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9. Explaining the growth in light electric vehicles in city logistics

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BOX 9.1 CARGO BIKE MARKET SNAPSHOT

Research finds that the global market value of cargo bikes will hit 2.4 billion euros by 2031. Analysts with Future Market Insights assessing the growth of cargo bikes have placed the parcel courier industry as a key buyer of electric cargo bikes, forecasting that 43 per cent of sales could go to this industry. This growth is driven by city logistics trends, particularly as studies emerge showing the high efficiency and cost saving of the cargo bike versus the delivery van. It will not solely be direct incentives that drive uptake, however. The policy that restricts motoring and emissions is expected to be a key driver for businesses that seek profitability, with three-wheeled electric cargo bikes making up nearly half the market. The advance of e-bike technology has seen a strong rise in market share for assisted cargo bikes, now accounting for a 73 per cent market share. Potentially limiting the growth is the legislation governing the output and range of electric cargo bikes (FMI, 2021).

To deal with the issues of faster delivery, clean delivery (low/zero emission) and less space in dense cities, the light electric freight vehicle (LEFV) can be – and is used more and more as – an innovative solution. The way logistics in urban areas is organized is being challenged, as the global growth of cities leads to more jobs, more businesses and more residents. As a result, companies, workers, residents and visitors demand more goods and produce more waste. More space for logistics activities in and around cities is at odds with the growing need for accommodation for people living and working in cities. Therefore, logistics real estate has been pushed out of the cities in the past decades, that is, logistics sprawl, and less space is available for logistics activities within and around the cities (Dablanc, 2011; Boer et al., 2017; WEF, 2020). The digitization of the 'customer journey' in business-to-consumer (B2C) and business-to-business (B2B) channels leads to more, smaller and more time critical shipments in all segments of city logistics, leading to a further growth in the number of delivery vans; more than 80 per cent of commercial traffic in urban areas now comprises delivery vans. City logistics represents 5 to 10 per cent of all vehicle movements in cities today (Boer et al., 2017; Deloison et al., 2020; DfT, 2021), and this share is even higher for the city centres. Urban freight transport vehicles contribute to deteriorating public-space quality, air quality and road safety, and cities worldwide are focusing on car-free public spaces in inner cities, campuses and residential areas, thus 'curbing traffic' (Bruntlett and Bruntlett, 2021). Within car-free areas, deliveries can be done with (autonomous) light electric vehicles or by foot, but curbing traffic will impact city logistics, since less public space will be available for supplying the city.

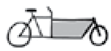
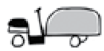
The LEFV can be an innovative solution for dealing with these challenges. LEFVs take up less road space, are zero emission, and are less intrusive than vans in city logistics. Companies like UPS, TNT, PostNL, Hermes, GLZ and DHL, along with many small and medium enterprises (SMEs), started first by experimenting with cargo bike deliveries in European cities on a small scale as an alternative to delivery vans after 2010. The experiences with LEFVs have been generally positive, with, for example, lower costs, better manoeuvrability, less space occupation on the roads and faster delivery. Cargo bikes can make urban freight more efficient by reducing delivery distances and times (Verlinghieri et al., 2021).

Moreover, these companies understand that by using smart processes, such as containerization, standardization and automation, extra handling costs in local hubs can be minimized. Dutch food retailers Albert Heijn, Plus and Picnic (online) successfully introduced LEFVs; Dutch electronics online retailer Coolblue, in the three years since introducing cargo bikes in 2018, has used them to deliver over a million orders; and Deutsche Post, Ocado and JD are testing ultra-compact LEFVs (with truck-robot solutions) that autonomously follow delivery staff.

A LEFV is a bike, moped or compact vehicle with an electric assistance or drive mechanism, equipped for the delivery of goods, or for the transportation of people, with limited speed. In general, LEFVs are (very) quiet, flexible in usage, emission-free, and need less space than conventional delivery vehicles (Balm et al., 2018). Three types of LEFVs are defined, as shown in Table 9.1.

The electric cargo bike looks like a real bike and is therefore agile, with a maximum payload of 350 kg. The bikes are suitable for delivering small volumes, such as food deliveries, mail and parcel delivery services. The electric cargo moped is really a moped; cycling is not needed. The maximum

Table 9.1 *Three types of LEFVs*

	Electric cargo bike	Electric cargo moped	Small electric distribution vehicle
Loading capacity (kg)	50–350	100–500	200–750
Vehicle weight (kg)	20–170	50–600	300–1,000
			

Source: Balm et al. (2018).

payload is 500 kg. Small volumes of construction materials and more heavier loads (like a keg of beer) can be delivered with this vehicle. The small electric distribution vehicle looks most like a mini-van. It has a maximum payload of 750 kg. The vehicle is used for retail and residential streams, such as waste collection, street cleaning and catering services. Manoeuvring and parking is much easier in dense city areas compared to a van. However, it is less agile compared to the bike and the moped, but still well suited for use in dense areas as parking and manoeuvring are much easier. This definition does not (yet) include light electric autonomous vehicles.

The number of different types of LEFVs on the market has increased and the performance of the LEFVs in terms of loading capacity, range and usability has improved. Still, logistics professionals seem to hesitate in making the switch to using LEFVs. Fleet decision-makers and city logistics operators show doubts about using LEFVs, as there are still many small engineering companies optimizing the design of the LEFVs instead of providing a full professional service (e.g. 24-hour maintenance services) (Balm et al., 2018).

Therefore, the following research question is posed in this chapter:

What are the success and failure factors of the introduction of LEFVs in city logistics and what are the future perspectives on LEFVs in city logistics?

This question is answered by carrying out an ex-post analysis based on the Technological Innovation System (TIS) framework (see Langeland et al., Chapter 7 in this volume). After this short introduction of LEFVs in this section, we continue with a description of the TIS framework evaluation operationalized according to Langeland et al. The last section ends with a conclusion and future perspectives on LEFV usage in cities based on the applied TIS framework.

EVALUATION BASED ON THE TIS FRAMEWORK

Literature on ex-post analysis based on real cases with LEFV usage is limited. The application of the TIS framework can provide insight on the cumulative systematic change towards more LEFVs being used in city logistics processes. While the processes are obviously important from a business perspective, the policy perspective is also important given that the negative externalities influence the living environments in cities as well. The TIS framework (Langeland et al., Chapter 7 in this volume; see Figure 9.1) has an active policy dimension and engages in developing targeted tools and policy mixes that can help to remove barriers. The system elements consist of actors (individuals, organizations and networks), institutions (habits, routines, norms and strategies), interactions (cooperative relationships) and infrastructures (physical, financial and knowledge). The main system functions are entrepreneurial activities, knowledge development and diffusion, influence on the direction of search, market formation, resources mobilization, legitimacy and development of positive externalities. The framework is represented in Figure 9.1 and will be elaborated on for our LEFV research experiences in Dutch cities and, where useful, extended to foreign experiences, to find the success and failure factors and the future perspectives on LEFVs.

