BENCHMARKING OF EXPERIENCES AND TENDENCIES IN LAST MILE DISTRIBUTION

Títol	Benchmarking of experiences and tendencies in last mile distribution
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Resum	Urban last mile deliveries represent one of the major concerns in modern cities. The great increase of the e-commerce and just in time delivery is threatening with severe congestion large agglomerations. Considering this situation, the analysis performed in this project deals with different solutions that have been applied in European cities and NYC in order to cope with the raise of freight vehicles. These measures have been mostly financed by public bodies such as the European Commission in order to provide support to cities in the job of making last-mile deliveries more efficient. The solutions analyzed comprise different measures such as implementing urban consolidation centers, the piloting of off-peak deliveries, the use of alternative fuels, the implementation of new regulations among the most important. Through the detailed analysis of the performance of these measures it is possible to in-depth understand the drivers of each measure and the reason for which a specific measure was or not successful. The final aim of the project is to provide practitioners and council officers and planners with potential solutions to mitigate the effects of freight vehicles in cities and help to design and plan better solutions for cities.

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1 INTRODUCTION

1.1 The evolution of City Logistics

European cities are becoming denser in population. By 2030, it is estimated that 60% of the world's population will live in large cities. This tendency causes enormous challenges in terms of accessibility and livability having direct effects in freight logistics. As there are more residents in urban areas the volume of urban freight transport within the cities increases (Transmodal, 2012).

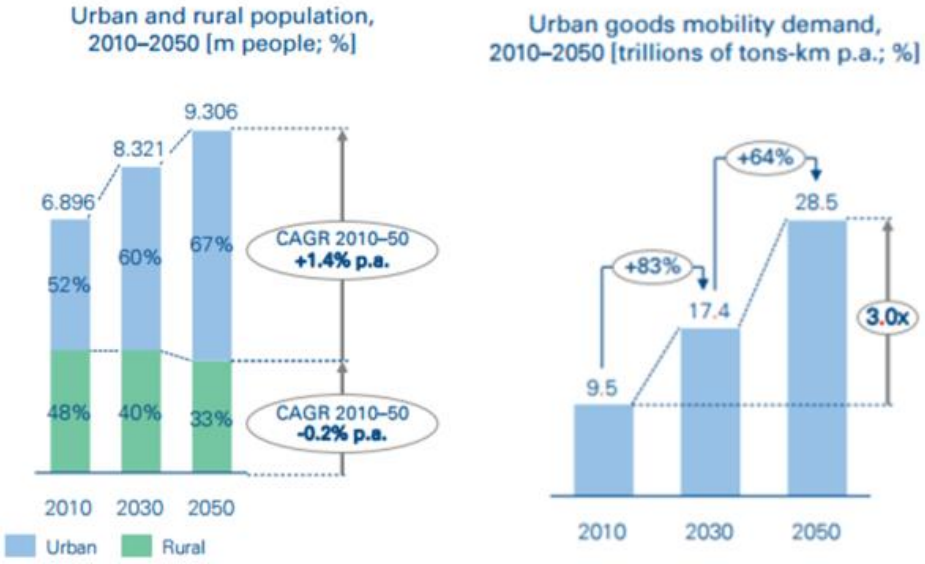

Figure 1. Prediction of urban population and UFD demand by 2050 (Van Audenhove, Korniichuk, Schoenmakers, & Lammens, 2011)

Growth of urban freight distribution

Today, 64% of all the trips happen within urban environments. Among other relevant data, it is remarkable to point out that the total amount of kilometers traveled by freight vehicles is expected to triple by 2050 (Van Audenhove et al., 2011). Although cities are addressing challenges associated to passenger mobility, strategies for last mile delivery of goods at city level are often missing.

Besides the growing population, shopping behavior is changing. City commercial areas are being unified and e-commerce is growing at double-digit rate. Last mile distribution is getting especial attention from investors and media for its economic

interest. More and more, new logistic models for city distribution are arising to face the wills and tendencies of society. New operators work together with the administration to create innovative solutions, their aim is to avoid high congestion and reduce pollution, and at the same time, be successful businesses.

Influence of e-commerce

The changes in consumer habits are causing many changes in urban logistics: on the one hand, a significant increase in ecommerce of both B2B and B2C, and on the other hand a crisis in traditional retail with decreasing turnover and closures of commercial establishments while phenomena take place such as flagship stores with increasingly larger stores that combine the offline and online experience and promote omnichannel. In last decade, B2B trade and e-commerce have experienced an important growth and impact in urban logistics. In 2015, e-commerce in Spain registered a growth of 26% over the previous year, exceeding a turnover of 20.000 million euros. Worldwide, the turnover of ecommerce is currently of 2.290 billion US dollars and according to different analysis this value is expected to continue growing in the near future.

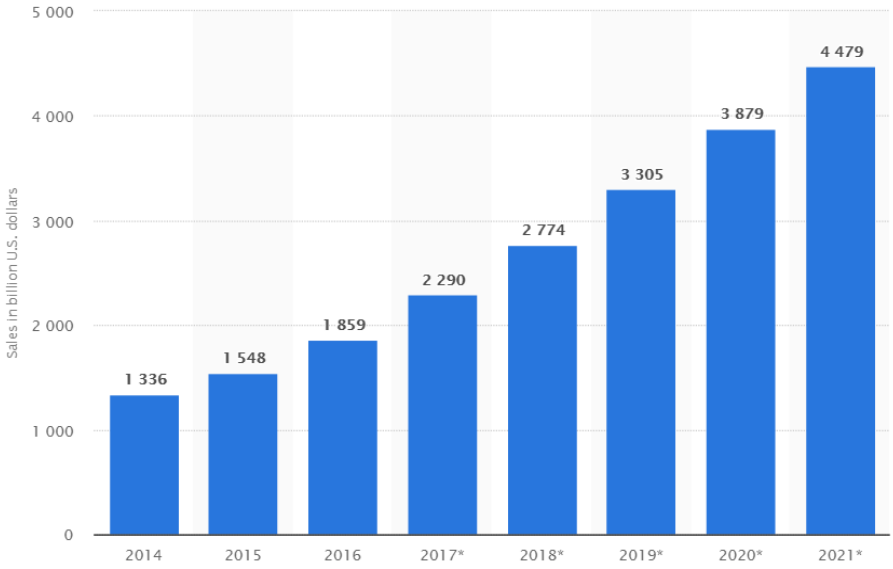

Figure 2. Retail e-commerce sales worldwide from 2014 to 2021 (Statista, 2017)

Commerce online allows customers to acquire goods from home, avoiding them to walk to retail shops. According to the European Commission, e-tailers consider that delivery services are one of the fundamental factors that determine a consumer's decision to shop with them, forcing retailers to develop a wide range of services offering flexible hours, reduced prices and fast deliveries. Hence, new generations are becoming used to those services hence producing a strong competition between carriers, who must come up with innovative services.

1.2 LMD impacts and Stakeholders involved

LMD externalities

The growth in urban goods mobility demand also contributes to a complicated urban congestion as well as the generation of other externalities. Although freight transport comprises about 15% of the total traffic flows in cities, it causes up to 50% of traffic pollution (Dablanc, 2011). It is due to the elevated emissions produced by the vehicles used.

Last mile distribution strategies can contribute to improve the negative impacts of urban logistics, mentioned in the Table 1. Those can be influenced by different factors and may even conflict and require careful prioritization according to the city characteristics.

Impact	Influencing factors
Urban congestion	Distance travelled and vehicle capacity
Number of trucks in the city	Vehicle capacity, load factor and congestion level
Pollution	Vehicle type, distance travelled and congestion level
Noise hindrance	
Energy consumption	

Table 1. Impacts of urban logistics

These impacts are taken into account by the developers of the freight regulation in cities. Nevertheless, the analysis of last mile delivery of goods involves several levels of complexity including multiple stakeholders. The complexity is due to each stakeholder having diverging interests and objectives:

Stakeholder objectives and interests

Among the stakeholders involved in LMD, the most relevant ones are: public authorities, transportation companies and retailers and consumers, which can be divided between the public and the private sector. For the implementation of any last mile distribution measure it is crucial to balance the benefits for both sectors.

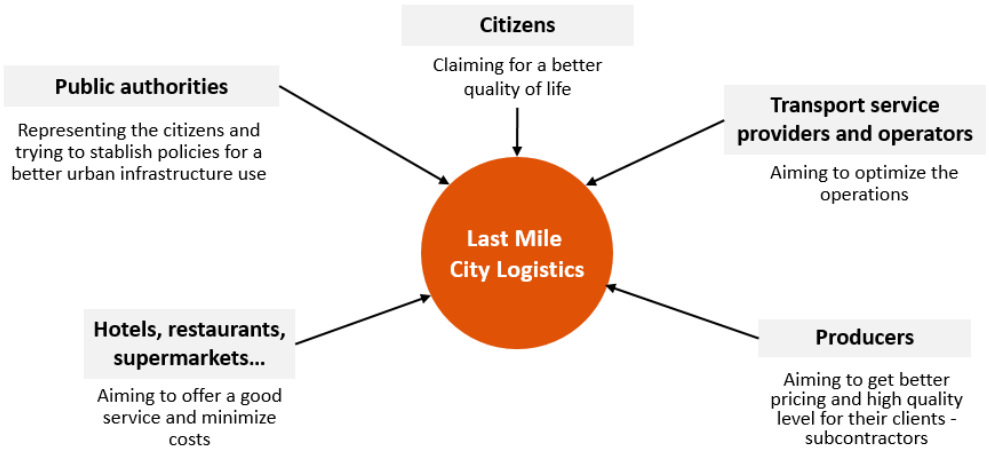

Figure 3. Stakeholders involved in LMD

As mentioned, the interests diverge among the different stakeholders, private sector invests its resources in reducing costs, while administration cares more about the impacts on the population and its health. Hence, economic and environmental conditions can be considered as the boundary conditions for the development LMD solutions, but also taking into account the technological limits and the political and regulatory conditions.

Contrasting with the limiters, there are multiple facilitators for the development of LMD. Infrastructure providers, system integrators, industry associations or equipment manufacturers, who work to offer opportunities led by society trends.

As the private operators are interested in these facilitators, they invest money and resources for its further development.

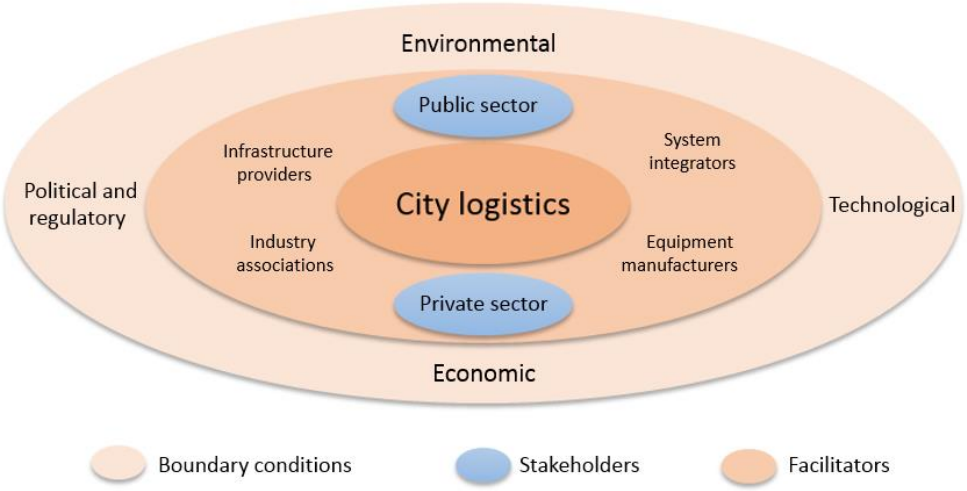

Figure 4. Boundary conditions and facilitators for the main stakeholders in City Logistics

One of the problems is that the different stakeholders often lack shared understanding of the priorities and most appropriate action levers. This complexity often leads to enforcement of partial, sub-optimal or even counter-productive decisions and solutions. For further improvements and innovation in this expanding sector it is needed the agreement, collaboration and cooperation of both parts.

1.3 Improvements and solutions in LMD

To enhance urban freight services not only logistic companies are trying to improve their operations by implementing new strategies or alternative vehicles but administrations are regulating the use of the urban public space. Overall, it is possible to differentiate two types of advances:

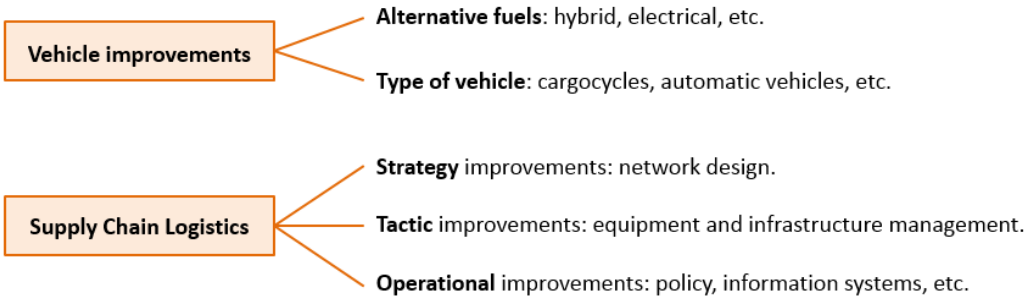

Figure 5. Classification of UFD improvements

Vehicle innovation

Thanks to technology it is possible to talk about vehicle improvements. On the one hand by alternative fuels, reducing fuel pollution. On the other, new types of vehicles are arising, integrated in some new supply chain strategies to improve the public space use and gain in distribution efficiency.

Supply chain innovation

Other type of improvements are related with the logistic planning and the supply chain. Due to the increase of demand, strategy improvements are needed to create new routes and network designs. Moreover, some tactical improvements are related with these strategies because of the necessity of new equipment and infrastructure.

And finally, to manage and enforce new transport systems, the improvements include operational modifications, involving information systems and policy regulations.

These kind of improvements are used to achieve the main goals in LMD. Regarding the supply chain improvements, among others, three remarkable strategies arising nowadays are: urban consolidation centers, off-hour distribution and pick-up points. All of them have a strong component of strategy improvement because require new route design. But also the tactical component is important, because the infrastructure needs to be adapted and well managed.

To control the strategies mentioned, some measures are imposed by the public authorities, with a stronger operational component. These are aimed basically to regulate the adequate behavior of the private sector for UFD operations, and are based in access and load parking regulation.

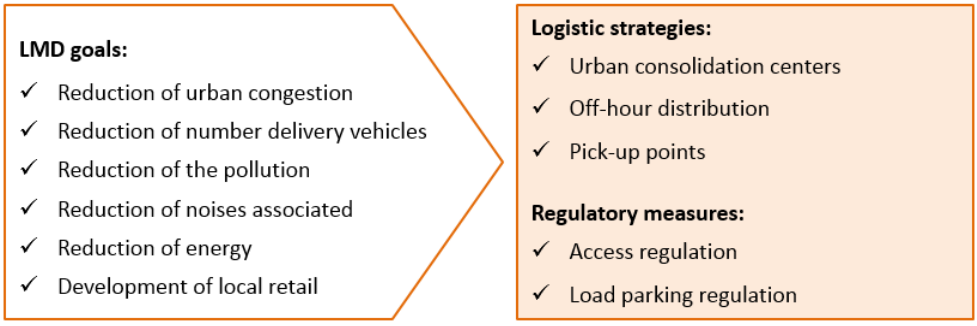

Figure 6. Logistic strategies and regulatory measures to achieve LMD goals

1.4 Benchmarking of experiences and tendencies in LMD

Purpose of the document

This study aims to be a reference on the current state of the last mile distribution sector within cities. It faces the identification of operator strategies and how these are combined with the new mobility city models that administrations are devising.

Methodological approach

For that purpose, an analysis of the most significant practices in last mile distribution around Europe and NYC has been conducted. The current situation is described using several examples and by comparisons, it is possible to perform an accurate analysis of tendencies that are influencing the present and could be determinant for the future of LMD.

Different kind of implemented practices are contemplated. These include ones that failed and others with successful results. It has been determined to study preferably the measures that have been carried out in the framework of the research and innovation projects financed by both European and National funds because of the existence of numerous information.

In addition, most of the initiatives have the participation of the public administration, which allow to have more information. To support information obtained, several interviews have been conducted with the administration members of some selected cities.

Document structure

First of all, three arising logistic strategies are characterized and exemplified: urban consolidation centers, off-hour distribution and pick-up points. In the next point, to complement those, regulatory measures imposed for the administrations are described for different cities, separating access and load parking regulation.

All the practices treated within each strategy or regulatory measure are compared with indicators, which are useful to evaluate and analyze the key success and failure considerations. This evaluation allow to extract the future trends for each strategy and measure and to have a clear idea of where the sector is located.

In addition, it is also considered the evolution of electrical vehicles and its possibilities for a freight distribution market penetration, considering its environmental, operational and economic issues.

Finally, other vehicle shifts and arising innovations in last mile distribution are presented with some example, including automated vehicles or crowdsourcing apps, among others.

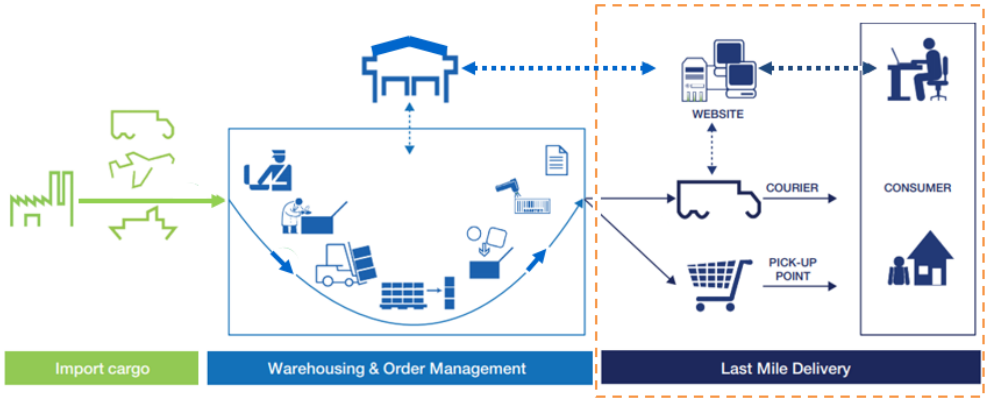

Figure 7. LMD identification, Damco

2 LOGISTIC STRATEGIES FOR LMD

Services provided by e-commerce and logistic operators are growing. This leads to a competitive market in which every business tries to create and offer new services with innovative solutions to attract customers. In addition to satisfy user willingness, logistic solutions need to cope with the regulatory measures applied by the public sector.

Despite operator strategies are not decided by the administration, politicians must orientate and define paths to make the strategies beneficial for the citizens, reducing environmental effects. Hence, despite the investments to change LMD models are done by private operators, it is good to promote positive models by funding pilot projects or providing facilities. Finally, the key point for success is to consider the balance among the society benefits and the minimization of costs for private operators.

Therefore, conventional shipments from the outer city warehouses destination to urban areas points are being substituted by the new LMD logistic strategies raised in last years. The new strategies affecting inner cities are based, above all the distribution phases, in LMD. Below, the most popular and successful models detected are explained in detail. These are based in creating consolidation centers in strategic points, replace deliveries to off-peak periods and provide pick-up points. Furthermore, specific cases applied in mid and big sized European cities are presented and compared to detect trends.

2.1 URBAN CONSOLIDATION CENTERS

Historic city centers with narrow streets are unfit to facilitate large-scale freight transport (Di Bugno, Guerra, Ambrosino, Boero, & Liberato, 2007). Consequently, streets in inner cities and shopping areas are frequently congested. Search for solutions is evident because large trucks do not need to carry out last mile small-scale deliveries.

A solution to substitute inner deliveries with large vehicles is to create urban consolidation centers (UCC) as intermodal platforms. UCC allow to bundle freight and carry out a more efficient last-mile distribution for a specific area. From UCC to retailers or customers, large trucks are replaced by alternative vehicles

improving the environmental conditions. These alternative vehicles are conventional vans in some cases, but increasingly alternative fuel vehicles and cargo-bikes free of emissions are promoted for this last mile to the final destination.

UCC goals

The main objective of UCC is to consolidate freight activities, being a step forward in city logistics. They provide reduction in kilometers driven by pollutant vehicles, making cities cleaner and healthier for citizens. In addition, a fleet turnover helps to prevent damage in delicate roads located in fragile old towns.

Advantages and disadvantages

As a barrier, several extra costs are introduced in the supply chain. A physical location to store the goods is needed and also an important investment in alternative vehicles is required. However, there is a variety of opinions about UCC implementation among users, some of them are against UCC since they consider lack of benefits. As the gains are mostly for the society it is difficult to find projects involving private initiatives without public grants. It leads this measure often relying on subsidies from the public sector, combined with a change in governance policies. (Ambrosini, Routhier, & Toilier, 2004) and (Regan & Golob, 2005) estimate that about 20% of the carriers are willing to use an UCC.

In Table 2 it can be seen the lack of advantages for carriers, contrasted by the positive gains for the local authorities.

Stakeholder	Advantages	Disadvantages
Carriers	-Trucks stay away of narrow streets and historical old towns.	-Fragmented deliveries. Need to coordinate the different parts. -More workers. -Increase in damage through extra handling.
Retailers	-Faster deliveries. -Possibility of receiving small volumes that allow to use less storage. -Attractive environment around retail shops, free of truck emissions.	-Higher service costs. More personal and dedicated warehouse. -Loss of the direct interface between suppliers and customers.
Local authority	- Less emissions and noise nuisance in inner cities. - Conservation of historical old towns. - Coordination and control over freight trips in fragile areas of the city. -Promotion of smart cities and use of new technologies.	-Necessity of important subsidies contribution to promote UCC.

Table 2. Advantages and *disadvantages of urban consolidation centers*

With accurate studies, authorities are facilitating to increase the number of UCC in several cities. In some places, before implementing the measure, it is tested in provisional transshipment points. Thus, it is possible to find practices performed with small mobile depots, as well as with large buildings, as consolidation centers.

Practices identified

For a good comparison, a series of pilots has been selected, testing UCC as main objective, with measurements and data available. Other criteria has been to choose representative projects using either mobile depots or buildings as warehouse. Besides some successful cases others present more difficulties to make a reliable analysis due to lack of data. The places and pilot tests identified are:

- Barcelona (2014), pilot using a transshipment depot as UCC within SMILE project (Valenciaport Foundation, 2014).
- Brussels (2013), pilot using a mobile depot as UCC within STRAIGHTSOL project (Verlinde, Macharis, Milan, & Kin, 2014).
- London (2014), pilot using a shared building for 3 boroughs as UCC within LAMILO project (Candem London Borough Council, 2016).
- Copenhagen (2011-2015), pilot promoted by the private enterprise Citylogistik-kbh (Bech Godskesen Andersen, Gammelgaard, & Olsen, 2015).
- Bristol (2004), one of the first UCC pilots in Europe within Civitas Vivaldi project (Hapgood, 2006)
- Madrid (2014-2016), pilot using a public building as UCC within FREVUE project (Ayuntamiento de Madrid, 2014)
- Stockholm (2001-2004), project involving a UCC for building material to cover a large construction area (Sunnerstedt, 2013).

2.1.1 SMILE pilots in BARCELONA, Spain (2014)

Barcelona has a complex old town street configuration with difficult access for freight vehicles. This aspect together with the City Council willingness to improve energy efficiency, were the main worries leading the city to develop a UCC trial.

During 2014, it was tested a program combining the use of electric tricycles (cargo-bikes or cargo cycles) and an urban transshipment terminal located in the inner city. It was designed to carry out LMD in the Barcelona District of Ciutat Vella, one of the places in the city with higher flow of people and goods.

Framework and background

Tourism and commerce generates many pedestrians in the narrow streets of Ciutat Vella and the vehicle access needs to be restricted. It is only allowed for freight service vehicles to enter the inner city in the hour periods 11.00-15.00 and 17.00-20.30. Transport operators have a very limited time window to deliver the goods, and they are mostly accumulated between 9.00 and 11.00. Regarding cargo cycle there are no restrictions, since they are considered other class of vehicles.

Taking profit of the lack of restriction for cargocycles, at the end of 2010, Vanapedal started to work. It was born as a pioneer company offering the transshipment of some packages with destination to Ciutat Vella. Some years later, in 2014, UCC pilots were performed using Vanapedal services. It meant a step forward for the city, discovering a good alternative for LMD, and for Vanapedal, who got the City Council support.

The pilots were within SMILE, a project focused on the promotion of innovative energy-efficient solutions for urban freight logistics. The project was publicly funded by EU and addressed to several cities in the Mediterranean.

The features (Valenciaport Foundation, 2014) for the pilot were:

- Give a minimum space to operate in a transshipment point
- Boost private participation, with minimum support from public authorities.
- Oriented to parcel services and similar shipments (fashion shops …).
- All shipments served in the same day. No warehouse services.

Stakeholders

- Barcelona Municipality.
- CENIT (Centre for innovation in Transport), as academics.
- DOYMO (Desarrollo Organización Y MObilidad), as study supporters.
- Vanapedal, as carriers.
- SABA Parking, providing night parking of the tricycles and re-charging, toilet facilities for workers, and other supplies. The transshipment depot was located just above a SABA car park.

Implementation details

Operation methodology

Large vehicles left the goods in the UCC and, during the same day, Vanapedal managed to deliver these parcels to the retailers and final customers. Three operators had regularly used the transshipment terminal and three more were using it occasionally. Regarding the vehicles, in the first three months it was enough with one tricycle, but when more operators joined the pilot a second tricycle was added.

Infrastructure

The intention was to store the parcels as short time as possible in order to use a small depot and ensure fast deliveries. The total space occupied by the transshipment terminal was 73 m^2 (33 m^2 for a covered module and 40 m^2 for a porch to load/unload). Covered module was composed of three different spaces: a small office to process information, a dressing room for drivers and a storage room for parcels if necessary.

Figure 8. Transhipment terminal (Valenciaport Foundation, 2014)

This temporary structure was located in a studied city location. Before the pilot, Vanapedal was operating without a depot for the exchange of goods. It suppose an important acquisition on commodity for carriers, allowing to improve the efficiency of the project. Besides, the small depot provided shelter and security for the transshipment.

Pilot phases

The implementation of the pilot was composed of six phases introduced and analyzed chronologically from December 2013 to June 2014.

- 0. Design of the pilot (some years ago- December 2013).
- I. Physical Implementation, ICT preparations (December 2013). Installation of terminal by modules, electricity, phone and internet services and test of the new bikes.
- II. First weeks of operation (January 2014). Experimentation phase with operators that were previously working with Vanapedal.
- III. Including new operators (February-March 2014). Using the funds of the project, it was promoted the usage of the terminal. Operators could use the terminal for a limited number of packages without any charge.

- IV. Evaluating the enlarge services (April-May 2014). It was even considered to extend the pilot offering pick up services or as collection point for individual users. However, it was not viable for the design of this pilot test.
- V. Improving operations (April-May 2014). Reconsideration of routes with the experience collected.
- VI. Considerations and conclusions (May-June 2014).

