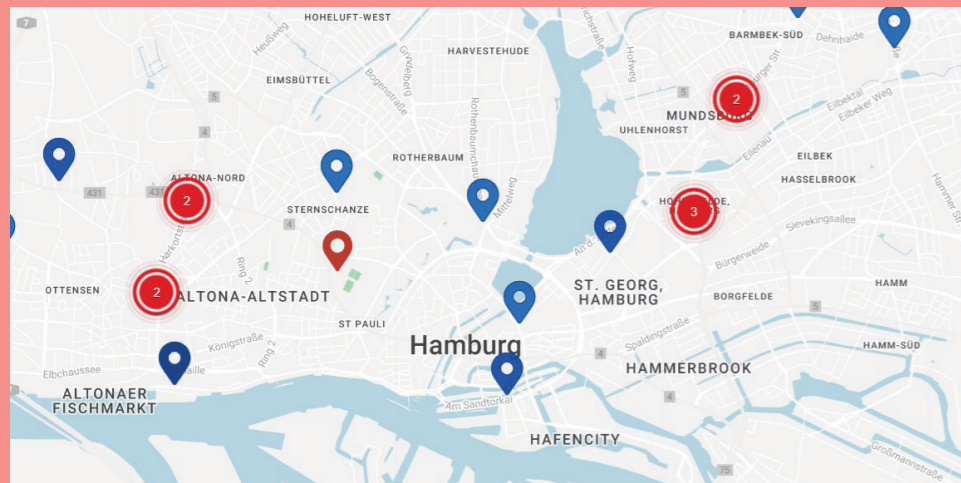
There are several articles found in the literature dealing with the facility location problem. For example, Rosenberg et al. investigated the success of the micro-depot network for LMD considering the economic, social, and environmental criteria. Awasthi et al. applied the fuzzy TOPSIS method to locate the urban distribution centres. They considered criteria such as accessibility, security, costs, environmental impact, proximity to customers and suppliers, resource availability, quality of service, the possibility of expansion, and conformance to sustainable freight regulations. Janjevi et al. developed a model for strategic scenarios evaluation for sustainable urban distribution using Urban Consolidation Centres (UCCs) in Brussels. They considered several scenarios and included geographical aspects, a fleet of UCCs vehicles, operation hours of the UCC, pricing of the UCC services, etc. Arrieta-Prieto et al. used the criteria such as layout dimensions, number of carriers, area, demand, and payload per truck to locate an urban micro-consolidation centre.

2.3 CASE STUDY HAMBURG

1. Microhubs initiative

Hamburg, as a city known for its innovative approach to logistics, has initiated trials of microhubs to address the challenges of last-mile deliveries. Under the direction of the Hamburg Ministry of Economy and Innovation (BWI), Hamburg Invest has been developing novel logistics solutions. Among these solutions, the identification of potential locations for microhubs in different quarters of Hamburg has been a key focus. The goal is to establish a comprehensive network of microhubs across the entire city, utilizing both municipal and private sites (Invest Immobilien Hamburg, 2016). The 'Living Lab Hamburg' has envisioned the pilot implementation of these hubs and other implementations in the framework of MOVE21 (Move21, 2018).

Having served as a testbed for various cutting-edge logistics initiatives, Hamburg has recognized the critical role of microhubs in coping with the rapid surge in delivery demands. A key aspect of these microhubs is their company-independent consolidation of goods, employing cargo-bikes or pedestrian distribution for the last-mile. Positive outcomes from a micro-hub pilot conducted by UPS in the city centre have reinforced the effectiveness of this approach. Moreover, a comprehensive study on last-mile logistics has projected that 100-150 micro-hubs would be sufficient to shift 40% of last-mile deliveries to cargo-bikes (Move21, 2018).



