INNOVATIVE SOLUTIONS FOR A "LAST-MILE" DELIVERY – A EUROPEAN EXPERIENCE

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Abstract

The "last-mile" delivery represents the last part of a supply chain that is considered to be the most inefficient due to its specificities such as a spatial distribution of relatively small receiving points, demands for more frequent but smaller shipments, delivery time windows, etc. As far as its ecological dimension is concerned, the "last-mile" delivery done by common type of delivery vehicles for an inner urban supply is thought to be significantly ineffective especially in cities that are faced not only with modern distribution practices but with increasing urbanisation and e-commerce development as well. This leads to the conclusion for necessity to introduce innovative types of delivery vehicles that improve business results while reducing a negative ecological and social impact of transport on functions in inner cities. With this reference, the paper presents the innovative transport technologies in the "last-mile" delivery in developed European countries that provide an ecological and social sustainability as well as an increased competitiveness of the suppliers.

Key words: "last-mile" delivery, City logistics, transport vehicles, sustainability of urban freight

1. INTRODUCTION

According to European Commission (2013a), 73% of European population live in cities where 85% of European Union's GDP is created. The process of urbanisation is foreseen to rise up further reaching 82% by 2050 or even more than 90% by 2050 in countries such as Denmark, Sweden, Belgium, Luxembourg, Malta and Netherlands. As cities are being places where population and economic activities concentrate, effective and sustainable transport is becoming more important for conducting all specific city functions and fostering its economic prosperity and economic welfare of its residents. Besides rising urbanization, other major factors that influence an augmenting importance of urban freight transport and the need for its systematic research are: increased purchasing power of the urban population that results in larger quantity and diversity of goods bought and delivered to customers in urban areas by diverse suppliers and their distribution channels, centralisation of production, JIT production and distribution and rising e-commerce with demand for smaller but more frequent deliveries usually performed by logistics service providers (Anand et al., 2012; Crainic, 2008; Crainic et al., 2009; Ehmke, 2012). As observed by Visser (2005, p. 1): *Although delivery of goods is vitally important for residents and industries in urban areas, the presence and operations of goods transport vehicles in urban areas are often regarded more as a nuisance than an essential service.* This is a common feature of all cities, not only of megacities but as well as of small to large European cities with historic city cores. From a logistics perspective, cities provided by multitude of supply chains are important logistics nodes where transhipment as well as "last-mile" transport occurs. As such, transport conducted in urban areas comprising "last-mile" delivery is an integral element of the whole transport chain and supply chain management.

A comprehensive categorisation of a wide array of externalities of the urban freight distribution, that encompasses the "last-mile" delivery in urban environment as well, can be found in Allen et al. (2000b). Within a research project on urban freight transport in the United Kingdom, the authors have extended the one delivered by *The UK Round Table on Sustainable Development* in 1996 by introducing the negative operational impact as an additional, fourth category. The four categories of negative impacts of the urban freight transport are as follows (Allen et al., 2000b, p. 72):

1. ***Negative environmental impacts*** such as depletion of non-renewable resources, air pollution and various sorts of waste such as tyres, vehicles and other materials
2. ***Negative social impacts*** involving various aspects of lowering quality of life such as decreased public health including deaths, illnesses and injuries emanating from traffic accidents and various types of pollution – air pollution, noise, vibration and visual pollution, consumption of valuable greenfield sites and physical threats and intimidation by the size of the transport vehicles
3. ***Negative economic impacts*** comprising road congestion and an economic burden to all stakeholders involved in urban freight transport due to freight inefficiencies and its negative environmental and social impacts
4. ***Negative operational impacts*** that refer to various congestion and traffic disruptions including obstructions to other road users emerging from inbound and outbound transport activities of goods and service delivery vehicles in the urban areas such as (un)loading, parking and manoeuvring as well as their overall effect on delivery service.

As stated in some sources, only the costs of environmental nuisance emanating from pollution of increasing traffic in the European cities amounts almost 100 billion Euros on a yearly bases or 1% of GDP of European economy (Bektaş et al., 2015, p. 2; EU Commission, 2007, Anderson et al., 2005 as cited in Lange et al., 2013, p. 110).

Drawing on this common characteristic of urban freight transport, in this paper an attempt has been made to point to some of the most innovative types of delivery vehicles in the "last-mile" delivery in developed European countries, among some are still in trial phase, that might improve freight flows and business results while complying with requirements of sustainable development and environmental concerns. Prior to this, the paper aims to provide a sufficiently broad background and contribution that will enable readers to extend their existing knowledge or even acquire a new one regarding closely related terminology and system of city logistics within which the "last-mile" delivery in urban areas is carried out.

The methodology comprised desk research of printed and web-based sources. Types of literature used include books, journal articles, conference papers, reports and internet-based information. Although city logistics that comprises the "last-mile" delivery as well is considered to be a relatively new field of research, many researches, initiatives and projects with various proposals have been conducted worldwide so far to combat the negative impact of urban goods transport. Their further in-depth study could be an incentive to innovative sustainable solutions tailored for specific needs and requirements of the interested that contribute to successful dealing with the current issues and proactively anticipate and answer to the future ones.

2. DEFINING TERMS

Terms such as urban goods movement, urban freight transport and city logistics have been mainly used interchangeably to describe freight flows throughout urban areas. As observed by Lange et al. (2013), a distinction in terminology indicates to differences in origin – whereas *urban freight transport* (as well as *urban goods movement* or *urban goods distribution,* the author's remark) prevails in Anglophone literature, *city logistics* has been the most widespread, especially in Germany where the concept has been developed during 1990s. Some of definitions that can be found in the academic and professional literature describing coverage and indicating the complexity of tasks in reference to these terms are the ones that follow.

