Logistics concepts for light electric freight vehicles

a multiple case study from the Netherlands

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LOGISTICS CONCEPTS FOR LIGHT ELECTRIC FREIGHT VEHICLES: A MULTIPLE CASE STUDY FROM THE NETHERLANDS

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ABSTRACT

The demand for the transport of goods within the city is rising and with that the number of vans driving around. This has adverse effects on air quality, noise, safety and liveability in the city. LEFVs (Light Electric Freight Vehicles) offer a potential solution for this. There is already a lot of enthusiasm for the LEFVs and several companies have started offering the vehicles. Still many companies are hesitating to start and experience. New knowledge is needed of logistics concepts for the application of LEFVs. This paper shows the outcomes of eight case studies about what is needed to successfully deploy LEFVs for city logistics.

INTRODUCTION

Today, companies recognize that the opportunities derived from the on-demand economy are becoming too big to miss. They also see that it's too risky to ignore. Like all major disruptions, on-demand economy startups are challenging industry incumbents with new business models and new ways of engaging customers (Colby & Bell, 2016). Existing companies need to embrace the on-demand economy and transform their service and delivery systems to meet consumer demand. The strong economy means shoppers want more of everything, and thanks to Amazon and other big companies, 70% of them want it delivered fast, leading to many small deliveries and average shipment size decreases.

55% of the world's population lives in urban areas, a proportion that is expected to increase to 68% by 2050 (UN, 2018). Residents, commercial establishments, commuters and visitors demand more goods. It furthermore contributes to employment, businesses to thrive, the functioning of services such as waste collection, and economic growth in general (Dablanc, 2011). This demands for more space for logistics activities in cities which is becoming more absent due to accommodating the growth of people in cities. This pushes logistics real estate out of the city and less space remains for storage in the city. As a result, the average shipment size reduces and the number of delivery vans in cities increases.

The climate change and air pollution in inner cities force the city logistics practice to zero emissions by the year 2025/2030. Therefore, the logistics sector stands for an extra-ordinary challenge to be fast, to be clean (low-emission) and not to occupy to much space in the dense cities. To tackle this challenge the Light Electric Freight Vehicle (LEFV) can be a part of the solution. However, many companies are hesitating to start and experience with LEFV.

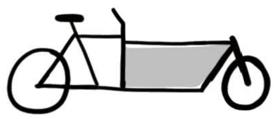
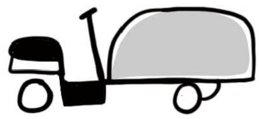
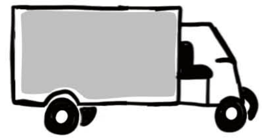
The Amsterdam University of Applied Sciences (AUAS), the Rotterdam University of Applied Sciences (RUAS) and the HAN University of Applied Sciences started the LEFV-LOGIC project (2016-2018). In this period, they have worked together with 60 public and private organizations to explore: how LEFVs can be a financially competitive alternative to conventional freight vehicles. The project started by exploring the potential of LEFV for specific freight flows (Balm et al, 2018). This paper presents the results of the second year, in which the study answered the question: *In which logistics concepts can LEFVs be used to create operational and financial benefits?*

The paper is organized as follows. The article begins with a definition of LEFV followed by an overview of different types. The next section explains the research methodology used in this research. The subsequent sections describe different case studies followed by the lessons learned. The paper ends with a conclusion about the results and directions for further research.

LIGHT ELECTRIC FREIGHT VEHICLES

The Dutch LEFV-LOGIC project defines a light electric freight vehicle as a bike, moped or compact vehicle with electric assistance or drive mechanism, designed for the distribution of goods in public space with limited speed (Ploos van Amstel et al., 2018). LEFVs are quiet, agile and emission-free and take up less space than conventional vans and trucks. The LEFV-LOGIC project distinguishes between three types of LEFVs.

