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Reorganizing city logistics to reduce urban movements – Experiences with hubs and decoupling inner and outer urban transport

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Abstract

To realize a more sustainable city logistics system the focus should go beyond reducing emissions only. Next to zero emission vehicles, reduction of urban logistics trips is required in light of several urban, environmental and economic challenges. This contribution focuses on the role of hubs and decoupling points, where logistics flows to and from a city are decoupled from the flows in a city, to optimize the city logistics. For six distinctive hubs or decoupling point concepts, we examine the potential under current market and legal conditions. By decomposing city logistics in subsegments and urban logistics trip structures, we estimate the realistic trip reduction potential of decouple points in the current city logistics conditions.

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1. Introduction

Dutch cities strive for zero emission city logistics by 2025: both the Green Deal Zero Emission City Logistics and the Dutch climate agreement work towards this objective, with a transitional scheme for new diesel trucks and vans until 2030 (Klimaatkoord, 2019). Movements related to city logistics contribute to air pollution and their CO₂-footprint is considerable, i.e. about one third of all freight CO₂ emissions in the Netherlands related to logistics (consisting of both light commercial vehicles and trucks, see Topsector Logistiek, 2017). The zero emission city logistics ambition contributes to both improving the local air quality in cities by reducing local pollutants, as well as to the reduction of the freight transport's carbon footprint in the Netherlands. In a recent study we show that establishing zero emission zones in 30-40 Dutch cities is one of the most effective policy instruments to reduce the

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current city logistics' carbon footprint of 3.6 Mton in the Netherlands by 1 Mton (Topsector Logistiek & TNO, 2021).

Achieving zero emission city logistics from 2025 onwards will be a big challenge for logistics operators, especially as one of the most obvious ways to do it, electrification of the fleet, is not straightforward. First, the one-to-one replacement of the existing diesel fleets with zero emission vehicles is expensive. Second, it is questionable whether enough OEM-produced electric vehicles will be available in time, considering the replacement cycles of existing fleets. Thirdly, the available charging infrastructure won't be sufficient to charge the required zero emission-vehicle fleets. This is the case for private (at the depot) charging infrastructure as well as public (opportunity) charging infrastructure. Finally, for logistics operators, replacing diesel vehicles by zero emission vehicles adds planning issues, due to, amongst others, the limited range and charging (Kin et al., 2021). Therefore, solely focusing on a one-sided technical solution, i.e. replacing vehicles that emit pollutant emissions from the tailpipe with zero emission – mainly battery electric – vehicles, seems obviously neither desirable nor feasible.

Non-technical solutions to deal with the zero emission zones focus on reducing the number of city logistics movements. In the end, every movement that is avoided means that no polluting vehicle must be replaced at all. A city logistics system that is not only zero emission but also more efficient turns out to be difficult, as it requires more changes than just replacing one vehicle type by another. This question has been studied extensively the past decades, mostly through different forms of consolidation (Björklund & Johansson, 2018; Verlinde, Macharis, & Witlox, 2012). Reorganizing city logistics to reduce the number of vehicle movements demands, first of all, space to decouple transport in and outside cities. It furthermore requires cooperation between stakeholders, and other efforts from local authorities, shippers, transporters and receivers.

This contribution discusses the requirements and potential of different logistics solutions – hubs or locations where decoupling of inner and outer urban freight trips are executed (referred to in the remainder of this paper as decoupling points) – on a city logistics system level. Those decoupling points are examined in the living lab CILOLAB (CItY LOgistics Lab, see also Cilolab, 2022), a cooperation between Dutch knowledge institutes, cities, and logistics operators. Decoupling points entail a variety of potential solutions that requires another organization of city logistics, in contrast to replacing diesel vehicles for electric ones. The feasibility of decoupling points to potentially reorganize logistics depends on the specific characteristics of a specific city logistics segment. Logistics movements are diverse with regard to the type of goods and services, vehicle type, operational requirements, trip distance, number of stops. There is no decoupling point concept that fits all urban logistics trips. The characteristics of a segment determine the potential of a decoupling point. For example, reorganizing parcel deliveries varies from (heavy) construction logistics.