Results

Evaluation methodology

To evaluate the measures, a series of indicators were established based in a Multi Actor Multi Criteria (MAMCA). The criteria used was divided in 4 different impact areas: environment, society, economy and transport. The stakeholders considered to establish the specific indicators where the shipper, the receiver, the logistic provider, citizens and authority.

Quantitative results

The most relevant result shows that incorporating an UCC, cargo bikes can save kilometers currently performed by vans or trucks within the city. It was approximated that each tricycle saves approximately 32 km of van circulating every day. Using this approximation the improvements in energy efficiency is evident, saving during the pilot nearly 8,000 km, 1.9 tons of CO_2 and 2,402 liters of fuel.

Qualitative results

Regarding a qualitative evaluation, one of the main achievements was to achieve that several transport operators worked together sharing a cargo bike. It was proved that last mile deliveries become more efficient when sharing needs.

Overall balance

Lack of economic profit is the main problem for Barcelona UCC, since deliveries turn to be more expensive for the retailers. It is the reason why there could be concerns when implementing this freight solution measures. The solution to encourage UCC could be based to introduce city regulation.

Due to the success of the pilot in attracting interest among stakeholders, the city council, together with all the partners involved, decided to continue the pilot test for four months, after the funding was over. Finally, the key considerations identified for a permanent implementation were: to remove the limitation of number of packages, to optimize orders in parcel delivery and to search for an economic equilibrium.

2.1.2 TNT express mobile depot in BRUSSELS, Belgium (2013)

In 2013, Brussels tried the concept of Mobile Depot as a UCC. It consists of a trailer fitted with a loading dock and warehousing facilities. It was transportable and drove every day from a hub located outside the city to a point inside the city where it remain stationary. From there, last mile deliveries were carried out by green vehicles, including small electric cars and electrically driven cyclocargos.

The case was studied and carried out in the most critical area of the city regarding the demand of small deliveries. The selected location involve Schaerbeek, Etterbeek and Saint-Josse-ten-Noode districts, in total an area of just over 12 square kilometers, densely populated and highly urbanized in the city center.

Figure 9. TNT Express Mobile Depot (Cherrett, 2015)

Framework and background

Freight deliveries in Brussels, as in other European big cities, are closely related to the high congestion traffic levels during some hours of the day. Having to deal with busy streets, it is difficult to carry out deliveries just-in-time as the trend sets. It turns to be expensive for the transport operator to keep the inner city deliveries reliable and fast. Moreover, distribution is carried out using vans and small trucks, which increase the carbon footprint.

These facts show that the inner city deliveries are a problem. This led both private and public sector to search for viable alternatives to develop in Brussels. In 2013, a private parcel service provider, TNT Express, in association with Vrije Universiteit Brussel engine a new concept of UCC to deal with last mile delivery efficiency. It was tested for a period of three months and supported with European Commission funds.

The UCC pilots were set up within Straightsol project (STRrategies and measures for smarter urban freiGHT SOLutions), a consortium of the European Commission that is pursuing several objectives for smarter and more cost-efficient city freight distribution.

Stakeholders

- Brussels municipality.
- TNT Express, as operators
- Vrije Universiteit Brussels, as research conductors.

Implementation details

The implementation of the pilot took place between May 28th and August 22th, 2013. The TNT hub in Brussels area is located at Brucargo. From there, to carry out deliveries to the city, two types of vehicles were used before the pilot: diesel trucks to do the pallet deliveries, and pick-ups and diesel vans for parcels and documents. The pilot project was based in parcels and documents, since the cyclocargos that are used in combination with the mobile depot cannot transport big volumes.

Operation methodology

Every day, the mobile depot was loaded in TNT Express hub at Brucargo, on the Brussels outskirts. At 9.00, the depot was driven to a car park in Parc du Cinquantenaire, in the city center. There, it remained stationary all day long and last mile deliveries were done. Around 18.00, the depot drove back to the hub again to be loaded for the next day.

Infrastructure

The TNT mobile depot could be extended and it was composed mainly of 3 different spaces: an office room, a bathroom and an area for loading, unloading and sorting. While it is on the road the mobile depot had normal dimensions (14 x 2.5 m). When parked the trailer extended automatically to its full size of 14 x 6.5 m. The depot dimensions could hold a total of 11 containers for the parcels.

From Parc du Cinquantenaire, four dispatch riders on electrically assisted cargo bikes picked up the parcels to deliver them around the city center. Some days, depending on the freight volume, it was needed some extra vehicle or some could be saved. In total, during the period of the test 5,286 deliveries were performed, which meant 4,534 cyclocargo driven kilometers and 2,544 truck driven kilometers.

Results

Evaluation methodology

To evaluate it, different indicators were set following a Multi Actor Multi Criteria Analysis (MAMCA). These were collected before and during the pilot if possible or derived, calculated or modelled if they were impossible to measure. So, results were based in a comparison with the scene before the pilot to find out whether the new concept makes a real improvement.

Environmental impacts

Comparison was done considering the number of kilometers driven. The number of diesel kilometers decreased from 1.291 van kilometers weekly to 141 truck kilometers weekly. It meant the following variations of pollutants: -24% of CO_2 and SO_2, +48% of NOx, -59% of $PM_{2,5}$ and -22% of PM_{10}. It was noticed a clear and positive difference, since cargocycles were practically emission-free.

Societal impacts

Citizens living or passing in the area were interviewed. They generally agreed to consider as a better solution the mobile depot than the current way performing deliveries. Specially, they strongly believe that the use of a mobile depot and cyclocargos will have a positive impact on the visual and physical nuisance of the area. This aspect was better evaluated than the improvements in congestion, in accessibility and in safety offered by the measure.

Other considered impact for society was the space consumption. It was considered the space needed at the depot, the space needed on the road for driving and the space needed for stopping, also considering the difference in number of stops. Results showed that delivering with vans requires 8858.1 m² a week compared to 2461.1 m² when using the mobile depot.

Transport impacts	The punctuality was also considered. Business as usual approach got an elevated percentage of deliveries in time. Nevertheless, the difference was less than a 10 % of deliveries with delays.
Economic impacts	Finally, it was perceived a notorious change in operational costs. The method tested was twice as expensive compared with the situation with vans.
Overall balance	The main key consideration to keep considering the mobile depot as a viable option is to make the project more sustainable in economic terms. To go further with UCC method tried in Brussels, solutions could be based on increasing the used capacity of the trailer, using it with less features or partnering with a supplier that is already operating electric vehicles. It can also be considered to change the depot location within the delivery area. Based on the results of the pilot, TNT will further develop the concept as part of Citylab, a project under the Horizon 2020 programme.

2.1.3 Edmonton Consolidation Centre in LONDON, UK (2014)

Camden, Enfield and Waltham Forest Councils worked together to improve their supply chain system in order to obtain environmental benefits. To achieve this, a pilot was developed for the implementation of a shared UCC. The aim was to centralize deliveries in one point, and from there, sort the goods out into fewer vehicles for the last mile. The UCC was clearly not designed to be a warehouse for long term storage.

As a UCC, it was used a building located in Edmonton (Enfield) with enough space for load and unload. It had 186 m^2 warehouse, operated by DHL to serve in total over 400 council buildings in central and north part of the city.

Framework and background

London's population has grown by more than one million of inhabitants in last decade. This situation has led to an intensification of deliveries inside the city. Authorities worried on the secondary effects that it can suppose, have been working for sustainable distribution. In 2007, Transport for London published the London Freight Plan with several objectives to achieve more efficient distribution. It also promoted to try alternative solutions on city deliveries. Thus, in the following years some projects were carried out involving different London Boroughs.

The Boroughs of Camden, Enfield and Waltham Forest identified similar needs regarding last mile deliveries. Different courier companies were working in the same area and this supposed many vehicles in the streets being most of them driving below their capacity. In addition, due to the lack of available depot space for overnight parking, council staff was authorized to take vehicles home, sometimes incurring the same distance again as the usage during the working day (Lamilo project, 2014).

In the summer of 2012 the Chief Procurement Officer at the London Borough of Camden embarked on a project to further explore the consolidation center concept and the feasibility of such a solution for Camden and its borough partners. The consolidation center opened in January 2014 and is transited from pilot project to a permanent solution (Transport for London, 2015).

The pilots were carried out within LaMiLo (Last Mile Logistics) project, receiving funding from two sources, the European Union and the Mayor's Air Quality Fund.

Stakeholders

- London Municipality.
- DHL, as operator.
- Office Depot, Banner, Janitorial Express and Bunzl Greenham, as initial suppliers.

Implementation details

Infrastructure	UCC was located in Edmonton, within the borough of Enfield. It had 186 m^2 warehouse space positioned in a strategic position with easy access to the road network. Overall, it served 300 council buildings across 3 London Boroughs (Camden, Enfield and Waltham Forest). An area of 143 km^2 was covered, which is approximately equivalent to 10% of London geography.
Operation methodology	The pilot was implemented in January 2014, for a 9 month period. The organization of the UCC was an everyday routine. The goods were received from the suppliers from 6.30 to 8.00. Then consolidation was done and deliveries were delivered to final customers between 9.30 and 16.00 by DHL. To do so, two 7.5Tn Euro 5 emissions standard vehicles were used. The center was capable of handling a wide variety of goods, ranging from library books, furniture, gym equipment, retail products, facilities equipment, ICT equipment, documents and mail and cleaning supplies to records, linen, ambient foods, office supplies, stationery and public health literature. (Transport for London, 2015)

Results

Evaluation methodology	To obtain quantitative results, the new supply chain model has been compared with the conventional model. Several differences in environment, economic and transport efficiency terms have been detected.
Environmental impacts	With the implementation of the UCC, 29 vehicle trips per week were reduced, which mean a 46% reduction. The new model also optimized the kilometers driven from 3.139 to 1.720 kilometers per week, a reduction of 45%. Overall, this meant a significant environmental impact, reducing pollutants as follows: 41% of CO2, 51% of NOx and 69% PM10. In addition, during the pilot a reduction of 72% empty vehicle running was also detected. Aside of that, consolidation of goods helped to increase the control around the movement and arrival of deliveries.
Qualitative results	Regarding the transport effectivity, it was well valuated that the goods were delivered based in just in time principle. It eliminated the need to store them overnight or for long period, and as consequence, it implied a reduction in warehouse space. This reduction of space was also related with economic impacts. Optimizing the space in the city of London is very positive due to expensive rates demanded by owners. However, the economic gains produced due the reduction of space, together with the reduction in number of vehicles, is counterpoised. The fact of having fragmented deliveries increases the costs of the supply chain because there are more companies involved.
Overall balance	To face the financial risk for a future implementation, some ideas have been considered. City Council could help to set-up a UCC and perhaps subsidizing part of it, and once it is up and running to ‘pull away’ and let the logistics operator run it on their own. (Candem London Borough Council, 2016) The model needs to be improved, especially to adjust the economic costs. Nevertheless, the balance was positive and as a proof, it is seen that there is further willingness to implement it. To keep searching, whilst the trial was scheduled to run until September 2014, the London Borough of Camden extended the contract with DHL to April 2015. And recently, in March 2016, the practice has been recognized at a prestigious London Transport awards ceremony as winner of a “Contribution to Sustainable Transport 2016”.

2.1.4 Citylogistik-kbh project in COPENHAGEN, Denmark (2011-2015)

A pilot concerning an UCC was carried out in Copenhagen after an accurate study. The project was operated by a private company Citylogistik-kbh and was a step forward to change the supply of goods model to the city center.

All goods were shipped to and consolidated at a distribution center outside the city center and then transported by the city logistics provider, Citylogistik-kbh, to the customer. In addition, the project also implied the promotion of a greener city, since environmentally friendly electric vehicles were used for last mile distribution.

Framework and background

Copenhagen has an extension of 86,2 km^2, with a medieval city center with an area of 1 km^2. About 500 retailers are located in this area; on a daily basis 6.000 trucks enter the center. Trucks may only visit stores in this area between 9.00 and 11.00 am. The larger LEZ harbors approximately host 2.000 retailers; trucks require a certificate to enter this zone. To be eligible to obtain the certificate, a truck must either be equipped with an effective particle filter or meet Euro 4 emission standards or higher. Currently, the city of Copenhagen charges 12,5 € for the certificate, which is valid during the entire lifetime of the vehicle (Van Heeswijk, Larsen, & Larsen, 2017). These restrictions, among other measures demonstrate the involvement of authorities to improve the efficiency of UFT. Besides regulations, other innovative solutions have been considered.

From 2011 to 2012, a study about a possible UCC, "Citylogistik – analyze og konceptudvikling", was conceptually developed. Then, as continuation, a demonstration was performed from June 2013 to March 2015. Citylogistik-kbh UCC has been running with subsidies from the Danish Transport Authorities. It aimed to test the business model of a city logistic concept that would be financially sustainable after the end of the subsidized demonstration period.

It was a demand from the Danish Transport Authority that after the first 1.5 years of the 3 year demonstration project, there had to be an evaluation of whether it seemed likely that the earnings of the company would be sufficient to reach break-even within 3 years. It was not been possible to reach this goal and the Danish Transport Authority had therefore to end the project (Bech Godskesen Andersen et al., 2015). Nevertheless, further studies, as (Van Heeswijk et al., 2017), are being carried out to provide favorable conditions for a UCC in Copenhagen improving its chances for a long term.

Stakeholders

- Copenhagen municipality.
- Danish Transport Authority, as supervisor.
- Citylogistik-kbh ApS, as operator.
- Danmarks Tekniske Universitet (DTU) and Copenhagen Business School (CBS), as study conductors.
- Transportens Innovationsnetværk (TINV), as coordinators.

Implementation details

The implementation of the designed tests started on June 2013 for a duration of 3 years. At the beginning, 150 retail shops were involved as final receivers, and during the pilot 10 more customers joined the program.

Infrastructure

To optimize the model, a perfect location was found to place the UCC. Most of the goods sent to the city center arrived from the south of Copenhagen, through E20 highway. Thus, the UCC was implemented close to this highway and close to the city center.

From the UCC, parcels were delivered using two electric cars, one Buddy and one Peugeot. These were driven every day by the same drivers in order to build up trust to the shop owners.

From the beginning the project did not result convincing to retailers due to the reduced number of participants. Therefore, Citylogistik-kbh kept advertising about the project to possible clients who were relative close to the route. They offer coordinated deliveries to the shop, checking the shipments on behalf of the costumer and handling the shops shipments out of the city.

Results

Some of the expected benefits for the UCC measure were achieved, even though the results were not positive at all because of the poor participation of retailers.

Success factors

The positive considerations for the different stakeholders were analyzed in (Bech Godskesen Andersen, 2014) during the project:

- For retailers: a shopkeeper does not have to receive multiple deliveries, but gets it all in one vehicle load.
- For transport companies: they can deliver the goods to the distribution center on the outskirts of the city.
- For shippers: by using the Citylogistik-kbh for deliveries, they provide a better service to their clients.
- For the city and its inhabitants: it increases the attractiveness and livability of the city through less congestion, noise and air pollution.

Overall balance

The lack of shops wanting to take part in the project was not expected. Only 10 customers joined since the project started up, which was not significant. Communication did not benefit the acquisition of new shops. Also, it was not expected to spend an average of 3 months between the first contacts with the shop and the first delivery performance.

Aside of that, it was noted the difficulty for the operator to set the delivery costs in every case because every costumer receive different amount of parcels.

2.1.5 Broadmead freight consolidation scheme in BRISTOL, UK (2004)

Bristol Consolidation Centre was one of the pioneer experiences of freight consolidation in complex European city centers. In 2004, it was tested a UCC located close to the main motorways passing through the city and 11 km away from Bradmead area, in the city center.

Freight arriving to the city, with destination to Broadmead area, was collected in the UCC to be delivered in short time to final destination. Precise delivery schemes were studied in order to improve transport efficiency.

Framework and background

Few UCC projects were developed when in 2002 the city of Bristol, associated with Civitas Vivaldi project, started to think about the idea of an UCC. The main attracting principle was to consolidate the goods destined to the city center.

The idea went further and in 2003 a freight consolidation scheme was studied in order to reduce delivery vehicles operating in the area. Broadmed area, in the city center, was the targeted area having over 90.000 deliveries per year. 118 retailers were surveyed to identify how to maximize the consolidation. As a result, delivery patterns and operational constrains were set for medium size, non-perishable and non-high value goods. Then, a six-month trial started in May 2004, being the first city center based scheme in the UK. The trial was free of charge to participating retailers, involving about 20 out of 300 retail units in the area. To try how the measure worked it was not needed economical support from the City Council because it was 100% EU public funded by Civitas Vivaldi project.

In order to promote the measure, in July 2004, an open day was carried out. It consisted on several talks and activities oriented to the range of stakeholders involved (DfT officials, FTA, Local politicians, research institutions, etc.). Due to the successful reception, the trials were extended to July 2005 recruiting 40 retailers and with a second vehicle in use.

This funding was time-limited, covering the scheme development phase from 2002 to 2006. For the continuation and further implementation, the project joined another EU project, START (2006-2009). Nowadays the measure is still active using two electric vehicles. DHL had a key performance indicator (KPI) to recover 40 % of the total cost through retailer contributions. In addition, Bristol City Council has been supporting the UCC from its revenue budget. It successfully managed to mainstream the scheme and secure further funding.

Stakeholders

- Bristol Municipality and the Broadmead Board.
- DHL Exel, as operator.
- Several shops located in The Galleries Shopping Centre and others, as retailers.
- IBIL, as charging point provider.

Implementation details

Infrastructure	The location of Bristol UCC was set close to M4 and M32 motorways. It was established on an industrial estate on northwest Bristol, 11 km away to Broadmead area, with a typical journey time of 25 minutes. The total space to consolidate the goods was 465 m2 and it was operated by DHL Exel.
Phases	The implementation of the tests were carried out in June 2004, for six months. Later, an extended phase was introduced until July 2005. During the first phase, the UCC was carried out to serve about 20 retailers, which were increased to 40 for the extended phase. The number of vehicle also needed to be doubled. At the beginning only one 7,5 tone Euro III standard engine was used, but for the extension a 17,5 tone with the same characteristics was introduced.
Operation methodology	Consolidated deliveries were carried out during the morning and the retailers receive deliveries with a frequency from 1 to 3 times a week. The majority of retailers served were related with entertainment and technology. Moreover, clothing, cosmetics, household goods and food shops took part in the pilots.

Results

Quantitative results	To express quantitative results, the situation during the pilot were compared with the previous situation with independent deliveries. A reduction of 68% in delivery vehicle movements for participating retailers was detected. The reduction of movements meant in total, up to October 2005, 42.772 km avoided and notorious positive impacts for the environment savings: 5.28 tons of CO2, 840 g of NOx and 11.374 g of PM10 emissions.
Qualitative results	In addition to these measured quantities, a Retailer Satisfaction Survey was carried out. According the results presented in (AL-Azzawi & Mathie, 2011), most of interviewed retailers (75%) chose the consolidation scheme. They positively assessed the improvements of the service and the opportunities in cost reduction. 45% of them perceived that working with consolidated deliveries, the staff were less stressed and have improved morale. And 38% also highlighted that the efficiency of deliveries enabled them to spend more time with their customers. This questionnaire was also useful to confirm that no retailer had received any loss or damage of stock. Finally, the survey was a potential promotion tool, due to the fact that 94% of retailers would recommend the service to another retailer.
Overall balance	Thanks to the success of the trials, after extending them as much as possible within EU projects, it was implemented an UCC shared for the cities of Bristol and Bath. It is running with the only problem of delayed and infrequent deliveries. The main aim is to attract more retailers to improve these parameters and make a more consistent and reliable scheme. Besides this measure, the city of Bristol has been very active in reducing environmental emissions to the atmosphere and in 2015, the city was recognized with the European Green Capital award.

2.1.6 FREVUE project in MADRID, Spain (2014-2016)

Between 2014 and 2016, it was tested in Madrid an UCC within the FREVUE project. Deliveries with destination to the city center were operated by three private partners, using electric vehicles for LMD. The pilot also counted with a strong support from the public sector. City Council collaboration, among other contributions, with a space concession. It was located in a good position in order to develop efficient delivery schemes and to cope with the high city congestion rates.

In addition, ICT solutions were a significant implementation to further improve the environmental impacts of the delivery model. These were tested through the participant electric vehicles used for LMD.

Framework and background

In terms of population, Madrid is the third largest metropolitan area in the European Union. It is a dense city with high populated center, characterized by narrow streets and a high density of shops. These features produce an elevated vehicle flow to cover the demand of the inhabitants, and consequently, pollution levels are too high.

There is an estimation asserting that more than 33.000 operations of loading and unloading of goods are carried out daily in the central part of the city. In 2014, the load/unload places capacity was over 8.000 vehicles, 25% higher than in 2004. Overall, this sector is responsible of 14% of the NOx emissions in the city (Fernández Balaguer, 2014). This was detected as a problem and Madrid joined FREVUE project with the aim to reduce congestion as well as the emissions created by the freight sector. The activities carried out in the city were based in testing a possible implementation of an UCC for the deliveries with destination to the city center. To cope with the objectives, electric vehicles performed LMD from the UCC to the destination. A studied pilot started to run in February 2014.

As the project was in the FREVUE framework, it received a big amount of EU funds. 562.749 € out of 926.662 € were EU contributions. The other 40% was financed by Madrid Municipality and by the partners.

Apart of the pilot, the city of Madrid is working with other measures to promote electric mobility. In 2015, some incentives and advantages for non-internal combustion vehicles were set in a decree (Ayuntamiento de Madrid, 2015) to promote a shift in urban mobility. These regulations include incentives through parking or access regulations.

Stakeholders

- Madrid Municipality.
- TNT, SEUR, Calidad Pascual, as carriers.
- ITENE, as data processor.
- Empresa Municipal de Transportes de Madrid (EMT), as coordinador.
- Renault, Nissan, Mercedes and IVECO, as vehicle providers.
- IBIL, as installers and managers of vehicle recharging points.

Implementation details

The pilot in Madrid was focused on alimentation and parcel shipments. The operators leading the tests were Calidad Pascual, from alimentation sector, and SEUR and TNT, dedicated to the distribution of parcels. The three together meant a large scope of freight quantities towards the city center:

- 6000 kg/day with 44 daily services by Calidad Pascual.
- 400 kg/day with 75 daily services by SEUR.
- 580 kg/ day with 24 daily services by TNT.

Figure 10. EV installation for FREVUE in Madrid (Ayuntamiento de Madrid, 2014)

Infrastructure

To carry out the transshipment of goods, it was adapted a 500 m2 part of the old fruit and vegetable market Legazpi. It was selected to be located close to M-30 motorway and close to the city center. A part of that requirement, it was taken into account that the place was municipality property (contribution of Madrid Municipality for the project). It had the necessary requirements in terms of surface, maneuver space, warehouse space, bathrooms, security, etc. In addition, it was a representative building, since it was built to be used as a market and logistic center.

Fleet used

The pilots were carried out at the beginning with 4 electric vehicles (2 Renault Kangoos, 1 IVECO Daily and 1 Mercedes Vito). Other vehicle providers were interested to join the project, and with the pilots in course Nissan added more vehicles. At some period during the pilot there were 10 vehicles simultaneously, but during most of the project it was enough to use between 4 and 6.

An application was developed and installed in the vehicles to allow an efficient management of recharging points. These points were spread along the delivery area and in the UCC, installed and managed by the private enterprise IBIL.

In 2015, within the decree written by the City Council (Ayuntamiento de Madrid, 2015), there was a measure affecting freight mobility. Load and unload period for eco-friendly vehicles was increased from 8.00-13.00 to 8.00-15.00.

Results

Evaluation methodology	To obtain accurate results, data loggers developed by ITENE were installed in the vehicles. These collected data as GPS position, velocity, electric consume, battery level, remaining autonomy, stops carried out, etc.
Quantitative results	Environmental preliminary results, extracted on October 2016, quantified the emission savings in of 16 kg CO2 per day. It means in other words, 4 tones savings of CO2 per vehicle and year, which could mean a significant economic gains for the operator as well.
Qualitative results	In addition to the environmental positive impacts for the society, other stakeholders also noticed about some benefits. Carriers, who normally base the results in the economy balances, found that the new model reduce costs in terms of fuel savings and vehicle maintenance. Other aspects well valued for the authorities were the improvements in the transport freight system and the promotion of new technologies in the city. Moreover, they welcome the visibility of that kind of initiatives in which administration is economic and socially collaborating.
Overall balance	The project had to finish because the concession of the UCC space is over. The initial plan was to use Legazpi market only for the pilots, from 2017 City Council plan to carry out other activities in this public space. Nevertheless, the initiative is going further because the private stakeholders are interested in continue this supply chain model and they are attracted by council support. Nowadays, Calidad Pascual are already looking for some private space to use as a UCC. It is a clear sign of the pilot success.

2.1.7 Hammarby consolidation center in STOCKHOLM, Sweden (2001-2004)

Hammarby consolidation center was an initiative to consolidate building materials for a redevelopment project in the former docklands and industrial area of Stockholm.

The center was located at the entrance to the construction site and received small deliveries of less than 4 pellets. The center provided temporary storage and deliveries were then consolidated and delivered by smaller vehicles to the specific site. A web-based computer system was used to coordinate deliveries (Beittoei, 2007).

Framework and background

In 2001, it was planned to create a new housing district in Stockholm, Hammarby Sjöstad. At that moment, it was the largest ongoing urban development in Sweden on the early residents. There was an estimation of 30.000 people to live and work in the redeveloped area, which meant 8.000 new apartments and thousands of new office spaces.

The construction needed to be completed in 2015. It was required a huge amount of building material and it was planned to concentrate the main material movements in three years (2001-2004). It could suppose many trucks transporting goods. In order to reduce the number of trucks, it was studied and implemented an UCC. It aimed the idea to reduce heavy vehicle traffic in the city. Heavy trucks supposed 50% of the city pollution emissions, despite accounting only for 5-10% of the total traffic.

Originally, 95% of the project's funding came from the City of Stockholm authorities (including EU funds through the CIVITAS Trendsetter programme). The total budget for the project was 20 million SEK (approximately 2 million €). But once operational, the benefits of the UCC to its users became better understood and the charges were raised. The result was that the public share of funding was reduced to 40% by the end of the project, suggesting that there was an increasing willingness to pay for the service (Scott Wilson Ltd, 2010).

Stakeholders

- Stockholm Municipality
- Construction suppliers

Implementation details

Infrastructure

The transshipment center was located in southern Stockholm for the construction of the new zone of Hammarby Sjöstad. It was in a strategic place, just in the entrance of the construction area. The total space available in the UCC was 8.000 m2, divided in 3.500 m2 of indoor and 4.500 m2 of outdoor storage.

Operation methodology

Four pallet trucks from different suppliers carried out deliveries to the UCC, where were unloaded by forklift truck. Then, after a computer registration, the received materials were moved to the corresponding warehouse area according the final destination. To distribute stored material, dedicated trucks made LMD twice a day. Overall, 700 tons of building material were distributed per day.

It was also developed a smart traffic guidance system in order to prevent traffic jams on the site and avoid congestion problems.