In 1992 Kenneth W. Ogden published the first comprehensive book on urban freight transport: *Urban Goods Movement: A Guide to Policy and Planning* that is considered as a pivotal source for transport experts worldwide (Dablanc, 2011). According to Ogden, urban freight transport is:

> *The transportation of, and terminal activities associated with, the movement of things as opposed to people in urban areas. It includes movement of things into and out of the area, through the area, as well as within the area by all modes, including transmission of electricity to the extent that it relates to the transportation of fuels, pipeline movement of petroleum, water and waste, and collection and movement of trash and mail, service truck movements not identified with person movements, and even some person trips which involve substantial goods movements such as shopping trips. Activities involving urban streets, waterways, railroads, terminals, loading docks, and internal distribution systems including elevators and related facilities must all be considered in fostering greater efficiency in the movement of urban goods.* (Ogden, 1989, p. 12 as cited in Allen et al., 2000a, p. 20).

In the study on urban freight transport in the United Kingdom, Allen et al. (2000a) elaborated coverage of the urban freight transport that includes: (1) all types and sizes of transport means for core goods deliveries and collections at urban premises, (2) all types of means used for movement goods to and from urban premises including core goods transfers between urban premises, ancillary goods deliveries to urban premises, money collection and delivery, waste collections, postal collection and delivery, other goods collected from premises and home deliveries from urban premises to customers, (3) service trips and other trips for commercial purposes to the urban premises of vital importance for its regular operation. *OECD Working Group on Urban Freight Logistics* defined urban goods transport as *(...) the delivery of consumer goods (not only by retail, but also by other sectors such as manufacturing) in city and suburban areas, including the reverse flow of used goods in terms of clean waste*. (OECD, 2003, p. 19 as cited in Lindholm, 2013, p. 7). In *An overview of the European research and policy,* European Commission (2006, p. 2) sees urban freight transport and logistics operations as *(...) concerned with the activities of delivering and collecting goods in town and city centres. These activities are often referred to as ‘city logistics’ as they entail the processes of transportation, handling and storage of goods, the management of inventory, waste and returns as well as home delivery services.* According to Dablanc (2011, p. 13) urban freight transport is understood as *(...) goods movements generated by the economic needs of local businesses, that is, all deliveries and collections of supplies, materials, parts, consumables, mail and refuse that businesses require to operate. It also includes home deliveries by means of commercial transactions.*

As city logistics is concerned, Taniguchi et al. (1999 as cited in Ehmke 2012, p. 13) explains it as *(...) the process for totally optimizing the logistics and transport activities by private companies in urban areas while considering the traffic environment, the traffic congestion and energy consumption within the framework of a market economy.* Later on, the definition has been extended by introduction of information technology as a foundation for optimization of these activities (Benjelloun et al., 2010) to state city logistics as *(...) the process for totally optimizing the logistics and transport activities by private companies with the support of advanced information systems in urban areas considering the traffic environment, its congestion, safety and energy savings within the framework of a market economy.* (Taniguchi, 2012). An emphasize on the optimization of employed transport means that reduce transportation and environmental costs can be found in Crainic (2008, p. 2) who takes city logistics as one that *(...) aims to reduce and control the number, dimensions, and characteristics of freight vehicles operating within the city limits, improve the efficiency of freight movements, and reduce the number of empty vehicle-km.* Further on, Crainic (2008, p. 3) indicates fundamentals of increased efficiency as seeing the city logistics as *(...) a system characterized by an optimized consolidation of loads of different shippers and carriers within the same delivery vehicles and the coordination of freight transportation activities within cities.* Similarly, Visser (2005, p. 7) points to systems view and collaboration as the main means to increase profits: *City logistics is an integrated approach for urban goods distribution based on systems approach. It promotes innovative schemes that reduce the total cost (including economic, social and environmental) of goods movement within cities. City logistics encourages collaboration between key stakeholders within a market based economy.*

Finally, the “last-mile” delivery in urban environment as an integral part of the urban freight transport and city logistics can be seen as *(...) the final haul of a shipment to its end receiver, be it a shop, a business, a facility or a residence in case of home deliveries.* (Dablanc et al., 2013, pp. 4-5). Such a broad definition could apply to various environments in which delivery might occur, from traditional distribution to e-commerce or both. Chopra (2003, p. 133) sees it as a part of one of six possible distribution network's designs, where *(...) the distributor/retailer deliver[s] the product to the customer's home instead of using a package carrier*. Specifically, in the context of rising e-commerce, the "last-mile" delivery can be defined as *(...) the last stretch of a business-to-consumer (B2C) parcel delivery to the final consignee who has to take reception of the goods at home or at a cluster/collection point.* (Gevaers et al., 2009, p. 2).

Due to significant share of logistics costs in retailing and their special impact on efficiency of urban delivery, further study could be continued toward Urban Retail Logistics, a new research area proposed by Lange et al. (2013), that builds and carries on the conjoint achievements of urban freight transport, city logistics and cooperation between suppliers in warehousing and transport activities.

From the definitions above one could agree there are no unique definitions of the terms but rather their different apprehension depending on the aims of the specific research. In reference to that, the "last-mile" delivery of goods in urban environment should be observed as the last leg of the integrated logistic system that aims to increase efficiency through various collaborative practices.

2.1. "Last-mile" delivery within the system of city logistics

Although the "last-mile" delivery, especially its direct-to-consumer deliveries by mail order companies, has been present since the 1980s and 1990s, it has drawn a significant scholars' and practitioners' attention with the rise of online and mobile shopping and increasing costs associated with the "last-mile" delivery that may range from 13% up to 75% of the total supply chain costs (Gevaers et al., 2009).

Since the "last-mile" delivery in urban environment represents a constituent part of city logistics as the final leg conducted over short distances to reach the customer, it could be observed within this broader system.