Left: Possible microhub location „BILLSTEDT-CENTER“
District: Hamburg-Mitte
MicroHubs: Single-User Hub „Basic“ (S), Single-User Hub „Max“ (M), Multi-User Hub „Basic“ (M*)
Location: Möllner Landstraße 3, 22111 Hamburg
Size: 60-70 sqm
Credit: Hamburg Invest

2. Functions of the microhub

Although the focus of these hubs will be on last mile deliveries or first mile pick-ups via cargo bikes, the MOVE21 framework addresses mobility measures as well, for instance, on passenger micro-mobility, sharing or on-demand solutions, or complementary to transportation measures, such as bike workshops or self-repair and service points. Specific uses involving social and cultural actions are planned to be implemented in hubs with available space for actions of this type. These uses aim at adding social value enhancing the social buy-in connected to the feeling of ownership (Move21, 2018). In addition to the pilot implementation of multi-functional 'neighbourhood hubs', the Living Lab Hamburg will address the inter-hub logistic traffic. In order to reduce the traffic of the individual carriers, consolidation of cargo is considered.

Characterized by modest floor spaces ranging from 20 to 250 m², these compact micro-hubs are designed to be shared by multiple courier, express, and parcel service providers (CEP) for their respective end-customer distribution. A single daily supply by a large vehicle, with a maximum capacity of 7.5 tonnes, ensures operational efficiency. Following the supply, the micro-hubs facilitate the last-mile deliveries through pedestrian, cargo bike, or other small e-driven vehicle modes as appropriate. This approach holds promise for optimizing delivery logistics in Hamburg and serves as a model for urban areas facing similar challenges.

3. Micro hub categories

Single-user hub "Basic" (S)

1 user, area of approx. 15–20 m², serves a delivery area with approx. 120–150 items per day

Single-user hub "Max" (M)

1 user, area of approx. 100–120 m², serves several delivery areas
Multi-user hub "Basic" (M*) Shared location for up to 3 CEP, area of approx. 100 m², serves a delivery area with 120–150 items per day each, plus pick-up station for parcels

Multi-user hub "Plus" (L)

Shared location for 3 to 5 CEP, area of approx. 150–200 m², serves one or more delivery areas with 120–150 items each, plus pick-up station for parcels

Multi-user hub "White Label" (XL)

Shared consolidated location for several CEP, area of approx. 250–300 m², serves several delivery areas by an independent provider with 600+ items, plus pick-up station for parcels as well as other services

2.3 CASE STUDY HAMBURG

4. Business model

The business model of these hubs is structured as follows:

Hamburg Invest has identified the potential locations of said microhubs, be it on municipal- or private sites.

The CEP who wants to set up a microhub on a municipal site would have to get a special permit for a fee (from the municipality) that allows them to use the space for a certain period.

Microhubs on private sites are (usually) owned by the owner of said private site.

In the hubs that accommodate several couriers rent is fairly divided based upon the amount of space used per courier, this is based on the predicted volumes of said couriers.

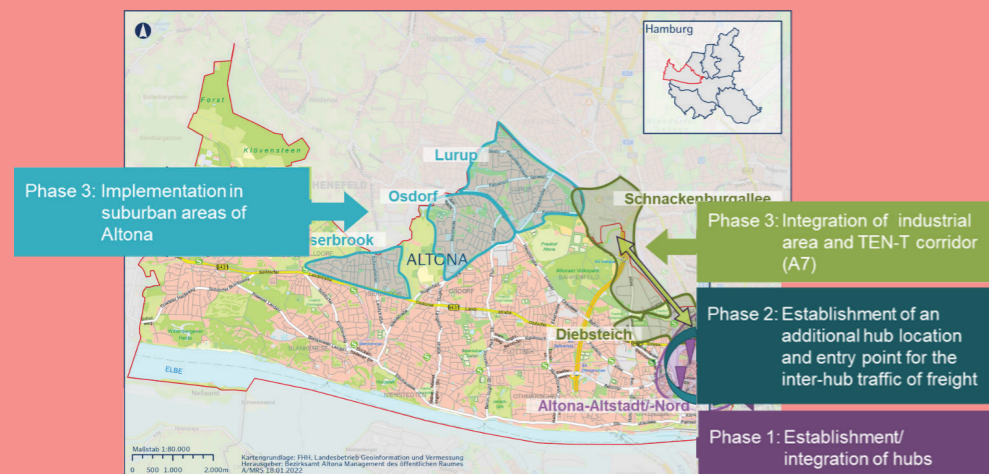
5. Implementation approach

The concept of the Living Lab Hamburg foresees a phase-based approach to ensure that the different measures can build upon each other, and experiences and lessons learnt can be considered already during the project duration of MOVE21. The iterative approach includes the following four phases:

Phase 1: Establishment of multifunctional neighbourhood hubs in the eastern, densely populated urban part of the District of Altona

Phase 2: Create connections between the neighbourhood hubs established in Phase 1 via simulated or real inter-hub traffic with one hub acting as start/end point.

Phase 3: Focus on the extension of the previously realized implementations to the third largest commercial and industrial area of Hamburg in the north-western part of the district and sub-urban neighbourhoods in the northern part.

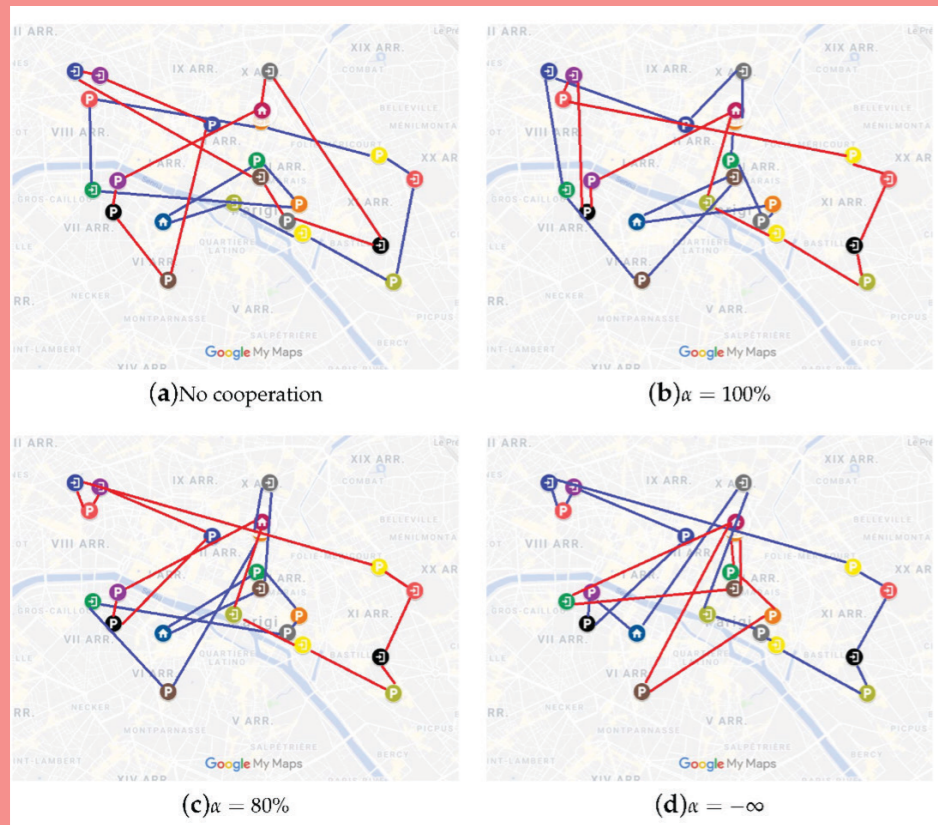


Microhub am Te Dam exploited by Smartcity | DB. Fresh goods are handled here in a cooled cell.

2.4 CASE STUDY HORIZONTAL COOPERATION

1. Share a ride problem

In a paper by Cavagnini and Morandi horizontal cooperation between different parcel delivery companies and public transport companies has been modelled in the 'static share a ride problem' to see if it can bring about more efficiency in the last mile.