2. Research approach

The goal of this contribution is to address the potential that different types of decoupling points have to improve the efficiency of the city logistics system. It is a synthesis of various quantitative case studies and qualitative input with both municipalities and transport operators in the CILOLAB project. The study is organized as follows. First, based on a literature review, we propose a typology of different types of decoupling points. Next, a decomposition is proposed to structure the diversity in city logistics in terms of city logistics segments and transport structures. This decomposition is based on Dutch cases in the specific segments in which trip data have been used as well as data on the total city logistics fleet through ANPR camera data. Based on literature and interviews with both municipalities and transport operators we subsequently estimate the potential of decoupling points for different city logistics segments and transport structures, as well as what the requirements are to reorganize city logistics through these specific decoupling points. Finally, based on various quantitative cases and the interviews, we provide an estimation of the potential vehicle trip reduction – or (realistic) bundle potential – on an urban systems level by enhancing decoupling points.

The next section describes the context and drivers for reorganizing city logistics, including a typology of decoupling points. After decomposing city logistics in specific subsegments and in urban freight trip structure, we estimate the potential of the different decoupling concepts to reduce urban logistics trips based on literature, interviews with partners and experiments in CILOLAB. Next, we also provide quantitative estimations before, we

describe the main results from this part of CILOLAB. Finally, we conclude what is needed for reorganizing city logistics and how reorganizing can become large part of puzzle to make city logistics more sustainable.

3. Reorganizing city logistics

Several developments in cities affect city logistics operations which are not solved by using zero emission vehicles. The most important developments that force the existing city logistics system to change are a growing urban population and consequently more housing, the competition for urban space (due to an increased focus on active mobility and greening of space) resulting in less road infrastructure for (logistics) vehicles, the changing food- and retail landscape (e.g. fragmentation in deliveries due to instant deliveries), and the increasing digitalization (World Economic Forum, 2020). The issues as well as the opportunities that arise from these developments require new city logistics concepts to reduce city logistics movements. Therefore, reducing urban freight movements is not only relevant for reducing emissions, but it also contributes to a city logistics system that fits better with the future urban developments. The one-to-one replacements of polluting vehicles with ZE vehicles does neither reduce city logistics' spatial footprint nor does it answer logistics operators' challenges (Quak et al., 2016).

Reorganizing the city logistics system almost always requires decoupling the flows to and from the city with the flows in the city. Decoupling points are not limited to urban consolidation centers, a concept that is widely discussed in literature (see e.g. Björklund & Johansson, 2018), but can also include other concepts varying from collaboration between logistics operators on a regional scale to pickup points close to the final receiver. Based on literature, we distinguish six types of decoupling points (CILOLAB, 2022):

1. Hubs in a closed network of transport operators that can absorb more volume and serve multiple cities in a region (e.g. distribution centers of parcel carriers).
2. Network cooperation between transport companies (with regional or local hubs) on a regional level that can serve multiple cities.
3. Hubs on the edge of the city: functionalities and applications vary (from a generic urban consolidation center, a construction hub, a facility hub, to a cross-dock location where diesel vehicles can park and drivers switch to light electric vehicles such as cargo bikes).
4. Decoupling points to enable electrification on the last mile (detachable swap-bodies and tractor-trailers).
5. Microhubs for area-level consolidation within a city.
6. A drop-off point in the city for pick-ups which can be manned or unmanned (such as parcel lockers).

These concepts are not new, and several studies discuss the decoupling points' potential for different stakeholders, as well as the barriers, the fail- or success factors (see Björklund & Johansson, 2018; Quak et al., 2020). In the Netherlands, we noticed that – also in light of the development of zero emission city logistics – several entrepreneurs started suchlike services (also within CILOLAB). Despite some success stories with operationally and financially feasible decoupling points, this remains a niche as a solution to reorganize city logistics. Overall, operators offering city logistics services from different types of decoupling points seem to get off to a limited start as the demand for these services is often low. Potential customers run pilot projects with these services, but often stop again after the pilots because there is no need to reorganize their logistics at this moment (see also CILOLAB, 2020).

Some decoupling solutions can provide a good proposition for one type of urban freight trip or activity, but not for another. The exact functionalities and details of a decoupling point depend on the specific city logistics segment. City logistics is diverse and consists of different types of goods and services that are being transported: general cargo, fresh goods, parcel deliveries, waste collection, construction logistics, and facility and service logistics (Topsector Logistiek, 2017). These six segments have a different potential when it comes to electrification but also to decoupling. Recent data show that almost 70% of light commercial vehicles are more service-driven than freight-related (in Dutch cities). Around 40% of the trucks transport general cargo, whereas a quarter is responsible for temperature controlled goods and around 10% is active in construction logistics (Topsector Logistiek, 2020a). This distinction furthermore determines the services and functionalities of a decoupling point; a construction hub, for instance, differs from a hub for fresh goods.