Results

Quantitative results

Delivery period was clearly more efficient than a hypothetic scenario without the UCC. It had been estimated that the 700 tons would be carried out through 400 uncoordinated deliveries each day without UCC. It makes evident the gain in sustainable terms of the project.

Other quantitative indicators had been extracted from a comparison of the project with the scenario in the absence of the UCC. It had been saved 38 km per day and vehicle, which meant a 60% reduction. The vehicle load factor improved from 50% to 80%. Efficiency was also checked regarding time savings, improving from 60 minutes per stop to 6 minutes per stop.

Environmental impacts were determined based on reductions of fuel consumption and noise indicators. CO_2 decrease 90% and the limit of 55 dB (A) was exceeded only 260 times per day, compared with 360 times per day without UCC.

Qualitative results

Carriers positively evaluate the initiative. Specific for this kind of logistics, the UCC provide a more secure place to store deliveries, it helped to improve the theft and weather damage problems compared to the situation of storing them out on side.

Overall balance and further situation

Among other influent aspects, thanks to the success of this UCC project, Stockholm keeps developing this kind of measure in the city. Since 2003, it is running an UCC in the old town for food consolidation and LMD. It was funded by EU at the beginning but since 2005 it is entirely financed on own terms. Moreover, in the beginning of 2017 started an UCC operated by Bring (transport company) and Regn Sells (waste management company). It is also destined to LMD and waste pick up.

2.1.8 Comparison

There are two groups of tests according the length of performance. It is differentiated the short-terms pilots, from 3 to 9 months duration, from the long-term ones, for few years. Projects requiring more infrastructure adaptation were planned to be tested for longer time. It was the case of Madrid and Bristol. In the other hand, shorter periods were enough to extract results from pilots using small depots as UCC, like in the cases of Barcelona or Brussels.

Depending on the objectives of each project, it was possible to find diverse kind of LMD fleet. Study cases prioritizing an improvement in pollutant emission by a fleet turnover tended to use eco-friendlier vehicles. Madrid pilot, where electric vehicle fleet was used, was within FREVUE project aimed to reduce emissions in city logistics. In other cases, it was also a priority to reduce the large vehicle flow in the inner part of the city, as Barcelona and Brussels. They used tricycles and cyclocargos respectively. Other projects with the main purpose oriented to consolidate the goods for a more efficient supply chain, as the case of Stockholm, use standard emission vehicles.

Objectives apart, the year when the performance took place is close related as well with the fleet used. Older projects, as Bristol and Stockholm, had less access to electric vehicles. In more recent projects, as Copenhagen and Madrid, it is seen a clear tendency to use zero emission fleet.

Some quantitative indicators has been extracted in order to analyze and compare the results in the different studied cities. In the case of Copenhagen, as the project had a strong private component, there is lack of data. It has been selected as determining indicators: driven kilometers saved and environmental, economic and delivery impacts.

Efficiency impacts

It is an indicator difficult compare and analyze in terms of kilometers per day due to different scopes of performance. Therefore, it is classified in percentages of reduction.

In general, the schemes allow a reduction around 60%, depending on the number of retailers, the area features and the vehicle load factor. In Brussels, there was a reduction of 89%, but it is based on the diesel kilometers reduction. It is that high because cargocycles are emission free.

Environmental impacts

Pollutant emissions improved in all the studied cases, but not in the same scale. Reductions are determined by several factors including the LMD fleet, the area covered and congestion levels of each city, among others. That is the reason why this data cannot be related proportionally with any other number and it is varying from 24% to 90% in the studied cases.

Economic impacts

In general, UCC cases where the freight distribution is based in small deliveries the economic impacts are negative. Despite the kilometers saved, the shipment goes through several processes, implying an extra economic cost. In Brussels, UCC deliveries turn to be twice more expensive in operational costs.

Moreover, if the shipments involve several companies as in Barcelona, the final cost per delivery is significantly higher. Compacted and larger volumes operating for bigger retailers, as Calidad Pascual case in Madrid, are associated with better economical balance. Furthermore, in this case it is considered a positive balance due to use electrical vehicles and fuel savings associated. Another case where the

economic impacts are not considered as a problem is in Stockholm, where time and kilometers savings counteract the operational costs of an UCC.

Delivery impacts

Regarding the transportation service each case detected different changes influenced by the UCC. While Brussels and Bristol had an increment of delayed deliveries, London well valuated just in time principle. Spanish cases did not notice changes in delivery times. Additionally, London retailers point out that more frequent deliveries led to a reduction of warehouse space used for goods.

Stockholm project consider as a relevant impact the time savings, quantifying it as a reduction of 54 minutes per stop. In this case, the consolidation of deliveries was more important than the punctuality of these to the final destination.

City	Barcelona	Brussels	London	Copenhagen
Project	SMILE	STRAIGHTSOL	LaMiLo	Citylogistik-Kbh
Year	2014	2013	2014	2011-2015
Length	6 months	3 months	9 months	3 years
UCC dimensions	73 m2	91 m2	186 m2	-
LMD fleet	2 tricycles	4 cyclocargos	2 Euro 5 vehicles	2 electric cars
Driven km saved	64 van km per day	89% reduction of diesel km	66%	-
Environmental impacts	7,6 kg CO2 saved/day	24% reduction of CO2	41% reduction of CO2	-
Economic impacts	Expensive deliveries	UCC model twice more expensive costs	UCC model more expensive	-
Delivery impacts	No relevant changes	10% increment of deliveries with delay	Well valuated just in time	-

City	Bristol	Madrid	Stockholm
Project	Civitas Vivaldi	FREVUE	CIVITAS Trendsetter
Year	2004	2014-2016	2001-2004
Length	1 year	3 years	3 years
UCC dimensions	465 m2	500 m2	8.000 m2
LMD fleet	2 Euro 3 vehicles	6 electric vehicles	8 Euro 4 vehicles
Driven km saved	68% reduction of trips	-	60%
Environmental impacts	9,78 kg CO2 saved/day	16 kg CO2 saved/day	90% reduction of CO2
Economic impacts	-	Positive balance due to electric vehicle benefits	Not contemplate as impediment
Delivery impacts	Delays in deliveries	No relevant changes in delivery demands	Time savings of 54 min/stop

Table 3. Urban consolidation centers comparison indicators

2.1.9 Conclusions and tendencies of urban consolidation centres

UCC commonly meet the objectives of citizens and local authorities but usually fail in meeting the economic objectives of the private stakeholders (Browne et al., 2005). Society is satisfied with UCC implementation, but they are not the ones who decide how the supply chain works.

The increasing rates of parcel deliveries, together with the stricter restrictions imposed for the administration in inner cities, makes obvious that the number of UCC will tend to growth in a close future. Nonetheless, it still remains to be seen how the centers will be operated. Regarding the cases studied, it can be stated that public sector is going to support them by funds, but UCC may become a need for private logistic companies to meet city regulation and could come totally privatized.

As a tool to foresee UCC future, looking for meet interests and create benefits for all the stakeholders, some key considerations has been selected. These include aspects related with the different sectors participation and UCC features.

Cooperation from public and private sector

It is seen in Copenhagen pilots that the concept failed because they only addressed the objectives to one of the stakeholders. Public sector is clearly the most satisfied stakeholder involved in UCC measure, appreciating improvements related with the traffic and environmental benefits. But in the other hand, the private logistic sector is appreciating a significant variation of costs in deliveries.

To balance it, cooperation of public sector is a requisite by funding the initiatives. Otherwise, the administration could study some changes in the legal framework to stricter conditions of LMD, which lead private operators to develop these satisfactory strategies for the society as an obligation. Public sector is not directly related with the supply chain of private companies but can significantly influence them to choose the model.

It is also important to point out as a limitation of UCC installations the impact of the growing rental price of urban warehouses. Depending on the city it become more influent, but a real solution to deal with that problem is the support of public sector, by granting spaces.

Carriers and retailers participation

Private carriers and retailers do not value many benefits because they base their activities in economical balances. Despite the public sector can contribute significantly by facilitating a legal framework, private sector is mostly who finally decide how to carry out the deliveries. So, it is needed to improve the benefits for them to get their impulse and open mind.

A key consideration to go further is the interaction between businesses, which lead to set agreements and work together in order to reduce costs. It has been proved that shared UCC are economically satisfactory. Another detected point to improve the acceptance of deliveries could be detail the costs to gain in trust.

Legal framework

Apart from funds, strong support from the politic sector could be achieved by strategic plans or changing local laws. The main focus followed to promote the measure by laws are the access restrictions in specific complex urban areas.

Delivery time restrictions are an option, encouraging the UCC by enlarging the access window to distribute freight. In the other hand, LEZ and CCZ can have a

positive effect as well. If the goods arrive consolidated to the specific zone from an UCC, less vehicles are used.

Another consideration based on the legal framework is to validate and encourage the legality of available spaces to create UCC in or near the city center.

Specific research for each city

Disassociated with the stakeholders involved, it is needed to have into account other considerations related with demand areas, dimensions and location of the UCC.

Normally UCC are built to serve the city centers but, as it is seen for example in the case of Stockholm, an UCC could be stablished to serve other parts of a city. Freight demand studies help to delimitate the area of service as well as to determine the kind of deliveries supported. Once known the area and parcel features, it could be determined the dimensions needed for the transshipment of goods. Regarding the location, the UCC needs to be close to the delivery area and to the main highways reaching to the city.

2.2 OFF-HOUR DISTRIBUTION

High-density cities dedicate an elevated number of resources to offer a complete transport infrastructures system, which can be saturated during the peak day hours. This situation is counterpoised at night and at early morning hours, the called off-peak hours when the same space is well below the corresponding capacity. Regarding this reality, and taking profit of the low demand in these hours, different alternatives are appearing to improve the efficiency on freight distribution within city centers.

OHD goals

Off-hour deliveries follow several objectives based on traffic and environmental matters; it also increases the competition between transportation companies and reduces conflicts between carriers and other public space users. Studying this concept properly can be a step forward to promote the livability in dense cities.

Advantages and disadvantages

Beyond these gains, the measure also follows some secondary effects that require careful studies. On one hand, it increases the noise level at night. On the other hand, it can reduce the work of logistic platforms and consolidation centers located outside the city.

The variation in costs is also an important point for analysis. Costs may increase due to the presence of workers in stores overnight and the use of silent vehicles and equipment. However, at the same time, logistics costs may be reduced by achieving a faster and more efficient freight distribution.

This kind of measure is a practice that is spreading, in several places there are interesting initiatives and commitment in this methodology. Despite the generalization of the concept, it should be noted that the limits of peak hours are not fixed for all cities. That lack of uniformity is due to the variability of the times of high demand in each city. The boundaries of these hours may be determined depending on the city by the opening business hours or by the noise emission standards, among others.

To shift the delivery model, the stakeholders involved are basically carriers and retailers, but also the society represented by the local authorities. Listed below are the advantages and disadvantages for each of the stakeholders identified:

Stakeholder	Advantages	Disadvantages
Carriers	-Shorter travel times. -Increment in the vehicle capacity, more readability. -Work atmosphere with less stress for the driver.	-Additional costs. Adaption of silent systems. -Risk of illegal parking in load/unload places.
Retailers	-Elevated percentage of freight received in the opening. -Availability to accept deliveries at any time.	-Higher service costs. More personal. -Elevated risk of insecurity. -Mistakes in the deliveries. -Less stock in the central hours and in the afternoon.

Stakeholder	Advantages	Disadvantages
Local authority	-Less traffic and pollutants during peak hours. -More efficiency of the urban space. -Increase the road safety.	-Noise problems during deliveries. It can be solved using silent vehicles.

Table 4. Advantages and disadvantages of off-hour distribution

A tendency to add OHD is well seen by local authorities as they are reacting to the studies. They started to assess the impacts of relaxing access restrictions for vehicles that meet noise emissions standards. This approach comes together with a set of pilot tested in numerous places either by funded projects or by its own initiative, with the objective to assess the feasibility of OHD and perceive a response by every stakeholder.

Practices identified

In this review, it has been selected a series of pilots testing OHD as main objective with measurements and data available. Other criteria has been to choose representative projects in both large and medium size cities, some successful ones and others with some trouble to analyze. The places and pilot tests identified are:

- Stockholm (2014-2016), OHD pilot project promoted by City municipality (Fu & Jenelius, 2017).
- Barcelona (2003-2007), two series of OHD pilots within MIRACLES-CIVITAS and SILENCE projects (Hayes, 2006; Musso et al., 2006).
- Brussels (2014), OHD pilot within STRAIGHTSOL project (Andersen & Eidhammer, 2015)
- New York City (2009-2010), OHD pilot coordinated by the City Department of Transportation (Holguín-Veras et al., 2010)
- Denmark (2011-2013), several small-scale OHD pilots within "Distribution i Ydertimerne" project (Kolstrup, Henriques, Hansen, & Zoega, 2014).
- London (2012), OHD implementation during the Olympic Games operated by Transport for London (Transport for London, 2012).

2.2.1 OHD pilot project in STOCKHOLM, Sweden (2014-2016)

The first off-peak trial in the world using environmentally friendly vehicles was experimented in Stockholm between 2014 and 2016. The goal was to examine the feasibility and potential of night delivery considering factors such as delivery times, environmental and noise aspects, requirements on storage facilities and delivery vehicles (Stockholm Stad, 2014)

Two trucks were specially designed to reduce noise and pollution nuisance. These trucks had different engine type, worked separately and with different schemes during two phases. The first vehicle, had a hybrid diesel-electric engine and carries out dedicated deliveries to 3 grocery stores. The other truck was gas-fueled and made consolidated deliveries of small volumes to multiple customers.

Framework and background

As a growing city, the demand for goods distribution in Stockholm increases constantly. In 2006, light and heavy vehicles accounted for 17% of all traffic entering the city, and 19% of the traffic exiting the city during the congestion charging hours (Transek, 2006). It kept increasing, and in 2010, there were approximately 10,000 heavy vehicles (over 3,5 tones) on the roads every day (Stockholm Stad, 2014).

This growth made the city council apply restrictions to fight against noise and environmental pollution caused by UFT. Some studies, (Jenelius & Koutsopoulos, 2013) and (Rahmani & Koutsopoulos, 2013), determined the average speeds in the inner city during the day, these were useful to delimit the congestion peak hours. It served as well to know that in off-peak hours (22.00-06.00) the average speed is around 30%-50% higher than day average.

Finally in 2014, using these studies, the Stockholm municipality promoted and financed OHD pilots tested from 2014 to 2016.

Currently, heavy vehicles above 3.5 tons are forbidden in the inner city from 22:00 to 6:00 due to concerns for noise caused by traffic and delivery activities. Even so, as it is seen in the description of the pilot project not all are restrictions, but also trials. Within the pilot project, the City of Stockholm issued special permits for these trucks to deliver goods during the restricted time period.

Stakeholders

- Stockholm municipality.
- Chalmers and KTH, as research conductors.

Phase 1 (2014):

- Svebol Logistics, as carrier.
- Lidl Sweden, as shipper and receiver. The store chain company selected the stores based on the feasibility of receiving goods during off-peak hours.
- Volvo, as vehicle provider.

Phase 2 (2015-2016):

- MartinServera, as shipper.

- Hotel and restaurants, as receivers.
- Scania, as vehicle providers.

Implementation details

Operation methodology

The first phase was tested in 2014. A hybrid diesel-electric truck made dedicated large volume deliveries to three grocery stores. It was carried out every night between 22.00-06.00 with three separated trips, one per each store. The vehicle started from the logistics company's terminal and went to the warehouse located in the north of Stockholm to do three different trips warehouse-store and went back to the terminal. The first store had personal to assist the unloading process, while the other two were unassisted. To help the driver, a special equipment was installed in these two stores.

The majority of the journey during this phase was made on the highway. A control unit managed a zone system in order to take profit of the vehicle engine. In this way, the electric motor was used in the inner city and the diesel one elsewhere.

The second phase was tested with a gas-fueled truck between 2015 and 2016. The procedure for this phase was different as well, consisting in consolidated deliveries of small volumes to multiple customers. Starting from a warehouse located in the south of Stockholm, a different tour was planned every day to run during both the day and off-peak hours.

The route was covering many places in the inner city but also others dispersed in the entire Stockholm region. The route was studied and adjusted to prevent and avoid maximum congestions. For example, between 15:00-18:00, the most congested period, truck delivered to locations with concentrated customers in order to avoid getting stuck.

Figure 11. Night deliveries in Stockholm (Scannia)

Results

Evaluation methodology

The results were extracted based in a comparison of data collected during off-peak hours and during the day. To obtain day data for the 2014 phase, there was an experimental period of 15 days when the truck did the same delivery route in daylight. For the 2015-2016 phase it was simpler and it did not need extra experimentations because the service ran during the day and off-peak hours.

Service efficiency

Regarding the driving efficiency there is an overall improvement. During the 2014 phase, the most outstanding differences were in the trip covering the first store, with an improvement of approximately 31% in driving speed (from an average of 62,1 km/h during the day to 46.0 km/h in off-peak hour). For the other store trips, there are slight changes. In the 2015-2016 phase, it was been noted an evidence of severe congestion during the period 15.00-18.00 with an average speed of 14.0 km/h, being approximately 59% higher during off-peak hours for a similar area.

Driving speed is related with the time savings. For consolidated deliveries it was determined an improvement of 4-5% of time based on service stops per hour (3,73 versus 3,58 stops per driving hour), and for dedicated deliveries up to 12% overall savings. Even so, the most evident differences are found at the trip to the first store, with the most congested delivery route during the daytime, a saving of 13 minutes was registered (44,2 minutes compared to 31,2 minutes).

Environmental impacts

Other concept to consider is the environmental impacts. Based on the fuel consumption and considering both phases, there is a CO2 reduction around 20-40% compared with the worse moment of the day, from 15.00-18.00 (30,96 liters/100 km compared to 27,23 liters/100 km).

Noise nuisance

The only problem observed during the trials was the noise complains. In 2014, one of the 3 delivery points had to be withdrawn due to the continuous complains. For the future trials the city council is considering to use a noise map to know where it is suitable to implant such deliveries noise wise.

Overall balance

In conclusion, it is seen that the driving and fuel efficiency impacts are moderated compared to other case studies due to Stockholm do not have as high congestion levels as other big cities. Nevertheless, it is crucial to evaluate the positive impact on transport efficiency and time saving, as well as the reduction of vehicles in the city during the day. Once it tried, wholesalers do not want to go back to previous model because of their stress and safety, they want to keep with the method.

In general, the results are positive and nowadays, despite the project is finished, the idea is to go further. There is an extension for these tests inside the project ECCENTRIC, led by Madrid, in which is being tested another truck transporting building material and waste. It is well seen and there are plans going on to add more night trucks in the future.

2.2.2 Night deliveries in BARCELONA, Spain (2003-2007)

The first off-hour freight distribution trial in the inner city was made by the national chain of supermarkets Mercadona. It was carried out with an adapted 40 tones truck with special unloading procedures. It can deliver goods to inner-city stores without having to stop at a regional distribution center, loading more freight than the ones running during the day.

The objectives were to test the social impact in terms of noise and the improvements for the operator, considering the return of investments for vehicle adaption and night shifts. As the results demonstrate the feasibility of silent overnight deliveries, some years later during 2006 and 2007 further trials were carried out with two more operators.

Figure 12. Quiet night deliveries in Mercadona Valencia street outlet (Hayes, 2006)

Framework and background

The city of Barcelona suffers an elevated congestion in specific hours. In the morning peak periods there is an accumulation of vehicles towards the inner city and in the evening peak periods towards the suburbs, where the logistic centers are located. This means high emission and long driving time for city center deliveries.

In the past, the City Municipality's Mobility Services had been involved in some experiments that led the city to tackle noise reduction and try the silent off-peak hour distribution using an adapted 40 tons truck. The supermarket chain Mercadona, member of AECOC (Spanish suppliers and retailers' association), was the operator who ran the pilot in 2003 in a trial within the MIRACLES-CIVITAS project and with collaboration of the Barcelona Municipality, through its Road and Traffic Department.

The positive feedback initiated a three-year research project called SILENCE, co-funded by the European Commission. It was a collaborative program involving the Municipal Mobility Services, the Municipal Noise Unit and three private transport operators, which have made trials between March 2006 and May 2007.

In Barcelona, there is a decibel limitation set for the traffic operation at night. During the pilots, the Municipality introduced an exemption in these night restrictions. Despite this exemption, the deliveries had to be performed by special trucks, using silent equipment.

Stakeholders

- Municipality of Barcelona
- Mercadona, Condis and Lidl, as private transport operators.
- Renault and Iveco, as vehicle providers.

During the period of application, the traffic urban police collaborated to measure noise levels in places and residences close to the supermarket sites.

Implementation details

Operation methodology

In both cases, 2003 and 2006-2007, implementation details were similar but the second pilot had a larger scope. The distribution trials were carried out in two different periods during the day, from 23.00 to 24.00 at night and from 05.00 to 06.00 in the morning. It was also taken into consideration a vehicle adaptation which consisted in carpeted loading platform and truck bed, low-noise rubber wheels and low-noise pneumatic lifting-system technology (truck ramp and fork lift). Besides the truck equipment, the employers were trained to use a set of procedures aimed to minimize the verbal communication and other unloading operations.

Results

Evaluation methodology

During 2006 and 2007, a total of 14 noise measurements were registered at 11 different locations. The devices were placed in 5 different districts, 5 located in street environment and 6 in residences close to the supermarkets. Measurements were performed in different times, around 05.00 and 23.00, but also around 03.00 in order to make a comparison.

Noise nuisance

It was identified at the noise registrations that the operation that caused most noise was mainly the truck arrival (62% of cases) followed by the goods unloading (15% of cases). In 55% of cases, the levels during all the procedure exceed reference guideline levels. Despite that fact, the devices registered an average of 23.5 dB(A) inside residences during unloading, only 0.3 dB(A) greater than those recorded before loading started. Regarding the street environment, the average maximum value was only 0.1 dB(A) greater in the case with deliveries. It can be stated that the noise levels vary slightly with or without the implementation of large lorries at night.

Efficiency impacts

The main strength considered by the operator is the reduced time for the vehicles spent in city centers, reducing traffic congestion and, consequently, noise emissions. This shift in distribution led to a saving of 1 hour per trip. Bigger trucks as the ones used in the pilots offer a gain in efficiency. It has been demonstrated that two 40 tones trucks can replace up to seven conventional trucks used during the daytime.

Environmental impacts

It is also available some data about the differences in fuel consumption. The program resulted in lower fuel consumption per ton transported, with an overall reduction of 70,000 tons of CO2 in 2010.

Overall balance

Mercadona estimates that full investment in vehicle adaptation is achievable within 3 years. A key concept for that return of investment is a nationwide upscaling. By the end of 2010, this operator implemented its Silent Nighttime Unloading in 407 stores (31% of the total).

Other related operators are keeping an eye to these implementations. It is evident that some small supermarkets cannot adopt a delivery pattern using such large vehicles, but the success on this concept guide them to investigate further implementations in Barcelona.

2.2.3 Colruyt and Delhaize OHD pilots in BRUSSELS, Belgium (2014)

The biggest Belgian food retailers Colruyt and Delhaize proposed to shift some of inner Brussels deliveries to off-peak hours. The idea to avoid congestion and provide a good customer service in a cost efficient way was very attractive.

The demonstration took place between January and April 2014. It involved five retail shops where deliveries usually take place between 8.00 and 20.00. Some of these trips were displaced at off-peak hours in order to have deliveries evenly spread over 24 hours.

Framework and background

Multiple traffic service providers rank Brussels as the most congested European city. Drivers in Brussels face average delays of over 33% during peak traffic hours. These delays do not only affect the everyday commuter, but also the inner-city freight deliverer. (Andersen & Eidhammer, 2015)

Facing this idea, in 2014 two important retailers working in Brussels wanted to challenge the delivery system introducing night freight distribution. As the plan also involved benefits for the society in terms of reduced congestion, increased traffic safety and fewer emissions, the project pulled forward. Colruyt and Delhaize conducted a pilot test with the cooperation of the city council in the framework of the STRAIGHTSOL project.

One of the problems caused by vehicles crowd is the noise emitted. In order to control it and improve the livability in Brussels residential areas, there is a ban for most of the shops to receive goods at night.

The project included several investments for quiet equipment. Even so, as a precaution the trial started to run only in evening hours. It produced positive vibes and led the selected stores to be released from ban to carry out a second phase adding trips at night hours.

Stakeholders

- Brussels Municipality.
- Colruyt and Delhaize, as promotors and operators.
- Vrije Universiteit Brussel, as research conductors.
- European Environmental Agency, as supervisors.

Implementation details

Operation methodology

To carry out the project, and in order to obtain clearer results, the off-peak hours had been divided in three periods: morning (06.00-08.00), evening (20.00-22.00) and night (22.00-06.00). In the other side, day hours are considered from 8.00 to 20.00.

The implementation was done in two steps. Before introducing all changes directly at night, the different stakeholders were willing to see a feedback for the evening off-hours, basically to obtain the extra noise produced.

To start, a complete delivery routine was tested between 20.00 and 22.00 to register the noise levels. The European Environmental Agency validated it and allowed to

continue with deliveries at night for a period of two weeks for Colruyt shops and one week for Delhaize shops. No complaints were received and the levels did not exceed the limits. This led to a second phase that started in January until April 2014, with a temporally shift spreading deliveries throughout the 24 day hours.

Two Colruyt and three Delhaize stores acted as a receiver points. Euro 6 and CNG diesel vehicles with special silent complements (silent trailers, covered unloading docks, silent rolling stock and educated drivers) were used to provide Colruyt a total of 99 deliveries during the second and decisive phase of the trial.

Results

The evaluation results are based in Colruyt performance because Delhaize did not provide data on time to analyze the project. A comparison was done using the results of the pilot and the data collected in some conventional trips.

Efficiency impacts

Regarding the total average speed, it is clear that morning and evening hours are better than office hours, exceeding them in around 10 km/h and 12 km/h respectively. Night delivery routes appear to be 50% faster (33 km/h to 48 km/h).

Nevertheless, the total time differences are not relevant. Minutes gained with shorter travel times at night deliveries are contrasted with time spent in unloading procedure in the store. At night no shop employees are available to assist the vehicle. Concerning the total time savings, the best moment to deliver is between 06.00 and 08.00, since the morning-shift employees are already at the supermarket

Environmental impacts

Regarding environmental issues, the averages obtained of fuel consumption in units of l/100km are: 26 in the morning, 48 during the day, 54 at evening and 42 at night. At first glance, these are not that logic. Despite having lower travel speed and congestion, evening periods present the highest fuel emissions. There is an explanation for this, during the demonstration for the evening shifts a CNG truck was used, which emits high CO_2 emissions. In contrast, a Euro 6 diesel truck was the selected one to carry out the shifted deliveries from the day to the night. Regardless, using the same truck, differences in fuel consumption rise up to 50% in daylight.

Economic impacts

One positive aspect considered for the operator was the reduction of empty shelves for customers in the morning, which can be a positive effect on sales revenue. However, economic effects in the pilot are not favored with night deliveries. Operational expenses decreased by 8%, but the investment in silent equipment were significant and increase the capital expenses by 24%.