In the figure above the route plans of two different service providers (blue and red) obtained with different cooperation schemes and levels of fairness of profit distribution (α) are represented. (a) Shows the usual noncooperative scheme (b) shows a scheme with cooperation and 100% fairness of profit distribution (α), (c) shows the same scheme but with 80% fairness and (d) shows the same scheme but with no fair distribution of profit.

The results indicate that horizontal cooperation benefits all agents in the system. Travel times significantly decrease, and vehicle occupancy rates improve, which is crucial for reducing congestion in city logistics. Additionally, the number of satisfied requests increases compared to noncooperative scenarios, resulting in an improved service level for customers. Moreover, an agreed balanced approach to cooperation leads to more satisfactory profits for service providers, making the system more appealing overall.

2. Crowdshipping

Ballare et al.'s research investigated the microhub and crowdshipping (M+C) delivery paradigm in comparison with the traditional hub-and-spoke (H+S) model. The study employed performance parameters

such as total vehicle miles traveled (VMT), number of dispatched trucks and crowdshippers, total daily operating costs, and fuel consumption for comparison. Sensitivity analysis was also conducted to explore the impact of network size on the M+C delivery paradigm's performance.

The results demonstrated that the M+C delivery paradigm offers significant advantages over the H+S model. It efficiently reduces the number of trucks, VMT, daily operating costs, and fuel consumption for equivalent customer demand. Moreover, the M+C delivery paradigm remains more attractive as the network size increases.

However, the success of the M+C model is contingent on the availability of a substantial number of crowdshippers willing to participate in the delivery process. Increasing the compensation offered to crowdshippers to attract more participants may affect the cost-competitiveness of the overall delivery model.

The study also revealed that the M+C delivery paradigm is better suited for cities with medium to high customer densities, such as Chicago and New York. Conversely, cities with low customer densities, like Los Angeles, may not be as compatible with this model.

To enhance cost-effectiveness, the research suggests optimizing the locations of microhubs in urban areas based on historical demand data. Additionally, future research directions include exploring the impact of a diverse fleet available to crowdshippers, encompassing cleaner electric vehicles and walking modes.

3. Consolidation

Because horizontal cooperation has been shown to work in theory, consolidation might be in order. Consolidation can be achieved by enabling multiple delivery companies to operate per distribution centre and potentially utilize the same vans. All cargo to one area in the city, for example a main shopping area, will be put together in one vehicle. This can potentially lead to better occupation rates of the vehicles and thus to less vehicles in the urban area (Marcucci & Danielis, 2008). Integrating smaller delivery companies with larger ones is a viable approach. However, pairing large companies together may not be ideal, as they already handle sufficient volume independently and may be reluctant to share their sales volumes with one another, this is something that has come forward in conversations with experts in the field. This strategy promotes efficiency and synergy among diverse delivery services while avoiding potential resistance from larger players in the market.

Daniela P.'s research shows that transport cost per delivery and per week is lower when using the consolidation scheme, as sharing the same vehicle for multiple deliveries allows reducing the costs related to the distribution of goods to the urban area. Considering that several studies found that both carriers and receivers would benefit from the use of a UCC (Browne et al., 2005; Paddeu, 2017)

2.4 CASE STUDY HORIZONTAL COOPERATION

4. Containerisation

A study from Rababah et al. explores the effects of containerization and mesh network (group of connectivity devices that can handle said containers) strategies on transportation costs, space utilization, and environmental impact. Findings reveal that using diverse container sizes and a mesh network approach significantly reduces operational expenses, improves space utilization, and fosters a greener transport system (Rababah et al., 2023). Containerised transport is therefore another way of consolidation that will be taken in scope for the last mile.