In addition to the six city logistics segments, a second typology is added to decompose city logistics further. We roughly distinguish four transport structures to classify city logistics movements. This distinction is important to

subsequently determine whether and to what extent transport can be organized differently, with decoupling (see also Topsector Logistiek, 2020b):

- a.* Point-to-point (full-truckload): full-truckload trucks to a single stop. Logistics is optimized and locations are visited regularly and predictably. This includes, for example, delivering building materials to a construction site or supplying a supermarket with a tractor-trailer.
- b.* Deliveries at different locations (less-than-truckload): trucks that leave a distribution center usually full but have multiple delivery addresses (in one city or region), delivering multiple partial loads.
- c.* Various small deliveries: small to very small deliveries that are diverse in nature and frequency. These can be delivered on demand to all possible locations. These vary from home deliveries by parcel carriers and online supermarkets, small business deliveries to shops or construction sites, to service parts or facility deliveries to offices.
- d.* A fourth category does not directly involve deliveries, but does generate commercial transport movements and is thus considered as city logistics. These are mainly services for which a van is often used to carry out work at private homes or businesses (e.g. painters, plumbers, mechanics).

To actually estimate a realistic potential for decoupling concepts, this contribution assesses the proportion of urban logistics movements that can potentially be reduced by using different types of decoupling solutions. To do so, we needed to have more detailed insight in how city logistics is actually structured: the decomposition. We divided city logistics in segments and transport structures to be able to estimate what decoupling solution could add value for what segments and trips. Table 1 gives an overview of the structures we observe in the different (sub-)segments in city logistics. Overall, the distribution of trucks across segments is different from that for vans. Many truck trips are organized according to structures *a* and *b* due to the fact that many trucks actually transport goods and there are fewer service-related trips. This means that in terms of truck transport planning, there is more optimization because it is the main activity of companies. Therefore, more truck-trips are organized according to structures *a* and *b* and, as a result, relatively fewer trips qualify for a decoupling concept than for van-trips. Structure *a* only qualifies for decoupling if it involves a transfer to an electric tractor or truck. Transshipment and bundling of goods is not relevant in this structure because the trucks already enter the cities fully loaded. For structure *b* this is not the case. In particular, structures *c* and *d* are interesting for decoupling concepts.

Table 1. Distribution of city logistics (sub) segments across the urban freight transport structures.

CL Segment	Subsegment	Urban freight transport structure and vehicle type				
		<i>a</i> - truck	<i>b</i> - truck	<i>c</i> - truck	<i>c</i> - van	<i>d</i> - van
Temperature controlled	Retail	X			X	
	Horeca and specialists		X	X	X	
	Home delivery			X	X	
General cargo	Retail	X	X			
	Specialists		X	X	X	
	Two-men delivery			X	X	
Waste collection	Business		X	X	X	
	Residents		X			
Parcels	Parcel & express			X	X	
Facility logistics	Maintenance / service	X	X	X		X
	Deliveries		X	X	X	
Construction	Groundwork/ civil engineering/ shell	X				
	Finishing & renovation	X	X	X	X	
	Staff				X	

4. Requirements for using decoupling points

Given the still lacking development of the market of decoupling concepts, we examined what – under the current conditions – could be a realistic estimate for the potential for decoupling points (see next paragraph). This follow-up question followed on the one hand from local authorities who are facing issues concerning their role in the development of decoupling points. Despite countless efforts in the past decades, authorities often eventually realize that direct intervention by setting up an urban consolidation center is not a good idea (Verlinde et al., 2012). Nonetheless, questions remain: how to actually reduce vehicle movements? How many and what type of decoupling points are necessary for another organization of logistics activities in the city and how to facilitate that? Should urban space be dedicated to city logistics and how to determine which activities should be allowed for on the determined areas (Kin & Quak, 2023). On the other hand, issues from private companies remain; i.e. what is a possible market share to aim for and for whom is it an added value? We explicitly examined the potential under the current conditions, as many urban consolidation center studies seem to provide a relative high bundling potential, but do not take the conditions – such as the market proposition and the actual perceived pressure of regulations – into account. As a result, many of these studies, both academic papers as well as consultancy reports overestimate the potential in comparison to the actual realization in practice.