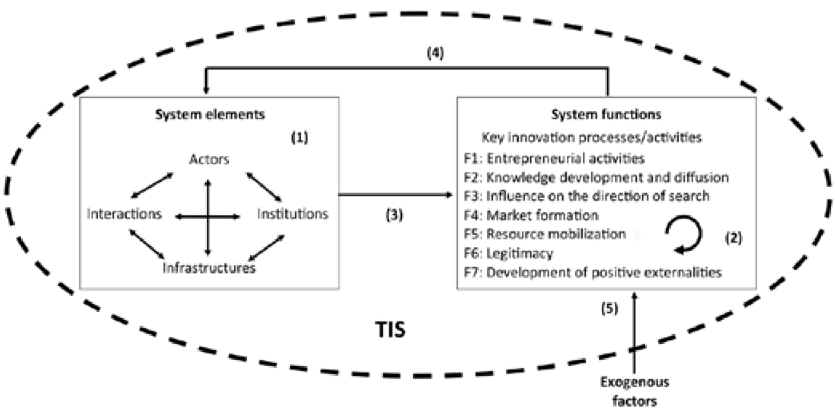


Figure 9.1 *The TIS framework (Langeland et al., Chapter 7 in this volume)*

System Elements

According to the TIS framework, actors, institutions, infrastructures and interactions need to be defined. The system elements are obtained from the literature and based on our practical research experiences in the European Union (EU; Cyclelogistics, 2014; Wrighton and Reiter, 2016; TRELab, 2019; Cairns and Sloman, 2019) and in the Netherlands (Balm et al., 2018).

Actors

The main actors in the application of LEFVs in the city logistics field are the municipalities, network organizations, logistics service providers, shippers, and receiving parties like consumers, storekeepers and constructors/servicemen (Lebeau et al., 2018).

Public actors

Municipalities consider LEFVs a sustainable solution for city logistics as they use less (urban) space, produce zero emissions and provide quick delivery in highly congested areas (Ploos van Amstel et al., 2018; Logistiek010, 2021). Still, they have worries about the safety issues related to the interaction of LEFVs with motorized and non-motorized traffic. Also, the potential market share is not fully clear to them.

Network organizations lobby for the use of new and cleaner vehicles and therefore can be stimulating agencies advocating the environmental benefits of the LEFVs to other stakeholders.

Suppliers of LEFVs

The supplier market of LEFVs (Original Equipment Manufacturers, or OEMs) is maturing. Within each type of LEFV, certain vehicles are dominating, like the Urban Arrow (and lookalikes) in the non-motorized bikes type, the Stint (and lookalikes) in the motorized bikes type and the Goupil/E-Seval (and lookalikes) in the motorized segment up to 750 kg. The market is still under development, and worldwide many different types of LEFVs are being developed that are dedicated to niche markets. Also, big OEMs (like Pon) are extending their market to LEFVs, which provides this market with strong backup facilities; for instance, the moment a LEFV breaks down, a new LEFV will be provided. At the same time these OEMs facilitate the development of LEFV lease/rental services, making the usage of LEFVs for logistics service providers easier as they do not need to make huge investments in their fleet.

LEFV users

Different professional users can be identified including logistics service providers, and constructors and servicemen (craftsmen).

The *logistics service providers*, and even retailers, consider LEFVs a potential solution for their future processes. However, they don't know whether the LEFVs are fit for their current processes. The planning, sorting, loading and invoicing of deliveries is currently geared towards the use of delivery vans and trucks. Efficient use of LEFVs requires a different view of logistics operations and customer segments. This is due to the smaller payload and delivery radius of LEFVs. Fleet managers in particular experience a lot of uncertainty as the suppliers of LEFVs are not yet sufficiently mature when it comes to their field service. Unforeseen issues are arising in practice during operations. Therefore, the service attitude of the suppliers in relation to operations, maintenance and repair is crucial.

Constructors and servicemen account for 35 per cent of the commercial movements in cities (Ploos van Amstel et al., 2020). The city is their area of operation, where they must have their materials and tools to do their job. Looking at the list of challenges, requirements and wishes, as a service company, a company should first define a service logistics strategy based on which customers they want to serve with which services. This service logistics strategy is in turn determined by the service and market segments that are chosen and the service agreements that are made with customers. The choice of vehicle is a result of this strategy. The business issues involved in the roadmap to zero emissions can be divided into those that are long term (strategical), medium term (tactical) and day-to-day (operational) (Ploos van Amstel et al., 2020).

Shippers

Shippers want their products transported in a fast, reliable manner, and at low cost. They wonder whether a carrier using LEFVs can guarantee the same service at the same cost.

Receivers

For storekeepers (B2B) and consumers (B2C), the reliability of delivery (level of service) is important. Storekeepers need to have personnel available to receive the goods, or to be available to receive a parcel, and may have limited space for receiving deliveries. Most storekeepers therefore want to have a minimum of deliveries during the day, as this distracts them from sales operations and can cause hindrance in the street. At the same time, they also appreciate if the delivery doesn't harm the living environment too much. In that sense, they have often a positive attitude towards the usage of LEFVs if it doesn't cost extra.

The consumer also likes to know when their ordered goods are going to be delivered. The consumer has become an important client of a city logistics system as the rise of e-commerce has been relentless (Statista, 2021).

Behavioural analyses (de Oliveira et al., 2017; Buldeo Rai et al., 2019) have shown that the means by which goods are delivered is not yet a decisive factor in people's choices in relation to home delivery. These studies show that fast and free delivery are still the most dominant attributes of choice. This is somewhat paradoxical as most citizens want deliveries to their homes to be safe, noise-free, healthy and less space consuming.

Another group of *receivers*, namely office, government and educational buildings, represent important clients because of their need for the supply of facility goods and services. When procuring facility goods, buyers can ask suppliers for smart and zero-emission deliveries. The facility service departments of public organizations generate many transport movements in cities. In public procurement, there is potential for smarter and cleaner urban distribution; public organizations can act as game-changers. Recent initiatives across Europe show that more public organizations are gaining knowledge of the transport volumes resulting from their purchases and the potential for improvement. For this improvement to be realized, a change is needed in the way public organizations make decisions about the selection of suppliers, incoterms, delivery service plans and performance indicators.

Together with their suppliers and logistics service providers, the Amsterdam University of Applied Sciences (AUAS) and the University of Amsterdam (UvA) are working on a sustainable supply of their premises. The impact has been fewer kilometres travelled by vehicles, more electric vehicles and more efficient handling of incoming goods. However, getting to the benefits requires a change in the way purchasers behave on a strategic, tactical and operational level. The result is an approach to sustainable logistics that can be scaled up and taken to other large cities.

Institutions

Following the TIS framework, the main institutions that can be identified in relationship to LEFVs in the Netherlands are the Amsterdam University of Applied Sciences (AUAS), the Rotterdam University of Applied Sciences (RUAS) and the HAN University of Applied Sciences. Together, these institutions initiated the two-year LEFV-LOGIC project that ran between 2016 and 2018. This project played a crucial role in knowledge development in city logistics by looking at the usage of LEFVs. The institutions set up new research initiatives and organized learning communities, among them new initiatives like the LEFV-LOGIC project (Ploos van Amstel et al., 2018).

Next, Transport Logistiek Nederland (representing the carriers) and evofenedex (representing the shippers) are relevant industry organizations helping their members (transport companies and shippers) to get acquainted with new technological developments in their field of operations.