Two notable companies, Rytle and Velove, have emerged as pioneers in this field. They have developed innovative concepts that combine electric cargo bikes with modular and exchangeable containers. These solutions operate through IoT (Internet of Things) platforms, accessible via mobile applications. These platforms establish a digital network connecting all components and participants involved in multimodal systems. Shippers, customers, hubs, and transportation providers are interconnected within this network, facilitating efficient coordination and communication throughout the supply chain. Rytle's concept also integrates microhubs, more on that in CASE STUDY NEAR CITY DISTRIBUTION, microhubs.

DHL is another company that has implemented containerised transport for their cargo bikes in the Netherlands with their concept the Cubicycle. It involves a smart trailer combined with DHL's container bicycle. This is a four-wheeled bicycle with a detachable one-cubic-metre container containing about 125 kilos of shipments. The containers are pre-loaded at an operational DHL facility, transported by trailer to the city centre and placed on the bicycle there. This so-called 'City Hub' for cargo bikes can carry up to four containers and allows for the environmentally friendly delivery of larger parcels in hard-to-reach city centres and the organisation of their return flow from the city. DHL has received subsidies in among other Rotterdam to accelerate the shift to this more sustainable form of transportation (Rijksoverheid, 2017).

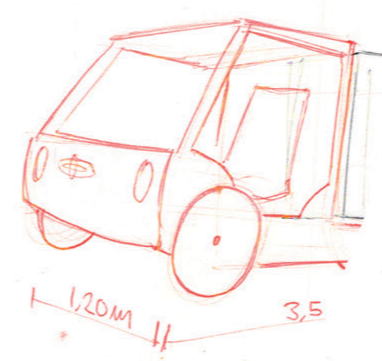
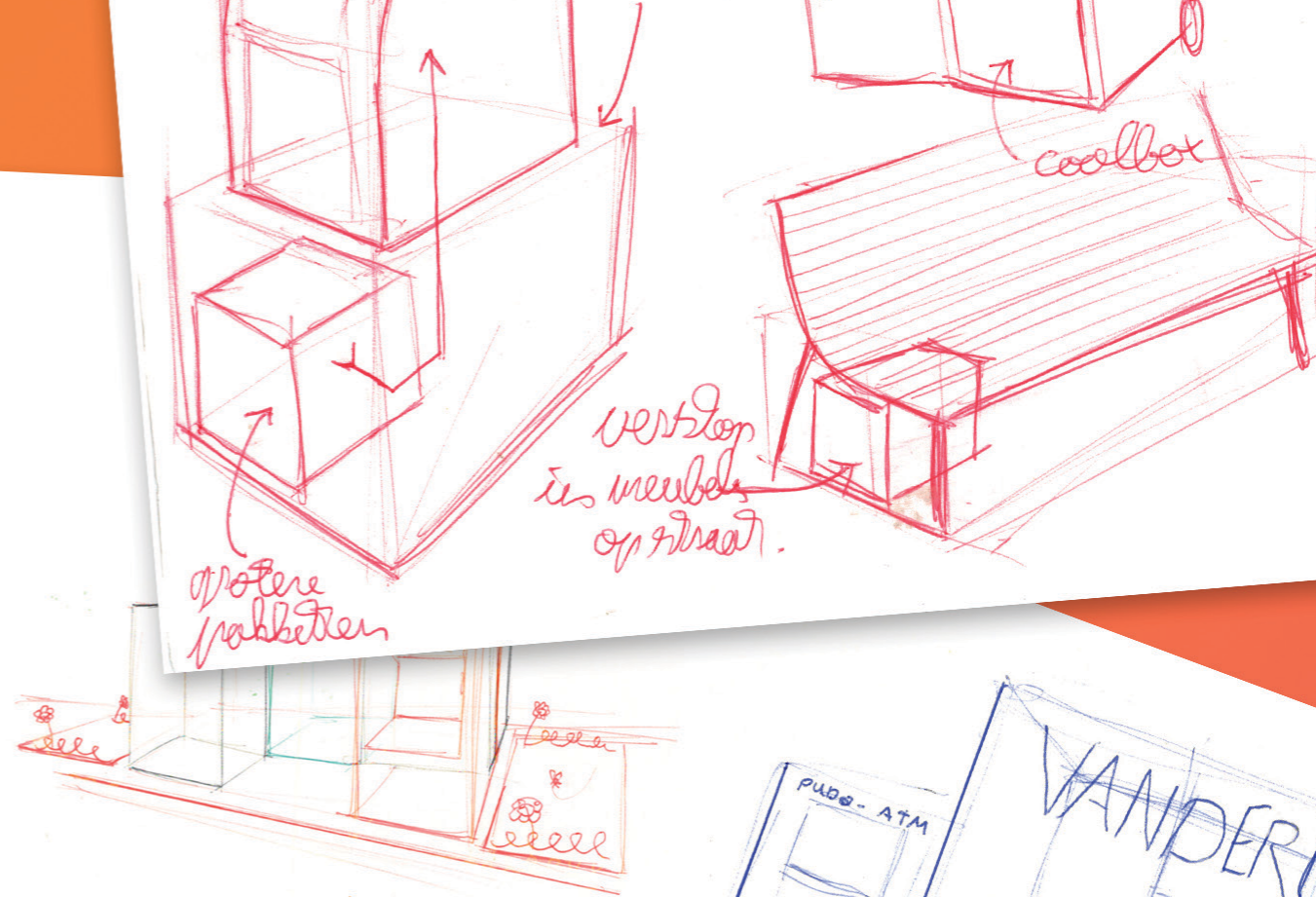
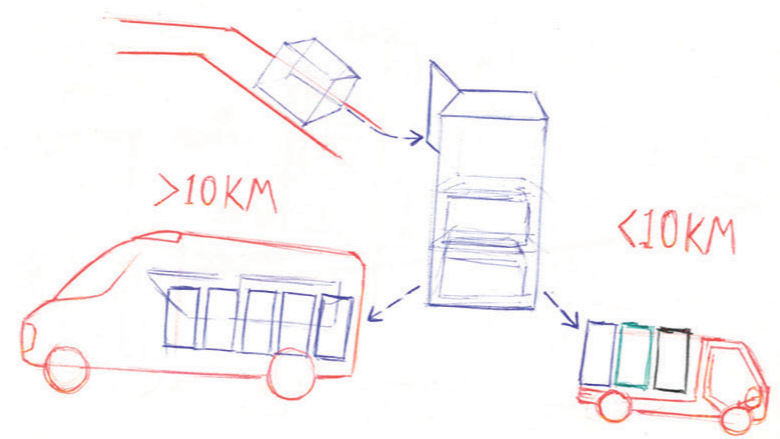
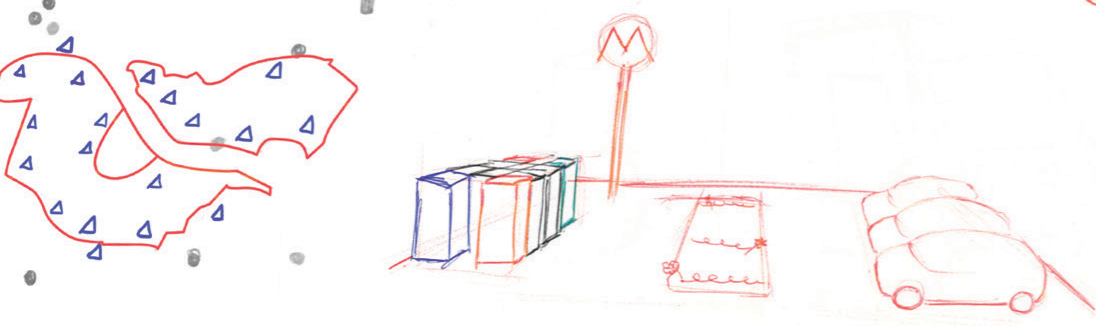
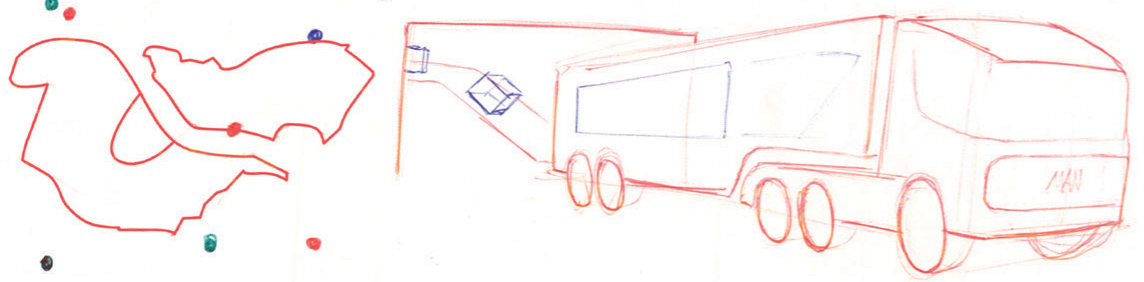


