Will automatic driving Light Electric Freight Vehicles be the future solution for urban Transport as a Service?




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Abstract
The number of light commercial vehicles in cities is growing, which puts increasing pressure on the liveability of cities. Freight vehicles are large contributors to polluting air and CO2 emissions and generate problems in terms of safety, noise and loss of public space. Small electric freight vehicles take less space, can manoeuvre easily, are silent and do not emit local emissions. There is an increasing interest in this type of light electric vehicles among logistic service providers in European cities. However, various technical and operational challenges impede large scale implementation. Within the two-year LEVV-LOGIC project, (2016-2018) the use of light electric freight vehicles (LEFVs) for city logistics is explored. The project combined automotive and logistic expertise find the optimal concept in which LEFVs can be a financial competitive alternative for conventional freight vehicles. This contribution to HVTT15 will present some design thoughts for a possible self-driving LEFV, in the European Automotive category L6e and L7e, as a smart last mile solution for future urban city logistics.

Keywords: Automotive, City logistics, Freight vehicles, Light electric vehicles, Last mile urban delivery, LEVV-LOGIC, Self-driving, Cargo-POD, Transport as a Service

1. Introduction

The number of new light commercial vehicles (LCV), registrations in Europe has increased from 1.3 million in 2009 to 1.7

million in 2015 [1]. In 2015, LCV, also known as delivery vans which gross vehicle weight below 3.5 metric ton, accounted for approximately 11 percent in the total light duty vehicle market, compared to 8.5 percent in 2009. The London Assembly Transport Committee reported an increase of 11 percent in kilometres driven by LCV, while lorry traffic remained the same [2]. The increase of LCV in urban traffic is a result of the rising e-commerce market, the growth of inner city construction work, the increase of self-employed workers, and trends in the food, catering and hospitality market. The average shipment size in city logistics becomes smaller and deliveries are more time-critical [3]. As a result, the maximum capacity of freight vehicles is rarely needed [4].

The delivery of goods and services are in essence required for the functioning of cities, but the vehicles put increasing pressure on the city in terms of pollution, congestion, accessibility and loss of public space [5]. One of the opportunities for improvement may be found in the use of Light Electric Freight Vehicles (LEFV) in cities. The vehicles are smaller in size, can manoeuvre easily, are silent and are free from polluting emissions. In recent years, various companies across European cities have started to offer city logistics with LEFVs. However, logistic operators with LEFV only play a marginal role, while the number of LCV in city logistics continues to grow. Producers of existing LEFVs see limited growth in demand. There is no large-scale production of LEFVs yet as the optimal vehicle specifications (per freight segment) has not been defined yet. Within the LEVV-LOGIC project, the Amsterdam University of Applied Sciences (AUAS) and the Rotterdam University of Applied Sciences (RUAS) work together with approximately 30 public and private organizations to explore how LEFV can be a financially competitive alternative for conventional freight vehicles. The research runs from 2016 to 2018 and has started by exploring the potential of LEFV for specific freight flows based on the characteristics of the logistics demand and according delivery profiles. Next, the optimal design of the vehicles is explored. The LEVV-LOGIC project defines light electric freight vehicles as electrically powered or electrically assisted vehicles that are in size smaller than a LCV and have a maximum loading capacity of 1200 kilogram. It includes electric cargo bikes and L6e and L7e category vehicles. This brings a first limitation of the vehicles as large or heavy goods are not suitable to be delivered with LEFV. Next, LEFV have a limited range in terms of kilometres and speed and are consequently not suitable to drive on high ways. Private and/or public infrastructure is needed to charge the batteries before or between trips, depending on the intensity of use.

Figure 1 – Examples of light electric freight vehicles

1.1 Research on electric freight vehicles

In European research and demonstration projects like DELIVER [6], FREVUE [7] and ENCLOSE [8] the potential of electric delivery vehicles has been explored extensively, from both a technical, financial, logistical and policy perspective. Despite the time and money spent on research and development, large-scale implementation of electric vehicles has not taken place yet. In fact, the development slows down [9]. While electric vans are considered to be credible [8] [10], the share of electric vans in the total fleet of LCV is only 0.1% [9]. The EU project FREVUE concludes after four years of research that the business case of EV's remains a challenge. The environmental friendly vehicles do not offer sufficient operational advantages to compensate for the significant higher purchase price [11]. Next, there is a lack of efficient manufacturer support in case of breakdowns and development in charging infrastructure is needed. In the meantime, the discussion on the negative impact of transport has developed into a broader debate including not only climate change, but also health issues (air quality and noise nuisance), public space occupancy and the attractiveness of cities in general. From that point of view, light electric freight vehicles offer an additional social benefit compared to conventional LCV as they are smaller in size. Next, LEFV are competitive with conventional LCV in purchase price [12]. Also, operational benefits have been observed as the vehicles are faster in congested cities [13]. The vehicles are (often) allowed on cycle lanes and can park more easily and closer to the delivery address, i.e. save time searching for a place to park.