Finally, a Multi-Actor Multi-criteria analysis was done and it exposed positive effects for the operators, authorities and citizens. The noise nuisance was considered the main trouble.

2.2.4 OHD pilot project in NYC, USA (2009-2010)

After several studies, New York decided to be a pioneer place in off-hour deliveries, experimenting a pilot in 2009. Focusing the issues of costs, congestion and air quality, a trial was developed with special caution due to the complex urban setting of the city.

During 4 months, 8 carriers participated in a pilot involving different voluntary 25 receivers attracted through the use of financial initiatives. It was coordinated by DOT (Department of Transportation), with other stakeholders involved. To supervise better the pilot, GPS and smartphones were provided.

Figure 13. Off hour deliveries in NYC (DOT)

Framework and background

NYC population has been rising in last few years, which means a higher freight movement into and within the city, exceeding 100.000 daily with 80% made to wholesale, retail and food enterprises. This is creating more congestions which led to a worse quality of life, but with a rise in the cost of living. Businesses have to pay more for the goods shipment because of higher travel times, parking fees and difficulties for the carriers to reach the stores. This idea encouraged to think about an alternative for commercial deliveries.

The OHD pilot originated in a request from the New York City Chapter of Supply Chain Management Professionals to the NYSDOT in 2002. NYSDOT issued a request for proposals and selected, Rensselaer Polytechnic Institute (RPI) to research the potential for OHD in New York City. RPI's research led to a focus on food and retail deliveries in Manhattan. A consortium of RPI, Rutgers University, the Rudin Center at New York University, and ALK Technologies incorporated received funding from the U.S. Department of Transportation in March 2007. DOT served as the lead coordinating agency and worked with the trucking industry to provide education and facilitate an off-hour deliveries pilot (NYC Department of Trasportation, 2010).

To promote the practice, receivers obtain an incentive of $2.000 (1.680 €) for successful participation, and the carriers $300 (250 €) per truck. The amount for

carriers was smaller, it is obvious due to they made profit from working in off-hours.

The project was funded with a $1.2 million (1 million €) grant from the RITA (DOT Research and Innovative Technology Administration) and $640.000 (550.000 €) from RPI (Rensselaer Polytechnic Institute).

Stakeholders

- DOT (NYC Department of Transportation), as promotor.
- RPI (Rensselaer Polytechnic Institute), as coordinators and research conductor.
- Rutgers University, New York University's Rudin Center and ALK Technologies, as research supporters.
- 35 establishments (Sysco, Whole Foods Market, New Deal Logistics and Foot Locker, among others), as receivers.
- 8 delivery companies, as carriers.

Implementation details

The pilot was carried out between October 2009 and January 2010. The receiving points were changing, each of them participating at least for one month. The features of deliveries were different depending on the establishment, some assisted and other providing the key to the carrier or using unassisted systems (double doors, delivery lockers, or storage pods).

Operation methodology

Delimitation for OHD was set between 7 p.m. and 6 a.m., carriers spread distribution during this period. Each of them worked independently from the others, starting from a different truck depot and covering six receivers on a tour. To facilitate their tasks, they were supplied with GPS enabled smartphones and navigation software, which were also used to set the results, having the position and speed data at every time.

Results

Evaluation methodology

Average speeds and travel times during the pilot were compared with data obtained with previous pre-pilot measurements. To analyze them, three different periods were considered during the day: morning (8.00-10.00), midday (10.00-16.00) and evening (16.00-22.00).

Efficiency impacts

The average speeds in Manhattan clearly improved during off-peak period, being 50% higher than during the morning and 130% higher than during midday and evening periods.

Average speeds are close related with the time savings. While a median service time for a night delivery was 25 minutes, during midday and evening it was 48 minutes. And during the morning it reached the maximum exceeding an hour per service. Taking into account that 6 deliveries were carried out in a tour, the total time savings were largely positive. Several participants considered this aspect as a key point and considered to maintain OHD programs, even without a financial incentive.

	Other key points considered were the reduction of costs dedicated to pay parking tickets and the opportunity to maintain a smaller fleet being able to balance the operations during 24 hours. From truck drivers view point it was also a positive implementation mainly because of the reduction of stress.
Environmental impacts	Having to do with the environment, the trucks involved in the pilot developed a fuel reduction between 20% and 75%. Even it was not one of the main aims to achieve, neither one of the key points considered, the feedback is clearly positive regarding this aspect.
Overall balance	The pilot was successful and after checking the results, DOT decided to keep working with RPI to develop an extended pilot scope. They are supporting the existing participants and looking for more, trying to refine the economic benefits of the model.

2.2.5 Distribution and Ydertime project in DENMARK, (2012-2013)

In Denmark, two private institutions noticed the OHD tendencies through the trials and implementations carried out in some European advanced cities and wanted to develop something innovative for the Danish ones. They created a project named "Distribution i Ydertimerne" based on last mile distribution at night. Within the project, several tests were carried out during 2012 and 2013 in Cophenague, Odense, Aarhus and Aalborg.

With a daily project management, several carriers and retailers were coordinated to deliver goods between 18.00 and 07.00. The project was focused on the environmental and energy benefits of driving during off hours. The possibility to have a positive effect on congestion would be a clear advantage.

Framework and background

The DYT project has its roots in a request announced for the Green Transport Center of Danish Transport Authority. Transport minister, Hans Christian Schmidt, divulged in spring 2011 that the possibilities of using distribution during off hours had to be studied deeper. Therefore, Incentive (a consultancy firm working on transport economics) together with the Teknologisk Institut (a research and technology company) wrote a project in summer 2011, and in February 2012 they got the green light to start it (Kolstrup et al., 2014).

To work for OHD and conduct a series of trails, the project received a total of DKK 3 million from the Danish Transport, Construction and Housing Authority.

Nevertheless, in connection with the project approval, the noise emitted from the goods supply was identified as possible impediment. It could interfere with the night regulations set for the World Helth Organization (WHO, 2011). To solve this, a significant part of the funds were used for noise lowering solutions.

Besides Incentive and Technological Institute, a large number of partners (Lantmännen Schulstad, M. Larsen, Nomeco, Alex Andersen Ølund, Carlsberg, Danske Fragt-mænd and Ancotrans) took part in the tests. In addition, the project involved the municipalities, where the trials took place

Stakeholders

- Cophenague, Odense, Aarhus and Aalborg municipalities.
- Danish Transport Authority.
- Incentive and Teknologisk Institut, as project conductors.
- Lantmännen Schulstad, Nomeco, Alex Andersen Ølund, Danske Fragt-mænd, as retailers, M. Larsen, Carlsberg and Ancotrans, as partners and operators.
- Several stores and restaurants, as retailers.

Implementation details

Pilot management

The whole project was divided in 6 groups, each of them managed and controlled a sub project covered by DYT. The groups were formed by representatives of the stakeholders involved in each of the sub projects.

Teknologisk Institut was responsible for 3 sub-projects: bread distribution at Lantmännen and Schulstad, flower transport at Alex Andersen Ølund and distribution services with M. Larsen. Similarly, Incentive, was responsible for Carlsberg's evening distribution to restaurants and kiosks and Nomeco's pharmaceutic distribution with an electric car from Danske Fragt-mænd. In addition, Incentive co-operated with AncoTrans on reporting to DYT project about Novozymes' night distribution experience.

In some sub-project, as flower distribution, it was difficult to attract stores to participate in the trial and the vehicles could not be loaded optimally. To analyze precisely the details and results of a realistic option, the bread distribution sub-project has been selected, which ran in optimal conditions and provided complete data.

Operation methodology

This trial took place in Aalborg, starting in June 2013. It used the same delivery pattern every day, planned between 0.30 and 7.00 from Monday to Saturday. Nevertheless some shops inside the city were affected by noise restrictions and they could only receive delivers after 7.00. That was an impediment and these extra trips took place in peak hours. During the development of the tests, the City Municipality decided to grant a permission for one store restricted and two routes were minimized in one. A new route started to work in September 25th 2013 until the end of the year.

Infrastructure

Stores participating had no personal to assist the goods arrival. To face it, special bread lockers were placed outside the establishments where both, carrier and retailer, had access and did not need to meet personally to execute the service. Moreover, to cope the noise nuisance, electric pallets and trucks with a hydraulic loading ramp were used. The rear alarms of the trucks were disconnected and the drivers were specially trained.

Results

The results are based on a comparison between the June-September period and September-December. This second one with two route minimized in one to serve one more store in off-peak hours.

Quantitative results

In the second period, 134 km were saved every week. It means 6.968 km and 6,16 tons of CO2 saved in a year. It is a 12% reduction and it is directly proportional to the reduction in variable economic costs.

Qualitative results

Different Stakeholders had positive feedbacks. The Municipality valuated positive the truck reduction in rush hour traffic. Retailers were satisfied as well because they accomplish the wish to have the goods before opening. And finally, the drivers' response was based on the reduction of stress. The only complain came from the Aalborg inhabitants, who had noticed an increase of noise. Some improvements on the fleet are being considered to improve the model for future experiments.

	Time savings in OHD mean a reduction of the routes that are normally carried out during the day in rush hours. Extrapolating these results to the case that all 400 stores with deliveries restriction could join to this model, it could mean savings of 80 cars and 6.3 DKK million per year for Lantmännen Schulstad.
Overall balance	Despite the positive feedbacks of the participants, the whole project has not been much successful. It was mainly attributed to the lack of interest, the receivers had to pay extra to receive staff during off-hour period and the carriers were not so open to change their equipment to low-noise solutions.

2.2.6 Olympic Games OHD tests in LONDON, UK (2012)

Transport for London developed a code of practice to carry out night deliveries during the preparation and celebration of Olympic Games in 2012. It was a solution to face an important increase of deliveries demand for these important dates.

Guidelines were cautiously studied since it was the first time that such a measure was tried in the city involving all the businesses. The public sector played a role as coordinator and leader, but the cooperation of all the carriers was also determinant.

Figure 14. Night deliveries fleet (TfL)

Framework and background

As happens in other complex urban spaces, roads in London are busiest when the city gears up for a traditional working day between 07.00 and 11.00. During this period, around 25% of the traffic is composed by freight vehicles.

To reduce traffic, especially in this time slot, the administration applied a congestion charging zone in 2003 and a LEZ some years later in 2008. Nevertheless, the problem with the big amount of freight vehicles in peak hours still remained. Therefore, to keep improving urban road efficiency and LMD in London further strategies has been purposed. In 2012, and coinciding with the Olympic Games in the city, an OHD trial was carried out.

Transport for London established a code of practice to direct carriers how to make off-hour deliveries during the 2012 Olympic Games. The purpose of the code, created in partnership with the Freight Transport Association and the Noise Abatement Society, was to help businesses and operators reduce disturbance for local residents. TfL provided general guidance including using newer and quieter equipment, ensuring that all staff were briefed and trained, providing copies of the code to all suppliers and receivers, and liaising with the local borough. The code includes extensive directions for how the driver should minimize noise during deliveries (LaBelle, Frève, & Gottschling, 2014).

The project did not have specific funds. However, Transport of London had special funds to develop a special plan for Olympic Games, hence the extra costs dispended by the measure were covered.

Stakeholders	- London Municipality. - Transport for London, the Freight Transport Association and the Noise Abatement Society, as code of practice developers. - All business affected.
	Implementation details The strategies were implemented for 3 months in 2012. This period covered the Olympic Games dates but also some weeks before, during its preparation. It was tried to tackle the peak periods of demand during these important dates for the city.
Operation methodology	In the most severely impacted locations deliveries were only possible between 00.00 and 06:00 for all the businesses. It was a win-win situation for the city and businesses because the traffic during the day was congested and the deliveries gain in efficiency. Nevertheless, there were some shops, offices, hotels and restaurants owing temporary restrictions. On the implementation it was stated that London boroughs reserve the right to continue to enforce against businesses that are inconsiderate or disturb local communities, especially if complaints are received about excessive noise being made when making or receiving deliveries.
	Results The OHD trials in London had been successful. It was mainly attributed to a favorable set of standards stablished in the code of practice where participants were facilitated to obtain information. Moreover, the strong collaboration both at the city level and at the local level was crucial. Finally, as the carriers notice improvements in deliveries and they did not need to invest, the changes were positively evaluated.
Efficiency impacts	Some quantitative indicators were pointed out by (Sánchez-Díaz, Georén, & Brolinson, 2017). It was considered as determinant the reductions of an hour per tour carrying out the deliveries at night. In terms of percentage it means travel time savings from 38 to 55% depending on the carrier.
Environmental impacts	The environmental effects were not computed directly. The city become more contaminant these days because due to the city hosted many people. But reduction results about the effects of the trial were extracted based on the kilometers reductions. It can be stated a reduction percentage of around 48 to 62% of CO2 because of the OHD.
Noise nuisance	During 10 weeks of out-of-hours deliveries, all the participating businesses reported that revising their delivery times worked well with no complaints from residents about noise.
Further situation	After Olympics, the measure has been tried again. During 2013-2015 more trials were organized by the “Re-timing Deliveries Consortium”. The consortium is working within existing regulations to re-time deliveries to participating retailer’s stores.

2.2.7 Comparison

Depending on the project, the tests were performed in different durations, varying all of them around 6 months. That is time enough to capture how the behavior changes due to the implementations. Some project, like in Stockholm, have a project duration of some years, but tests were carried out in different 6-7 months phases.

The scope is another feature to compare, in which there is more variations depending on the stakeholders involved. Resources and participation is close related with who is the coordinator of the project. Public sector could be interested in the implementations and promote it, but in other cases the promotion comes from the private sector, a university or a consortium. While initiatives coordinated by Municipalities involve more partners, as Stockholm and NYC; the pilots with private promotors have more specific operators, as Barcelona and Brussels.

Off-hour periods could change as well depending on the city traffic behavior. Office and sunlight hours are not the same for all the cities. It is the reason why for example in Barcelona the period for OHD starts at 23.00. In other cases, as Brussels or NYC, turns to be at 19.00 and 20.00 respectively.

The results can be unified using some indicators about what is willing to be analyzed. It has been selected as determining indicators: travel and service time savings, environmental impacts and noise nuisance.

Travel time savings

Savings in trips are closely related with the speed average of the vehicles. As it is coherent, with less congestion, the travel speeds are higher in OHD. But this does not increase equality for all the cities. Cities with more important congestions, suffering bigger difference between peak and off-peak hours, perceive more differences.

Bigger cities, as Brussels and NYC, reach high percentages of travel time savings in night trips. Contrasting this numbers with the project analyzed in Aalborg, the differences are smoother due to be a medium-scale city with relatively modest traffic.

Service time savings

Total time for the whole distribution process is not only dependent on the travel speed. It is also influenced by the time spent in the stores carrying out the unloading procedure. Schemes implemented by the pilots analyzed include both assisted and unassisted OHD. Most of the assisted ones are establishments, as restaurants or hotels, which work in off-peak hours. In the case of unassisted OHD, the carrier is provided with the key or there is some method to facilitate the exchange of goods.

It is clear that assisted services are carried out faster. In the cases studied, it has been detected a combination of assisted and unassisted deliveries, without any entire pilot with assisted deliveries. However, in the case of NYC, an elevated number of retailers assist the unloading procedure and it results to be transcendent. That led to decrease even more the total time service. Overall, with travel and unloading time considerations, one hour per service is been registered in OHD with respect to normal deliveries. In the opposite side, Brussels had unassisted deliveries. Time saved by the travel times was neutralized for the extra time used in unloading procedure. Total time savings for OHD are not relevant for this case.

Another step forward has been reported in Barcelona and Aalborg. It has been proved that routes can be reduced taking profit of time savings. That implies less distance travelled, less working hours and more sustainable deliveries.

Environmental impacts

Efficiency aside, other of the effects detached from OHD is the contamination reduction. It has been quantified in terms of fuel consumption and it also varies from one city to other.

It is seen that the emissions generated in Stockholm are moderate compared to what has been reported in NYC or Brussels. That's because congestion levels in inner city Stockholm are not that relevant.

The reduction of environmental impacts is mostly promoted for the administration. In the public sector projects, as Stockholm, special attention was paid on this aspect. However, it is the reason why some pilot test with big private influence, as Barcelona, does not contemplate contamination as one of the main goals. Even though, the results are clearly positive in all cases.

Noise nuisance

Finally, it is necessary to contemplate as an indicator the noise generated. Lack of noise measurement data led to quantify it by the complaints received. Most of the projects paid special attention to extra noise emitted in order to respect the night rest time. Project promotors also knew that it is one of the impediments to carry this measure further.

In some cases, as Barcelona and Aalborg, exceptions of normative has been conceded during the pilot. It remains to be considered what could happen if the measure became a reality. But what had been generalized for all the projects is the investment in silent equipment, as covered unloading docks or silent rolling stock. These considerations were well valuated. None of the cities studied, excepting Brussels, received any complaint. Even so, all of them see noise improvement as an aspect with further development.

City	Stockholm	Barcelona	Brussels
Project	OPPP 2015	Night Deliveries	STRAIGHTSOL
Year	2014-2016	2006-2007	2014
Length	3 years, 2 phases	6 months	4 months
Scope	2 carriers, 19 receivers	3 supermarkets as operators, 40t trucks	2 carriers, 5 receivers
off-hours	22.00-6.00	23.00-24.00 and 5.00-6.00	20.00-8.00
Travel time savings	Up to 60%	16%	up to 50%
Service time savings	Up to 4-5% based on service stops/h	Around 66%	No relevant
Environmental impacts	CO2 reduction 20–40% based on fuel	n.a.	CO2 reduction 35-50% based on fuel reduction
Noise nuisance	No complaints	Small changes- no complaints	Assessed as a problem

City	NYC	Denmark	London
Project	OHD DOT	DYT - Bread distribution	Olympic Games
Year	2009	2013	2012
Length	4 months	7 months	3 months
Scope	8 carriers, 25 receivers	1 carrier and several receivers	All business affected
off-hours	19.00-08.00	00.30-07.00	00.00-6.00
Travel time savings	50-130%	12%	38-55%
Service time savings	up to 1 h/service	Reduction of routes	n.a.
Environmental impacts	CO2 reduction: 20–75%	CO2 reduction: 12-17%	CO2 reduction: 48-62%
Noise nuisance	no complaints	Improvements in fleet ahead	No complaints

Table 5. Off-hour distribution comparison indicators

2.2.8 Conclusions and tendencies of off-hour distribution

During the last years, OHD has progressively been considered by both private and public sectors. Several cities are starting to adapt policies to promote night deliveries and more and more private operators are becoming interested. The strategy is causing special interest among supermarkets and big businesses, who are allowed to enter to the inner cities with big vehicles. They are beneficed because OHD allows them to consolidate deliveries on large trucks, saving kilometers, time and resources. Despite it is spread for big businesses, the strategy is not discarded for particulars. In Europe there are still no practices for particulars, but they are starting to arise in China.

There seems to be a consensus on the benefits of this measure, but there are several aspects to take into account for a correct development in a future. OHD is a strategy that needs to be adapted slowly and cautiously to be accepted for its secondary effect of noise. Selected experiences allow to define generalized conditioners that should be present in any initiative of OHD to get a successful acceptance. These are closely related with the stakeholders involved and how they should act for a good development.

Cooperation from public sector	To carry out OHD the Municipality support is always needed. Usually a change on the city policies is needed, introducing new control and access measures. Regulatory public entities which manage the policy of OHD have to see the positive incentives of the measure in order to be flexible with the restrictions. It also means that authorities should invest time to analyze how to change these restrictions and control them.
Carriers and retailers participation	It is clear that modifications in the distribution procedure needs a strong commitment from both, carriers and retailers. These should be benefited and experience improvements that justify the change to OHD. They all need to work as one and agree with the flexibility of the schedule of delivery. Thus, an open mind is needed from different retail businesses. In some pilot projects, it is revealed that the high cost of staffed unloading at night led to unsustainable routines. Further development may be accompanied by technological or legal measures to carry out safer and silent deliveries without the recipient present.
Legal framework	It is important to promote a legal framework for the noise reduction requirements during the operations. In addition, since the carriers base the services on economic costs, the legal framework has to allow carriers achieve operations without additional charges if they are able to carry out deliveries according the noise levels.
Specific research for each city	Each city has different transport behavior and congestion periods. It is already seen in the studied cases that depending on the city features, time slots are different. To maximize the benefits of distribution it is crucial to analyze and identify the off-peak hours.

2.3 PICK-UP POINTS

Framework

One of the biggest trends that influence the global logistics industry in recent years has been the e-commerce. Whilst the retail sector in the developed world has stagnated due to the economic recession, e-tailers have seen their figures grow significantly. Those companies that have been able to embrace the new distribution channels have prospered. The revolution has created a new revenue stream for post offices and delivery companies.

Origin of pick-up points development

Due to high cost, poor flexibility, low efficiency and other weaknesses of traditional parcel delivery, the promotion of customer pickup mode relying on the convenient pickup points attracts extensive attention in the e-commerce logistics distribution. It offers convenient, flexible and easy parcel distribution for a specific group and is expected to relieve (in some cases this has already occurred) the terminal delivery bottlenecks in e-commerce. The rapid increase in the home delivery of parcels is generating a large number of trips in urban areas, which influence the congestion of cities as well as the use of transport resources and space in the city. It is difficult to quantify the impact that this trend is having in the last mile distribution sector but it is undoubtedly affecting the number of trips done in a city.

Pick-up points goals

There are several motivations for operators to set up a network of pickup points (or to outsource logistics and delivery to a company that has pickup points). These include cost, service to customer, profit and environment. Cost motivation relies on the control of delivery cost. Door to door delivery rises costs and it is not suitable for massive low sized parcel deliveries. Setting a network of pickup points in a city can cut human and vehicle consumption. Service motivation is another very important factor used by e-tailers to arrange pickup points and locker services. Developers aim to provide personalized and customized delivery service to obtain the selection preference of the target group and increase loyalty of customers. Research shows that young people and full-time workers are prone to accepting this model mainly due to the lack of time spent at home. Profit motivation is yet another reason for implementing and promoting this mode of delivery. According to information from the Swedish company PUDO, delivering a package weighting 2 kg to a pick up point is 4 times less expensive than when the package is sent to the customer directly. With total distribution costs decreasing, the e-tailer will have a better margin for maneuver to make its prices attractive and may therefore see sales increase. Finally, environment motivations are also considered, since final customers' value more than ever the sustainability in which a product is produced and delivered. Convenient pickup points and locker systems can reduce vehicle consumption which is beneficial to the public by cutting carbon emissions, relieving traffic pressure and avoiding traffic jams. (Edwards, Mckinnon, Cherrett, Mcleod, & Song, 2009) concluded in his study that in the area of West Sussex (UK) that the carbon emission could be maximally reduced by 87% if the first delivery failure parcels were transferred to the pickup points.

In Europe, pickup points are becoming increasingly popular. An overview made by the Dutch logistics company Paazl determines that there are over 120.000 pickup points and lockers in Europe. Most parcel companies are offering, as an alternative, pickup points to online consumers in Europe. Pickup points are especially popular in France and the Netherlands; while in the former the most popular service is Click&Drives, in the latter the e-commerce has been embraced by all layers of

society and picking up goods is just something that is taken for granted by many online shoppers.

Country	bpack@bpost	Afhaalpunt	DHL	Parcelshop	Pakketshop	Pakketpunt	Afhaalpunt	Access Point	TOTAL
The Netherlands		50	1000 20 lockers	700	500	2800 9 lockers		835	5885
Belgium	1250 120 lockers		400 planned	700 & Luxembourg		600 Kariboo!	600	900	4150
Germany			55000 2650 lockers	5000	5000			2800	67800
France			4300 Mondial Relay	6500			4300	4500	19600
Great Britain			1200	2500 planned				3000	6700
Spain			908				1200	1200	3308
Italy			11000					2100	13100
Notes		All 50 are unmanned						Incl. Kiala pick up points. These will become UPS AP's	

Figure 15. Number of pickup points offered by company (Ecommerce News, April 2015)

Advantages and disadvantages

Pickup points and locker services are being conceived as part of the solution for carriers to the large number of deliveries performed.

Stakeholder	Advantages	Disadvantages
Carriers	-Reduced cost for deliveries (the solution of lockers can be more expensive though). -Reduced number of kilometers covered in urban areas -Possibility to consolidate deliveries -Providing clients with different delivery options -It partly solves the problem of failed deliveries	-Additional costs. (fee paid to the pickup point or locker use) -Having to subcontract a certain company that has the agreement with retailers (pickup points) -Cost of purchasing and maintenance (for locker services)
Retailers	-Possibility to increase revenue of the store through the use of empty spaces available -Increase the number of visitors to a store.	- Subject to fees paid by carriers which not always compensate the effort done by retailers - Time consumed by personnel for delivering an item to a customer
Local authority	-Less traffic generated due to ecommerce. -More efficiency of the urban space. -Attended pick-up points favor the urban commerce.	-No problems seem to be associated to the installation of pick up points. -The installation of lockers sometimes need the agreement with local authorities to place these devices at a public space.

Stakeholder	Advantages	Disadvantages
Final customers	-Customers have a wider number of delivery options -Extended hours of pickup points	-Companies may incentivize the use of pickup points instead of home delivery, which may affect negatively some customers.

Table 6. Advantages and disadvantages of pick up and locker services.

2.3.1 ATTENDED PICK-UP SERVICES

There are several companies in Europe offering attended pickup point services for the delivery of parcels. Different business models coexist in offering these services. Companies like Mondial Relay, UPS, SEUR (Dpd group) and many others are both carriers and have an own network of pickup points whereas companies like PUDO offer exclusively a network of pick-up points to carriers. Also, retailers or market places such as Amazon contract the services of National postal offices (such as in Spain or UK) as their carrier suppliers network of pick up points.

Example cases

Regardless of the multiple business models, in the end the pick-up service is very similar elsewhere. It consists of a street store (retailer) or postal office chosen by the customer where the shipment is delivered. The customer is then notified and usually has up to 14 days for picking up the parcel. Some of the services offered are explained below:

- Mondial Relay: The company delivered last year over 40 million parcels through its network of 4.900 (France, Luxemburg and Belgium) pickup points and home delivery services. 12 of the 15 largest e-commerce sites rely on Mondial Relay to deliver to their customers daily. In Spain, the company has 1.400 delivery points, which are mostly small local retail stores. Book stores, laundry shops, etc are the type of retailers that offer the pickup services. These can be also used to return the items that consumers are not happy with.
- Amazon: This Company acts as an e-tailer and contracts all delivery services to different transport companies such as SEUR among others. Since the company is 100% user-centric, it tries to offer as many delivery options as possible and uses the delivery points of its different carrier company. In Spain SEUR has a network of 1.600 pickup points through which 85% of the population is served within a radius of 15 minutes.
- PUDO (Pick-Up Drop-Off): PUDO offers a network of convenience stores to which any user can send their parcels or bring them for shipment. It is usually not a delivery point associated to a carrier but a place to which users can send their parcels. Anyone can become a member of the PUDO network and send any parcel bought at any shop to the desired pickup point. In addition, it can be used to bring parcels to be shipped. In this case, the operator selected by the user picks up the parcel at this point instead of home or office.