Rytle microdepot and Rytle bike being operating in Hamburg Germany.

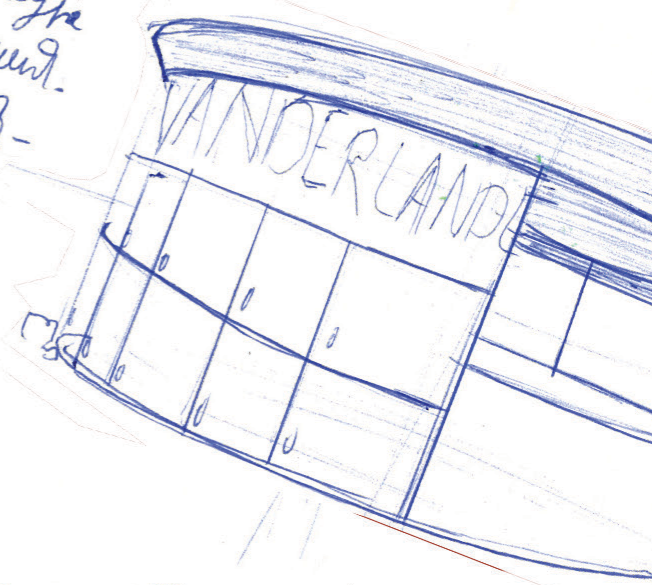
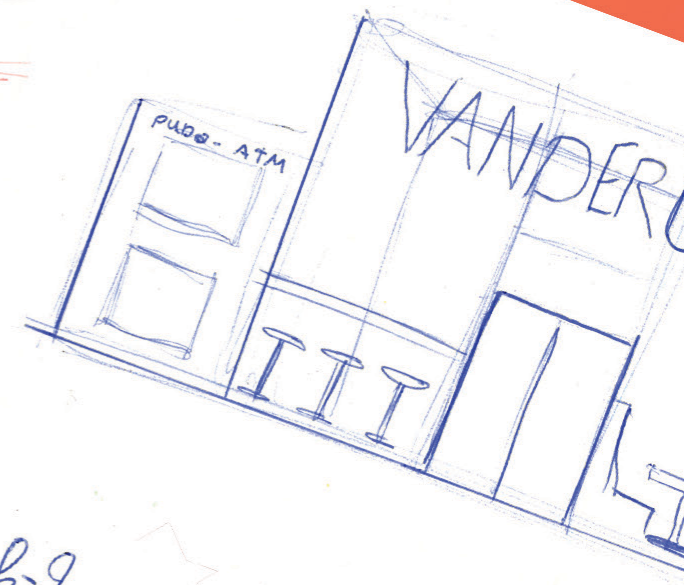
3. Creative sessions with Vanderlande



Employees of the research and development department as well as the technical and financial department discussing the businessmodel canvas of a possible last mile system with horizontal cooperation.



Kieske-type
PUDO-punt.
met pakket-
bluss aan
de achter-
kant.



← Op straat
PUDO, kan naast
de winkelbak
gezet worden.
Grote PUDO
aan eigen