City logistics has been introduced as a special field of study in logistics by Ogden and Taniguchi (Anand et al., 2012). The literature points to the probably beginning of its development in 1970s - a period marked by traffic regulation aimed to reduction of heavy freight vehicles in the cities. Due to rising traffic problems, the new wave of interests in city logistics arose again in 1990s when the first projects undertook mostly in cities in Japan and countries of Western Europe prevalently due to a common constraints such as scarcity of available land and strong urban planning tradition (Anand et al., 2012; Benjelloun et al., 2010; Crainic, 2008; Crainic et al., 2009). As stated in Benjelloun et al. (2010, p. 6217), *[t]he City Logistics concept has emerged as a comprehensive approach aimed to mitigate the negative impact of urban freight transportation without penalizing the city's many economic, social, administrative, cultural, touristic, and other activities.* A sole term has been coined in Germany where researchers of that time studied city logistics as a joint delivery system of different transport companies for local purposes. The decade concluded by establishing the *Institute for City Logistics* (in further text – *ICL*) in Kyoto, Japan in 1999 as a centre of excellence in fundamental and applied research on city logistics and urban freight transport symbolizing the beginning of a heyday of city logistics research and its application (Anand et al., 2012; Benjelloun et al., 2010; Crainic, 2008; Crainic et al., 2009; ICL; Visser, 2005). Since then, the city logistics have come forth as an emerging field of research that evolves rapidly (Bektaş et al., 2015; Crainic, 2008; Crainic et al., 2009; Dablanc, 2012 as cited in Dablanc et al. 2013; Rodrigue, 2004 as cited in Dablanc et al., 2014).

2.1.1. Main stakeholders in the “last-mile” delivery

The basic feature of city logistics is heterogeneity of the stakeholders whose different behaviour and objectives should be integrated into unique logistics system that involves the “last-mile” delivery as well (Taniguchi et al., 2012). The four key stakeholders are (1) shippers that tend to minimize their total costs while maximizing the level of their service through timely delivery, (2) freight carriers that aim to minimize transport costs while maximizing the level of their service through strict designated time, (3) residents (consumers) who tend to maximize their gain by timely purchase of needed goods at a reasonable prices due to which are being exposed to traffic nuisances and (4) administrators aimed to maximize economic prosperity of the city and to align conflicting interests of all by establishing a sustainable transport system (Taniguchi et al., 2008 as cited in Ehmke, 2012; Taniguchi et al., 2012). Other categorizations of the main actors involved in the “last-mile” freight delivery derived from the aforementioned one can be found in the literature as well (for example: Russo & Comi, 2012; Wohlrab et al., 2012).

2.1.2. The “last-mile” delivery and subsystems of the city logistics

As stated by Bektaş et al. (2015), the system of city logistics is based on the following four subsystems: (1) *(...) the demand for transport the system aims to satisfy* referring to freight flows (p. 5) and (2) facilities as nodes that split freight transport into outside (external) and inside city area and where many value-added logistics activities are carried out, such as: consolidation of delivery flows, coordination of transport, transhipment and storage. Two pivotal facilities within the system of city logistics are city distribution centres (in further text - CDC) or urban-freight consolidation centres (in further text - UCC) and satellites platforms. In their study on potential development of the UCCs, Browne et al. (2005, p. 4) described UCC *(...) as a logistics facility that is situated in relatively close proximity to the geographic area that it serves be that a city centre, an entire town or a specific site (...), from which consolidated deliveries are carried out within the area.* It is a share–user hub settled outside the city area where long-haul freight vehicles coming from various suppliers are received, sorted, consolidated, uploaded and distributed to the final receiver point (either satellite platforms or direct to customer) by fully-loaded larger urban friendly vehicles. Very similar to UCCs are satellite platforms located close to or even in the dense city centres where only cross-docking transfer of freight coming by urban vehicles from UCCs or other external points is performed onto the city freighters for its “last-mile” delivery to the final consumer. City freighters are small vehicles adapted for delivery in dense city centres (Crainic et al., 2009) while parking spaces, bus stations, train stations, city squares or other similar existing sites can be used as satellites (Bektaş et al., 2015). The third subsystem of city logistics as indicated by Bektaş et al. (2015) is (3) layout determined by tiers or echelons – a number of subjects providing similar service. Depending on the number of levels where consolidation-distribution activities take place, it is possible to distinguish single-tier systems where freight consolidated in CDC is delivered directly to final receiver and multi-tier systems where freight is passed through several different sorts of facilities, transport modes and vehicles before reaching final customer. The last subsystem is (4) transport that deals with appropriate choice of green vehicle ranging from light rail to bicycles (Bektaş et al., 2015).

2.1.3. Specifics of the "last-mile" delivery

According to Boyer et al. (2005), a product can be moved to a customer by four "last-mile" delivery types (extended supply chains) that differ in two dimensions - order fulfilment and delivery type. While order fulfilment can be done in a store or in a distribution centre, delivery can be conducted either directly to customers' home from the company or by freight carrier or indirectly at collection/pick-up point. The authors have differentiated these types as semi-extended supply chain (with store-based fulfilment and indirect delivery), fully extended supply chain (with store-based fulfilment and direct delivery to consumers' home), decoupled supply chain (with fulfilment via distribution centre and indirect delivery) and centralised extended supply chain (with distribution centre fulfilment and direct home deliveries). Each type varies in four critical factors that companies have to balance – customer convenience, delivery cost, picking efficiency and capital investment (Boyer et al., 2005). A similar and comparable approach with detailed advantages and disadvantages of each option can be found in Chopra (2003). Further elaboration of the typology of Boyer et al. (2005) can be found in Greavers et al. (2009) or in Hübner et al. (2014) if "last-mile" delivery in online and offline presence concerns.