2.3.2 LOCKER PICK-UP SERVICES

Another collection point solution is automatic lockers, which come in the form of a safety-deposit box, where a package is dropped before being collected by the customer at whatever time suits them. Locker services are being set up by companies in order to substitute the human interface of a pickup point. If lockers are placed at public spaces, these can be used at any time including night hours and weekends. Alternatively to public spaces, lockers are also be located in the ground floor of office buildings or particular residences. This last kind of lockers are not still spread around Europe, but it is an important phenomenon in some Asian countries as South Korea.

Lockers are automated devices that store parcels and are delivered to customers through an automatic interface that identifies the user and opens a safety-deposit box in which the consumer parcel has been stored.

Secure electronic parcel lockers are alternative delivery locations that can be used either as a delivery address or as part of a delivery strategy with home deliveries. If a first-time a consignee cannot be reached, the redelivery can be made to a locker box. Logistic and transport companies as well as postal operators are today offering secure electronic parcel lockers, with a range of value-added services targeted at consumers, e-tailers and mail order companies.

Limitations

Several characteristics impede a higher development of these services:

- High investment costs, including management, maintenance, repairs and running costs
- Efforts obtaining a suitable location (negotiation with public authorities if the locker is placed in a public space, lease arrangements, legal considerations)
- Postal and logistic companies are investing in their own individual secure electronic parcel lockers, available for use only by that company and its customers.

Example cases in Europe

Despite locker practices born in North America, nowadays in Europe several companies offer their clients parcel locker services using different business models, some examples are explained below:

- Bring service offers secure electronic locker services in Denmark, Estonia, Finland, Norway and Sweden. Currently it has 43 package stations in Sweden. In this case, lockers have not been purchased and nor are being maintained by the post company, the service has been contracted to the company SwipBox. This company offers post companies the provision and maintenance of a network of locker services, so that logistic operators pay a fee to SwipBox for delivered parcel.

Figure 16. Bring locker (International Post Corporation)

- Post Denmark launched its first ten secure electronic parcel lockers (Dognposten) in Copenhaguen in April 2008. Currently, in addition to parcel collection, consumers can send national parcels and packages under 10kg from Dognposten facilities. Lower price points are offered for items sent and received at the parcel stations to reflect the reduced transportation cost by Post Denmark.

Figure 17. Post Denmark locker service (Dognposten)

- CityPaq is a locker service provided by the Spanish post company Correos. Most lockers have been placed at public places such as railway and metro stations. Locker devices have up to 80 boxes of different sizes to accommodate different type of parcels and packages. There are two ways for using the service, the easiest one is to select the locker option when purchasing at a e-shop that is already integrated with the service. For purchases at non integrated shops, the customer can insert a postal direction given by its CityPaq account and the delivery will be redirected to the selected locker.

Figure 18. CityPaq solution, (Correos)

- Homepack is the alternative of Citypaq, from the same company, but the lockers are located in residence builings for its neibourhood. The infrastructures installed are smaller than the previous case, but the operation methodology is the same.

Example case in New York City

All the examples viewed are response of the good acceptance of locker services, firstly implemented in North America. Actually, there are several companies working with lockers around USA, but this services were lead by Amazon, the company who innovated in them and start its implementation in New York City, among other American cities. It is still one of the leaders in locker services.

- Amazon locker is a self-service parcel delivery service offered by the online retailer Amazon. Its customers can select any locker location as their delivery adress, and retrieve their orders at that location by entering a unique pick-up code. This service started in 2011 in the USA to adress concerns of parcels being stolen or customers missing the mail delivery. Nowadays, in one of the most important commercial areas in USA, Monhattan (NYC), with an extension of 59,1 km^2, it is possible to find around 20 pick-up locker services. The service has been extended in the

whole country and in Europe, available in over 1.800 locations in more than 50 cities.
The operation methodology is simple, when a customer orders a parcel to be delivered at a locker, amazon's preferred carriers deliver the package, at which point the customer recieves a digital pick-up code via email. Amazon customers can also return packages at the locker network.
Finally it is relevant to point out that Amazon is developing a new service called *Hub*, a delivery locker for apartment lobbies.

Figure 19. The first Amazon locker (Adam Matan, wikipedia)

2.3.3 Pick-up points in GERMANY

Framework and background

Germany is one of the countries where locker bank networks has had better acceptance. The main responsible of deliveries in German cities, DPDHL, created the largest automated pick up service network called Packstation. According to their 2016 Business Profile, DPDHL controls 62.1% of the German mail communication market and 43.7% of the German parcel market.

The implementation started in 2001 by a pilot project carried out in Dortmund and Mainz with two automated pick up points based in lockers. Positive results and future perspectives encouraged launching the service in 2002 as permanent installing 24 packing stations. From then on, the model growth was clear. In 2011, 2 million customers were registered on the system and in 2016, the number increased up to 5 million. Currently around 3.000 DPDHL locker stations cover more than 1600 municipalities. It means, according to DHL (DHL, 2009), that 90% of the German population is within 10 minutes of a packing station.

As far as pickup points in Germany are concerned, five private service providers adapted the model. Hence, DPDHL, Hermes, DPD, GLS and UPS share the market. All together more than 36,000 pick-up points are available throughout the country (Morganti, Seidel, Blanquart, Dablanc, & Lenz, 2014).

Operation details

Packstation installations are placed in public spaces, most of them within urban areas. A standard station includes 76 lockers, but the actual number depends on the location.
There are different sizes of locker in each station, to fit different kinds of packages.

Using Packstations is free of charge for all the customers, both for private and business

Figure 20. DPDHL locker station (Packstation)

customers, however prior registration is needed. To receive parcels in a locker, instead of writing the house number in the address, the customer number must be introduced in the system, then the package is sent directly to the associated Packstation. As soon as the parcel arrives, the customer is notified via SMS and email. Then, during the next seven business days the package is available for collection. The customer logs in with basic details in a screen to open the locker and retrieve the parcel. In case the parcel is sent to a home address, it can be redirected to a Packstation if the recipient is not available to sign for the delivery. For those cases, the users may open the lockers using bar codes without advance registration.

Quantitative results

Studies carried out in 2006 in Cologne (population one million, 29 stations) reveal that in that city alone the Packstation scheme saves 35.000 trip-km annually. This is due to less delivery traffic and fewer stops, as well as a reduction in the need for private car trips to collect shipments from postal outlets or depots, as locker box collections are integrated with the client's daily routine (Forkert & Eichhorn, 2007)

As indicated, the locker service increased in last years, in 2009, with around 14.000 pick-up points in stores/shops in Germany with Hermes dominating the PP market. Der Aktionär reports that Hermes earned 1.018 million € with its core business parcel service, mail service, info service, furniture service and its bulky goods segment. GLS has the second largest network, with 5.000 parcel shops in Germany. It offers parcel recipients the option of collecting their delivery from their nearest parcel shop if they were not at home when GLS made the first delivery attempt. (Morganti, Seidel, et al., 2014)

In addition, there is a graph representing the preferred delivery option used by customers in Germany collected in 2014. Despite representing still 4% on the total of delivery forms, pick-ups through lockers are increasing. The system is getting good client satisfaction. According to information from DHL (DHL, 2011), 70% of all packages are collected within 24 hours.

Figure 21. Current forms of deliveries used in Germany (Morganti, Dablanc, & Fortin, 2014)

2.3.4 Pick-up points in FRANCE

Framework and background

Compared with other Western Europe or North American countries, the presence of locker box network in France is limited. The presence of stations run by La Poste under the name Cityssimo limits the service to 33 locker stations.The small number of services carried out using lockers is mainly related to security regulations. France is a country that suffered many terrorism attacks in lasts years and it has been constantly threatened. The Vigipirate antiterrorism measures prohibited leaving unattended parcels in automated lockers. Despite the restrictions, the options are still contemplated and the law has recently been revised and locker parcel stations are now allowed in certain areas.

As a result and instead of lockers, the attended pick up points in stores has grown to cover the e-commerce delivery demand. Pickup point deliveries within the country are basically managed by four competing providers, with more than 18,000 pick-up point locations. The trend to send the parcels to pick up points instead of home gains popularity. Assessed in (Morganti, Seidel, et al., 2014), the aggregate number of ventures serving as a pick up points rose from 10.900 in 2008 to 18.200 in 2012, which means an increase of 67% in 4 years' time.

Operation details

The network of attended pick up point locations is operated by four similar competitors: Mondial Relay, Kiala, Relais Colis and Pickup Services. Each of them have a structured pick up point network, providing online shoppers with between 4.000 to 6.000 points around the country. Some of these networks can actually share the same physical stores.

Pick up point providers define different specific criteria to select the independent shops that can be included as pick up point. Among the features considered there is the available space that the shop is able to use to store parcels, the opening hours and the kind of goods sold. The store profiles are different, from florists or press kiosks to bars or gas stations. In addition, Figure 22 shows the composition of stores types composing the four current networks.

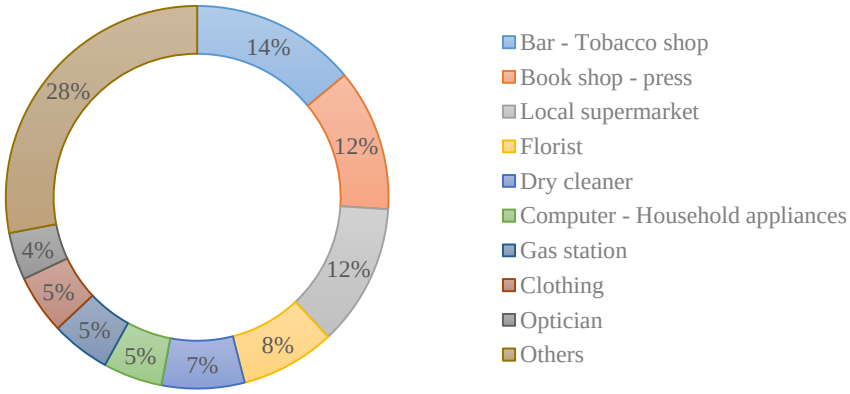

Figure 22. Type of store working pick-up point in France (Morganti, Dablanc, et al., 2014)

Quantitative results

(Morganti, Seidel, et al., 2014) reported diverse quantitative data in order to make highlight the good reception of the model in the country. In 2010, about 60 million parcels were delivered in France via attended pick up points, which is approximately 20% of the total volume of parcels generated by distance selling. The density of sites working as pick up points has increased significantly as well. For the whole population, while in 2008 there were 5.9 pick-up points per 100,000 inhabitants, in 2012 it had increased to 7.

3 REGULATORY MEASURES AFFECTING LMD

The trend of closer destinations of goods to final users is a chance for new generations, if the logistic processes are well managed it will cause satisfactory gains for a better quality of life. City councils, governments and public sector in general are in charge of the regulations that could allow or forbid massive freight transportation within the city centers or other dense urban areas.

Society is getting used to receiving goods directly at home and, in addition, with very short delivery times. This is a trend causing deliveries to be composed of small packages and with low vehicle load factors in its deliveries. Besides short times, the competition among businesses offering home deliveries, including e-commerce, is increasing and there is a trend to offer low price shipments, or even for free. It is a marketing strategy in which users do not perceive the delivery costs. Therefore, it eases customers to get used to demand goods frequently and not consolidate them in a unique order.

The main objective of restrictions and regulations are to cope with detected adverse trends generated by the private sector. Hence, it is aimed by the public sector to make the operators become more environmentally responsible and avoid unnecessary trips.

In addition, to improve transportation system in general, most of the regulatory measures aim at promoting the shift to more sustainable vehicles. This is carried out by adapting restrictions to new environmentally friendlier technologies, which together with the trip reduction will help the transition to greener cities.

Different types of regulations affecting LMD are explained in detail in this chapter. To characterize them, a division is done among access regulation and loading parking regulation. Furthermore, specific cases applied in mid and big European cities are presented and compared to detect current trends.

3.1 ACCESS REGULATION

There is a wide range of tools promoted by the administration with the aim of reducing traffic emissions. Depending on the effects, these can be divided into global and local. Global tools include measures as governmental subsidies for the purchase of electric vehicles or vehicles that run on compressed natural gas. In contrast, local tools can be generally called urban access restrictions (Pwc, 2010).

Access regulation goals

Restrictions aim to reduce congestion in frequented urban zones, and consequently reduce pollution, noise and traffic incidents. Aside from the health benefits proposed, the city gains attractiveness for its inhabitants and visitors.

Types of regulation

There are many ways to reduce the number of vehicles in a specific area of the city. The most simple and extended practice is to develop pedestrian zones. Another one, which does not require a change in the urban streets use, is to restrict the entrance to specific areas by penalizing some types of vehicles. It could be a simple ban for some vehicles or alternatively, a less common measure is to charge a fee to drive in the limited zone. These measures can also be accompanied by time window restrictions, reducing the restrictions to time periods of the day. These time windows usually affect only freight vehicles but could also affect others.

The areas in which only certain vehicles are penalized are called Low Emission Zones (LEZ) because their main aim is to minimize the pollutant emissions in these areas. There are several criteria followed for the restrictions: vehicle type (car, van, truck, bicycle, etc.), vehicle weight (over 3.5 tones for example) or driver type (residential, for a delivery, etc.). Nevertheless, the most typical restriction is based on the vehicle emission, classified by the Euro Standards.

Regarding the other option, pricing is currently limited to a few cities, which have a Congestion Charging Zone (CCZ). The method to charge can vary, defining a cordon area inside the city, with charges for passing the cordon line; area wide congestion pricing, which charges for being inside an area; a city center toll ring, with toll collection surrounding the city; and corridor or single facility congestion pricing, where access to a lane or a facility is priced (Chlaň & Lejsková, 2010).

For both cases (LEZ and CCZ) and for time windows as well, one of the concern points is to find a method to control the access. Despite barriers or physical tolls take up space and can produce queues, some cities use them. Other cities use cameras, police or local authority officers to enforce the control. Moreover, it is incrementing the use of labelling to differentiate and recognize the type of vehicles. These labels are mostly distributed according the emissions produced by each vehicle.

A part of the system to control, there are other aspects to take into account as the size of the area or the costs of implementation.

To decide the size where the restrictions need to be applied requires an accurate study. It depends on the characteristics of each city, but if the restricted area is too small it will be circumvented and its effect will be reduced. If it is sufficiently large, it will also change the vehicle fleet in the surrounding areas. It should at least be large enough not to cause increased traffic by vehicles driving around it (Fellerman, 2015).

Regarding the costs, besides being a measure that is quick to introduce, an elevated amount of money to start-up is not needed. Nevertheless, it is much more difficult

to rise support among drivers. One option to promote the measure is providing retrofit subsidies for fleets that have to be adapted. The amount dedicated can increase as desired and thus avoid complains. Once introduced, restrictions can cause positive economy effects for the administration because of the money raised in tolls and in exemption fees. In many cities, these extras are used to finance improvements in transport for the city.

Advantages and disadvantages

Taking all this into consideration, Table 7 shows the advantages and disadvantages among the stakeholders involved in LMD.

Stakeholder	Advantages	Disadvantages
Carriers	-Less congestions -Reduced time in traffic jams -Better working conditions for the driver	-Additional costs -Necessity to adjust routes -Adapt the fleet and introduce new vehicles.
Retailers	-Reduction of noise in the area. -More attractiveness for pedestrians.	-Higher service costs inside restricted area.
Local authority	-Easy to implement and quick to introduce -Low start-up costs. -Gains in pollution, noise, congestion, traffic incidents -Extra money to improve transport in the city.	-Complains from carriers and/or citizens

Table 7. Advantages and disadvantages of access regulation

Practices identified

Nowadays, there are about 8.000 cities and towns in Europe with such traffic restrictions. These are mostly faced for freight vehicles, so it affects significantly the LMD. For a closer insight, some cities have been selected to analyze their progression in implementing these access restrictions.

To choose them, disposing of accurate results of a specific implementation compared with an older scenario has been considered. For this reason, most of the chosen cities have had some EU funds to finance projects. Moreover, some of the cases contemplate simple LEZ restrictions, others charging prices and there is even one with both measures combined. The selected cities are the following ones, with the specified restrictions of access:

- London, CCZ inside a larger LEZ, both combined (Ellison, Greaves, & Hensher, 2013).
- Milan, CCZ considered as a LEZ (Croci & Ravazzi, 2015).
- Stockholm, CCZ (SUGAR, 2011).
- Copenhagen, LEZ (Solvang, Ketzel, Klenø, & Wåhlin, 2010).
- Utrecht, LEZ (Bertens et al., 2011).
- Berlin, LEZ (Lutz, 2009).

3.1.1 CCZ combined with a LEZ in LONDON, UK

The Greater London is one of the pioneer places in implementing access restrictions, currently there are several types of rules to follow depending on the area and type of vehicle.

Restrictions involve a LEZ for large vehicles and a CCZ within the LEZ affecting a huge range of vehicles. In addition, there is a Safer Lorry Scheme regarding the required equipment for large freight vehicles. All of them work separately and further restrictions are planned, including an Ultra LEZ.

Figure 23. LEZ signal (Martin Addison, wikipedia)

Framework and background

In the early 2000s, London's air quality was considered to be amongst the worst for European cities, with emissions of PM10 and NOx being particularly problematic and failing to meet both EU and UK standards for air quality in urban areas (Transport for London, 2008). Considering that most emissions are produced by vehicles, the Mayor requested a report from TfL (Transport for London) to improve the transport system in the city. A series of measures were purposed as conclusion, including traffic regulations and a small congestion charge area.

After some studies, congestion fees were implemented for London inner Ring Road in 2003. Nevertheless, further approaches were needed to improve air quality. As consequence a complete feasibility study (AEA Technology Environment, 2003), published in 2003, concluded the necessity to implement an extended LEZ.

In 2005, the Mayor delegated to TfL to study the detail of a LEZ. TfL consulted the London Assembly and the Greater London Authority (GLA) Functional Bodies, and finally published the Order in 2006. After a public and stakeholder consultation, the Mayor confirmed in 2007 the Greater London Low Emission Zone Charging Order and it was implemented in 2008, affecting large and freight vehicles, but not the private cars.

Aside from the LEZ implementation, in 2007 the western extension of the congestion charging area was introduced, but after 3 years, in January 2011 the extended area was cancelled. What is still in use is the increase of the standard charge by 15% done in 2011.

Another restriction specific for lorries was included in 2015, The Safer Lorry Scheme. It legally requires HGV lorries over 3,5 tones gross vehicle weight driving

in London to be specially equipped in order to increase city safety for cyclists and pedestrians.

Currently, to keep improving these type of restrictions, TfL plans to implement an Ultra Low Emission Zone (ULEZ) in 2020. It will operate 24 hours a day, 7 days a week within the same area as the current CCZ. In addition to the price for CCZ, all vehicles will need to meet exhaust emission standards to travel. The ULEZ standards will be implemented in addition to the prevailing CCZ and LEZ requirements.

Implementation details

As pointed out, different restrictions have been implemented, but these work independently. Details are explained for each measure.

Low emission zone details

The LEZ covers most of Greater London for 24 hours a day, every day of the year. For this zone, most pollutant vehicles are restricted, affecting only freight and large vehicles. It was implemented in 4 steps between 2008 and 2012 affecting the following vehicles:

- Feb 2008: Euro III lorries over 12 tones GVW, and buses and coaches over 5 tones GVW.
- Jul 2008: Euro III lorries over 3.5 and 12 tones, buses and coaches.
- Oct 2010: Euro III larger vans and minibuses.
- Jan 2012: Euro IV lorries over 3.5 tones GVW, buses and coaches over 5 tones GVW.

Owners of vehicles not fulfilling the standards of the LEZ are required to pay a fee for each day in the LEZ. Fines for freight vehicles are of £500 (570 €), which double if not paid within 14 days. There are some exceptions including historic vehicles, vehicles operated by the Ministry of Defense and Specialist vehicles designed for off-road use.

Congestion charging zone details

The CCZ covers London inner ring road, a smaller portion of the LEZ. The measure applies to all vehicles a charge of £11.50 (13 €) daily for driving a vehicle within the charging zone between 07:00 and 18:00, Monday to Friday. There is no charge on weekends and public holidays. For this zone, besides exemptions for motorcycles or emergency service vehicles, there are discounts for residents and other special cases. In case to enter the zone without paying, the penalty is £65 (74€) and double if it is not paid within 14 days.

Ultra low emission zone details

The ULEZ covers the same area limits as CCZ. For this case, a greater number of vehicles are affected with the following limitations: Euro 3 Motorcycles; Euro 4 for petrol cars, vans and minibuses; Euro 6 for diesel cars, vans and minibuses; and Euro VI for lorries, buses and coaches. Those not meeting the standards are subject to a charge of £12.50 (14 €) (light vehicles) and £100 (114 €) (heavy vehicles).

Safer lorry scheme details

The scheme ensures that only lorries with basic safety equipment fitted are allowed on London's roads to avoid disproportionate number of fatal collisions involving cyclists and pedestrians. Under the scheme, vehicles over 3.5 tones are required to be fitted with Class V and Class VI mirrors giving the driver a better view of cyclists and pedestrians around their vehicles. In addition, to protect cyclists from being dragged under the wheels in the event of a collision they need side guards.

The scheme operates 24 hours a day, seven days a week, covering the same area as the LEZ with a fixed penalty of £50 (57 €).

For all the restrictions, there are no physical barriers or tollbooths. The zone is enforced through fixed and mobile cameras, which read the vehicle registration license plate as the vehicle enters to the zones and circulates within it.

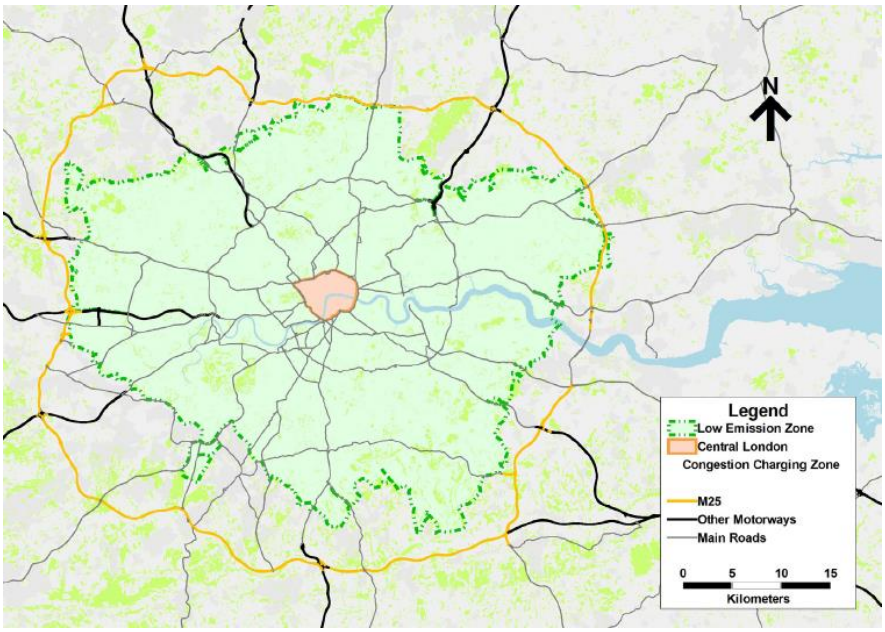

Figure 24. Map of London's low emission zone (Ellison et al., 2013)

Results

Results are based on the most influent restriction for freight vehicles, the London LEZ. Thus, these are contextualized between 2007 and 2012 with two different trends considered, the fleet turnover and the effects on air quality.

Fleet turnover

In 2008 after the first LEZ restriction was implemented there was a significant drop of pre-Euro III vehicles in London, from 47.4% to 31.9%. Next years, the trend was still remarkable and in 2011 London had the lowest national proportion of pre-Euro III vehicles (19.4% compared with a national average of 29,8%). Regarding large vehicles, smaller figures were noticed. Due to the higher purchase costs of articulated vehicles, fines for not meeting the minimum standards required by the LEZ are less likely to exceed the costs of replacing a vehicle (Ellison et al., 2013). A key consideration could be to increment the fee price.

In contrast with the restrictions, the e-commerce keeps increasing and it is producing a switching from heavy lorries to light commercial vehicles. In three years (2008-2011) the increments of e-commerce in London were of about 80%. A part of this shift may be due to the LEZ in which until January 2012 did not include light commercial vehicles.

Environmental and congestion impacts

Overall, despite the existence of the LEZ, freight vehicles increased in the city. However congestion was reduced by 30% and the volume of traffic was reduced by 15% in CCZ.

Concerning pollution levels, PM10 and NOx were determined by London’s Air Quality Network run by King’s College London (2012) comparing the areas inside and outside the LEZ. Reductions were not as expected due to an increase in the

number of freight vehicles within the LEZ. Nevertheless, PM dropped about 3% inside the LEZ compared with 1% outside this zone. NOx did not experiments relevant changes.

Overall balance

In conclusion, LEZ has played a part in improving air quality, but the overall effect has still been relatively small. Nonetheless, other non-quantitative effects were been detected as positive, as the improving in attractiveness and population consciousness of the air quality problems. In addition, the money raised in fees and in CCZ has been used to improve the London transportation system, and no significant negative impact has been identified on businesses and the economy.

3.1.2 CCZ as a LEZ in MILAN, Italy

Italy is one of the European countries with more LEZs. The city of Milan is especially interesting because it involves a regional LEZ in Milano Province and an urban CCZ, considered as well as a LEZ, in the city center.

Figure 25. Ecopass road sign (Damien Meyer, wikipedia)

The CCZ was created to reduce pollutants in a programme named "Ecopass", in which vehicles entering the CCZ needed to pay according their Euro standard. After some years, the program needed to be tightened to reduce congestion and it was substituted by a programme called "Area C". It is still working and it does not allow the dirtier vehicles access the city. Currently, the minimum standards allowed to enter in the zone are Euro 3 diesel vehicles, and Euro 1 petrol vehicles.

Framework and background

Lombardy region, where Milan is located, has poor air quality compared with other regions in the country. It is due to traffic emissions but also due to the adverse geo-climatic area conditions, which difficult particulate dispersion.

In order to improve it, in January 2008, a CCZ scheme called "Ecopass" was introduced. Most of the polluting vehicles had to pay a daily charge to enter to a delimited zone according their PM10 emissions. The system started as a one year trial and was extended year by year.

Few years later, the necessity to tight the programme was evident from the population point of view, but the local government was not willing to update the system. Thus, a citizen committee was created who led the first proponents of the change. They promoted a referendum, under the Municipality rules for public participation, with five questions one of which regarded the future development of "Ecopass"(Croci & Ravazzi, 2015).

In 2011 the referendum was carried out and results were in favor to change CCZ policy. It happened in coincidence with new municipal elections, which facilitated the modifications. In 2012, a new programme called "Area C" to replace "Ecopass" was born, covering the same area but more strictly. As it happened before, a trial period was introduced and then extended. Finally it turned permanent as of 2013.

Further studies had been carried out, and a new Milan SUMP was approved in 2015, setting directions for the development of mobility in Milan for the next decade. The mobility plan defines the revision of the congestion charge as a long-term horizon intervention, dependent on the realization of further improvements in accessibility to the area and in parking regulation controls (Comune di Milano, 2015).