The Dutch Safety Board is also an important actor as in some ways the LEFVs constitute a new type of vehicle that is operating on our public roads, bicycle lanes and sometimes even in pedestrian areas. The consequences of the access to roads and bike lanes should be carefully evaluated to provide the vehicles with a clear legal status.

Slob (2021) uses the concepts of institutional logic to capture the various values of actors involved in the development and implementation of LEFVs in the Dutch mobility sector. By means of qualitative research, he conducted interviews with these actors, which resulted in the distinguishing of three institutional logic types: the automobile logic, the society logic and the regulation logic.

- In the automobile logic people are used to car driving, which hinders LEFV implementation. The policy focus is aimed at car manufacturers and the fuel industry. LEFVs are often labelled as unsafe due to outdated rules and regulations, and the infrastructure system is built around car use with little room for LEFVs. Regulators pay little attention to LEFVs as a solution to social goals (e.g. inclusivity, less congestion, liveable streets) other than sustainability. Implementation of LEFVs is hindered due to unclear roles and poor communication between the Ministry of Transport and the Netherlands Vehicle Authority (RDW).
- The research describes how the infrastructure and regulation mechanisms are influenced by the car-dependent automobile logic, and how this makes it difficult for LEFVs to substitute the car. It is observed that actors aiming at the implementation of LEFVs have a variety of social values like safety, liveability and sustainability, institutionalized in the society logic.
- The regulation logic should balance between, on the one hand, securing the safety and performance of the current infrastructure system and, on the other hand, transitioning in line with the urgent call for a more holistic view on mobility. The holistic view of the society logic creates tensions with both the automobile logic with its economic focus and the regulation logic with its primary focus on safety.

Infrastructures

The LEFV is a vehicle and as such makes use of roads, bike paths and sometimes even pavements for (un)loading activities. Urban infrastructure and traffic rules are not yet prepared for an increase in the number of LEFVs. There is uncertainty over which part of the streetscape LEFVs will be allowed to use to drive, load and unload, and there is a shortage of parking facilities. Further speed limits on the road, the construction of bicycle streets, and the installation of loading and unloading spaces for LEFVs offer opportunities for better integration of LEFVs in traffic.

The growth of LEFVs in cities (especially in the Netherlands) leads to conflicts with regular bike traffic, causing dangerous situations on the bicycle lanes. The Dutch Fietsersbond (cyclists' union) prefers not to have cargo bikes on the bike lanes. They don't think the bike lane should be the 'drain' of the traffic system. Like the high-speed lanes for fast e-bikes, new ideas for having separate freight cargo bike lanes and for avoiding rush hours are often brought up for consideration by local authorities. Power grids will play a role in charging the vehicles. Joint efforts by the municipalities and the energy providers, involving good thinking and planning, are needed for the suitable locating and dimensioning of charging stations for all the electric vehicles in the future, including the LEFVs. Whether this should be public or private spaces, combined or not combined with (un)loading areas, is an interesting research question.

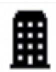
As the range of the LEFVs is limited, it is necessary to make use of (micro-) hubs. The hub is a fundamental infrastructure element for the functioning of a city logistics concept based on LEFVs. The usage of hubs touches again on constraints as the hubs take space (space is scarce and expensive) in cities; hubs can create congestion and need space for operations (including outside the building). Still, in practice there are some companies who are operating from a hub (for instance Fietskoeriers, Cycloon). The search for a hub location is like the search for a new house. Patience is needed and a long period of searching should be calculated for, especially for so-called micro-hubs in the inner city. A study by Ploos van Amstel et al. (2021) illustrates potential hub locations and their relative advantages (Table 9.2).

Interactions

Considering the TIS framework, interactions are here interpreted as interactions among the stakeholders involved. The interactions are mainly based on the development of LEFV experiences/knowledge in festivals, projects, Living Labs and daily practice.

The International Cargo Bike Festival (ICBF) is a yearly event organized by exhibitors and many passionate LEFV believers/users to bring the LEFV to the attention of municipalities and SMEs. The exhibitors include many small companies, not only cargo bike producers but also a range of related organizations and start-ups. More than forty countries participate in this event, with demonstrations of new prototypes as well as established LEFVs, knowledge dissemination through presentations, and exchange of experiences with LEFV usages. This yearly festival is a key event in motivating people to switch over to LEFVs. Although attention to this festival is growing, an important note should be raised here, namely that this event is mainly focused on LEFV lovers. The general public still don't know much about receiving goods through delivery by LEFVs.

Table 9.2 Overview of potential hub locations

Different options for hub locations for zero emission city logistics and their respective advantages:		
	1. At the employee's home	– Optional private use of zero-emission vehicle – The battery can possibly be charged at home – No additional transfer required at a hub in the city
	2. At a secure parking facility in a public space or at a parking garage	– Option for sharing system – Can be set up through an (area-oriented) public–private partnership
	3. At the company's own premises	– Option for sharing system and easy to realize – Visible for employees – Can be combined with central delivery of goods
	4. At the premises of a friendly competitor (other service company)	– Many possibilities for locations and option for sharing system – Visible for employees – Can be combined with central delivery of goods
	5. At a wholesaler where the company buys goods	– Many possibilities for locations and creates value for wholesaler – Can be combined with central delivery of goods – Possibility to create parking spaces with charging infrastructure
	6. In a semi-mobile container in a parking lot or company site	– Can be moved depending on the amount of work in an area – Location for stock and delivery of materials in the hub – Suitable as an experiment after which the location may/may not become permanent

	7. At a public transport junction (train, metro)	– Accessible for employees who can travel with public transport – Possibility to connect to existing concepts (such as public transport/bicycle) – Promising areas for low-traffic/zero-emission transport
	8. At a logistics service provider (city hub)	– Making use of existing logistics facilities – Can be combined with central delivery of goods – Possibility to create parking spaces with charging infrastructure

Source: Ploos van Amstel et al. (2021).

A key project on the experiences with LEFVs is the LEFV-LOGIC project. The study has shown the potential for a market share of 10 to 15 per cent of delivery vehicle movements. The sectors with most potential in city logistics are food, construction, services, non-food retail, and post and parcel delivery. LEFVs demand a different logistics concept and transportation costs are determined largely by personnel costs. LEFVs can be beneficially deployed if the delivery can be performed faster than with a conventional vehicle. LEFV vehicle technology is still at an early stage, and LEFVs are not yet mass produced. There is currently a very limited offering when it comes to cooling capabilities and to standardized load carriers (containerization). In the case of small electric distribution vehicles, the electric delivery van is becoming increasingly competitive in terms of cost, speed, load capacity and deployability. Purchase subsidies, experiments with LEFVs and realization of policy objectives (such as emission-free or car-free cities) help to bring about a behavioural change among businesses. LEFVs have been successfully deployed in market segments where low weights and volumes are transported, in which operational excellence is key, or where the use of LEFVs contributes to a distinctive social and innovative value proposition. Recipients of goods or services themselves feel no urgency to pursue supply by LEFV by vendors and carriers but do respond positively if it happens. Based on these project experiences, many new initiatives have started and show positive results in terms of both business potential and sustainability (see also *F1: Entrepreneurial activities*).