The special issue regarding "last-mile" delivery that particularly arises in the e-commerce environment are attended home deliveries that are either marked by so called "not-at-home syndrome" (without specific delivery time assigned) or "ping-pong" effect (with specific delivery time assigned) that increase economic and environmental costs including driven kilometres (Greavers et al., 2009; Edwards et al., 2009; Hübner et al., 2014). Furthermore, there are problems of low consumer density that lacks the advantages of economy of scale (in the case of home and clustering deliveries), secure reception problem (in the case of unattended home deliveries) and returns (Edwards et al., 2009; Greavers et al., 2009). Other main issues common to all types of "last-mile" delivery are (Greavers et al., 2009; Edwards et al., 2009): empty running, additional sorting requirements and inefficient routing due to small consignment lacking the economy of scale and increasing carbon footprint. The list could be extended by restricted delivery routing and timing and general competitiveness of delivery industry (Xing et al., 2010 as cited in Dablanc, 2013).

3. INNOVATIVE VEHICLES

Many initiatives, projects and innovations have been carried out so far to contribute to positive environmental outcomes regarding urban freight activities especially since city logistics has come forth. According to Patier and Browne (2010, p. 6230), innovations carried out in city logistics can be grouped to those that refer to: *[c]onsolidation of goods flows within the urban area (achieved through new organisation or new concepts such as consolidation centres); [u]se of new non (low) polluting vehicles (e.g. electric powered vehicles); [r]egulation (usually focused on restricting certain types of activity by time of day, size/type of vehicle).* Greavers et al. (2009, p. 6-11) point to five characteristics of the “last-mile” delivery and their sub-characteristics as subjects of innovation that directly influence efficiency, costs structure and environmental impact. These are: consumer service level (with sub-characteristics: time windows, maximum lead times, frequency of delivery, possibility of returns), security and type of delivery (with sub-characteristics: (un)attended deliveries, collection points, delivery boxes), geographical area and market penetration (with sub- characteristics: market density, average distances between points of reception, share of goods to be pooled/clustered during delivery routes), fleet and technology (with sub-characteristics: type of vehicle and ICT used) and the environmental issues that depend on the aforementioned sub-characteristics.

A review of projects and initiatives introducing innovations to mitigate negative impact of urban road traffic in the “last-mile” delivery reveals a number of innovations regarding transport vehicles. New freight delivery vehicles are required to be of small size, flexible to operate within urban core and in compliance to low emission standards. The usage of electric vehicles or trucks on alternative fuel technology or environmentally friendly transportation modes are preferred (Visser, 2005). As observed by Bektas et al. (2015), specially designed trams, regular rail, barges or buses are taken into consideration or even implemented as well.

According to the European Commission's White Paper (European Commission, 2011), usage of all conventionally fuelled vehicles should be halved by 2030 and completely banned in the city centres by 2050. Research data of the European project CycleLogistics
[1] (CYCLELOGISTICS, n.d.) shows the potential to shift 51% of all motorised private and commercial trips[2] related to goods transport among which 25% refers to delivery in an average European Union's cities to bicycles or cargo bicycle. This proportion makes 25% of all trips made in European Union's cities or 42% of all trips made by motor vehicles in European Union's cities. The share reaches 50% in case of the light goods. All the shares could be even be bigger if electric assistance is used. (European Cyclists’ Federation, 2012; CYCLELOGISTICS, n.d.)

Usage of cycles for the “last-mile” delivery is mainly suited for short distances (2,5km to 3,5km in average) and light goods transport usually made with lorries and vans below 3,5 tones (CYCLELOGISTICS, n.d.). According to the data from CycleLogistics projects, commercial bikes could be used for light loads of 80–200kg with some exceptions reaching up to 400kg. In terms of volume, this amounts to 400 – 800 litres delivered to a distance up to 7km with electric assistance. Besides common mail services, bikes are particularly convenient for a delivery of small weight

[1] The research was limited to transport of light goods weighing less than 200kg/m³ and to trips length less than 7 km with trip chains excluded (CYCLELOGISTICS, n.d).
[2] Private trips are all personal trips that include commuting, shopping and leisure trips. Commercial trips include delivery cargo trips, service trips and business trips (CYCLELOGISTICS, n.d.).

packages, ranging from online purchases, takeaway foods, drinks, flowers, office supplies, newspapers, mail, small parcels or even furniture. Among standard bicycle with shoulder bag or panniers for loads up to 40kg or standard bicycle with trailer for loads up to 80kg, other types designed for professional use including security and weather protection are: cargo bike for loads up to 80kg and volume of 0,5m³ (Figure 1) and cargo trike/quad for loads up to 250kg (Figure 2) (CYCLELOGISTICS, n.d.).

Figure 1. Electric cargo bike

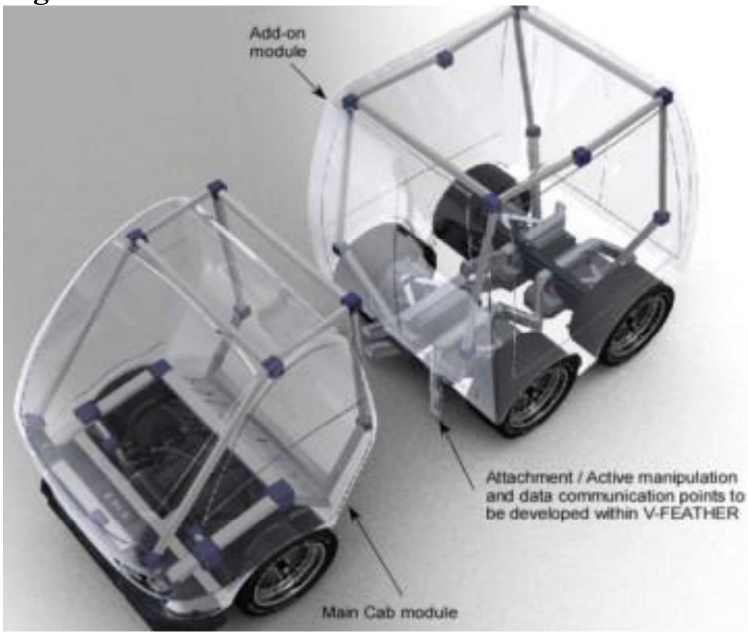
Source: Institute of Transport Research (n.d.)