After the distribution of city logistics (sub-)segments over transport structures and an overview of different types of decoupling points, the next step is to assess what type of decoupling points have a potential for different (sub)segments and transport structures. Based on interviews with stakeholders from the different segments, the proposition of various types of decoupling solutions has been assessed using a business model analysis approach (see CILOLAB, 2020 and 2022). Combined with the findings in the Outlook City Logistics in Topsector Logistiek (2020b), the interviews provide an indication of potential for the decoupling concepts that are partly already used for the different segments or the conditions that are required. CILOLAB (2022) explains in detail how a decoupling concept can be applied to a segment; for this contribution we summarize the main insights. The considerations – based on literature, interviews and real-life demonstrations – were used to estimate the potential for decoupling concepts for urban freight van trips and truck trips per (sub)segment:

- Temperature controlled (mainly decoupling point type 1 & 2): the part of the vans for retail and horeca (hotel, restaurants and cafes) and specialists could make use of existing wholesalers (closed network) that already visit the horeca addresses or a hub specialized in food. These options as well as regional cooperation also applies to truck trips in the horeca and specialist subsegment.
- General cargo (all types of decoupling points): all decoupling concepts could apply in the general cargo's subsegments: some of these van trips performed by SMEs with their own vans could use parties offering transport (closed network). In addition, distributors, parcel carriers and (cooperating) transporters could take up more volume. This is already increasingly happening with B2B deliveries transported with the same vehicle as B2C deliveries. Hubs on the outskirts of cities can also be used, especially since these are (often) not critical goods. Shops are increasingly micro-hubs from which goods can be collected (by for example local bike couriers). Entrepreneurs can also collect goods themselves. For the truck trips in this segments, the transport of partial loads (structure b) can be bundled or outsourced in various ways: by having volume included in a closed network, in a partnership and in hubs on the outskirts of the city. For structure a trips, no decoupling concepts are used.
- Waste collection (sometimes decoupling point type 3): for waste collection trucks in the business segment, we see some options to reduce trips via area-based tendering that allows waste collectors to organize waste collection by area and redistribute the waste to handling locations via a hub outside the city.
- Parcel and express (decoupling point type 3, 5 & 6): extra volume (from other segments) can be added these networks, as most operators in this segment are in fact already operating from a local hub in a closed network. Within cities, kilometer reduction can be achieved by using pick-up points and (micro) hubs can provide a transfer to cargo bikes (or light electric freight vehicles, LEFVs).
- Facility logistics (decoupling point type 2 & 3): to reduce truck and van kilometers for facility delivery, suppliers can cooperate and a hub on the outskirts of the city can be used with the help of an incentive in procurement requirements (see e.g. Balm, 2022). For the maintenance- and service trips the van kilometers

could be reduced by the use of a P+R location which may be at existing hubs on the outskirts of cities and within cities, or mobility hubs.

- Construction (mainly decoupling point type 3 & 2): a construction hub could reduce truck as well as van trips in the city for especially finishing and renovation; especially feasible for construction sites where space is scarce, e.g. infill construction in the city center. Some van trips can be replaced by service trips via the parcel and express network, as well as services for craftsmen that can park their vans at a P+R location, from where cargo bikes or LEVVs can be used (in busy cities).

5. The bundle-potential within the current conditions

For the final potential estimation, we made a distinction between the decoupling concepts and the subsegments and vehicle type. The results show the variety in decoupling points (in size, operator and functionalities) and the need to tailor to a specific segment and its customers. Based on a decomposition of city logistics in segments and structures, and of the typology for decoupling points, we came up with an estimate on the potential urban freight transport trips that could be reduced under the current circumstances – being the current city logistics regulations and the existing market proposition the decoupling point operators offer the (potential) customers. Table 2 shows the estimates (see CILOLAB, 2022). Subsegments that have no expected (extra) bundling potential, i.e. for vans fresh home deliveries, waste collection, and construction - groundwork/ civil engineering/ shell and for trucks fresh retail and home deliveries and waste collection residents, are not included in table 2.

Table 2. Potential estimate for inbound van trips by segment for the different decoupling concepts in for vans and trucks.