Implementation details

Operation methodology	The main difference between both programmes is that while "Ecopass" was faced as a pollution charge, "Area C" is faced as a congestion charge. In 2008, with "Ecopass" implementation, the charges were not so restrictive and without any ban, only penalizing the most pollutant vehicles. These became stricter in 2012 with "Area C", which is explained below in detail. The CCZ in Milan, where both programmes have been applied, covers 8 km2 of the city center, which means 4,5% of Milan historic urban district and 6% of urban population. Restrictions have been present during weekdays from 7.30 to 19.30, except Thursdays (7.30-18.00). These has been not prevalent during weekends and bank holidays. For "Area C", prevalent nowadays, all the vehicles are affected excluding EV, hybrid vehicles and some special exceptions which can enter whenever they need for free. There are two kind of restrictions, entrance fee for some vehicles and entrance ban for others. The banned ones are: vehicles measuring more than 7,5 meters in length, petrol Euro 1, diesel Euro 3 vehicles, diesel Euro 4 vehicles without a diesel particulate filter (DPF) and freight vehicles only during the period 8.00-10.00 (excepting e-freight vehicles). Other vehicles need to pay daily feed from 2€ to 5 €. The standard daily price is 5€, but there are multiple discounts for resident and service vehicles.
Infrastructure needed	The enforcement is monitored by an electronic system of cameras located in 43 toll entrance gates around the zone. It works with tickets that can be bought online or at an ATM. Vehicles paying less than 5 euros need to be registered online. Not paying the fee within the CCZ is fined, penalties vary according the vehicle emissions. Penalty for non-payment varies from 70 to 285 euros.

Results

Qualitative results	At the implementation moment, the main aim of the initiative was to improve the air quality and the travel times. Up to 2015, these points were achieved according the Milan City Authority with the following results treated by (EU, 2016b).
Quantitative results	On the one hand, pollutant emission suffered a significant reduction. The "Ecopass" programme meant reductions of 19% of PM10, 11% of NOx and 9% of CO2. Similarly, during "Area C" operation (7.30-19.30) up to 2015, traffic emissions reduced by 18% of PM10, 10% of NOx and 22% of CO2. On the other hand, reductions of incoming traffic reached 20% in "Ecopass" programme and overpass 30% in "Area C" case. It meant less congestion and consequently improved travel times. A commercial speed increment of 5,7% for buses was measured.
Economic impacts	The reduction of entries in the zone were significant, but despite the restrictions 41.000 entries per day in average were counted. These entries sum a total gross revenue of 30 million € per year in "Area C" period. Regarding the Ecopass period, as pointed out in (Croci & Ravazzi, 2015), although the revenues were considerable, these decreased from 12,1 million € in 2008 to 5,9 in 2011 because of the increase of exemptions included and the growth in ecological vehicles. For both cases, average operational costs per year amount 14 million €, directly funded by the scheme's revenues. The rest of money was allocated to expand subways, trams and buses and to implement a second phase of bike sharing in Milan. It has been allowing the City Administration to reinvest in sustainable mobility.

3.1.3 CCZ in STOCKHOLM, Sweden

Inspired by the success of London's congestion charge, Stockholm introduced its own congestion pricing system in August 2007. Before introducing the scheme as permanent, 7 month trial and a referendum were carried out to test such initiative.

It was implemented as a CCZ with a clear objective of reducing congestion, but also to minimize pollutant emissions and improving the air quality in the city. No specific assessment of the scheme impact on freight traffic has been made, but the measure helped to reduce the large freight vehicle entries.

Framework and background

The city of Stockholm is spread across a total of 17 islands. To cross from one to another the city is fitted with several bridges which suffer from the city traffic. At the beginning of XXI century, it was noticed that, as the population of Stockholm County was growing too fast, the two main bridges were often greatly exceeding the capacity for which they were originally built.

It led the City of Stockholm to tackle the problem and in 2003 local parliament decided to request a law to the national government to introduce a CCZ. Congestion Tax Law was adopted one year later with several fixed objectives, but with the CCZ not implemented yet. The primary objectives were to reduce congestion, increase accessibility and improve the environment. To do so, more specific objectives were set: reduce traffic to and from the city by 10-15% during rush hour, increase level of service in Stockholm city traffic, and reduce the emissions of carbon dioxide, nitric oxide and particulate matters.

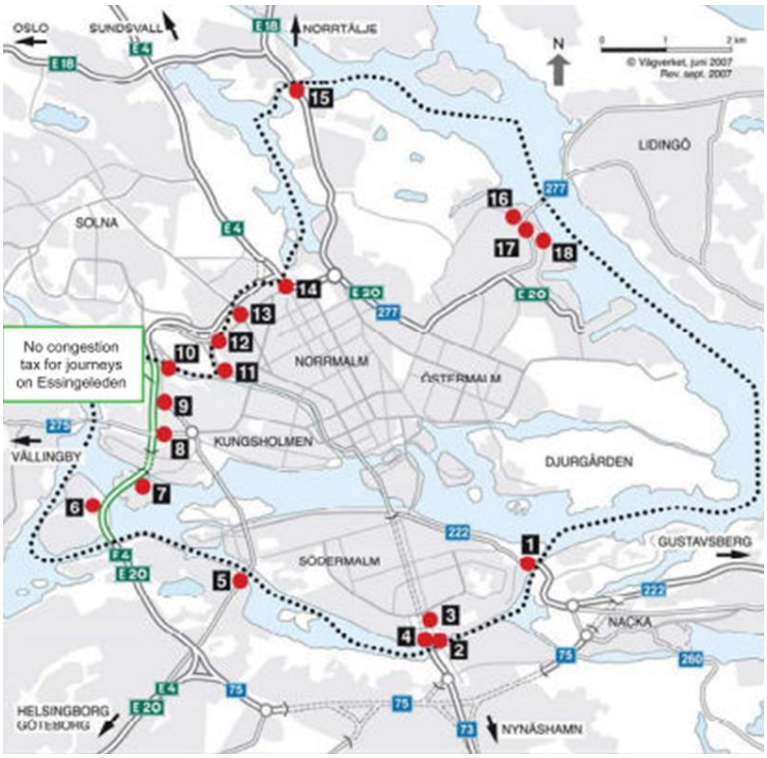

Figure 26. Tax cordon in Stockholm (The Swedish Transport Agency)

To be prepared for the CCZ implementation, the public transport service was extended. Some months later, in 2006 it started a 7 month trial of a CCZ. When it finished, a referendum was carried out in order to know the priorities of the

citizens. While before the trial 75% of the citizens were against of a CCZ, after the trial a majority voted for a continuation.

Finally in August 2007 the scheme restarted to be permanent, and in the following years some modifications have been introduced. Both the trial and the entire implementation costs were paid with revenues from the tolls. In 2008, a new type of payment, consisting in monthly invoice, improved the system. More recently, in 2016 some modifications in taxes were adapted and fees were raised. Today all political parties support the CCZ, almost no opinion groups are against it.

Implementation details

Operation methodology

The CCZ in Stockholm covers 30 km2 in the city center, which means a 16% of the city. Access regulation is set for all vehicles only between 6:30 and 18.30 for all the weekdays. When it was implemented, It consists on a charge dependent on the time of the day the vehicle enter to the zone, varying from SEK 20 (2 €) in the rush hours to SEK 10 (1 €) in the lighter ones. There was as well a maximum amount established per car and day, SEK 60 (6 €). These fees were raised in 2016, covering a range from SEK 11 (1,1 €) to SEK 30 (3 €) with a maximum of SEK 105 (10,5 €) daily.

Figure 27. Road signs and enforcement (The Swedish Transport Agency)

Exemptions and enforcement

All vehicles are affected with some exceptions (emergency service vehicles, diplomatic cars, taxis, motorcycles and vehicle equipped with technology for running, among others). The method to control the vehicles is to register the license plate number when driving through a control point. The cordon scheme is equipped with 164 cameras and 159 laser detectors within 18 control points.

There are 3 methods for paying: Internet banking, direct debit or over the counter at Pressbyrån kiosks and 7-Elevens (convenience stores). If the tax is not paid on time, a surcharge of SEK 500 (~50€) is imposed.

Information campaigns

During the implementation, several advertisement campaigns were launched. During the first week of the test, a press conference was given every day and then once a month. SRA did a huge advertising campaign about the mechanism and how to pay. Information channels: websites, customer services, letters to vehicle owners, advertisements in the daily and trade press, media/press information, information in the traffic environment, information on the radio, etc (SUGAR, 2011).

Results

As the balance on the trial in 2006 was assertive it was implemented a permanent CCZ next year, and is still working with positive feedbacks either from the society and politics. City gained in pedestrian attractiveness, air quality, and the economic benefits for the authorities.

Quantitative results	During the trial, light good vehicles reduced by 22%. After some years, (SUGAR, 2011) published results comparing the actual moment (2011) with the year before the implementation showed 20% less traffic in and out from the inner city during peak hours and 10-14% less emissions and 30% less travel times.
Economic impacts	According to (Croci & Ravazzi, 2015), investment costs were in total SEK 1900 million (~200 M€) and operational costs sum to SEK 220 million (~20 M€) per year. Revenues are enough to cover these costs, the scheme has a gross revenue per year of SEK 763 million (~80 M€). Net revenue is spent on infrastructure investments in the Stockholm region.
Population acceptance	As explained in the framework and background point, population change its opinion about the CCZ once it was tested. Thus, a key consideration for this type of measure is to test it before its consultation and implementation.

3.1.4 LEZ in COPENHAGEN, Denmark

The Copenhagen LEZ called Miljozone was the first access restriction introduced in Denmark. After some years of controversy, it was implemented in 2008, when other LEZs started to arise in other European cities.

The main aim of Miljozone was to improve air quality, and for that reason restrictions were based in Euro standards. It is a relevant measure for LMD because it did not allow the entry for some freight vehicles, affecting large vehicles (>3,5 tones) and a significant number of vans and buses.

Framework and background

Particle pollution has been one of the primary concerns of the Danish government in recent years, which causes almost 500 early deaths every year. Emission scenarios reveal that large duty vehicles (>3,5t) are the responsible of approximately 50% of the harmful air pollutants, in particular, particulate matter. For this reason, LEZs were chosen as an option to restrict the access of high polluting vehicles to inner cities.

The first request came in 2003, when Copenhagen municipality applied for permission to implement a LEZ requiring particulate filters for heavy vehicles. After a two-year period the Ministry of Justice denied the application. The key denial argument was that LEZs were expropriation of business vehicle owners' right to pollute. The Danish Ecological Council then worked intensively using media coverage to create political pressure towards the LEZ topic. Finally in 2006 an amendment was made to the Law of Environmental Protection to allow LEZ, and the LEZ authority moved from the Ministry of Justice to the Ministry of the Environment (Press-Kristensen, 2014).

The Danish parliament approved LEZ act in December 2006. The act allows the largest five urban municipalities to implement LEZs. The municipalities of Copenhagen and Frederiksberg implemented a LEZ in 2008; the municipality of Aalborg in 2009, and the municipalities of Odense and Aarhus decided to implement these kind of zones in 2010.

On behalf of the Danish Environmental Protection Agency, the Danish National Environment Research Institute (NERI) at Aarhus University carried out an evaluation of the impacts to air pollution of the LEZ. An Impact assessment as carried out to evaluate the implementation of the Copenhagen's LEZ requirements (Solvang et al., 2010).

Implementation details

Area covered	LEZ is located in the Copenhagen city center and Frederiksberg, covering approximately half of the city where 65% of its inhabitants live.
Operation methodology	Restrictions for this area affect to all diesel vehicles over 3,5 tones and vans/buses with more than 9 seats for the 24 hours of the day during all the year. To enter to the limited LEZ they must follow some rules established in 2008, but changed in 2010. Initially it was set that vehicles must meet Euro 3 or higher. In case to be lower than Euro 3, the affected vehicles had the possibility to enter only in case to have an approved particle filter installed. After July 2010 rules keep affecting the same weight vehicles, but having to meet Euro 4 standard instead. For vehicles

	lower than Euro 4 it was possible to enter as well, as the pervious case, with an approved particle filter installed.
Enforcement	Inspectors and urban police carry out manual enforcement. In order to control the requirements, vehicles need a LEZ sticker in the windscreen, which is valid for the other Danish cities with LEZs. Foreign vehicles must meet the same emission requirements, but do not need an environmental zone sticker. Injuries against the LEZ rules are strongly punished, with fines up to DKK 20.000 (2.700 €).
Exemptions	Vehicles of the military, the police and the emergency services are exempt, besides other special cases. Moreover, there is a special transit road from the port and within the LEZ exempted for all the vehicles in order to facilitate the traffic for ferry boats from and to Copenhagen.

Results

(Solvang Jensen, Ketzel, Nøjgaard, & Becker, 2011) reported the several methods that had been used to evaluate and quantify the effects for emissions and air quality. A combination of air quality measurements, a dispersion modelling and registration of vehicle number plates.

Environmental impacts	Measurements were collected in a busy representative street (H.C. Andersen Boulevard) after and before the introduction of the LEZ to isolate its effects. Regarding the emissions, results measured of the street contributions are 23% of PM2.5, 8% of NOx, and 9% of CO2. Concerning the dispersion modelling, street concentrations of PM2.5 and PM10 are within -7% and 11% of measurements. The reduction is less for PM10 compared to PM2.5 since exhaust emissions for PM10 constitutes a smaller proportion of the total emission.
	On the other hand, the registration of number plates was carried out in another significant busy street (Åboulevard Street) by video cameras for 2 periods of 3 months (in 2008/09 and 2010/11). The main purpose was to couple the number plates with vehicles information for an evaluation of how the requirements for heavy-duty vehicles had influenced the distribution of Euro emission classes and hence the vehicle emission. By an accurate study, it was confirmed a moderated reduction of PM2.5 and PM10 levels and slight changes of NO2.
	Another impacts reported are related with the health effects. (EU, 2016a) reported that, compared with the standards, in the firsts two years of implementation there was 90 premature deaths less and a reduction of 10 million € in health care costs.

3.1.5 LEZ in UTRECHT, The Netherlands

Utrecht adapted a LEZ in 2007 within a national framework where several Dutch cities agreed to put into practice access regulations. Some requirements were fixed to ban the most pollutant lorries over 3,5 tones. Furthermore, the city of Utrecht made a step forward in 2015 extending the LEZ regulations to old registered cars.

It was a referent city in the country to implement both the first LEZ for lorries and later LEZ for passenger cars. Other Dutch cities learnt about the policies and applied similar schemes.

Framework and background

In 2007, motivated by some successful LEZs practices in Europe, the Dutch government, municipalities and other stakeholders signed a National Covenant for 12 Dutch cities on stimulating clean heavy duty vehicles through LEZs. It allowed implementing LEZs with the same features in all the involved cities in a 3-years period.

The city of Utrecht was the first one; on July 2007 a LEZ was implemented for its medieval city center. At the beginning, only some lorries over 3,5 tones were affected according their Euro standards. As it was a pioneer and unknown initiative, the city council launched an information campaign to raise awareness, and to announce and promote the measure.

Encouraged by the success of LEZ, in September 2008, the Utrecht City Executive created the Utrecht Air Quality Action Plan. This plan consists of a wide range of measures to ensure that the whole city of Utrecht meets the European air quality standards by 2015. After evaluating the public input, the City Executive submitted the final plan for approval to the City Council in spring of 2009. This plan included the present LEZ and further improvements.

Over time, in 2010, time regulations for UFD were imposed in some streets in the pedestrian inner city, and as the car technology improved year by year, the LEZ was adapted in 2010 and again in 2013 the restrictions for the vehicles to meet stricter Euro standards.

More significant changes came in July 2015 when restrictions were extended for some cars, the older ones were banned to enter to the zone. Utrecht was also the first Dutch city to include passenger cars in LEZ. In this case, the regulation was decided independently from any other city, but it was an example and the others learnt from it. Currently Rotterdam and Amsterdam have LEZ involving cars as well.

Implementation details

Area covered and restrictions

LEZ is located covers the surroundings of the train station, Jaarbeurs and some roads in the neighborhood composing the medieval city center. The restrictions are settled for 24 hours a day during all the year, and these has been modified over time:

- 2007: Entrance ban to lorries over 3,5 tones with a lower standard than Euro 4. Euro 2 and Euro 3 were allowed to enter in case to have particulate filter installed.

- 2010: Entrance ban to lorries over 3,5 tones with a lower standard than Euro 4 or older than 8 years. Euro 3 were allowed to enter in case to have particulate filter installed.
- 2013: Entrance ban to lorries over 3,5 tones with a lower standard than Euro 4.
- 2015: Entrance ban to all vehicles registered before 2001.

Operation methodology

In addition to these restrictions, in 2010, access time regulations were imposed in the pedestrian inner city for UFD. Every weekday it was only possible to drive during the periods 6.00-11:30 and from 18.00-19.00.

Exemptions

For all this restrictions, as the other studied cases, some vehicles are exempt. Exceptions for cars include historic vehicles and disabled persons among other special cases. In the case of lorries the excluded are the ones transporting goods that cannot be transported via a provider of sustainable urban distribution, companies whose financial situation does not allow to buy cleaner vehicles, and other few cases.

Penalties

All these exempt cars need to be registered at Dutch national vehicle register, otherwise they could be fined as banned vehicles. To control it there is enforcement by cameras and police officers, and the punishments are 230 € for lorries and 90 € for other vehicles.

Penalties are useful for the administration because even the economic efforts from the private companies to modify their fleets, there has been subsidies of 85% for the installation of certified filters and also a smaller percentage for the purchase Euro 5 lorries. The municipality also paid the implementation costs of cameras, traffic signs and communication.

Results

Fleet turnover

The restrictions for access led many companies to change their fleets. It was observed in which proportion of vehicles working in the area of the LEZ in 2006 were replaced in 2007. After the first months of experimentation, percentages vary for every kind of vehicle. It is significant to point out the growth of Euro 4 and 5, together were multiplied per 12. In the other hand, Euro 0 and 1 were half reduced and Euro 2 and 3 slightly reduced. The fleet turnover also implied that companies had to invest in adapting or replacing vehicles. In total around 6,500 vehicles needed to be modified, meaning economic costs of around 69 million €, as said before, part subsided by the administration.

Qualitative results

These variations had positive environmental effects, but these have not been quantified. Other significant but not quantified impacts are the reduction of traffic accidents and the increase of quality of life.

A weakness detected for this model is that vans and light freight vehicles were almost not affected by the current air quality action plan (only partially, by higher parking fees). They produce a significant proportion of the total traffic emissions in the city. A not expected effect was that some lorries were replaced by pollutant vans (Bertens et al., 2011).

3.1.6 LEZ in BERLIN, Germany

Berlin is one of the biggest Europe capitals and the concentration of pollutant emissions from vehicles have significant local and global effects. To mitigate this issue, Berlin Municipality set several measures including a LEZ.

Affecting all vehicles, the LEZ was implemented in 2008 and adapted in 2010. Restricted access is carried out according emissions produced differentiated by a labelling scheme.

Framework and background

EU set limit values for PM and NOx levels, the two predominant pollutants from road traffic. In the German capital, until 2006, these limits were exceeded along one third of Berlin's main road network. So, like hundreds of other EU cities, Berlin had to draw up a clean air plan which spells out measures to meet the air quality standards. Hence, current abatement measures in Berlin focus on the transport sector. As a second pillar of the strategy to reduce traffic related pollution an urban master plan for transport (StEP) was adopted in 2004 as a blueprint for a sustainable transport policy and traffic planning (Lutz, 2009).

In StEP the LEZ idea was introduced. As a consequence, in 2005 a study was carried out considering several aspects and options for the city of Berlin to evaluate the emission reduction potential. The conclusions of the study revealed the feasibility to implement the measure in the city center, for its huge population density. Moreover, the study indicated that a scheme covering both passenger cars and HDV leads to substantially higher emission reductions than a concept limited to HDV.

Two years later, in 2007, German government pushed by Berlin adopted a national labelling scheme faced to implement LEZs. It differentiate the emission classes and it was a step forward for all the German cities to encourage LEZs. Each city could decide whether, where and when to do a LEZ, and what emissions standards want for its LEZ.

LEZ in Berlin was implemented in 2008 with slight access restrictions, but later in 2010 it was modified to be stricter. In the further years the conscience of improve air quality become more and more transcendent and it was created The Air Quality Plan 2011–2017 of Berlin.

Implementation details

Area covered

LEZ is defined by the local railway ring (S-Bahn Ring) in the city center, covering 85 km2 with more than 1.1 million residents. It works permanently the 24 hours of the day and for the 365 days of the year.

Since 2008, environmental criteria to enter to the LEZ is defined by emission categories. To define the type of vehicle and differentiate them according their emissions, the labelling is separated in the following categories:

Figure 28. Labelling in German LEZ (Berlin City Council)

- Red sticker (num.2): Euro 2 or Euro 1 diesel vehicles plus a particle filter. Ban for the ones older than 1992.
- Yellow sticker (num.3): Euro 3 or Euro 2 diesel vehicles plus a particle filter. Ban for the ones older than 1996.
- Green sticker (num.4): better than Euro 4 or Euro 3 diesel vehicles plus a particle filter. Ban for the ones older than 2000. Euro 1 petrol vehicles with a catalytic converter are also included.

Vehicles not meeting any of these criteria belong to pollution class 1. They cannot be exempted from any traffic ban.

Operation methodology

In 2008, in order to enter to the LEZ it was needed to have a red, yellow or green label. Out of 1.3 million registered vehicles before the implementation, around 80.000 vehicles, among them about 30.000 commercial vehicles, were affected by the traffic restrictions. Two years later, in 2010, LEZ was modified to allow entrance only to vehicles with green label and even more cars needed to be changed. In addition, it was set for foreign vehicles to be classified according to their age if the Euro standards cannot be clearly identified in the vehicle registration.

Exemptions and enforcement

No general exemption is granted for residents or commercial traffic, but some leeway exists in cases of proven financial hardship for businesses, for disabled people and night shift workers. Two-wheelers, vintage cars, police, emergency vehicles and few other special cases are also exempted from the scheme. To control it enforcement is done by urban police, punishing with 80 € standard penalty those who infringe the LEZ rules or drive without sticker. The fine is the same for all the vehicles and drive without a sticker is considered an offence and punished with the same standard fine.

Results

Evaluation methodology

During the first year with LEZ in use, results were extracted in order to observe the possible changes in air quality and in flow traffic. After an accurate analysis comparing the situation before and after the implementation, (Lutz, 2009) presented together key indicators and considerations of the implementation in 2008.

Different methods were used to obtain severe data including video recordings via cameras and recording pollution via monitoring stations, both set up in strategical points within the city road network. In addition, consultations in Berlin's vehicle registration data base were also carried out to identify the fleet turnover.

Efficiency impacts	During the implementation year, the motor traffic reduced by 4% inside the LEZ. Apparently it is a good effect caused by the implementation, but the same indicators showed a reduction of 6% in the surrounding areas of the LEZ. This means that the traffic flow was not a relevant impact sparked by LEZ, but rather as a result of the peak in fuel prices in 2008.
Fleet turnover	LEZ caused more significant variations in the fleet turnover towards cleaner vehicles. In 2008, the number of registered vehicles in the whole city with pollution category 1 dropped by 70% for passenger cars and 50% for commercial vehicles.
Environmental impacts	A calculation extracted from the recorded vehicle composition was carried out to express environmental impacts. It was revealed a net reduction of 24% of exhaust particle emissions and by 15 % of black carbon with the LEZ. Regarding the main traffic pollutants, during 2008, NOx fell around 14% and PM10 around 3%.

3.1.7 Comparison

All the considered cities adapted access restrictions around 2007-2008. It was the beginning of the introduction of these areas in a *large* scale in Europe. The first clear difference among the examined cases is that some of them apply an entrance ban and others a congestion charge to satisfy the same objectives, reduce congestion and reduce pollutants. The main difference between them regarding the implementation details is that CCZs affect to all the vehicles, while LEZs are only to the most pollutant ones. Following these rules, it is logic that CCZ obtain better results regarding the congestion impacts.

Area covered

Although CCZ obtain better congestion results, as this kind of measure affects more vehicles, the areas covered cannot be so big. Thus, CCZs are generally smaller than LEZs, which can cover huge urban areas, for example in London (~1.500 km2).

Type of restriction

Regarding the vehicle limitations of LEZs, most of them are marked by Euro standards according the pollutant emissions, which are actualized every 2 or 3 years because of the constant technology progress. Currently the LEZ limits marked in last years are Euro 4, and some of the LEZ also accept Euro 3 with approved particle filters, as Copenhagen or Berlin.

Penalties

Fees to disobey the restrictions vary significantly among the cities, but all of them are around 100 €. As exemptions there are two cases where this price is much higher than the others, London and Copenhagen, where penalties could reach 570 and 2.700 € respectively.

Enforcement

Technology is also under development, more and more cameras are used to control the vehicles. However, in some places is still the police and dedicated inspectors who watch over the restrictions, as Berlin and Copenhagen. In these places special labels are used differentiating the pollutant level, which are located in the cars windscreen.

Environmental impacts

Despite measure impacts vary depending on the city, area covered and type of restrictions, it is checked that environmental effects are positive for all the cases. It is true that some cases reach better success than others, but all of them get impact reductions and a consciousness of a fleet turnover.

However, in order to identify any impact of the LEZ in the air quality data, it is not sufficient to simply compare concentrations by direct measures or excess days of certain limit values. Changes in the weather conditions are relevant for dispersion, dilution and re-suspension of emitted traffic pollutants. Hence, weather also have a large impact on measured pollution levels. While NO2-levels are largely dominated by local emission sources, total PM concentrations also depend on regional and long-range pollution transport. Likewise, any shift in traffic volumes around the air quality monitoring sites used for the impact analysis need to be taken into account as such changes are barely related to the LEZ (Lutz, 2009).

In other hand, congestion reduction is very effective for CCZs but it only gets small changes in LEZs (4 % traffic volume reduction in Berlin).

Overall, all the effects are positive but in different proportions. It has been observed that apart of the city and restriction features, the quantification of impacts is related with the quantity of exemptions conceded. It is crucial to control the number of exceptions in order to maximize the different impacts.