Living Labs form a practice-based methodology for evaluating new solutions in the city logistics sector, such as LEFVs. To understand the full added value of a new solution in city logistics the evaluation should be done with representatives from all stakeholders. The Living Lab methodology starts with the multi-stakeholder commitment in the project, although each stakeholder can have its own stakes. In a controlled environment, the stakeholders are involved by providing them performance measurements and asking them about their opinions on these performances. Also, different experiments can be realized in a short time, which provide new insights for all stakeholders (Nesterova and Quak, 2016).

Conclusion on system elements

Following the Paris Agreement, by setting up the goals of CO_2 reduction, there is a strong consensus in cities that the environmental situation and related liveability in the cities need to be improved. The liveability is at risk both from traffic congestion caused by the lack of vehicle space and accidents and from emissions. A greater awareness leads to new thinking about delivering concepts with new elements. The LEFVs in combination with (micro-)hubs could serve some niche markets in city logistics like food, construction, services, non-food retail, and post and parcel delivery. There is a positive attitude among the first suppliers and users of LEFVs. Companies are open to learning from and sharing experiences and are willing to exploit the possibilities in practice through the setting up of joint projects and Living Labs. Based on the dynamic interrelationships between the stakeholders involved, the adaptation of LEFVs in city logistics will become essential in making cities more sustainable.

System Functions

Following the TIS framework (Langeland et al., Chapter 7 in this volume), the system functions are clarified for the LEFV innovation. In accordance with the framework, entrepreneurial activities, knowledge development and diffusion, influence on the direction of search, market formation, resource mobilization, legitimacy and development of positive externalities (Bergek et al., 2010) are analysed for the LEFV innovation in this section.

F1: Entrepreneurial activities

Entrepreneurial activities can be divided in three categories: (1) general promotion of LEFVs (the ICBF has already been discussed as an interactions element, see above), (2) development of the vehicles and (3) development of the service supplier side. Examples illustrate the presence of active entrepreneurs as the prime indication of the performance of this innovative solution.

Supplier side: development of the vehicles

Since 2011 there has been a growth in the supply and use of light electric vehicles. The growth is evident not only in the numbers, but also in the diversity of types of LEFVs. Several Dutch companies, including Urban Arrow, Easy Go Electric and Stint Urban Mobility, started developing light electric solutions for passenger transport before 2010, following which they also began to see market potential in freight transport and started to standardize the cargo bikes. Internationally, companies like Goupil, Citkar and Velove are obtaining more and more market share as suppliers of LEFVs. Despite this growth, especially for the larger LEFVs, there are not many suppliers (as the Cargohopper and Picnic examples below show).

Cargohopper

One of the first light electric vehicles was the Cargohopper. It was an adapted golf cart.

In the Cargohopper project, a private logistics company developed and tested a sustainable solution for inner-city deliveries using electric transportation. The solution was first piloted in the city of Utrecht, and was then replicated in Amsterdam in collaboration with the municipality (van Winden and van den Buuse, 2017). The project demonstrated that firm-level internal knowledge transfer is important for replication; effective management of ambidexterity is needed to move from exploration to exploitation; prospects of economies of scale can be a prerequisite for a scalable business model; and local-level regulations can be a driver of sustainable innovation.

Transport company Transmission initiated the project. Transmission, with various establishments across the Netherlands, developed the idea for the Cargohopper as a response to the growing number of Dutch cities that had introduced bans on large diesel trucks to limit pollution and congestion. The Cargohopper solution consists of two components: a LEFV and a smart distribution system. The LEFV has the features of a 'road train' with separate carriages, and delivers shipments to businesses in the city's central area where no diesel trucks are allowed. In a distribution centre (located at a facility just outside the inner city), shipments are processed, bundled and loaded onto the electric freight vehicle. These shipments are bundled by address into separate carriages, allowing efficient delivery to businesses based on the proximity of delivery addresses in the same area. The project stopped in 2017 after technical issues with the vehicle meant it didn't pass the rules set in legislation and because of a lack of support by the supplier, typical problems that face an early adopter.

Picnic

Another example comes from Picnic. Picnic is an online supermarket currently operational in the Netherlands and Germany. Groceries are ordered from an app and delivered to the consumers using a light electric last-mile delivery vehicle. This vehicle is currently used for densely populated residential areas and works well enough to support the current number of Picnic deliveries.

However, the current last-mile delivery vehicle can't access all households. This is because its speed is limited to 50 km/h and it can only carry a limited volume of cargo. To expand and reach new households, Picnic is looking for a new last-mile delivery vehicle.

Having started a joint venture with VDL and TNO, Picnic is looking to design and build their very own last-mile delivery vehicle that is purpose-built for their needs. They are looking to become bigger, faster and stronger on the roads. Increasing the vehicle speed to 80 km/h and carrying more cargo allows them to reach the households that are currently out of geographic scope. Having a vehicle that can reach those extra households would significantly increase their customer base and consequently market share in the food market.

With the opportunity to build a purpose-specific vehicle, they can also control the aesthetics of the vehicle. Picnic relies heavily on their brand image and identity as a means of differentiation from their competitors. Therefore, translating their brand assets to the vehicle will give them a stronger brand presence in the consumer environment. Having identified the raison d'être of the vehicle – reaching new households in less densely populated areas – research was carried out to find different design cues and assets that could be leveraged in the exterior design of the new vehicle.

Accompanying these was a design vision also derived through research and by talking to the relevant stakeholders: 'Design a next-generation company icon, to remain a local hero.' Using this input, the sketch phase was conducted with a funnel approach, creating a broad spectrum of different designs and options that were in accordance with the design vision guided by the research. Through the method of elimination based on the principles of Quality Function Deployment (Cohen, 1995), and with the input from the different stakeholders, the sketch phase reached a point of maturity, which consequently yielded a final design that satisfied the requirements derived from the research and embodied the Picnic aesthetic while remaining functional for the runners.

Velove

Velove developed the Armadillo. An Armadillo uses only 6 per cent of the electricity of a small electric van, for the same transport work, and is more productive. In 2019 they won the first International Cargo Bike of the Year award in the category small electric vehicles. The Armadillos form the basis for successful last-mile solutions in Berlin, Oslo and Gothenburg. Velove also designed their vehicles to be suitable for containerized processes. At the same time leasing and rental solutions have been set up to make the market more accessible. The Armadillos are now operational in 20 different countries. To grow into a more mature business with a maximization of the uptime of the vehicles, Velove also organized two maintenance partner events to exchange knowledge and experiences on maintenance services (Erlandsson, 2020).

Supplier side: development of the service supplier side

From the service supplier side one can observe a tremendous growth of companies delivering products by LEFVs. An illustrative example of such a company is Pedal Me, an e-cargo bike logistics and pedicab company in London.