(Sub)segment and vehicle type	Total Reduction	Closed network	Cooperation	Hubs	Micro hubs	Drop-off point
Fresh retail, horeca /specialists - vans & trucks	-10%		-5%	-5%		
General cargo retail and specialist - vans	-20%	-6%	-6%	-6%	-1%	-1%
General cargo - Two -men delivery vans	-3%		-3%			
Parcel and express – vans & trucks	-20%			-12%	-4%	-4%
Facility - service and maintenance vans	-10%		-9%		-1%	
Facility - delivery vans	-20%		-14%	-6%		
Construction - Finishing and renovation and Staff vans	-15%		-9%	-5%	-2%	
General cargo - retail trucks	-5%		-5%			
General cargo - specialists trucks	-15%	-5%	-5%	-5%		
General cargo - two men delivery trucks	-3%	-1%	-1%	-1%		
Waste collection business trucks	-2%		-2%			
Facility - service and maintenance trucks	-2%		-2%			
Facility - delivery trucks	-20%		-6%	-14%		
Construction - groundwork/ civil engineering/ shell trucks	-5%			-5%		
Construction - finishing and renovation trucks	-25%			-25%		
Construction – staff trucks	-15%			-15%		

As an illustration, to show what these percentages mean we made an illustrative quantitative example for the (not yet implemented – large) zero emission zone in the city of Utrecht. Based on a decomposed city logistics fleet visiting the city center of Utrecht, calculated based on the method explained in Rondaij et al. (2023), we assign the observed 43,000 van trips and almost 5,300 truck trips that enter the Utrecht city center on a daily basis in 2025 (Topsector Logistiek, 2020a) to the different city logistics segments and urban freight transport structures. Given the potential estimated in table 2 this will result in a total reduction of more than 6,000 van trips per day (14% of the

total) and just over 200 truck trips per day (4% of the total), as a realistic estimate of what could be organized via a decoupling concept in the current situation. The share is relatively low for trucks because the decoupling concepts mainly apply to trips organized according to structure c and d. From the perspective of the operator of the decoupling concept, one trip equals one potential (paying) customer (even though one transport company with several vehicles can use a decoupling concept). Next, to showing a reality check: what can be expected under the current conditions, this illustrative example shows three things: first, which segments contain the market potential for decoupling-concept providers, and that this is probably higher for vans than for truck trips. Second, based on such an exercise, an estimate can be made of the space that will be needed (per city) for decoupling. Finally, this can also give more insight for companies that do not need to invest in electric vehicles (because a decoupling concept offers an alternative). In the city of Utrecht several (small scale) decoupling concepts already exists that mainly focus on trucks, so based on these calculations there is especially room in the market for decoupling points aiming at van trips. If conditions change, see for example Kin and Quak (2023) on the development of a car-free neighborhood (in Utrecht), the potential for decoupling points might increase.

6. Conclusions

From a system perspective, there are potential benefits to decoupling concepts (less emissions, less nuisance, more safety, etc.), but for individual companies, the benefits are (still) small. In CILOLAB (2022) we were able to learn from following, monitoring several decoupling point operations and discussing with the involved stakeholders as well as with several local authorities the main reasons for the current (still) limited market of decoupling concepts as a solution for reducing urban logistics trips as well as make zero emission city logistics possible:

1. The focus of governments and transporters is more on issues around organizing ZE transport (mostly electric) rather than decoupling.
2. There is no need (yet) for companies to use decoupling solutions, the current conditions do not require the reorganization of city logistics (yet), where there is a potential for decoupling in terms of load factors, to transport differently or to outsource. This is because restrictions in cities (e.g. time windows, zero emission zones) are not such that alternatives are sought (e.g. outsourcing to a hub or bicycle courier). Also, reduced accessibility, and as a result additional costs and lost time, is not yet such a big problem that companies start looking for alternatives. Moreover, many service providers are driven by a good customer relationship, which they can better maintain one-on-one. In other words, many of the decoupling point concepts, including the urban consolidation centers, have no attractive (value) proposition to a paying customer. The decoupling concept promises positive results for the city, e.g. fewer movements and reduction in emissions, but might increase costs for the stakeholders targeted without offering a better service. So there is an mismatch in the distribution of the gains and the pains of such a concept.
3. Non-logistics parties need to get moving: logistics is ultimately a latent demand caused by shippers and receivers. Depending on the segment, these parties can encourage decoupling in different ways (e.g. through tender requirements and/or the use of new contract models).
4. There is a lack of need for broadening the (last mile) proposition among carriers (for example: many logistics operators, such as parcel- and e-grocery deliverers and food wholesalers, have consolidation centers near the cities, but these operators do not consider to start offering (zero emission) city logistics services for new customers other than their existing services and market.
5. The importance of a proactive government is touched upon in roughly three ways: i) clarity on announced policy; ii) bundling its own procurement and thereby stimulating a market for decoupling ('practice what you preach'); iii) decoupling requires space for logistics. This space is scarce and, moreover, the lead time for permits and zoning plans is a bottleneck.

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