Table 1. LEFV: Three categories

	Electric cargo bike	Electric cargo moped	Small electric distribution vehicle
Loading capacity	50 – 350 kg	100 – 599 kg	200 – 750 kg
Vehicle weight	20 – 170 kg	50 – 600 kg	300-1000 kg
Example			

Electric cargo bike: an agile and active form of transport with a payload of up to 350 kilograms. Suitable for mail and parcel delivery services, food delivery and for services in which small volumes are delivered. However, designing for maximum payload could lead to compromises in the friendly character and manoeuvrability of the electric cargo bike.

Electric cargo moped: a robust form of transport with a payload of up to 500 kilograms. Suitable for heavier loads such as bulky food deliveries and small amounts of construction materials. No effort is required from the driver (unlike the e-cargo bike), who is not protected from the elements (as opposed to drivers of the small electric distribution vehicles).

Small electric distribution vehicle: a mini-van with a payload of up to 750 kg. Suitable for catering, street cleaning and waste collection (residential and retail streams). Less manoeuvrable than both the cargo bike and moped, but in comparison with a van, better suited for use in crowded areas and easier to park and manoeuver.

STATE OF THE ART

While diversification and performance have increased in available LEFV models (see Table 1), many businesses are still reluctant to implement the use LEFVS. Fleet decision makers and the customers of logistics operators show reservations about using cargo cycles, while the prevalent conditions and cultures of many small-sized cycle freight companies prevent a professionalization of the sector

Only a few successful commercial use cases for cargo bikes have been found throughout Europe (Schliwa et al. 2015; Lenz & Riehle, 2013). Most studies are based on simulation approaches and ex-ante analyses (Melo & Baptista, 2017; Gruber et al., 2014; Gruber & Narayanan, 2019). Only Browne et al. (2011) did an in-depth case study of Gnewt Cargo in London. Total distance travelled and the CO_2 emissions per parcel delivered fell by 14% and 55% as a result of the cargo-bike system. The trial was successful from company's perspective in transport, as well in environmental and financial terms and therefore decided to continue the operation.

Still, the literature on ex-post-analysis from real cases in light electric freight vehicles is scarce.

The case-based research was carried out using different theories, models and practical methods and with input from specialists through workshops, expert sessions and interviews. Experiments were set up in Amersfoort, Utrecht, Maastricht, Amsterdam and Rotterdam to test and collect knowledge, on the one hand via evaluations with stakeholders and on the other hand by monitoring vehicles with GPS loggers and cameras. In collaboration with ten businesses, various logistical concepts with LEFVs were mapped out and changes regarding transport with delivery van analysed.

MULTIPLE CASE STUDY

Balm et al. (2018) have investigated the potential of LEFVs for different freight flows within city logistics. They identified four criteria that influence the potential of LEFVs: small and light shipments, high network density, time-critical shipments and sufficient opportunities for growth and innovation. Most promising sectors for the use of LEFVs include mail, parcel and local retail deliveries, and smaller shipments in food, construction and service logistics. Within these sectors the following seven case studies are carried out:

APS Barand Glass Supply: warehouse in the city – nonfood

APS Glass & Bar Supply is a supplier of bar goods to the hospitality industry. In the centre of Amsterdam, APS increasingly experiences delays to deliveries carried out by traditional delivery vans. APS has already had good experiences with deliveries by logistics service providers using LEFVs and wanted to know if extending their use is worthwhile. In the study, several alternatives were assessed. For consignments within central Amsterdam, the use of LEFVs resulted in transport costs savings (personnel and vehicles) of 50 to 60%; for both internal transport and for outsourcing.

Vers bij u thuis: catering / meal boxes

Vers bij u thuis (Fresh at home) was a provider of ready-to-eat meal boxes for the elderly and nursing homes. The meal boxes were sent to customers with a delivery van. For this study, a cost-benefit analysis was carried out comparing the van with LEFVs and electric vans. Using a LEFV on one of the three routes and an electric van on the other two could allow them to save up to 37% of transport costs. Research showed that in the deployment of LEFVs, in addition to electric delivery vans, could allow 15 to 25% savings on their transport costs.