2. Logistics and technical concept

City logistics is very diverse in terms of type of goods, volumes, conditions and transport units. A survey among current users of LEFV in The Netherlands shows the diverse usage of LEFV in urban freight transport, see Figure 2. However, the respondents mention the lack of suitable LEFVs as the main barrier for upscaling. The main problems encountered are related to the capacity and battery/charging system.

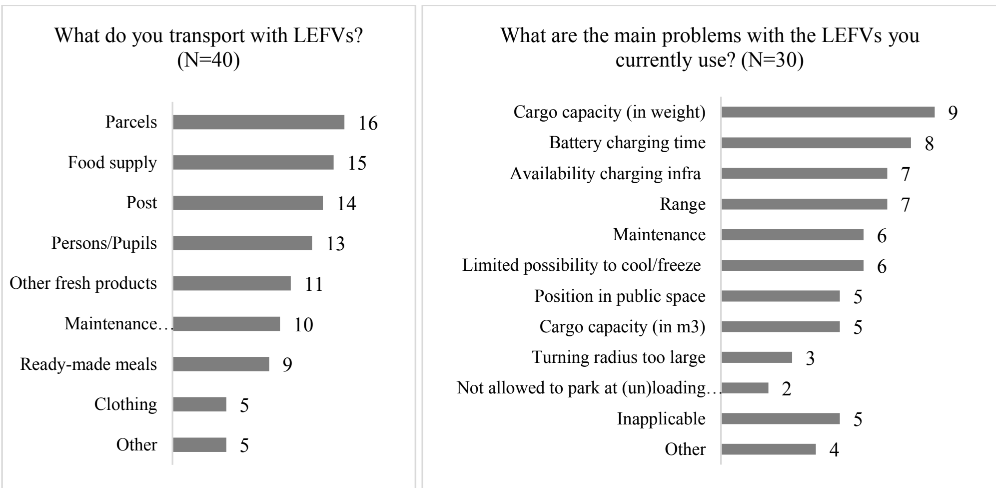

Figure 2. Results LEFV survey in The Netherlands

Presently, LEFV concepts are being developed from two directions: up scaling bicycles and down scaling freight vehicles. For a successful transition to larger number of LEFVs in urban traffic, understanding of the fundamentals on functional requirements, performance and passive and active safety is crucial. During the first half year of LEVV-LOGIC, the functional requirements and challenges for the design of LEFV have been defined as follows:

- There is a need to design LEFV for larger loading capacity (mass and volume)
- There is a growing delivery market in the food sector, both B2B and B2C, and therefore a need for standardization in volumes, load units and cooling systems.
- There is a need for easy battery replacement or fast charging.
- The interaction with other traffic and the existing infrastructure should be taken into account during the design

phase as it currently creates uncertainty among users.

The research on vehicle design and charging infrastructure will therefore look at standards to enable efficient transfer of goods from larger to smaller modalities. Three standards have been selected as vehicle loading: Euro pallets, roll containers and a standard small container. Based on the drive cycle and the homologation category, the vehicles in category L6e and L7e are designed on the maximum power and load of 6 kW and 750 kg respectively 15 kW and 1,200 kg and a maximum speed of 45 km/h respectively 90 km/h. Based on functional requirements the design of the technical and functional packaging has been made. Parallel to this design process the 'body of knowledge and skills' with focus on performance and passive and active safety has been composed from preceding projects [14] [15], literature and automotive engineering standards on the specific education on the RUAS. Following the product definition, detailed design will be made with the focus on standardization in components and subsystem design. In the paper ‘Designing Light Electric Vehicles for urban freight transport’ for the EVS30 [16] we described a first L6e LEFV vehicle concept for two standardized rolling containers with 800 mm length, 640 mm width and 1,600 mm height (Figure 3). Specification of this vehicle concept can be found in Table 1.