Figure 2. Cargo trike/quad

Source: European Cyclists' Federation (2012)

V-Feather vehicle represents a light electric freight vehicle composed of multiple building modules of various sizes and types. One cabin module is where a driver sits while others are adaptive freight modules for carrying various goods (refrigerated goods, dangerous goods, etc.). These modules can easily be dropped off or picked up after recharging at different locations within the city, meeting different delivery requirements (new system of "last-mile" delivery known as Deposit, Rapid Recharge and Recollect - *D3R*) (Luxembourg Institute of Science and Technology, n.d.; European Commission, Horizon 2020).

Figure 6. V-Feather



Source: Aggoune-Mtalaa (2014)

Another light electric delivery vehicle is Deliver (Figure 7). It is a next generation vehicle intended for large scale production. It is 40% more efficient compared to other conventional vehicles in the category. It has a maximum load capacity of 700kg or 4 m³ for urban delivery services with extensive stop-and-go driving (EUCAR, n.d.).

Figure 7.

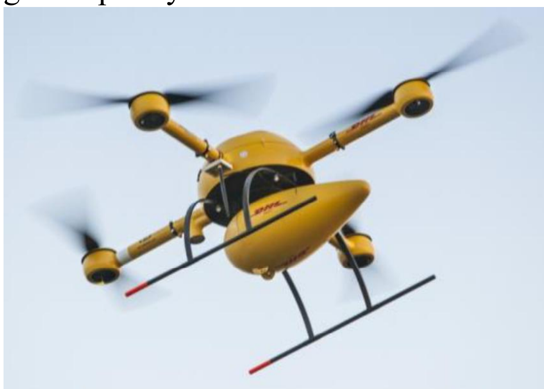
Source: EUCAR (n.d.)

Delivery drones – remotely or automatically piloted aerial vehicles are another innovation. So far, they are still in a trial phase and mainly used for parcel delivery of medical supplies and other urgently needed goods. First civil drone known as *parcelcopter* launched by Deutsche Post DHL has reached travel distance of 12 km (Figure 8). It has weighted below 5 kg with loading capacity up to 1.2 kg and has reached travel speed up to 18 meters per second at an altitude of 50 meters (DHL, 2014a; DHL, 2014b). Their features have been a subject of further improvements regarding load capacity, delivery distances and power solutions (Figure 9) (GEOPOST, 2015; YEAIR, n.d.).

Figure 8. Deutche Post DHL's parcelcopter

Source: DHL (2014a)

Figure 9. Improved delivery drone guadcopter year!



Source: YEAIRE (n.d.)

The German logistics provider DHL anticipates the introduction of autonomous driving technology. Self-driving road vehicle could be used for business purposes for the "last-mile" delivery of parcels and letters, either as an assistance vehicle to a delivery person, as an autonomous vehicle that substitutes the delivery agent in parcels' loading and unloading into standardized reception boxes or as a self-driving shipment repository. Other potential applications refer to its usage as a shared, crowd shipping, shopping car for the "last-mile" deliveries of online purchases or as a self-driving vehicles in size of the parcel (*self-driving parcels*) with individually determined and controlled delivery path, temperature and handling modes that would enter the final recipients' home through a specially designed small gate. After unloading, recipient would send the vehicle back to carrier by using a smartphone application (DHL, 2014c).

Figure 10. Self driving parcel

Source: Prestigefilms as cited in: DHL, 2014c, p. 32

Caps (Figure 11) are fully automated electrically powered freight delivery vehicles to be used in underground transport pipeline system in congested urban areas. They are driven at constant speed of 10m/s (36 km/h) and designed to carry various goods[3] packed on two Euro-pallets maximally weighting up to 1500kg - 2000kg. Upon delivery to final destination, common automated machines are used to automatically unload Caps and to transport cargo further up to the surface. Due to flexible planning and executing of the network system, unloading stations can be placed according to the need of the customer including direct delivery to a single customer by vertical conveyers (CARGOCAP, n.d.; Rijsenbrij et al., 2006).

Figure 11: Caps with fully automated horizontal (un)loading conveyors

Source: CARGOCAP (n.d.)

There are many tram freight systems that have been implemented so far. The pioneering one can be find in Dresden that has been used by Volkswagen since 2001 to supply its production while excluding delivery by heavy trucks and its related externalities. Dresden CarGo Tram drives on the same light rail that is used for passenger transportation, although it does not interfere with it (Jacyna & Szczepański, 2013; Living RAIL, n.d.). Zurich has followed and has implemented its cargo tram system for the purpose of waste disposal since 2003 (Jacyna & Szczepański, 2013). Similar solution for Istanbul city is proposed by Gorçun (2014) where urban rail systems and freight trams could be used exclusively for goods distribution from

[3]*Consumer and investment items, bulk goods, cargo, production components, building material, parcel and express freight, as well as food and allied products rank among the goods that may be transported via CargoCap* (CARGOCAP, n.d.).

suppliers to retailers for night deliveries or in combination with passenger transportation during daytime.

Another innovative solution might be crowdsourcing delivery - engaging incentivized individuals to provide "last-mile" delivery service from a retailer to the shopper on their way by using mobile application. This approach has been implemented by Deutsche Post DHL in Sweden called MyWays (DHL, 2013) while the latest news in the field report that Amazon.com, which is recognized as the world's leader in e-commerce, considers it as well (D'Onfro, 2015; Heller, 2015).