Deudekom and MAAS and PostNL: city hub at the edge of the city – office supplies / facility goods

Deudekom is a removals company and has a warehouse in the Duivendrecht area of Amsterdam in which goods are stored for customers. Deudekom is developing into a logistics service in the Amsterdam region. The company uses its warehouse as a hub for the bundling of goods going in Amsterdam, including the University of Amsterdam (UvA), AUAS and the City of Amsterdam. UvA and AUAS want their suppliers to use bundling to reduce mileage, CO2 emissions and overall number of deliveries. Research showed that logistics facilities in the city, such as a micro hub, can contribute to the cost-effective deployment of LEFVs, because the distance to the customer is shortened. The condition is that there is sufficient scale: these facilities must be used daily to cover the costs. The extra costs of these facilities are compensated for by the reductions in cost compared to transport by delivery vans. As a result, LEFVs can be used profitably in city logistics.

MSG Post en Koeriers: mail services (social return)

MSG provides postal and courier services in the eastern Netherlands. They wanted to know if there was a logistics concept which would make it possible to use LEFVs for the collection and delivery of mail for the business post market in the region. An analysis of the routes showed large differences in their characteristics. For example, the shortest route was 15 kilometres, whilst the longest was more than 60 kilometres. Only a small amount of the capacity of the delivery vans was used. Two scenarios were developed: one in which only LEFVs were used and another with a combination of LEFVs and a delivery van. These scenarios resulted in savings in the transportation costs of 7 and 10%, respectively. The second scenario would allow MSG to better fulfill agreements with their customers.

Energiewacht: service logistics

Energiewacht in Heemstede carries out the installation of smart energy meters in the Amsterdam region. Parking spaces in Amsterdam are scarce and traffic in the city is very busy. This leads to Energiewacht mechanics spending a lot of time travelling and parking. A solution was provided by placing a hub outside the city centre for the supply and preparation of orders, together with a logistics service provider. At the hub, mechanics transfer from their own vehicle to a LEFV. The LEFV itself does not have enough space for the necessary materials for all the customers a mechanic visits in a day. Therefore, a choice was made to use a mobile hub, which is centrally parked in the work area of the mechanics throughout the day. Here the mechanics can collect new meters and installation materials. This system has the potential to save 30% on transportation costs and achieves 80% reduction in CO_2 emissions.

Parcls: micro hub in the inner city

Parcls is a local parcel service where parcels are delivered to a neighbourhood collection point, so that the recipient does not have to be present when packages are delivered by the courier. The recipient can pick up the package themselves, or when they arrive at the delivery address, it can be delivered there within a specified 15 minute time slot. A survey in the Oude Pijp area of Amsterdam (AUAS, 2016) among 86 entrepreneurs (shops, catering establishments and companies) showed that 13% were directly positive about such a collection point and 8% set certain conditions for the costs (5%) and opening hours (3 %). Nearly a quarter (24%) thought that goods should only be delivered to their door, the main reason being that there are not sufficient staff to collect the packages elsewhere. In Oude Pijp, UPS outsources delivery of packages for consumers to Parcls. Parcls also offers its services to entrepreneurs in the neighbourhood and to other parcel delivery companies.

Nedcargo: LEFV's serve the Rotterdam bar district

Nedcargo is one the largest logistics service providers in the Netherlands. Specialised in freight transport (mainly food and beverages) and forwarding. Nedcargo services their customers in city centres by lorry's. Due to more environmental restrictions for freight transport in the inner cities and the unsafe loading and unloading activities in the narrow streets, Nedcargo is forced to execute the last mile with smaller vehicles and without pollution. In 2018 students from the University of Applied Sciences Rotterdam set up a consolidation centre from which they delivered the goods to Nedcargo's customers in the inner city of Rotterdam by different types of LEFV's. The data they gathered in the last mile operation is used to research impact on efficiency, costs, sustainability and customer satisfaction and is compared to the 'business as usual truck delivery'. Research shows that the time for roundtrips decline with 30%. The cost-price per km based on the full cost valuation method is €3.34 for LEFV, and €4.08 for a lorry. The well-to-wheel method is used to calculate the difference in pollution per vehicle. A lorry emits up to 12 times more CO_2 and up to 44 times more NO_x compared to a LEFV. From a survey among customers it appears also that the customer satisfaction rises. This holds especially for bar and terrace owners