Figure 3: First concept design for LEFV with two standard rolling containers

Table 1: Vehicle specification (worst case) [16]

Specification	Design	Homologation maximum value
Length [m]	2.830	3.000
Height [m]	1.990	2.500
Width [m]	1.380	1.500
Wheelbase [m]	2.300	Not specified
Motor power [kW], at 45 km/h	2*3	6
Battery capacity [kWh], 75 km range at velocity 30 km/h	8	Not specified
Battery voltage [V]	96	Not specified

2.1. Guidelines for applied design of LEFV

From the previous study these are the important design guidelines;
With respect to the propulsion:

- Take care of reducing vehicle driving force (air drag and rolling resistance).
- Choose the components for the regular user profile and take measures to prevent for worst case scenario's. For example, by being able to replace or charge a battery when the capacity is too low.

With respect to the packaging:

- Put the load on the lowest floor level close to the vehicle centre and design the vehicle around this load.
- Maximize the vehicle track width within the allowed range (1,500 mm vehicle width).

3. The concluding studies

In comparison to the other LEFV, like electric cargo bikes, the compact and more Automotive LEFV in the L6e and L7e homologation category has clear advantages regarding pay-load, range, safety and driver comfort. The latter is of great importance at higher speeds and extreme weather conditions. However, according a market search in the LEVV-LOGIC project most current LEFV in this class are designed for other applications like street & park maintenance. These high floor LEFV can be used for parcel and grocery distribution, like DHL and Picnic do. But for these applications, an electric delivery van (N1 class) is often still the more cost competitive option. Both, high floor LEFV and electric delivery vans cannot distribute standard rolling containers as described in paragraph 2. For supply of for most shops these containers are essential. Moreover, according to the distributors the LEFV that supplies inner city shops should have enough space for 6 to 8 standard rolling containers to logistically compete with small distribution trucks. Some distributers also ask for higher pay-load than 750 kg. The L7e that may transport 1,200 kg is an option but will require a driver with a driving licence.

3.1. Vehicle redesign for CityHub

For the LEVV-LOGIC partner CityHub an Automotive student started a redesign of the first concept [17]. At this moment in time CityHub is distributing for small scale retail shops with a Goupil type G3-1 which is towing a trailer with maximum four rolling containers. The high floor Goupil itself can only transport small parcels or cradles. This is not an ideal solution since the LEFV in combination with the trailer is relatively heavy, which reduces the range and long which restricts the manoeuvrability and parking possibilities (see Figure 4)

Figure 4: Current situation CityHub, a LEFV tows a trailer with four rolling containers

The new redesign is optimized to transport four rolling containers thanks to the low floor, narrow in wheel electric motors and a side- and back-door (see Figure 5). It can be homologated as a L6e (<45 km/h, 750 kg load) or a L7e (<90 km/h, 1,200 kg load) category LEFV. In this redesign, the combined and completed requirements from the user perspective of CityHub, with the vehicle requirements of the Dutch homologation agency RDW, are fulfilled. However, even in this optimized design, no more than four containers will fit within the legal foot print of L6e & L7e vehicles of 3,000 mm length and 1,500 mm width. This makes the cost of vehicle and the cost of the driver relative high compared to the value of the commercial payload. Due to load restriction, it's more difficult for LEFVs to compete on cost with traditional delivery vans and truck. Unless of course, traffic regulation makes it impossible to enter city centres with bigger vehicles than L6e and L7e LEFV.

Figure 5: Artist impression of the redesigned LEFV for CityHub with four rolling containers

4. Conclusion, discussion and follow-up

LEFV in the compact Automotive homologation category L6e and L7e are, from and environmental and space standpoint, appealing for inner city distribution. LEFVs are very flexible in use, but due to the compact size they are also very restricted in the cargo-space. Current LEFV can be used for parcel and grocery distribution, but there are no LEFV on the market that can transport standard rolling containers to retail shops or boutiques. This design study shows that a manned LEFV cannot transport more than 4 rolling containers. According to the distributors this is not enough to make them a competing enough against electric delivery vans or light distribution trucks. Due to the cargo space restriction, the relative cost of the vehicle and the driver will be too high. In good transportation by trucks the cost of the driver can be as high as 50% of the total cost of operation. This is the main reason that the transport sector is more and more looking to the possibility of self-driving trucks [18]. Nice examples are the Automatic Guides Vehicles in the sea port terminals, but also the underground transport system at Masdar City. The electric PODs, build by the Dutch Spijkstaal, are used for automatic transport of people but also for cargo. Only an unmanned LEFV could be able to transport the by the distributors requested 6 to 8 standard rolling containers. This can be done completely automated, in silence and due to the low speed relatively save, during the night. This is the urban 'Transport as a Service' vision of a future automated last mile solution. A LEVV-LOGIC follow-up project, called the 'Cargo-POD', has already been started to study the technical, logistic and commercial viability [19].

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