4. DISCUSSION ABOUT BENEFITS OF INNOVATIVE VEHICLES

According to CYCLELOGISTICS (n.d.), besides environmental benefits, the advantages of using bicycles are: no fuel costs, more simple and intensive exploitation of the existing road network, exclusion of parking or accessibility problem, independence on time windows for deliveries and on vehicle weight and size restrictions, adequacy for wide range of goods, especially for light goods, faster, reliable and flexible delivery service on short distances especially at peak hours and in small but high density commercial and residential areas. In some cases, a 40% reduction of delivery by implementation of cargo bikes have been reported (Torrentellé et al., 2012, p.139). Other advantages include decreasing delivery costs and positive image. Major obstacles refer to general behaviour change toward acceptance of bicycles as an alternative delivery vehicle in urban areas. Disadvantages especially regarding cargo bikes and cargo trike/quad include purchasing costs that amount between 2000 and 5000 Euros or 3000 and 12000 Euros, respectively, greater reliance on riders' training and strength, security, storage and parking concerns and questionable reliability on weather conditions and when fully loaded and dependency of cargo trikes on road network.

V-Feather is announced as a vehicle of the near future (CORDIS, 2015). Due to its modular structure, it enables better flexibility while reducing costs. Regarding Deliver, it should be used for postal services. An intended large scale production is expected to be launched by 2020 with market penetration by 2030. More detailed figures on economical side of these vehicles are unavailable.

According to some sources, delivery drones could be in use within the next five years (Mehra, 2015). Currently, the major obstacle to their introduction refers to legal restrictions and technical difficulties – such as battery power, unreliable location data, limited weight and travel distance. Other obstacles comprise increased costs of changing existing logistics process in compliance to drones usage, investment costs, security issues and weather dependency (Mehra, 2015).

Benefits of implementation of autonomous vehicles comprise improved carbon footprint due to exclusion of returning trips for reloading vehicles and increased productivity of delivery person. Parcel station loading contributes to increased speed, shorter delivery times, reduction of labour costs and increased efficiency. Major obstacles for introducing self-driving technology to public roads refer in general to law restriction, doubtful public acceptance in terms of safety and willingness to pay more for a driverless service (DHL, 2014c).

The benefits of the underground pipeline transportation system of CargoCaps includes the provision of sustainable, reliable, cost effective and energy efficient transportation solution convenient for supplying various establishments in dense urban areas with various goods. Although rail or road have bigger maximum load capacity, due to its independence on other transport modes and traffic jams, it administers continuous and safe flows within shorter delivery time in comparison to road transport. The processes of (un)loading are faster as well. The extendable and space-saving pipeline infrastructure is considered to be easy to build with ability to be set up in a close vicinity of an already existing underground infrastructure. The tunnelling costs, although very high, are estimated to be 4 to 8 times less than those for trains due to new infrastructure with smaller diameter (in case of CargoCaps of only 2m). The economic benefits include direct and continuous freight flows with JIT delivery at competitive transport prices that applies even to small consignments. The system is able to provide additional services to retailers such as stockkeeping, picking, reverse logistics activities etc. So far, the system of CargoCaps has been planned only for Ruhr region in Germany with prediction of further increase in volume and network extension due to rise of toll charges for road freight transportation and increasing returns from network investment. Disadvantages of the system refer to its application only to massively palletized or roll boxes freight that hinders a possibility to gain interests of an adequate market player to implement the system. The system's adaptation for usage in intermodal transport increases costs that outrange infrastructure costs savings (CARGOCAP, n.d.; Rijsenbrij et al., 2006). According to some estimation the full costs per tonne.km is 1,51 Euros/tonne.km that amounts to 70% of the costs with an average truck while infrastructure costs are about 52% of all costs (Kersting et al., 2005 as cited in Rijsenbrij et al., 2006).

As observed by Jacyna & Szczepański (2013), the major obstacle to introducing cargo trams is a difficulty to estimate the real costs of such a project. Gorçuns' case study on Istanbul city (2014) showed multiple benefits of urban rail transportation in comparison to urban road transportation that refer to costs, environmental conditions and externalities.

Crowdsourcing is considered to be a relatively new approach whose practicability and reliability of the service is uncertain. Behind companies' motivation to reduce shipping costs while enabling same-day delivery, there are many unsolved issues, such as secure delivery, theft or fraud (D'Onfro, 2015; Heller, 2015). Shopwing in Germany that has been proving similar service has closed down (Bershidsky, 2015).

5. CONCLUSION

In this paper, drawing on the augmenting importance of urban freight transport and its main characteristics, the terminology that relates to "last-mile" delivery has been defined and the "last-mile" delivery with its specifics has been explained within the broader system of city logistics. Based on the research of projects and initiatives introducing innovations to mitigate negative impact of urban road traffic in the "last-mile" delivery, a number of innovative transport vehicles have been presented and their benefits have been presented. These vehicles range from labour intensive bicycles, optionally electrical assisted, crowdsourcing, electric road and aerial freight delivery vehicles, underground pipeline vehicles and freight trams.

6. REFERENCES

Aggoune-Mtalaa, W. (2014). Solwing new urban freight distribution problems involving modular electric vehicles [available at: http://www.itsineurope.com/pdf/its10/Wassila%20Mtalaa%20-%20Best%20Scientific%20Paper%20SP%200056.pdf [available at: access September 13, 2015]

ALICE / ERTRACT Urban mobility WG (2015). Urban Freight research roadmap [available at: http://www.ertrac.org/uploads/documentsearch/id36/ERTRAC_Alice_Urban_Freight.pdf, access July 6, 2015]

Allen, J., Anderson, S., Browne, M. & Jones, P. (2000a). *A framework for considering policies to encourage sustainable urban freight traffic and goods/service flows - Report 1: Approach taken to the project*. London: Transport Study Group, University of Westminster.