Table 2. Characteristics of the Business case studies

Company name → **Characteristics↓**	**APS**	**Vers bij u thuis**	**Deudekom**	**MSG Post & Koeriers**
Market	Hospitality non-food	Food service	Facility services	Post
Goods	Not conditioned and packed	Fresh food	Not conditioned and packed	Crates of post
LEFV user	Partly	Partly	Partly	Possible
Which shipments go with LEFVs?	10-20% of shipments for customers in the inner city are delivered with LEFVs. These are the smaller shipments.	A third of shipments are delivered by LEFVs, mostly within Amersfoort.	There is at this moment no deployment of LEFVs. The research was aimed at potential use.	There is at this moment no deployment of LEFVs. The research was aimed at potential use.
Motivation	High costs of using delivery vans in heavy traffic (drivers are on the orad for a long time).	Can it be done cheaper?	Wish to deliver bundled goods with zero emission deliveries to customers.	Can it be done cheaper?
Operation	Outsourced (to Bubble Post and Fietskoeriers)	In-house	In-house	In-house
Delivery	From stock	From stock	From stock and cross dock	From own hub
LEFV	E-cargo bike	E-cargo bike	Goupil	E-cargo bike
Shipments	1-20 kg	Maximum 50 kg	Larger volumes	10-50 kg
Addresses on route	1 to 5 addresses	5 to 30 addresses	3 to 4 addresses	5 to 15 addresses
Length of LEFV route	10-20 km	50 km	10-40 km	30-40 km
How to develop further?	With one cargo bike of their own and partly outsources to cycle couriers.	The business is no longer operational	Deployment of electric freight trucks due to the large volume	Financial feasibility and LEFV range are still barriers

	Energie- wacht	Parcls	Nedcargo
Market	Service logistics	Packages	Hospitality non-food
Goods	Not conditioned and packed	Not conditioned and packed	Liquor
LEFV user	Possible	Possible	Full
Which shipments go with LEFVs?	There is at this moment no deployment of LEFVs. The research was aimed at potential use.	Parcls delivers all shipments within Oude Pijp (Amsterdam) with LEFVs.	All shipments in the inner city of Rotterdam are delivered by LEFV
Motivation	More demands upon delivery vans in the city center. It is becoming increasingly difficult to park. Can it be done cheaper?	Better service for consumers (who are not at home) and more efficient for delivery personnel	Freight delivery restrictions in Rotterdam are becoming more and more strict.
Operation	In-house	In-house	In-house
Delivery	From stock via hub	From own hub	From stock via hub
LEFV	E-cargo bike	Bike	E-cargo bike, Stint and Goupil
Shipments	10-50 kg	2-10 kg	up to 800 kg
Addresses on route	Mechanic takes multiple shipments to work area	A few dozen shipments per day	1 to 5 addresses
Length of LEFV route	20-25 km	Less than 10 km	10-40 km
How to develop further?	Case is being developed for central Amsterdam.	The case is in the process of being developed for consumers	The pilot will be upscaled, more volume will result in a higher load factor

LESSONS LEARNED FROM THE EXPERIMENTS

LEFVs are suitable for a wide range of applications, from independent entrepreneurs with a briefcase to logistics service providers who transport roll containers. The expected fields of application for LEFVs (Balm et al., 2018) are proven in practice. The costs of the LEFVs can be up to 20 to 30 percent cheaper than those of the traditional delivery van or lorry. The use of LEFVs for short journeys in (inner) cities yields time savings due to the presence of cycle paths and one-way roads. The surveys show that bicycle routes in cities are on average 15 to 20 percent shorter than car routes. Together with the advantage of loading and unloading on food paths, delivery times can be up to 30% faster. These results show better results than the study of Gruber & Narayanan (2019). They showed that expected 12 travel time difference for trips with distances between 0 and 20 km (12.4 miles) ranges from -5 (cargo cycle 5 minutes faster) to 40 minutes. This value can decrease if users take the optimal cycling route and the traffic conditions are worse for cars. Obviously, Gruber & Narayan didn't consider the faster (un)loading time. According to Butrina et al. (2018) cargo bikes have some competitive advantages over delivery trucks. This type of LEFV has more choices to maneuver through a city using the road, bike lane, sidewalks, and accessing pedestrian-only areas to find the quickest or shortest route to the destination.