Pedal Me

The company was founded in 2017. It normally operates within five miles of Central London, using bikes built by Urban Arrow. The company also offers cargo deliveries. Pedal Me proved in a trial run that the company's riders delivered construction materials from Wood Green to Whitechapel faster than a van. The contractor plans to continue receiving deliveries by bike. During the COVID-19 lockdown in April and May 2020, Pedal Me partnered with Lambeth Council to deliver care packages to the individuals and families most in need. This was the largest operation conducted by Pedal Me to date, and perhaps the single largest e-cargo bike logistics operation in the UK. In total, the Pedal Me fleet covered over 20,000 km to distribute nearly 10,000 packages, moving around 150,000 kg across the borough of Lambeth. Recently they have opened a 6,500 sq. ft warehouse in Zone 1, the Central London zone, to support their freight operations (Pedal Me, 2021).

Conclusions – F1: Entrepreneurial activities

From the entrepreneurial activities and the lessons learned from the LEFV-LOGIC study (Ploos van Amstel et al., 2018) it could be concluded that the frontrunners of LEFVs have had an open mind to collaborating with suppliers to create a purpose-built vehicle for their specific needs (Picnic, DHL; see also *F5: Resource mobilization*). They are willing to adjust their designs according to the demands of their users and are open to experimenting. From the entrepreneurial activities, we learn that the most important issues are related to how to reduce the total cost of ownership compared to conventional vehicles/electric vans while at the same time continuing to guarantee a good quality service with everyday, intensive usage. The interaction with other traffic can sometimes lead to unsafe situations on the roads, which means that alongside the issue of specialization of LEFVs in specific niche markets, road safety and EU homologation are also important issues. Having a driving licence, use of a helmet, and a minimum age for driving are aspects where conformity is needed, with a minimum set of regulatory, technical and safety requirements being met by all countries. For suppliers of LEFVs, it is a challenge to meet the growing demand for these vehicles both in terms of producing LEFVs in sufficient numbers and in terms of providing the necessary maintenance. Many initiatives that started out with tests followed by experiments (Living Lab settings) have now reached the stage of real-world applications. Daily practice shows that there is still a poor set of suppliers, little cooperation among suppliers and little communalities in their vehicle designs (leading to unique maintenance instead of joint maintenance), and that full-service concepts are not yet fully provided, which can lead to uncertainty in the operations of the logistics service providers. Considering these factors, it can be said that the LEFV product is not sufficiently mature to make it a reliable proposition for its potential users. At this point it can be reflected that the maturity of the service levels diminishes as the size of the vehicles increases.

F2: Knowledge development and diffusion

Knowledge development in the LEFV sector is based on the setting up of (inter)national (feasibility) projects, Living Labs as practice-based research, and international cargo bike events. Some examples of knowledge activities are described in this section.

Cargo bike events

Earlier, the International Cargo Bike Festival (ICBF) was discussed. Here, the project RIPPL (Register of Initiatives in Pedal Powered Logistics), a knowledge-sharing project which highlights examples of businesses, organizations, projects and initiatives using bikes, trikes or pedal power, is mentioned. The project also identifies trends in cycle logistics and aims to share best practices and innovation from across the world. RIPPL is an initiative from Jos Sluijsmans and researcher Tom Parr. In the past, RIPPL has been funded by Topsector Logistiek, through the Dutch sustainable mobility organization Connekt. Although based in the Netherlands, Sluijsmans and Parr are aiming at exchanging knowledge and experiences throughout the world by setting up their own magazine and organizing events.

Scientific research

Although the Living Lab initiatives provide new knowledge and experiences with LEFVs, only a few successful cases for LEFVs have been found in scientific research (Schliwa et al., 2015; Lenz and Riehle, 2013). Simulation approaches and ex-ante analyses (Melo and Baptista, 2017; Gruber et al., 2014; Tipagornwong and Figliozzi, 2014; Arnold et al., 2018; Zhang et al., 2018; Gruber and Narayanan, 2019; Sheth et al., 2019; Naumov, 2021; Caggiani et al., 2021; Llorca and Moeckel, 2021) are most commonly applied in practical research. Fiori and Marzano (2018) developed an EFVs energy consumption model. The estimated model was validated by collecting real-world data from 144 observed trips for pickup/delivery made by five EFVs operating in the city of Rome.

In the literature only one real-life case can be found (Browne et al., 2011). Browne et al. performed an in-depth case study of Gnewt Cargo in London. In transport as well as environmental and financial terms, the trial of LEFVs was proven successful from the company's perspective, as the total distance travelled and the CO_2 emissions per parcel delivered dropped by 14 per cent and 55 per cent respectively using LEFVs. At the end of the project they decided to continue their delivery operations with the LEFVs.

LEFV-LOGIC: a national project

In the Netherlands, a research project with over 25 participants in the Netherlands developed insights into the types and logistics usage of LEFVs. In 2018, Ploos van Amstel et al. (2018), as part of the LEFV-LOGIC project, investigated for which types of goods the LEFVs are most promising within the framework of city logistics. Four crucial criteria have been identified for LEFV usage: small and light shipments, high network density, time-critical shipments and sufficient opportunities for growth and innovation. In line with these findings, they came up with the sectors mail, parcel and local retail deliveries, and smaller shipments in food, construction and service logistics that meet all the criteria. Moolenburgh et al. (2020), as part of the same project, performed case-based research. Several experiments were set up in different towns in the Netherlands to test LEFVs and collect knowledge on the practical experiences of their usage. Stakeholder consultation was performed to obtain feedback on LEFV usage. Also, the LEFVs were monitored with GPS loggers and cameras to obtain real-time measurements. Ten companies volunteered to take part in these experiments to experience using LEFVs.

This project shows that LEFVs are suitable for a wide range of users and applications, from independent entrepreneurs with a briefcase who want to transport a letter or small parcel to logistics service providers who transport roll containers. The expected fields of application for LEFVs (Ploos van Amstel et al., 2018) are proven to be viable in practice. The costs of the LEFVs can be up to 20–30 per cent less 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 footpaths, delivery times can be up to 30 per cent faster.

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. As the range of the vehicles is limited, all logistics concepts using LEFVs need to have a collection/consolidation point that is nearby.

The position of LEFVs 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 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, weather conditions can have a strong influence on the maintenance of the cargo bikes. Driving a LEFV takes some time to get used to in the beginning, but is perceived as simple. Drivers of LEFVs receive positive reactions from customers and the public.

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.

Living Labs

As follow up on the feasibility studies, Living Labs have been developed to cover the lack of practical knowledge on city logistics concepts with the use of LEFVs. Each year students of the Rotterdam Applied University of Sciences run a city hub with LEFVs. The hub is located on the Noord-West business park in Rotterdam, in-house at a logistics partner; ride and route planning software from RoutiGo is used, a dedicated software for cycling; and three electric vehicles are deployed: an Urban Arrow XL (cargo bike), a Sevic Cargo 500 (LEFV) and sometimes, as backup, a Nissan e-NV200 (which is not LEFV). The main services requested are the collection of returns and delivery of packages. Furthermore, light Value Added Logistics (VAL) activities are supplied and short-term stock storage services are offered. During the pilot, 3,108 inner-city kilometres were travelled, 726 stops were made, 4,278 parcels were delivered and at least 889 kg of CO_2 has been saved (van Duin et al., 2022). Transport space, vehicles, warehouse space, office space, software, personnel and knowledge are shared with logistics partners, and the available overcapacity pushed back. Ultimately, it turned out that a hub can be profitable, but at the same time it was realized that entrepreneurship, networking, good marketing and a wide range of services and collaborations are indispensable. The hub (working as a Living Lab) not only became visible in the city (in the COVID-19 period there was strong increase in customers of this service), but perhaps more importantly it has been shown that it is possible.