City	London	Milan	Stockholm	London
Access restriction	CCZ	CCZ	CCZ	LEZ
Restriction type	Charging fee	Charging fee	Charging fee	Entrance ban
Implementation	2003	2008	2007	2008
last modifications	2011	2012	2016	2012
Area covered	21 km2	8 km2	30 km2	About 1.500 km2
Vehicles affected	All vehicles	All vehicles	All vehicles	Pollutant heavy vehicles
Limit accepted	-	-	-	Heavy lorries (>3,5T) Euro 4.
Charge (for CCZ)	£11.50 (13 €) / day	2-5 € / day	11-30 SEK (1,1-3 €) / entry	
Penalty	£65 (74 €)	70-285 €	SEK 500 (50 €)	£500 (570 €)
Enforcement	Cameras	Cameras	Cameras	Cameras
Working time	Weekdays 07:00-18:00	Week days 07:30-19:30	Weekdays 06:30-18:300	24h / 365 days
Environmental impact	-	18% of PM10, 10% of NOx and 22% of CO2	10-14% reduction of pollutant emissions	3% of PM no significant of NOx
Congestion impact	15% of traffic reduction	More than 30% traffic reduction	20% of traffic reduction	-
Fleet turnover	-	-	-	16% reduction of pre-Euro III

City	Copenhagen	Utrecht	Berlin
Access restriction	LEZ	LEZ	LEZ
Restriction type	Entrance ban	Entrance ban	Entrance ban
Implementation	2008	2007	2008
last modifications	2010	2015	2008
Area covered	40 km2	n.a.	85 km2
Vehicles affected	Pollutant heavy vehicles	Old vehicles and pollutant heavy vehicles	Pollutant vehicles
Limit accepted	>3,5T lorries Euro 4 or Euro 3 diesel with filter.	Registered in 2001. Heavy lorries (>3,5T) Euro 4.	Registered in 2001. Euro 4 or Euro 3 diesel with filter.
Penalty	Up to DKK 20.000 (2.700 €)	90-230 €	80 €
Enforcement	Inspectors and police (labelling)	Cameras and police	Police (labelling)
Working time	24h / 365 days	24h / 365 days	24h / 365 days
Environmental impact	23% of PM2.5, 8% of NOx, and 9% of CO2	Positive but not quantified	Reduction by 3% of PM10 and 14% of NOx
Congestion impact	-	-	4% of traffic reduction
Fleet turnover	-	Euro 4 and 5 together multiplied per 12	Category 1 (most pollutant) vehicles reduce 70 %

Table 8. Access regulation comparison indicators

3.1.8 Conclusions and tendencies of access regulation

The delivery private sector is growing and freight vehicles are trying to take profit of the urban infrastructure to maximize their gains. To control the city progress and the private sector growth, some actions need to be managed from the administration.

Access restriction is a measure decided, studied and controlled by the administration. This means that in contrast with the other strategies treated, money for implementation comes basically from the public sector. Nevertheless, the start-up investments are not so high and once the measure is prevalent it produces significant economic gains, from the charging or penalty fees. It leads most of the cases to a positive balance and money earned can help to improve transport infrastructure. For the administration this is a key consideration, which can encourage to implement further access restrictions.

Population acceptance as a key consideration

As it is an innovative measure, it can produce uncertainties of implementation. In most of the cases studied it is demonstrated that provide information and perform campaigns for the users is important. Moreover, to have population compliance, it can be planned a trial and a referendum, as in Stockholm. In case to realize them it has been detected that it is better to carry out the trial before answer the citizens. Once they see how it works, they can appreciate better the results and with a referendum a possible LEZ can be implemented with more security and accordance among society and politics.

Acceptance and collaboration from the citizens is essential for the restrictions success. They also have to understand that it is a measure that needs to be adapted over time. As seen, limitations are set according the pollutions emissions emitted, defined by Euro standards or the year when the vehicle is registered. As the vehicle technology is in progress and new Euro standards are arising, it is needed to adapt the restriction characteristics to the new trends in vehicle fuels.

Penalty analysis

Some technical points for implementation are required to be accurate for LEZ and CCZ. Exceptions should be minimized to maximize impacts. The penalizing prices are also relevant and it is important to set them high enough to avoid the entrance of restricted cars. It has been detected that there are delivery companies who prefer to pay the penalties than to renew the fleet because of cost reasons.

Impacts for stakeholders

Concerning retailers, they do not notice many UFD differences with or without an access restriction in the area. The small changes produced are contracted, in one hand streets gain in attractiveness, but in the other hand, delivery prices are increased. The effects for carriers are apparently negative because they need to adapt the schemes for their vehicles. Despite this fact, access restrictions can be seen as a positive advance for them because these kind of measures could lead them to find other solutions for LMD, as UCC or OHD, which can maximize their service and produce also better impacts for the society.

Tendency evolution

It is clear that access restrictions will tend to increment and be stricter. Few restrictions were present in Europe in the early 2000s, when Italy and Germany, among other pioneer countries, kicked off the first LEZs. Nowadays urban restrictions are present in many European mid and big cities. By the end of 2016, there were more than 500 cities with access restrictions and 231 LEZs in Europe.

Cities must choose this option to be become environmentally friendlier and promote a gain in transportation efficiency by the use of new technologies. Advanced cities are already studying future restrictions and are planning some implementations. The Ultra LEZ in London (UK) planned to be extended is an example. Among other cities with strict plans there is Oslo (Norway), aiming for net zero emissions in the city by 2030. It plans to raise tolls for cars to enter the city, cut parking spaces, phase out fossil-fuel heating in homes and offices, shift the bus fleet to renewable energy and build ever more bicycle lanes.

3.2 LOAD PARKING REGULATION

Freight vehicles have deliveries spread around the urban areas. Occasionally, the goods destination is a place with its own unloading parking spot where freight vehicles are able to stop as much time as they need. These cases mostly involve shopping malls or big businesses commonly located out of the city center.

For busy and narrow streets the situation is different. Freight vehicles when arrive to the destination need to find a spot to unload the goods, it can be a difficult and stressful process. Moreover, looking for a spot to carry out the unloading procedure contribute to congestion, especially in peak hours. This aspect is of particular interest wherever local conditions oblige freight vehicles to stop for loading and unloading outside designated spaces. Vehicles can stop at junctions or along a lane, in both cases leading to a reduction in capacity, and the problem is more serious for medium or heavy goods vehicles (Bouhana, Zidi, Fekih, Chabchoub, & Abed, 2015). Besides congestion, it produce other consequences which can be avoided through freight parking regulation.

Types of regulation

Several solutions are used to improve the freight parking service. Regarding what is arising in Europe, three different methods are detected:

- Control and managing spots by IT systems. Technology is used to inform drivers whether the loading zones are free or not, booking a spot, inform about the time spent parked in a spot, etc.
- Multiuse parking places. Allowing to increase load/unload spots by sharing them. Other vehicles can use them, but it is restricted for freight services during a time period.
- Parking restrictions to pollutant freight vehicles, it ensures and ease the unloading procedure for eco-friendly vehicles and leads to a positive fleet turnover.

Load parking regulation goals

According to the method implemented, parking regulation objectives slightly change. Generally, the first two cases are faced to reduce congestion in busy streets, reduce traffic accidents, reduce kilometers driven, and consequently, reduce pollutant emissions. However, while IT systems are also based in improving driver comfort, multiuse parking aims at improving the urban land use. Finally, pollutant vehicle restrictions have different priorities following the main intention of reduced pollution and promoting a fleet turnover to greener vehicles.

Not all the cities priorities are the same. Hence, to maximize the expected impacts for each urban area studying several elements of interest is needed. These pertain to three main spheres: the demographic, economic and spatial characters of transport demand; the supply of transport and logistics infrastructure and services; and the external environment (Comi et al., 2017).

Parking regulation, as LEZ and CCZ, is also managed by the administration. This means that authorities are in charge to decide how to implement a measure and what to prioritize, but also to pay the economic costs. These can be high in case of introducing IT systems.

Advantages and disadvantages

Regarding the other stakeholders involved, retailers do not notice significant changes. The relevant variations are for the freight drivers. Although carriers need to adapt to new technologies or change delivery schemes, those together with the

citizens are the most beneficiated stakeholders. In the Table 9 it can be observed the advantages and disadvantages from the different UFD stakeholder point of view.

Stakeholder	Advantages	Disadvantages
Carriers	-Less stress. -More information about parking load/unload places. -Driven kilometers saved.	-Adaption of technology. -Adaption of schemes.
Retailers	No influences	No influences
Local authority	-More control freight vehicles. -Less traffic accidents. -Less congestion in busy streets. -Less pollutant emissions.	-High start-up costs (depending on the IT solutions involved).

Table 9. Advantages and disadvantages of load parking regulation

Practices identified

Overall, parking regulation, regardless of the method carried out, suppose an improvement in LMD. Anyway, in case of implementing regulation schemes it is important to secure that it is feasible, especially in the IT side due to its elevated start-up costs. Some cities with parking regulation implementation in last yeast have been selected, including two IT introduction cases, a multiuse parking case using IT and two different cases banning parking for pollutant vehicles:

- Barcelona, introducing an app to manage and improve loading parking regulation (BSM, 2015).
- Lisbon, creating vehicle detection sensors and adapted parking meters to monitor loading parking regulation (Andersen & Eidhammer, 2015).
- Poitiers, introducing multiuse short stay parking areas fitted with IT solutions (SUGAR, 2011).
- Bremen, restricting the access to a parking place located in the edge of the pedestrian zone (Glotz-Richter, 2009).
- Amsterdam, exempting electric vehicles of some standard freight vehicle restrictions (FREVUE, 2017).

3.2.1 AreaDum in BARCELONA, Spain

In Barcelona, an app for freight drivers named AreaDum was created to update and improve the management of freight parking spots. The app registers all the load and unload operations in the city, aiming to recollect information which would help to implement further solutions in urban deliveries. At the same time, it fosters an adequate use of the reserved parking, reducing indiscipline and generating more empty spaces.

Figure 29. AreaDum Sign (Aj. de Barcelona)

The app registers all the operations because the carriers have to indicate when they start and finish their loading and unloading operations. Drivers also dispose of advantages because they are informed via app about the time left to finish their operation besides other relevant information about freight spots.

There is the willingness to keep improving the system. For the future it is expected to offer the availability in real-time of free spots, avoiding extra driven kilometers, pollutant emissions and time.

Framework and background

Since the early 2000s, the system to control the time spent in a freight parking place in Barcelona had been timing disks. The driver indicated the hour and minute the vehicle had parked and it could stay there for the next 30 minutes.

To improve the methodology, a new option was developed through IT solutions. It consist of an app registering parking times and providing information to carriers and to administration via technological devices. It was an innovative initiative, so before implementing it, a pilot test was carried out. Hence, in 2014 and within Barcelona Urban Mobility Plan (PMU), it was tested in Passeig de Gràcia, as a representative street.

As the feedback was positive both for the administration and for the drivers, the app started to be in use permanently at the beginning of 2015. The new method was established as permanent and the timing disks were removed.

The developer and actual operator is BSM, a company founded in 2002 with the aim of unifying municipal services in a single company. The same year of its implementation, the European Parking Association congress nominated AreaDum to be the best project about surface parking in Europe.

In 2017, after two years of its introduction, an analysis of data recollected was carried out within Novelog, a European project. It analyses the quantity and other aspects of the operations in Barcelona during one week

Implementation details

Parking spots regulated

Currently, the application regulates parking in 1.973 areas distributed in 564 streets. Overall, around 9.000 parking spots dedicated to UFD. Fright vehicles dispose of 30 minutes period to carry out the loading or unloading operations and they cannot stay during two time periods.

Figure 30. AreaDum app (Aj. de Barcelona)

Technological resources

Carriers need to register their vehicle in the app, indicating the type of car and license plate. If the user is registered the actions to carry out during the operations are simple and repetitive. Once parked, the driver only needs to indicate the area number where he/she is, showed in signposts, and press to initiate the timing. When the operation is completed, the driver needs to indicate it by a simple press and the time stops. Alternatively, in case to do not dispose of a Smartphone with IOS or Android, it is possible to use the AreaDum parking areas by sending an SMS.

Operation methodology

The app allows the users to have a detailed register of their operations, they are able to check during all the leading process how much time is left to finish it. Other information that carriers are able to find in the application is the number and location of freight parking areas. In the other hand, administration receives data of all the loading and unloading operations. It allows them to study the number of vehicles using each area, how many operations a vehicle carries out in a day and the hours with higher demand, among other interesting behaviors. The occupation in real-time of each place is not able yet, but BSM is working on it.

Results

The following results have been reported in 2017 within a study done in the framework of the European project Novelog. It analyzed the data extracted from the app during a representative week in May 2016. This evaluation helped to make an idea of how it worked, but it would not be correct to extract a global quantification of AreaDum. The reason is that there were many carriers not registered yet.

Data obtained

The application, nearly computing all the operations, approximately registered 40.000 operations per day executed by about 11.000 vehicles. From 25.456 freight vehicles that were operating during all the week, 19.656 carried out between 1 and 10 operations, which means 77,2% of freight vehicles registered. Other interesting figure is that about 50% of the freight vehicles present in the area daily only perform one operation throughout the day. This data collection proved that the efficiency of UFD in Barcelona needs to be improved. Many kilometers could be saved unifying deliveries before entering to a dense city as Barcelona. It encourages to develop other forms of LMD adapted to the vehicles that only perform a service, which probably have a low load factor. Moreover, it has been detected that about 400 parking areas were receiving less than 10 operations per day. This can lead to a redesign of the distribution of some UFT parking areas.

Finally, it is important to point out that the introduction of IT solutions for parking regulation reinforced Barcelona's leadership among Smart Cities.

3.2.2 IT solutions for load parking in LISBON, Portugal

IT solutions were developed in Lisbon to be used in order to mitigate traffic problems related with freight vehicles and their parking spots. Two different technologies based schemes working independently were tested. One of them consisting in adapted parking meters that issue special tickets for 30 minutes of loading operations. The other, detection sensors to control the presence of a vehicle in the loading bay and send the data to a control center of the Transport Authority.

The main aim of the introduction was to solve the present situation problems about unregulated loading activities, involving road congestions and illegal parking on sidewalks or double parked. Consequently, improvements in LMD and in city attractiveness were expected.

Figure 31. IT solutions tested in Lisbon (Rodrigues & Sardinha, 2013)

Framework and background

Loading and unloading activities has been unregulated during many years in Lisbon, the 9th most populated urban area in the European Union. This causes road congestion in the historical protected urban center and temporary blockage of roads. In addition, deliveries are difficult in this area for its narrow streets, small and irregular routes and complicated parking slots. These difficulties result in an inefficient logistics sector for both mail deliveries and services (EMEL, 2012).

The first innovative solution in Lisbon involving loading parking and IT solutions was included in the Municipal Regulation for on-street parking, approved in 2004. Nevertheless, it required a wide range of technology mechanisms to support it. Lack of money retarded the implementation, and later, insecurities led to a completely suspension of the measure in 2007. No solution was found to substitute the measures planned and as a consequence, significant conflicts raised constantly between the urban freight operations, pedestrians, private car users and public transport.

In the following years, Lisbon's Public Municipal Company for Parking and Mobility (EMEL) tried to find a solution, integrating smart systems but avoiding to represent a heavy financial burden to the city. After studying the situation, EMEL decided to try new IT solutions for loading parking in a small street before the implementation in the whole city. The implementation of these measures found an external support and was developed within the framework of a European project, Staightsol.

Two different solution were tested starting December 5th, 2011 and lasted until April 30th, 2012. The responsible for the demonstration was EMEL, but the trials also involved other stakeholders as transport operators, the chamber of commerce, other road users and retailers, taking profit from more reliable deliveries.

Implementation details

The demonstration tried to test the behavior of two different technologies independently but at the same time and place. For the trial, it was defined the need to choose a street covering a wide diversity of shops (ranging from small shops to large ones) and of loading and unloading procedures used (by hand, in pallets, in trolleys, etc.). Requirements were found in the Guerra Junqueiro Avenue, which is 450 meters long. Tests were carried out there during 5 months.

Technological resources

Parking meters were adapted to issue special tickets for freight carriers valid for 30 minutes, which needed to be located under the windshield to be verified by the parking officers. Contactless cards were provided to the drivers to get these tickets through the parking meters every time they needed to carry out an operation.

In the other hand, vehicle detection sensors were installed on the ground, activated by magnetic field above. The sensors were connected with a data base. Hence, EMEL dispose of the data about all the loading and unloading operations within the city, which could be used to manage LMD. The technology was set to be activated only if the magnetic field changed more than a certain value to avoid detection of proximity cars or other objects. However, it also had some imperfection because it was not able to detect whether the parked vehicle is allowed to use the freight operation parking space or is only a private car illegally parked. The enforcement to control this fact was carried out by police inspectors checking the tickets issued by the parking meters.

Economical costs

As it needs the installation of new appliances, both systems were associated with economic costs, divided in investment costs, operating costs and enforcement costs. Investment costs, related to installing the technologies were around 500€ per sensor with an estimated lifetime of 5 years; and 7.500€ for each parking meter, covering several spaces with an estimated lifetime of 7 years. Operating costs, which include communications, maintenance and management costs, are variable but not so relevant because the system works on solar energy. Finally, enforcement costs, were counted to be around 30€ per place and month.

Results

Evaluation methodology

The tests allowed the identification of the challenges and needs for improvement associated to each one of the technologies being tested. In order to evaluate the two solutions, (Delmas & Nunes, 2014) developed a study based on a CBA for each of the IT solutions. In order to perform it, it would have been ideal to dispose of diverse data related with pollutant emissions, safety of pedestrians, time savings, etc. Although this data was not extracted, it was available the time and date when the vehicle entered and left the parking spots, and it allowed to quantify the number of loading operations. In addition, (Delmas & Nunes, 2014) also used information about infractions by parking fines issued, and about the number of damaged installations, which together with the implementation costs helped to complete a feasibility study.

Quantitative results	CBA concluded that both IT solutions give a positive Net Present Value considering 15 years period of operation, 12.0 million € in the case of the detection sensors and 10.5 million € regarding the parking meters. Moreover, with the implementation of monitoring systems, comparing the numbers of the west side of Guerra Junqueiro Avenue during the pilot (December 2011 – March 2012) with the numbers in the previous year (December 2010 – March 2011) it was possible to conclude that there had been a 57% reduction of the number of parking fines with the implementation of monitoring and enforcement systems.
Overall balance	Finally, the trial was evaluated positively for its good reliability and the fact that could be supported by a centralized management system. Despite the high economic costs of implementation, the monitoring system was user-friendly and resulted easy to install and operate with.

3.2.3 Multiuse parking in POITIERS, France

Multiuse parking areas were set in Poitiers in 2007. Urban freight vehicles and the rest of vehicles share several parking areas around the train station, where most of the shops are located. For a determined period of time (5.00-11.00) the spaces are reserved for UFD, but during the rest of the day these are considered as short-term parking, where all vehicles are allowed to park but not to stay longer than 10 minutes.

The enforcement is carried out by police inspectors, but to help them there is an IT tool consisting in physical bollards with special detection sensors. It was considered a successful innovative solution.

Framework and background

For many years the most important commercial area in Poitiers has been located in the surroundings of the railway station. To control UFD, the vicinity included 124 spaces of "minute" stops and 760 parking spaces to facilitate short-term car parking near the shops, while approximately 75 deliveries were carried out per week.

Nevertheless, in 2007, the station was renovated and the area was reorganized to better facilitate loading and unloading areas near the station. Parking improvements consisted in introducing a dynamic multi-use of some areas. Hence, an innovative procedure was designed for parking areas implementing physical bollards with IT incorporated.

After discussions in the City council about practical details, a proposition was completed by technical services. Finally, it was approved from the council in cooperation with retailers, setting up a small-scale trial phase starting after the renovation of the station.

For the trial, 5 bollards were settled to manage parking places. The scheme was assessed. There was a satisfactory increase of vehicles' turnover. By 2011, 23 bollards were already implemented in the city center of Poitiers (SUGAR, 2011).

Implementation details

Operation methodology	To separate the different uses of several parking spaces in Poitiers, the day is divided in 2 periods. From 5.00 to 11.00 parking is reserved for deliveries, and outside this time slot the spaces are set as short term car park, where vehicles cannot stay more than 10 minutes.
Enforcement	These parking places are fitted with a bollard and a sensor in the ground. The principle is simple: the sensor detects the presence of a vehicle. On the bollard, a screen displays the authorized park use currently operational (which is delivery or private car parking). When a vehicle is present, the time of authorized parking is displayed on the bollard. If the car is not moved within 10 minutes, a SMS is sent to the local police so that it moves the car (SUGAR, 2011). It allows the municipality to control the use of the spaces from a distance and reduce the inspectors' staff.
Phases and economic costs	At the beginning, 5 bollards were installed to try the measure. Later, after a positive assessment, 18 more were added. Regarding the implementation costs, each bollard costed from 3000€ to 4000€ (SUGAR, 2011).

Results

Data obtained

After 4 years of the implementation, (SUGAR, 2011) pointed out that more than 40 vehicles on average were using one parking space between 8.00 and 20.00, 74 % of them parked for less than 10 minutes and 48% for less than 5 minutes. Regarding the 26% cars breaking the time rule, it was demonstrated the success of the IT measure since 63 % of them were leaving in the 5 minutes after receiving the first alert.

Qualitative results

As a consequence of this parking regulation, an improvement of delivery times and a better road occupancy had been perceived. Freight vehicle drivers had been forced to reduce indiscipline and respect the load and unload timings. However, retailers and carriers considered too short the time dedicated for the procedure.

Regarding the feasibility of implementation, positive results were clear. Bollards are not so expensive and they can be implemented in all critical sites where numerous vehicles have to share the space. Moreover, although the police inspectors need to be trained for an efficient link with the system, it is possible a reduction of control staff.

3.2.4 Environmental loading point in BREMEN, Germany

Bremen carried out a pilot project testing an environmental loading point. It consisted of a parking place reserved for deliveries and pick-ups exclusive for environmentally improved vehicles and above Euro 5 standards vehicles. It was located in the center of the city, at the edge of the pedestrian area.

It focused mainly on reducing the number of vehicles necessary to serve the area and do it in a more sustainable way, but it also aimed to offer improved service hours that bear a particular benefit also to inner city commerce.

Framework and background

Bremen is a harbor city with significant freight movement involving both national and international commerce and industry, which implicate important logistic platforms and routes. Nevertheless, the city has a pedestrianized center trying to avoid as much as possible the presence of pollutant vehicles.

The huge presence of freight vehicles has been one of the causers of the raising pollutant emissions in last decade. In 2007, (Glotz-Richter, 2007) reported some data about expected emissions in the city for 2010. One of the relevant points was that the heavier vehicles, being less than 10% of the total, would be causing about 50% of NOx emissions.

Hence, in 2007 and to deal with the growth emissions, logistic enterprises proposed to test an environmental loading point to benefit the use of environmental friendly vehicles. The loading measure was set as a pilot project supported by the PARFUM-Project within the EU environmental programme LIFE. The details of the loading point were decided in cooperation of local authorities, logistics operators and the chamber of commerce. The PARFUM pilot project in Bremen lasted for 2 years. Nevertheless, it serve as framework to implement in 2009 a LEZ in the city center, following the same objectives.

Implementation details

The environmental loading point was located in a pedestrian area, Jacobikirchhof, where most of the shops are located. The parking place had dimensions suitable for vehicles up to 7,5 tones and a length of 8,5 meters.

Operation methodology	It gives extended time access for environmental vehicles to support clean deliveries. The parking place is oriented to freight services and it is restricted only to environmentally enhanced vehicles and above Euro 5 standards vehicles. To differentiate the vehicles, carriers meeting the restrictions receive a label to be located in the windscreen and a RFID (radio frequency identification detector) transceiver for authorization measures.
Technology resources	The parking place was technologically fitted with an induction loop under the pavement. It registered the movement and the RFID sensor above the traffic light stablished communication with the on-board RFID transceiver. If the vehicle had a transceiver, nothing happened and the user was welcome to park on the point and start unloading the shipments. Otherwise, if the vehicle did not have a transceiver, the traffic light begins to shine orange, which indicates an unauthorized parking. Additionally, there were traffic signs which explain the Environmental loading point, which was another part of the enforcement against parking violators (Glotz-Richter, 2009).

Results

The combination of environmental restrictions with the use of technology to monitor the operations was positively evaluated. Although the implementation of mechanisms could suppose an important economic investment, it was counteracted with the reductions of personal staff to control and the reduction of pollutants.

Environmental impacts

The variations of emissions due to the measure could not be measured directly, since the results are generic and refer to the all the measures implemented in Bremen during the PARFUM project. But in general, it was achieved an emission reduction of the polluting gases NOx and PM10. This reduction was estimated at 1.065.300 grams of NOx and 74.370 grams of PM10 (Glotz-Richter, 2009).

Fleet turnover

Regarding the fleet turnover, besides its promotion, natural gas fueling station network had been extended. Some carriers had pronounced their opinions about the measures and no complaints were detected, but positive reactions. One important parcel service announced to purchase further natural gas powered delivery vehicles in its fleet.

3.2.5 Parking exemptions for freight EV in AMSTERDAM, The Netherlands

Parking exemptions were stablished for some carriers in a small central part of Amsterdam. This measure wanted to differentiate and promote electric vehicles fleets benefiting them by offering the possibility to carry out more efficient deliveries.

Testing the exemptions for 2 years (2015-2017), the City of Amsterdam wanted to know how important the incentives could suppose for transportation companies to change their fleets to electric.

Framework and background

Amsterdam has approximately 800,000 inhabitants and receives about 20 million visitors a year. Every day approximately 3,500 trucks and 25,000 vans drive into the city, with the consequent problems of congestion as well as air pollution. In the last years, the city took consciousness about the pollution problems due to traffic and consequently several measures have been adopted.

In October 2007, a LEZ was stablished and was modified over time to meet stricter restrictions. Investigation in new measures are constantly carried out by the municipality to promote a fleet shift. Likewise, equipment oriented to electric vehicles is being installed to cover the desired demand.

In 2015, Amsterdam became a city partner of FREVUE project, which aimed to promote electric vehicles. In order to enforce its interest to boost this type of fleets, as project partner, the city tested a new kind of regulation consisting in parking policy. Some spaces were free for selected carriers who drove freight electric vehicles. Time window periods and access to pedestrian zones were enlarged as well.

It was a pilot implemented for 2 years. To evaluate it, a research study was carried out by TNO, a Dutch partner responsible for the economic analysis under the FREVUE project.

Implementation details

Operation methodology

The measure exemptions were in practice from March 2015 to April 2017. Freight electric vehicles were allowed to carry out loading processes directly on the pavement. Moreover, they could enter to pedestrian zones and they did not need to respect the time access windows, which allowed them to operate with no time restriction.

The measure was applied in small areas with frequent deliveries. These areas were defined based on participants' preference and traffic situation. Logistics operators could request exemptions related to their business needs. As a result, the number of exemptions provided varied by participating operators, ranging from 3 to 28.

Approximately 20 vehicles, both vans and trucks, from seven logistic operators took advantage of the exemptions in tailored designed areas

Results

Evaluation methodology	After six months of operation, to identify results of the measure the participant carriers were interviewed. The questions were targeted to recognize both quantitative and qualitative indicators of daily operations.
Quantitative results	Money savings were based in reduction of time to carry out deliveries. Each driver walked every day between 15 and 45 minutes less as a result of parking the vehicle closer to the final destination. Less walking time implied to carry out 4 to 5 additional deliveries per hour. In addition, driving time was minimized as well, reducing the distance spent finding parking and leading to an average of 5 to 6 additional stops per day.
Working conditions	On the other side, qualitative results were resumed in reduction of stress for carriers leading to a better performance. The reductions of stress cause fewer mistakes in deliveries, higher productivity and fewer aggressive behavior incidents.
Ideas emerged	Aside from the results, some ideas emerged from the interviews. The positive reductions of stress made evident the drivers will to have wider time windows to carry out deliveries, not only for electric vehicles. Another idea that emerged is the necessity of a stricter enforcement. Higher fines would prevent conventional vehicles to park at the exempted locations due indiscipline which is one of the relevant problems of loading areas.
Overall balance	When the project finished, the City of Amsterdam was very pleased with the outcome of the pilot. As a result, they are currently working on improving and broadening the pilot to the whole city. In overall, operators agreed that an extension of the privileges would be beneficial, not only for the positive results observed, but also because it would lead to long-term agreements with the receivers, making the deliveries more efficient.