To deploy LEFVs efficiently, adjustments must be made in how logistics are planned, for example by clustering orders (even more) geographically and using planning software with routes suitable for LEFVs. This requires sufficient shipment density, or short distances between the stops. All logistics concepts have a collection/consolidation point. This is in line with Lenz & Riehle (2013) who claim that the availability of city center hubs ensures the necessary efficiency is one of the special requirements associated with the use of cargo cycles. Also, Anderluh et al. (2019) define the 2E-VRP (2 Echelon), where freight is transported from the depot(s) to rendezvous points, so-called satellite facilities, from which it is transported in the second echelon to the final customers. The 2E-VRP can either incorporate synchronization constraints between the first and second echelons depending on whether the possibility of intermediate storage at the satellites is given or not. Other distinguishing factors are the number of depots, heterogeneous or homogeneous fleets, time window constraints, etc.

LEFVs' position in traffic, including the rules for the use of cycle lanes and pedestrian areas, is not unambiguous and requires further investigation. The integration of the vehicles into the urban traffic networks is a necessity. Examples include the design of comfortable and safe routes, such as bicycle streets, and the creation of loading and unloading areas. Experimenting with LEFVs leads to greater awareness, knowledge and behavioural change. For instance, the weather conditions can have a strong influence on the maintenance of the cargo bikes. The driving of a LEFV takes some time getting used to in the beginning, but is perceived as simple. Drivers of LEFVs receive positive reactions from customers and the general public. More pleasant than the grumbles that truck drivers often get when they are unloading. According to Gruber et al. (2014) a majority regards the LEFVs as highly competitive for delivery tasks in their specific urban surroundings, which include 7 of the 15 biggest German cities. Furthermore, messengers see LEFVs as an opportunity for generating public attention (and possibly new customers) and contributing towards environmental protection. In contrast to electric delivery vans, many LEFVs, particularly those that are more bicycle-like, have the advantage that the range is less dependent on interim charging. With limited use of LEFVs, businesses do not experience any barriers when charging. With an expansion of electric vehicles in the fleet, smart charging offers a solution to balance out any peaks and troughs in energy demand.

CONCLUSION

Our practical research has shown that city logistics with LEFVs requires good locations for hubs in the distribution network, robust processes, cooperation between customers, logistics service providers and suppliers, good insight into the costs involved, modern ICT and good organization. LEFVs lend themselves to logistical flows with 5 main characteristics: (1) time-critical shipments, (2) those with small numbers of shipments per trip, (3) Short distances between stops, (4) Those in busy areas where the speed of cars is relatively low and (5) Areas with strict vehicle restrictions or privileges for LEFVs.

What is needed to successfully deploy LEFVs for city logistics? To conclude a LEFV is usually a solution alongside other solutions. A mixed fleet guarantees flexibility and offers certainty that customer demand can be met. Not all shipments lend themselves to the profitable use of a LEFV. In addition, Planning and control systems must be able to distinguish between the different loading capacities of the available vehicles: which consignments should go in which vehicle? And which routes are ideal for which vehicle?

Furthermore, transshipment points must be located close to or inside the city. The further the distance to transshipment points, the less suitable LEFVs become. For trips with long initial distances (more than 5km to the first stop) and long journeys (more than 30 km), the LEFV is often not an appropriate option. Due to the relatively large number of transshipment points, it is essential that facilities at the hubs in the distribution network, such as receiving and storing goods, loading facilities and parking facilities, are shared at an affordable cost. Affordable facilities are not available in all cities. The development of standards for containerisation reduces the amount of activity necessary at transshipment points, meaning lower costs. It is therefore wise to follow and contribute to developments in this area. And finally, the current driver shortage encourages operators to search for other solutions, such as LEFVs for which no driving license is required. The use of LEFVs does not require personnel with qualifications as, for instance, delivery vans. There is also the possibility of employing socially disadvantaged people, with a 'distance on the labor market'. However, at present there is a severe shortage of drivers in large cities.

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