Conclusions – F2: Knowledge development and diffusion

Besides the most important knowledge that gets shared at events and comes out from experiences with LEFV projects, it can be concluded that most knowledge remains at local level, especially for the Living Lab experiences. At a national scale, universities (of applied sciences) have been working together more in long-term (eight years) city logistics programmes. This supports the development of scientific and practice knowledge by ensuring the knowledge is both verified and sound.

It is good to have a dedicated International Festival for Cargo Biking in order to keep the knowledge more focused. Other conferences such as the Transportation Research Board (TRB), the World Conference on Transport Research (WCTR) and the International Conference in City Logistics (ICCL) have themes on city logistics but still the attention to LEFVs remains fragmented and only accessible to scientific researchers. When it comes to knowledge sharing, the exchange of user experiences and best practices now seems to be most hotly in demand.

F3: Influence on the direction of search

This function (F3) encompasses mainly visions, targets and regulations set by governments and/or industries. For the LEFVs this is evidently the Green Deal for Zero-Emission City Logistics (Green Deal ZES, the Dutch climate agreement introducing the establishment of zero-emission zones for logistics in the centres of the 30 largest Dutch cities, as a direct follow-up on the Paris Agreement) and the resulting new plans for many cities to ban car traffic from the inner cities.

In 2014 the Green Deal ZES was signed by a list of Dutch governmental bodies, businesses and institutions. The parties signed up to the Green Deal ZES want to supply inner cities efficiently and emission-free by 2025. It was agreed that the period up to 2020 would mainly be used to 'experiment' with small, often local projects, to explore and learn as much as possible, and to share the acquired knowledge and experience with each other; pilots could fail, however, and therefore were continued rather than stopped, mainly to see where things went wrong and how things could be improved. These projects were called 'Living Labs'.

The Green Deal ZES has a term of ten years. In November 2014 there were 50 participating parties: governmental bodies, entrepreneurs (transporters and shippers), sector parties, interest representatives and knowledge institutes. Since then, more than 200 parties have joined, all experiences have been evaluated, and the projects are now being scaled up towards 2025, the year that, as far as possible, city logistics must be zero emission in at least 30 Dutch city centres. Supply to shops in those areas may only take place with zero-emission powered vehicles (for exact plans and details of the planned transition period, see GovNed, 2021a).

The Green Deal ZES is one of the six hundred measures in the Dutch climate agreement. To make this all happen a City Logistics Implementation Agenda has been developed (GovNed, 2021a) providing guidelines on how to set up regional cooperation and allow scope for local customization in preparation for the introduction of zero-emission zones.

Car-free/liveable cities

Some cities and neighbourhoods are beginning to rethink where cars can go – and redesigning streets to prioritize other uses, from public transportation to parks. It's happening around the world, including to major streets in cities like San Francisco and New York, but is occurring at the largest scale in many European cities.

The 'City as a City Launch' (Municipality of Rotterdam) is the provocative title of an initiative to redesign the inner city by allowing more space for bikers and pedestrians. This development can also be observed in many other Dutch cities, but in a less strict a way as is happening in Rotterdam. It is likely they will follow the Amsterdam agenda, as Amsterdam doesn't plan to fully ban cars. Rather, the key step in Amsterdam is removing 11,200 parking spots by 2025 and then using that space for wider pavements and bike lanes, trees and bike parking. Some streets will be narrowed or blocked off, and the city will issue fewer parking permits. It also plans to redesign roads for better cycling and add bike parking at metro stations, and may experiment with free public transit at rush hour. The few cars that are left will soon be electric or otherwise emissions-free. The same development is happening in other European cities: Milan is giving its squares back to residents, Paris has extended a 30 km/h speed limit to most of its city streets, and Barcelona is restructuring its city with fewer intermediate roads and has issued 12,000 free annual public transport tickets to former car owners.

Conclusions – F3: Influence on the direction of search

It is obvious that the Green Deal ZES and local car-reduction policies (including freight vehicles) represent a strong push towards LEFVs. At the same time a new type of space shortage is occurring at the edges of inner cities, where (micro-)hubs should be developed to facilitate the transhipment from trucks/vans to LEFV (see also '(micro-)hubs' in *F5: Resource mobilization*).

F4: Market formation

Market formation started with suppliers offering cargo bikes or other LEFVs for sale. Dutch companies today work together to offer 'full service' concepts for LEFVs that include, for instance, financing and maintenance. An example is DOCKR Mobility. DOCKR (a Pon Mobility company) helps entrepreneurs to navigate the inner city. It achieves that result by providing flexible contracts and electric vehicles with roomy cargo compartments, according to the one-stop-shop concept: insurance, periodic maintenance, and replacement transport are included as standard. Lease contracts can be terminated within one month, creating greater flexibility. Urban Arrow has a relationship with DOCKR as the latter leases out a big assortment of Arrows, and European lease company Paribas Arval offers all kinds of cargo bikes, including Arrows, as an option to fleet managers. On a small scale, similar initiatives are found elsewhere in the world, which sees the market for renting/selling LEFVs slowly developing.

Conclusions – F4: Market formation

A market for the supply of LEFVs is emerging. Many suppliers are coming to the market and the market is becoming more accessible with the introduction of rental contracts. This gives the companies options to experiment and learn with the LEFV usage for a period instead of having to make large fleet investments. A point of concern is the service and maintenance options. Due to the high volume of delivery tasks, fall-back options need to be available in times of disruption.

F5: Resource mobilization

Resource mobilization is discussed here from the LEFVs' own development perspective, a sharing perspective, their linkage with hubs, and their linkage with the development of Physical Internet (PI).

LEFV development

Two developments are associated with the practical usage of LEFVs. The first development is the mobilization of the LEFVs themselves. Nowadays there are many (proto)types of LEFVs available on the market. Due to the need to overcome the limited loading capacity of normal-sized cargo bikes, the market is now booming for XXL cargo bikes, which can have a loading capacity up to a box of 1,350 litres and weight of 150 kg. As well as electric-driven engines, hydrogen engines are also becoming available on the market.

Sharing LEFVs

On the demand side one can observe that large companies purchase LEFVs exclusively for their own operations, because they often want to have full use of the LEFVs, are able to make the investments, and take the uncertainty related to innovations for granted. SMEs, however, cannot do this. Sharing is a new trend in logistics in general (Gesing, 2017), and sharing of LEFVs, where several parties share one or more LEFVs, can offer SMEs a solution. Sharing LEFVs may represent a good opportunity, as it could become attractive, as demonstrated by transport-sharing concepts for private individuals such as bicycle sharing from GoAbout or shared scooters from Felyx. Research (van den Band and Roosendaal, 2020) shows that the business community is willing to accept the concept of sharing LEFVs, because it can reduce transport movements, reduce costs and can provide additional, flexible capacity to one's own transport fleet. However, there are some challenges that need tackling, such as the need for mutual trust and a good platform that supports the concept and maintenance.