Allen, J., Anderson, S., Browne, M. & Jones, P. (2000b). *A framework for considering policies to encourage sustainable urban freight traffic and goods/service flows - Report 2: Current goods and service operations in urban areas.* London: Transport Study Group, University of Westminster.

Annand, N., Yang, M., van Duin, J.H.R. & Tavasszy, L. (2012). GenCLOn: An ontology for city logistics. *Expert Systems with Applications*, 39 (15), pp.11944 – 11960.

Bektaş, T., Crainic, T.G. & Van Woensel, T. (2015). *From Managing Urban Freight to Smart City Logistics Networks*. Montreal: CIRRELT.

Benjelloun, A., Crainic, T.G. & Bigras, Y. (2010). Towards a taxonomy of City Logistics projects. *Procedia - Social and Behavioural Sciences,* 2(3), p. 6217–6228.

Bershidsky, L. (2015). Why German Startups Fail [available at: http://www.bloombergview.com/articles/2015-07-23/why-german-startups-fail, access September 13, 2015]

Boyer, K. K. & Hult, T. (2005). Welcome Home: Innovating the Forward Supply Chain. *Business Strategy Review*, 16(2), p. 31 -37.

Browne, M., Sweet, M., Woodburn, A. & Allen, J. (2005). *Urban Freight Consolidation Centres Final Report*. London: Transport Studies Group, University of Westminster

CARGOCAP (n.d.). [available at: http://www.cargocap.com, access June 27, 2015]

CORDIS (2015). V-Feather [available at: http://cordis.europa.eu/project/rcn/103964_en.html, access September 13, 2015]

Crainic, T. G. (2008). *City logistics*. Montreal: CIRRELT.

Crainic, T. G., Ricciardi, N. & Storchi, G. (2009). *Models for Evaluating and Planning City Logistics Systems*. Montreal: CIRRELT.

CYCLELOGISTICS (n.d.). [available at: http://www.cyclelogistics.eu/, access June 27, 2015]

Dablanc, L. & Rodrigue, J.P. (2014). City logistics: Toward a Global Typology, *Transport Research Arena, 5th Conference: Transport Solutions from Research to Deployment.* Institut Francais des Sciences et Technologies des Transports, de l'Aménagement et des Réseaux (IFSTTAR), Paris, 14-17 April 2014.

Dablanc, L., GIULIANO, G., HOLLIDAY, K., O'BRIEN, T.: Best Practices in Urban Freight Management : Lessons from an International Survey. TRB, Transportation Research Record (TRR), 2013, 22p. <hal-00854997>.

Dablanc, L. (2011). *City distribution, a key element of the urban economy: guidelines for practitioners*. In Melo, S. and Macaris, C. (Ed.). *City Distribution and Urban Freight Transport: Multiple Perspectives*. Chelthenam: Edward Elgar Publishing Limited, pp. 13 – 37.

DHL (2014a). Press Release DHL parcelcopter launches initial operations for research purposes [available at: http://www.dhl.com/en/press/releases/releases_2014/group/dhl_parcelcopter_launches_initial_operations_for_research_purposes.html, access June 27, 2015]

DHL (2014b). [available at: http://www.dhl.de/paketkopter, access June 27, 2015]

DHL (2014c). *SELF-DRIVING VEHICLES IN LOGISTICS - A DHL perspective on implications and use cases for the logistics industry*. Troisdorf, Germany: DHL Customer Solution & Innovation.

DHL(2013). DHL crowd sources deliveries in Stockholm with MyWays. [available at: http://www.dpdhl.com/en/media_relations/press_releases/2013/dhl_crowd_sources_deliveries_stockholm.html, access September 13, 2015]

D’Onfro, J. (2015). Amazon Developing Uber-Style Delivery Service.

[available at: http://www.supplychain247.com/article/amazon_developing_a_uber-style_delivery_service, access September 13, 2015]

Ehmke, J. F. (2012). *City Logistics*. In Ehmke, J. (Ed.) *Integration of Information and Optimization Models for Routing in City Logistics*. Springer Verlag - New York, pp. 9-22.

Edwards, J., McKinnon, A. & Cullinana, Sh. (2009). CARBON AUDITING THE “LAST MILE”: MODELING THE ENVIRONMENTAL IMPACTS OF

CONVENTIONAL AND ONLINE NON-FOOD SHOPPING. 14th Annual Logistics Research Network Conference, 9th-11th September, 2009, Cardiff.

EUCAR (n.d.). [available at: http://www.eucar.be/deliver/, access June 27, 2015]

European Cyclists' Federation (2012). FACTSHEET Cycling Logistics: the Future of Goods Delivery [available at: http://www.ecf.com/wp-content/uploads/Factsheet-ITF2012-CLOG.pdf, access June 27, 2015]

European Commission (2006). Urban freight transport and logistics. *An overview of the European research and policy*. Brussels: European Communities.

European Commission (2011). WHITE PAPER Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system COM(2011) 144 final, SEC(2011) 359 final, SEC(2011) 358 final, SEC(2011) 391 final. [available at: http://ec.europa.eu/transport/themes/strategies/doc/2011_white_paper/white_paper_com(2011)_144_en.pdf, access June 27, 2015]

European Commission (2013a). COMMISSION STAFF WORKING DOCUMENT A call to action on urban logistics *Accompanying the document* COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS Together towards competitive and resource-efficient urban mobility {COM(2013) 913 final}, {SWD(2013) 525 final}, {SWD(2013) 526 final}, {SWD(2013) 527 final}, {SWD(2013) 528 final}, {SWD(2013) 529 final}. [available at: http://ec.europa.eu/transport/themes/urban/doc/ump/swd(2013)524-communication.pdf, access June 27, 2015]

European Commission HORIZON 2020 The EU Framework Programme for Research and Innovation (n.d.) Bringing sustainable freight delivery to urban centres [available at: http://ec.europa.eu/programmes/horizon2020/en/news/bringing-sustainable-freight-delivery-urban-centres, access June 27, 2015]

GEOPOST (2015). [available at: https://www.geopostgroup.com/, access June 27, 2015]

Gevaers, R., Van de Voorde, E. & Vanelslander, T. (2009). Characteristics of innovations in last mile logistics – using best practices, case studies and making the link with green and sustainable logistics, *European Transport Conference, 2009 Proceedings,* Association for European Transport and contributors, Leiden, 5-7 October, 2009.

Gorcun, O.F. (2014). Efficiency Analysis of Cargo Tram for City Logistics Compared to Road Freight Transportation: A Case Study of Istanbul City, *14th International Scientific Conference Business Logistics in Modern Management,* Segetlija, Z., Mesarić, J., Dujak, D,.Karić, M., Potočan, V., Rosi, B., Jereb, B., Trauzettel, V. (ed.) Faculty of Economics in Osijek, Osijek, 16 October 2014, p. 189 – 204.

Heller, L. (2015). Amazon's Uber-Like Delivery Service Could Be Coming Soon [available at:http://www.forbes.com/sites/lauraheller/2015/06/16/amazons-uber-like-delivery-service-could-be-coming-soon/, access September 13, 2015]

Hübner, A., Kuhn, H. & Wollenburg, J. (2014). Last Mile Fulfillment and Distribution in Omni-Channel Grocery retailing: A Strategic Planning Framework [available at: http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2497000, access September 13, 2015]

Institute for City Logistics (ICL) [available at: http//:www.citylogistics.org, access June 27, 2015]

Institute of Transport Research (n.d.) [available at: http//:www. http://www.dlr.de/vf/en/DesktopDefault.aspx/tabid-2974/1445_read-35092/gallery-1/gallery_read-Image.12.21752/, access June 27, 2015]

Jacyna, M. & Szczepański, E. (2013). *Holistic approach to the ecological cargo distribution in urban areas with the use of multi-modal transport.* In: Brebbia, C.A., *URBAN TRANSPORT XIX*. Southampton: WIT Press, pp. 53 – 65.

Lange, V., Auffermann, Ch., Mahlstedt, K. & Mőde, S. (2013). *Urban Retail Logistics – Research into the Bundled Urban Store Deliveries of the Future*. In Clausen, U., ten Hompel, M. and Klumpp, M. (Ed.). *Efficiency and Logistics.* Berlin Heidelberg: Springer-Verlag, pp. 109-119.

Lindholm, M. (2013). Urban freight transport from a local authority perspective – a literature review. *European Transport \ Transporti Europei*, 54(3).

Living RAIL (n.d). CarGo Tram Dresden: urban freight transport on tramways. [available at: http://www.mcrit.com/livingrail/, access September 13, 2015]

LUXEMBOURG INSTITUTE OF SCIENCE AND TECHNOLOGY (n.d.). V-Feather - Innovative Flexible Electric Transport [available at: http://www.list.lu/en/project/v-feather/, access June 27, 2015]

Mehra, G. (2015). (8 Obsacles to Drone Delivery, for Ecommerce [available at: http://www.practicalecommerce.com/articles/91935-8-Obstacles-to-Drone-Delivery-for-Ecommerce, access September 13, 2015]

Patier, D. & Browne, M. (2010). A methodology for the evaluation of urban logistics innovations. *Procedia - Social and Behavioural Sciences,* 2 (3), p. 6229–6241

Rijsenbrij, J.C., Pielage, B.A. & Visser, J.G. (2006). State-of-the-art on automated (underground) freight transport systems for the EU-TREND project [available at: http://www.johanvisser.nl/mediapool/51/519305/data/State-of-the-art-AFTS-EU-TREND-March2006-FINAL.pdf, access September 13, 2015]

Russo, F. & Comi, A. (2012). City characteristics and urban goods movement: A way to environmental transportation system in a sustainable city. *Procedia – Social and Behavioural Sciences,* 39, p. 61 - 73.

Taniguchi, E. (2012). The Future of City Logistics [available at: http://www.delivering-tomorrow.com/the-future-of-city-logistics/, access June 27, 2015]

Taniguchi, E., Thompson, R.G. & Yamada, T. (2012). Emerging techniques for enhancing the practical application of city logistics models. *Procedia – Social and Behavioural Sciences,* 39, p. 3-18.

Torrentelle, M., Tsamboulas, D. & Moraiti, P. (2012). C-LIEGE: Clean Last mile transport and logistics management for smart and efficient Local Governments in Europe [available at: http://www.c-liege.eu/fileadmin/Media/cliege.eu/Downloads/Elicitation_Good_Practice_on_UFT_01.pdf; access June 27, 2015]

Visser, J.G.S.N. (2005). Urban freight transport policies and planning in Europe: an overview and classification of policy measures [available at: http://www.johanvisser.nl/mediapool/51/519305/data/Microsoft_Word_-_paperNUFCjvisser.pdf, access June 27, 2015]

Wohlrab, J., Harrington, T.S. & Srai, J.S. (2012) "Last Mile Logistics Evaluation – Customer, Industrial and Institutional Perspective". *23rd Annual Production and Operations Management Society (POMS) Conference*, Schoenherr, T., Seshadri, S. (ed.), Chicago, Illinois, April 20 – 23

YEAIR (n.d.). [available at: https://yeair.de/, access June 27, 2015]