(Micro)Hubs

One should understand that the mobilization of LEFVs is not a standalone development but has links with the development of (micro)hubs. The LEFVs often form an integral part of the last-mile solution, where goods are traditionally transported to hubs located at the edges of the city centres (often just outside the zero-emission zones) and then transshipped from trucks/trailers/vans to electric vans and LEFVs which deliver the goods to the final destinations in the inner city or vice versa. Although the research related to hub location problems (Farahani et al., 2013) is extensive, in practice the value of these facility location models is limited as in many cases the space available for hubs is limited or is not available at the calculated best solution in terms of (distribution) cost. Still, the hunt for good hub locations is increasing while real-estate prices are rising excessively, leading to scarcity of affordable space in the cities and sometimes in neighbouring regional districts. With respect to the electricity supply, this is not such a big issue for LEFVs as for other electric vehicles as the recharging of significant numbers of LEFV batteries at the same time doesn't cause a big peak in (power) demand. Still, not much space can be found for installing hubs in the inner cities.

Physical Internet

Another trend that is important to mention here is the growth of the Physical Internet (PI). The PI concept is inspired by the digital Internet and is an open, collaborative, and standardized transportation concept in which containerized freight moves through a network from hub to hub in a self-organizing manner. It is hypothesized that the PI will significantly increase the efficiency, transparency, scalability and robustness of the transportation network (Ballot et al., 2014; Montreuil et al., 2010). Crainic and Montreuil (2016) have translated the PI vision to the context of city logistics. Combining the fields of city logistics and the PI, they have come up with the notion of the 'Hyperconnected City', in which a scalable distribution structure is developed based on standardization of loading units (PI containers) and information exchange, and where LEFVs could play an important role in the urban last mile.

An illustration of the principles of PI development is the initiative DHL took to integrate their networks based on standardization. DHL has been using bicycles for 20 years and was previously involved with bike designs and modifications, from which the Parcycle and Cubicycle emerged. DHL sees the bike as the new industry standard for delivering parcels. DHL Express is taking the next step in rolling out a fully containerized last-mile delivery process, starting in the Netherlands. The containerized delivery process enables the cost-efficient and secure transfer of goods between terminals, motor vehicles and specialized last-mile delivery vehicles. The containers are transported by motor vehicles to handover points in city centres. At the handover points, the containers are quickly and safely transferred to last-mile delivery vehicles, and the couriers have all the information about the contents in their hand units. The last-mile delivery vehicles used are Velove Armadillos (called Cubicycles within DHL) and electric vans. Which type of vehicle is chosen depends on the last-mile delivery zone. Parcels are sorted and handled only once in the delivery process, at the sorting terminal. This makes it economically viable for the last-mile delivery vehicle to refill during the workday, as the distance to return the empty container and pick up more goods can be minimized, and the transfer of the goods is fast and secure.

Conclusions – F5: Resource mobilization
It can be concluded that resource mobilization is developing well for the LEFV industry. Several different types of LEFVs are coming to the market, serving all kinds of city logistics niche markets including, among others, conditioned deliveries, service deliveries, facility deliveries and parcel deliveries. At the same time, PI can support future integration into the logistics processes in co-creation with the drivers by looking at standardization of LEFVs so that multipurpose vehicles and boxes can be utilized in different niche markets. For SMEs, opportunities for sharing LEFVs are arising through service platforms. The link with hubs development is evident as many times the final delivery from the hubs is carried out by a LEFV.

F6: Legitimacy
Industry associations and companies in a few countries have started to work on cargo bike standards in the last few years, but the need for a consistent European approach has really come together in 2020 under the umbrella of CIE's partnership with the European Cycle Logistics Federation (ECFL, 2021). With this umbrella view, coordinated by a joint Expert Group, we can see that there is little consistency in the national approaches, and even worse, some of the proposals could seriously damage the growth of some cargo bike and commercial vehicle services.

In November 2020, the expert group made its first proposals on how cargo bikes could be regulated to an EU review of mobility devices, an achievement celebrated as a major milestone in the development of the sector. Together with the proposals were the results of a comprehensive survey on cargo bikes in commercial use, the first of its kind at the international level. According to industry partners, this showed that cargo bikes are possibly the safest bikes in the world, because after millions of kilometres of use in commercial fleets not a single fatal accident had been reported, and there were few injuries to riders or the public. That allowed the new proposals for cargo bike regulation to be compared confidently to existing regulation for bikes and e-bikes.

Also, the industry organization LEVA-EU plays an important role at EU level. To promote the market uptake and deployment of light electric vehicles (LEVs), LEVA-EU guides LEV companies through the maze of rules and regulations governing the vehicles. A better understanding of these rules and regulations facilitates the market access and development of LEV businesses. In turn, the EU market benefits from a more varied and high-quality LEV offer. Rules and regulations are sometimes outdated or inaccurate and therefore create legal bottlenecks for the LEV community. LEVA-EU has a direct line with EU decision-makers to negotiate improvement of the rules. It is also in contact with national decision-makers to exchange information on best practice. Furthermore, LEVA-EU works pro-actively and gives its members a voice in European LEV advocacy. It monitors all EU legislation and policy-making that may be relevant to LEV companies. In consultation with its members, it selects those issues that are most relevant to the LEV business and develops and implements a European advocacy strategy.

The current infrastructure system and urban planning are mainly organized around the use of cars. The transition towards a more sustainable mobility system is also mainly directed towards the replacement of fossil fuel cars by electric cars. However, with the development of many other types of LEFVs, it becomes clear that the infrastructure system cannot support all these different types of vehicles. Formerly, in the Netherlands, the main roads were used for cars, and bikes used the cycling lanes. Currently, there is a debate on which lanes LEFVs should use.

Former Minister of Infrastructure and Water Management Cora van Nieuwenhuizen recently presented a new framework for LEFVs (GovNed, 2021b). Among other things, this states that cargo bikes may have a maximum total weight of 425 kg, may be up to three metres long and may be driven by persons of 18 years and older. For access to bikeways the Minister proposes a maximum speed of 25 km/h and maximum width of one metre.

What regulations should be in place for LEFVs:

- *Infrastructural changes such as speed limits, car-free roads and road widening*. This will give all road users more space and the city's infrastructure will be equipped for a further increase in sustainable (freight) vehicles in the city centre.
- *Unambiguous technical requirements*. These ensure that all vehicles have the same safety standard. Currently, there are no technical specifications that LEFVs must meet. As a result, many cargo bikes are built with vulnerable components from consumer bikes.
- *Inspection of LEFVs by an official independent body such as the RDW*. This organization is objective and operates using European vehicle regulations, and it has the necessary relevant experience from the automotive sector.

Conclusions – F6: Legitimacy

Today it can be seen that the legislation on LEFVs is tightening and that it is dominated by safety concerns. It is obvious that this is happening as the usage of LEFVs is growing and the number of accidents involving them is concurrently increasing. Most Dutch people can remember the horrifying accident in 2018 involving a Stint, which at that time, as well as being a very popular vehicle for parcel delivery, was also used for passenger transport. The accident occurred at a level crossing, where a train collided with a Stint that was transporting young children to kindergarten. Four children sadly passed away.

F7: Development of positive externalities

According to a new analysis from the European Cyclists' Federation (ECF), there are almost three hundred tax-incentive and purchase-premium schemes for cycling offered by national, regional and local authorities across Europe to make it attractive to cycle more and drive less, to reduce transport CO_2 emissions and to provide important growth stimuli for the European bicycle industry.

The usage of electric cargo bikes in particular, as a category of LEFVs, can contribute to bettering the health of drivers. The use of cycling as a means of prevention against welfare diseases such as diabetes and obesity is gaining ground. However, it is still hardly known that cycling has other positive effects too, that is, it is reducing the risk of depression as it induces an increase in various neurotransmitters including dopamine (provides satisfaction and reward), serotonin (a happiness hormone) and endorphins (an anti-stress hormone) (MensLine, 2021).

CONCLUSIONS AND FUTURE PERSPECTIVES

In answering the research question '*What are the success and failure factors of the introduction of LEFVs in city logistics and what are the future perspectives on LEFVs in city logistics?*' the TIS framework has provided us insights on the usage of LEFVs in city logistics concepts.

The framework provides a complete overview of factors that have influence on the development of LEFVs. The distinction between the system elements, which are more related to the stakeholder dynamics, and the system functions is a valuable insight. However, working with the framework didn't provide us explicit insight on whether the factors are success or failure factors. At the same time, it is not fully clear whether a factor mentioned in the TIS framework is an internal strength or weakness, or whether it can be seen as an exogenous opportunity or threat. It doesn't provide any steering or support towards a further valorization/implementation of the LEFV innovation.

For this reason, an additional framework is suggested here to find strategies on how to proceed with the outcomes of the TIS framework by categorizing them into strengths (S), weaknesses (W), opportunities (O) and threats (T).

Here a special form of SWOT analysis is suggested, that is, the confrontation matrix of Kearns (1992). The confrontation matrix contrasts opportunities

Table 9.3 SWOT strategies matrix

	Strengths (S)	Weaknesses (W)
Opportunities (O)	*Challenge* Use the strengths to better exploit the opportunities	*Defend/improve* Use the opportunities and challenges to improve/cover the weaknesses
Threats (T)	*Protect* Areas where there are issues and a choice must be made to invest, disinvest or work together	*Keep the damage* Minimize the weaknesses and prevent the threats

Source: Kearns (1992).

and threats with strengths and weaknesses. This creates a matrix with four cells (Table 9.3) that can have the following meanings for research:

- Investigate many promising opportunities to make large innovation steps possible with the strengths (OS);
- Investigate whether opportunities can contribute to an improvement of weaknesses (OW);
- Investigate to what extent the threats have a negative impact on the strengths of the system (TS);
- Investigate to what extent the threats are threatening to the weaknesses and/or can be converted into improvements or be made to disappear completely (TW).

The SWOT analysis can be used as a kind of compass for navigating the research opportunities and offers the possibility of continuously identifying where possible points of interest lie in the research field. The SWOT analysis diagram on the usability of LEFVs is presented in Table 9.4.

As can be gleaned from Table 9.4, due to their strengths, LEFVs offer good value propositions to stakeholders. At the same time, the list of opportunities forms a solid basis to extend the current usage of LEFVs. The weaknesses might come from the real-estate markets as the LEFVs require hubs for their operations. Space for hubs will be scarce and expensive in the next decade. The growing use of LEFVs asks for a safe position on the roads and more professional services from their suppliers. The threats come from the legal position on the road and the fierce competition from e-vans. Most of the threats can be covered by the LEFVs' strengths.

As can be noticed from Table 9.4, some additional factors are provided. Applying the TIS framework rigidly doesn't give space for these factors. Most of these factors are logistics characteristics of the LEFVs which are not explicitly addressed in the TIS framework.

Table 9.4 SWOT analysis on usability of LEFVs in city logistics

STRENGTHS	WEAKNESSES
TIS Functions • F3: Influence on the direction of search. Fit with current views of liveable cities. • F4: Market formation. The supply of LEFVs is emerging. • F6: Legitimacy. Implementation of LEFVs: (safety) position on the road due to influential groups (EFCL and national governments). *Additional Factors* • Perception is based on 'fun' factor: people love cargo bikes. • Zero emission, less space, easy loading/unloading. • Fit for purpose for different segments of city logistics.	*TIS System Elements* • System Infrastructures: bicycle lanes (unsafe interference with other cyclists). • System Infrastructures: hubs (need for many locations). *TIS Functions* • F4: Market formation. No all-in-one solutions are widely available for fleet managers. DOCKR is still an exception in the market, with Pon Mobility as a supportive OEM. *Additional Factors* • Payload. • Restricted radius. • Only suited for specific products (small, low weight/volume). • LEFVs are not linked to upstream processes: (micro)hubs, containerization, difficulty in scaling, IoT (Physical Internet).

OPPORTUNITIES/ENABLERS	THREATS/BARRIERS
TIS System Elements • System Actors: OEMs; logistics service providers having a hub; receivers; office, government and educational buildings procuring facility goods; demand for zero-emission deliveries. • System Interactions: Living Labs. *TIS Functions* • F1: Entrepreneurial activities. (1) General promotion of LEFVS, (2) development of the vehicles and (3) development of the service supplier side. • F2: Knowledge development and diffusion. Based on the setting up of (inter) national (feasibility) projects, Living Labs as more practice-based research, and international cargo bike events. • F3: Influence on the direction of search. Green Deal ZES and fewer vehicles in the city: LEFVs are a real solution. • F5 Resource mobilization. LEFV development, sharing concepts, hubs and Physical Internet (PI). • F7: Development of positive externalities. Health issues. *Additional factors* • Awareness: understanding the usefulness of LEFVs in different segments of city logistics.	*TIS Functions* • F6: Legitimacy. Implementation of LEFVs: current safety position on the road. Legislation needs to be further developed. *Additional Factors* • Emerging autonomous delivery systems. • Human talent: not everybody wants to ride a LEFV. • Competition developing better delivery vans. • High total cost of ownership. • Not ready for many large-scale implementations.

To conclude, the TIS framework as an ex-post analysis tool makes a lot of things clear in terms of system elements (the stakeholder environment) and system functions. However, to apply the TIS framework for deeper analysis in order to come up with strategies for innovation acceptance, the additional usage of a SWOT analysis is useful to position the elements and functions better. In particular, the discussion on the position of the elements and functions helps in understanding the implementation of the innovation and facilitates thinking on new strategies for implementation.

Looking again at the initial estimate of a potential market share of 10 to 15 per cent (Ploos van Amstel et al., 2018), a more optimistic estimate has been recently presented by Verlinghieri et al. (2021), who suggest that up to 51 per cent of all freight journeys in cities could be replaced by cargo bike. For other cities in the world, the findings from the TIS framework and the SWOT analysis are likely to be more or less identical. Together with Sweden and Denmark, the Netherlands has a leading position in terms of LEFVs usage, but one can observe a growing usage of LEFVs in cities throughout the world. In our opinion, more growth than the initial estimate of 15 per cent is certainly possible, however 51 per cent of all freight journeys is not a realistic estimate considering all the influencing factors derived from the TIS framework.

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