3.2.6 Comparison

Since there are several types of parking regulation measures, the different implementation cases are difficult to be quantitatively compared. Moreover, indicators about parking regulations are calculated in relation with the specific objective of each case. Therefore, in some cities it is possible to obtain data about fleet shift, in others about time savings, in others about indiscipline reductions, etc. For this reason the comparison between the studied cases is based in qualitative terms and done to bear out how diversely the parking can be regulated.

According to the main objective of each measure, the restriction implemented is different. The five cases are divided in three groups. In one of them, Barcelona and Lisbon aim to monitor the loading activities for a further improvement on loading areas. Both cases try to achieve it by strong systems of IT solutions, introducing an app in Barcelona case and parking meters and detection sensors in Lisbon. The second group bundle Bremen and Amsterdam, which apply the measure to promote a fleet turnover and leave pollutant vehicles. These measures are based in exemptions and priorities for green vehicles. Finally, Poitiers follow the objective of maximizing the land use, proposing an initiative of multiuse parking.

Technology implementation

As said, two cases base the measure in the introduction of IT solutions, but these are also used in most of the cases to cover some functions. Among the cities studied, only Amsterdam does not contemplate technology implementations to assist the measure. It is a clear trend that the improvements in technology are valuable for freight parking measures, being the introduction of detection sensors the most applied alternative.

Parking spots regulated

The cases studied also involve a wide range of affected parking spots due to the measure. From around 9.000 places in Barcelona, involving most of the freight parking places in the city, to 1 place in Bremen. Some options consider that applying regulations to few places is enough to achieve the aimed results. These cases coincide with the stricter restrictions. The ones affecting more places are softer and imply few changes for the users. It is the case of Barcelona, where the drivers just have to learn how to use the app and the policy remains the same.

Duration of pilots

As innovative measures, all of them are risky at some point. To confirm the positive results studied and for a better acceptance, pilot phases are needed. In the five cases, pilots have been carried out and vary in duration from 5 months to 2 years. In Barcelona and Poitiers the positive and fast results of the pilots permitted to adapt the new regulations permanently. In the case of Bremen, the trials were useful to implement a further LEZ. In Amsterdam, the administration is currently thinking to adapt the exemption permanently. And finally and in contrast with the other cases, in Lisbon it was decided not to implement the measures further than the pilot. Although the positive effects shown, the implementation was considered too expensive.

City	Barcelona	Lisbon	Poitiers
Restriction type	IT solutions introduction	IT solutions introduction	Multiuse parking
Year	2014	2011	2007
Main objective	Monitor loading activities	Monitor loading activities	Maximize land use
IT solutions	App for drivers	Adapted parking meters and detection sensors	Bollards with detection sensors
Regulated parking spots	Around 9.000	Small number covering one street	23
Pilot	Short period before implementation	5 months	Short period before implementation

City	Bremen	Amsterdam
Restriction type	Environmental loading point	Exemptions for electric vehicles
Year	2007	2015
Main objective	Fleet turnover	Fleet turnover
IT solutions	Induction loop + RFID sensor	None
Regulated parking spots	1	No places but special conditions
Pilot	2 years	2 years

Table 10. Load parking regulation comparison indicators

3.2.7 Conclusions and tendencies of load parking regulation

Big cities tend to concentrate more and more the commercial areas in big shopping malls and in city centers. Loading and unloading operations for shopping malls normally does not involve big problems because these activities are normally carried out in specific private points, not interfering the urban users. But doubts and challenges arise in deliveries on the street, where the space is limited and carriers share the space with other users

Large vehicles are decreasing in city centers because of access restrictions increment, but small vehicles delivering parcels to small businesses and particulars are incrementing. Hence, loading operations, from the vehicles to final destinations, will remain requiring parking spaces in urban areas. However, the loading and unloading requirements are changing and parking restrictions will need to be adapted. Due to just in time principle and small quantity of freight transported by urban vehicles, it is a tendency that deliveries and loading operations are turning to be shorter in time and more dynamic.

Technology dependency

It has been demonstrated that the future of the freight parking control is dependent on the new technologies. As seen, the progress to a more efficient loading operations in urban areas involve in most of the cases IT solutions. Together with the evolution of new sensors and systems, parking features can be improved. Likewise, more data can obtained to control and optimize loading procedures.

As concluded in (Repo, Sol, Rategies, & Solutio, 2013), it is noteworthy finding that in a project in which a technological solution is sought it might be interesting to let the market come up with the best solution possible. This can be achieved by making a tender which specifies the main issues to be addressed instead of making a full specification, and thus letting competitive innovation work. However it is important that this specification is complete and well-done so that the solution found is feasible and reliable.

Not all IT solution are worth to be implemented. Some of them fail because of its elevated economic costs, as the intelligent sensors tested in Lisbon (Portugal). But there are experiences failed because of its poor technical results. It is the case of some cities, as in Bilbao (Spain), which tried to add a booking system for loading places through sensors and an app. Up to the moment it is not a good option to consider. It had been proved that once the place was booked, there was no possibility to be sure that the parking place would be empty at the arrival because of the indiscipline.

Enforcement manage

Indiscipline is a problem not only for the cases treated but in loading parking in general. Stricter enforcement of fines would prevent conventional vehicles to park or stop at the exempted locations. Therefore, the availability for carriers to find a spot would improve and the efficiency would be beneficiated, which would allow to reduce freight parking spaces.

Population acceptance as a key consideration

Another of the lessons learned is that all the stakeholders from the outset of the project need to know the measure conditions and be engaged. As an example, the case of Barcelona needs that all the carriers entering to the city install and use the app. Otherwise the data collected is not representative.

Finally, it is remarkable to note that measures carried out in urban space are decided and managed by the administration. Therefore, parking regulations, as the access ones, are financed by public funds. Nevertheless, for a good acceptance and conduct of stakeholders is positive to promote and agree the measures with all the road users.

4 SHIFT TO LMD ELECTRIC VEHICLES

As pointed out in (Schoemaker & Allen, 2006), urban freight vehicles account for about 6%-18% of the total urban travel, for about 19% of the energy use, and for about 21% of the CO2 emissions. These effects can be significantly reduced shifting conventional vehicles to less pollutant vehicles which run without burning fossil fuels.

Types of EV in European market

Currently, several alternatives of EV have been tested and most of them are in the market. These are differentiated according to the fuel used as explained in Table 11.

Acronym	Description
EV or BEV	All-electric or battery electric vehicles are powered only by one or more electric motors. They receive electricity by plugging into the grid and storing it in batteries. They consume no petroleum-based fuel while driving and produce no tailpipe emissions
PHEVS	Plug-in hybrid electric vehicles use batteries to power an electric motor, plug into the electric grid to charge, and use a petroleum-based or alternative fuel to power an internal combustion engine or other propulsion source.
HEVS	Hybrid electric vehicles combine an internal combustion engine or other propulsion source with batteries, regenerative braking, and an electric motor to provide high fuel economy. They rely on a petroleum-based or alternative fuel for power and are not plugged in to charge. HEV batteries are charged by the internal combustion engines or other propulsion source and during regenerative braking.

Table 11. EV Types (Foltyński, 2014)

Pollutant emissions vary according to the type of engine considered, reaching nearly zero emissions in purely EV cases. For this study, these type of vehicles will be considered. Even so, the other ones have similar pros and cons, but in different proportions.

Although the external design of an EV could be the same than a conventional vehicle, the electric power of its battery determines a smaller shapes and limited capacity. Apart of conventional van shapes, it is also possible to design EV with the shape of a bicycle or tricycle with a small electric engine hybridized with human power propulsion.

FREVUE project

In recent years, there has been an increasingly number of pilots and demonstrators running EV fleets for UFT. As culmination of several small EV freight projects performed to date, in 2013 started an important EU project. Its acronym is FREVUE (Freight Electric Vehicles in Urban Europe) and it is still running involving eight of Europe's largest cities. Its main aim is to support the introduction of electric freight vehicles by demonstrating and evaluating innovative urban logistic solutions.

An example of how EV fleets could be introduced is presented in Table 12 including some details of FREVUE demonstrations. As these are still running, there are no results and conclusions of these specific trials. However, FREVUE examples together with other cases and studies helped to analyze the main aspects to put into practice EV in UFT fleets. The analysis has been divided into environmental, operational and economic issues.

City	Description
Amsterdam	In Amsterdam three companies and the municipality were involved in the FREVUE demonstration: Heineken's logistics service provider was using a 12 tons electric truck Ginaf to supply hotel, cafes and restaurant establishments in the city center; UPS used six retrofitted large electric vans which are similar with the typical UPS van; and TNT started operating 5 large retrofitted electric vans based on Fiat Ducato chassis for their express deliveries. In addition to subsidies, the municipality of Amsterdam took complementary policy measures to make EFVs use more attractive. Those privileges are exemptions on traffic codes, such as parking on sidewalks to load / unload, driving into roads that are only for pedestrians, etc.
Lisbon	In the demonstrator the Portuguese postal company CTT uses 10 small electric vans (type Renault Kangoo ZOE) for post and parcel operations in Lisbon. EMEL uses five small electric vans for maintenance of the on street parking and charging point infrastructure. The Lisbon local authorities look at supporting policies for EV fleets and already uses some EV fleets for waste collection and gardening and city maintenance.
London	For FREVUE UPS has 16 retrofitted EV with a changed powertrain and refurbished old vehicle running in London. These EV replaced existing roundtrips of diesel vehicles of 75 kilometres a day, fitting perfectly into the daily range of the EFVs. In the other London demonstration Clipper uses two EV of ten tones for the operation of the UCC in London. These EV make two roundtrips per day between the large UCC in Enfield (10 miles north of the London city center) and the smaller one at Regent Street in central London.

City	Description
Madrid	The Madrid demonstration included three operators and an UCC. 4 to 6 electric vehicles were running daily (operated by Pascual, TNT and SEUR). Regarding an UCC, after a search for an available and suitable location, local authorities found an old market for fruit and vegetables in the southern part of Madrid that was empty. A part of this old market was reconditioned to make it suitable for an UCC, including charging infrastructure for the EV fleet. The use of the UCC was offered for free to the operators in the FREVUE project, except for some really minor costs as the costs for cleaning, maintenance, etc.
Milan	The Milan demonstration was slightly delayed due to several technical and legal barriers when trying to get a French-authorized EV with temperature controlled box to operate in Italy. A logistics operator, specialized in temperature controlled distribution of pharmaceutical, diagnostic and biomedical products to pharmacies, hospitals, third party distributors, nursing homes and patients, operated two EV in the demonstration.
Oslo	In the Oslo demonstration Bring used subcontractors to deliver and pick up parcels. The company planned to operate 4 EV (Peugeot Partners) to replace existing conventional vehicles. The logistics concept is as follows: in the morning deliveries are made and in the afternoon pick-ups are done. Basically, the routes start at home, to the post office, to the Bring customers, doing pick-ups, to the post office and then back to home.
Rotterdam	In Rotterdam the Binnenstadservice's local franchisee RoadRunner used a Nissan eNV200 for its deliveries. TNT started operating 4 large electric vans and UPS operates 4 large electric vans. Next, Heineken operates one large 19 ton electric truck Hytruck. The city of Rotterdam prepared a study in cooperation with the local grid operating company to determine the spatial distribution of business vehicles (trucks and vans) and derive the overnight charging requirement if all vehicles were electric. Moreover, the city examined ways to include promoting zero emission logistics in the procurement of goods and services.
Stockholm	Originally one demonstration was planned with a construction UCC and EV carrying construction materials from the UCC to the construction sites. After one year as the capacity of the electric vehicle was too limited for all construction deliveries, the electric van (Mercedes Vito) was used to move materials from the UCC to the construction sites accompanied by two conventional trucks with hybrid cranes. Now Stockholm is examining the possibility for an UCC to deliver goods in the city center using electric freight vehicles.

Table 12. FREVUE pilots (adapted from Quak, Nesterova, Van Rooijen, & Dong, 2016)

4.1 ENVIRONMENTAL ISSUES

In Europe and USA, around 80% of the population lives in urban areas already. Since urban areas usually contain large populations, extensive commercial establishments, and an increasing demand of services and commodities, there is a need to increase the frequency of urban deliveries (Juan, Mendez, Faulin, De Armas, & Grasman, 2016). Increasing the quality of life by ensuring these services led to a more intense transportation flow.

EV adaption

This intensification in urban freight transportation implies a set of externalities related with the environment: noise, flow congestion, air pollution, visual intrusion, infrastructure wear, decreasing road safety, etc. Despite the huge amount of them, the main environmental studies are based on the most well-known and decisive ones, noise and pollutant emissions. (Russo & Comi, 2012). Even the negative effects of transportation, there is an increasing consciousness to consider these externalities in order to reduce the environmental impact. Nowadays, policies and logistic strategies are being formulated to cope with these challenges. In addition, there is a constant research for new technologies. A prominent evolution of EV is allowing and will help to reduce externalities carrying out a transition from conventional vehicles to EV, offering similar or better freight service models.

Environmental advantages

Several cities and companies already introduced EV in fleets and these manifest an improved performance in reduced CO2 emissions and reduced local emissions. (Figliozzi, 2010) quantified the CO2 emissions comparing an EV and a diesel van with the same freight features in a “standard” city. For one kilometer driven, while a diesel van produces about 645 grams of CO2, an EV only produces about 12 grams. CO2 production considered by an EV is related with the emissions occasioned by the source of electrical power needed. It means that a diesel van emits about 54 times the CO2 released by an EV for the same distance driven during the service. Another point clearly improved by the use of EV is the noise pollution. As there is no combustion, there is no noise from the vehicles, but only from the infrastructure, loading equipment and driver behavior.

In addition, the promotion of EV would imply the development of the power generation sector. This means a positive shift from big pollutant and limited fossil fuel extractions to more sustainable electric power plants and renewable energy installations. Therefore, the replacement of the vehicle will stand reasonable while the electricity generation maintain a low level of carbon production.

4.2 OPERATIONAL ISSUES

The shift to an EV fleet also implies some strategic and planning measures due to their characteristics. The main difference from conventional vehicles is the necessity to refuel more frequently. It is a result of the limited loading capacity of the batteries used. In addition, the long times needed for the recharging process in some cases led to a change in the delivery schemes.

The modification in routes is linked with the stops needed to recharge. It means that it is crucial to analyze the kind, number and the location of recharging stations. Furthermore, these changes are influent to the number of vehicles used, and charging processes will be considered to find the optimal fleet size.

4.2.1 Charging network

Charging station types

Different kinds of charging station could be considered depending on the fleet priorities. There are slow and fast stations, where full charging period can vary from less than 5 minutes to 8 hours. In one hand, slow refueling stations are divided in levels 1, 2 and 3. For a fully battery charging, while in the first two level stations (110–240 V) it is needed period of 2-8 hours, in level 3 stations (480 V) it is enough with 20-40 minutes. In the other hand, fast station can quickly recharge an EV in less than five minutes. Even so, these ones are not perfect because this kind of charging can significantly shorten the life of the batteries.

Another option is what (Li, 2014) proposed. As the time spent recharging is too influent for the EV implementation, a suitable solution is to remove the existing battery and replace it with a fully charged one. Then, during no working hours, recharge all the batteries in a base point.

Decision variables

Public and private initiatives of EV can help to decide the kind of stations implemented in a city. It is also related on the service they want to offer. Thus, in urban distribution it is interesting the agreement between different transportation companies in order to maximize the EV charging installations and offer a larger level of service. Another important point to consider for a suitable decision are the economy factors. As it is evident, more resources imply better installations, so public support is determinant.

Freight distribution in urban areas is a great opportunity to implement EV technology because there is no necessity of high velocities. Specifically, LMD routes are repetitive for every day and cover small areas. It can facilitate the design of stable policies for battery recharging and helps to set the stations location.

Based on UFT, according recharging times, level of service and city features, there will be the necessity to locate more or less charging points. In addition, these three issues will also determine how closer the charging stations need to be.

4.2.2 Fleet size and routing

Necessity of EV re-routing

In general, it is potentially not sufficient to perform the typical delivery tour of a logistic service provider in one run or to reach customers located far from the depot. Because reducing the number of deliveries performed by one vehicle is clearly not a profitable option, visits to recharging stations along the routes are required (Juan et al., 2016). Consequently, as mentioned, recharging involves a time penalty.

It is a restriction that is needed to be neutralized to maintain the quality of service. So, if a delivery service decides to shift their fleet to EV and wants to offer the same service, an increase of the number of vehicles is needed.

Influencing factors for an EV fleet

It is also needed to take into account that the storage space in EV vehicles can be different. EV for urban transportation involve an extensive range of dimensions.

Losses in time and storage factor are different for every case, so there are diverse conditions of implementation. The new EV fleet could also be mixed with conventional vehicles. Thus, it is necessary to develop an accurate study of required vehicles for each specific case. It also must be accompanied by a routing analysis.

Routing of vehicles is a critical aspect of EV management, it consists of designing routes for maximizing the vehicle range. Small package shipping tend to be time definite and retailers penalize more and more the delays. This causes the requirement to have precise schedules.

In the actual EV models, most batteries allow to drive about 180-220 kilometers (Feng & Figliozzi, 2013). However, it is reduced significantly by cold temperatures and so-called range anxiety (Botsford & Szczepanek, 2009). An example of FREVUE project is located in Oslo, where the average temperature during the year is less than 10 ºC, reaching negative numbers in some periods. The city does not consider low temperatures as an impediment, but as an influence to take into account. To reduce their impacts in routing, fast charging stations are chosen, and station points are closer one to another. It also implies an elevated economic support, the city of Oslo strongly bet for this kind of measure.

Another influencing factor to consider for efficient routing is the chance to develop a pre-booking system for charging point. It is also developed in the Oslo case to optimize the waiting time to recharge and avoid queues. Finally, there are other cases that optimize routing avoiding too large tours in order to perform only one overnight recharge at the depot. It is the case of a pilot in electric logistics for parcel services operated by UPS in Rotterdam within FREVUE project, designed to cover short routes.

4.3 ECONOMIC ISSUES

The incorporation of EV also implies a range of costs which must be analyzed to know how economically sustainable and doable are the modifications. EV have more elevated procurement costs than conventional, the cost of the battery is crucial and makes the difference. Nevertheless, these prices are offset due to the lower maintenance costs of EV, being the fuel savings the most relevant factor. (Feng & Figliozzi, 2013) point out that commercial EV operational costs can be nearly four times lower than diesel trucks, the downside is that their purchase costs are approximately three times higher. Another study, (Taefi et al., 2016), affirmed that maintenance costs decrease in 20-30 % from EV to intern combustible engine vehicles.

Comparison of Diesel vehicle vs EV economic costs

In overall, total cost of ownership (TCO) for EV tends to be higher than diesel vehicles. Even so, there are examples where it has been evaluated an economical cost-benefit analysis and the results does not show significant differences. Table 13 corresponds to the balance done by Lisbon pilot within FREVUE project. The EV used were 16 Renault Kangoo ZEMaxi, 5 Renault Kangoo and 7 Nissan eNV200. Average costs of these cars and conventional ones had been approximated considering 8 years lifetime. It can be seen divergence for different costs, but to sum up, last numbers corresponding to the total costs are equal. It is close related with the duration considered. As the lifetime increments, EV vehicles tend to be more sustainable due the low maintenance costs. In contrast if less than 8 years were considered it would not be worthy at all to use EV due the elevate acquisition value, which elevate too much the TCO.

Total Cost of Ownership	DIESEL	EV
Acquisition value (€)	14.203 €	20.301 €
Energy cost (€/km)	0,14 €	0,05 €
Total travelled distance per year (km)	13.926	13.926
Lifetime (years)	8	8
Energy cost (€/8 years)	15.374 €	5.459 €
Charging station (€)	N/A	5.000 €
Insurance (€/8 years)	5.256 €	5.752 €
Maintenance (€/8 years)	2.650 €	1.392 €
TCO (€)	37.483 €	37.904 €
TCO/km (€)	**0,34 €**	**0,34 €**

Table 13. TCO Lisbon demonstration FREVUE (Dalle-Muenchmeyer, 2017)

Despite the equality of final costs, the EV shift requires huge implementation costs. In order to reduce the costs of charging stations, it is considerable the possibility of use public space to locate them. In addition, public funds and financing support is crucial to encourage private transportation corporations and other urban car owners to consider the transition towards EV. Besides subsidies, other kind of government support is possible. It could consist in regulations promoted by the authorities allowing more efficient operations, per example environmental limited zones, larger time windows, free parking, etc.

To compete the economic analysis and encourage public sector to develop EV implementation, environmental costs tried to be monetized. It has been too difficult and it is complicate to associate them to TCO because they are dependent on several features that change in each city.

Effects of EV economical costs

Even the well-known environmental benefits of EV, the economic issues are an impediment for its implementation. Leasing and financing companies are also reluctant to invest due to uncertainties. Operators are more focused on short term benefits, which hold back the purchase and wider uptake of EV. It is the reason of the limited production volumes of these vehicles. In longer term it is expected a more competitive market. Experience and developing technology will led to incorporate operational savings and to reduce purchase prices. Consequently, an expansion will produce an optimization of resources.

4.4 KEY CONSIDERATIONS FOR EV MARKET PENETRATION IN LMD

LMD is a great chance to incorporate EV's because routes performed in urban distribution are repetitive or similar daily. This fact allows establishing precise routing schemes and charging station locations. Some of the LMD strategies already presented improve the outputs using EV. In the case of OHD, it is preferred EV fleet to be more silent. UCC is also a good opportunity for EV due to short

distances and slow velocities performed. Finally, EV is beneficiated by regulations in access and parking in complex city areas.

Technology dependence

To further develop the arising initiatives a progress in EV technology is needed. Nowadays a considerable barrier is the lack of charging stations and failing batteries. Another problem for those who choose EV option is the limited or late technical support. It could be analyzed as an economic issue, because a strong funding commitment is needed. The possible users will start to shift vehicles easily once they observe that there is the disposal of an adequate infrastructure and technical support.

Closely related with the increment of users, more availability and types of vehicles will be present in the market. Currently, the limited models are also an impediment for some UFT corporations. Maybe they need special features for their fleet, which are impossible to find in actual EV models.

Other influencing factors

Despite the slow implementation, there is a wide acceptance of EV by population, who perceive the environmental impacts, and for drivers, who appreciate improvements in driving comfort. So, another consideration to take into account is that the most beneficiated stakeholder is the society and the public sector. Private initiatives need their support by funding or regulation incentives. Otherwise, modal shift is hard due to private sector considers economic balances above other issues. Furthermore, operators are focused in short term benefits and this presents a problem. Subsidies are needed to be strong especially during the implementation.

Finally, it is relevant to see in Figure 32 the evolution of the EV market penetration in last years and how it is the current situation. It corresponds to the market share of not only to freight vehicles, but vehicles in general. The European countries with higher percentages of EV market share has been selected, all of them overpassing 1% in 2016. These are the countries where it is easier to incorporate EV fleets for UFT because they dispose of more infrastructure and experience.

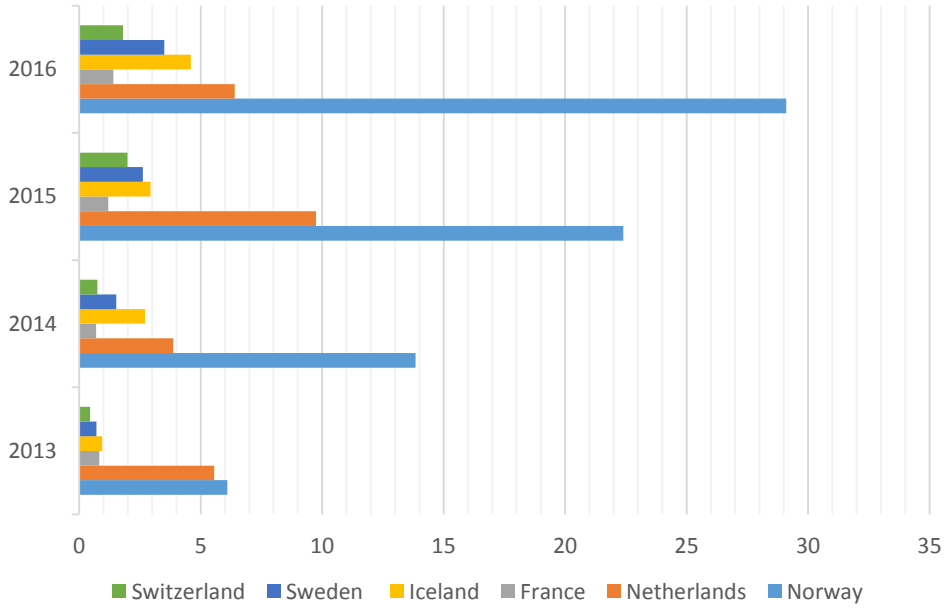

Figure 32. EV market share (2013-2016)

5 OTHER ARISING PRACTICES AND VEHICLE SHIFTS

LMD concepts presented up to this point involve a wide range of new strategies and regulatory measures, and the analysis of the progressive introduction of EV for distribution services. A part of what is considered up to this point, other tendencies are identified that could be determinant for the future of the LMD. The progress of LMD is not only marked by the strategies already implemented, but also for the ones that are under development. To recognize key innovations it is an important signal to identify if big companies are dedicating resources for its improvement.

Below, there is a description and exemplification of detected shifts and arising practices in LMD. The introduction of cargocycle fleets is presented firstly and in addition, different types of shared economy practices. Finally it is included the arising existence of information platforms for more efficient deliveries exemplified with the NYC case.

5.1 CARGOCYCLES

More and more, in complex urban areas the couriers employed to deliver small parcels use bike and tricycles transformed to cargocycles. The benchmarking study involves the introduction of cargocycles in several cases.

Particularities

It is a practice often seen in point to point delivery, especially for B2B documents and prepared food. Moreover, some small retailers are acquiring their own cargocycles to offer home deliveries. These kind of vehicles for LMD are becoming an alternative, together with the EV, to face the strong environmental restrictions in complex urban areas. That is the reason why other big logistic operators are also including these kind of vehicles in their fleets.

DHL shift to cargocycles

DHL, an express services provider, is introducing cargocycles in their fleets for LMD in inner cities. To test its feasibility, new fleets are being piloted in two different cities with complex urban grids, Frankfurt (Germany) and Utrecht (The Netherlands).

They created their own cycle model, able to carry a container with a load up to 125 kilograms. These works into system based in a hub where a customized trailer can carry up to four containers, and these are spread from the hub to the destination through cyclocargos. The removable containers are secure and waterproof, and offer a large volume while not impairing the view of other cyclists. Furthermore, they are self-powered by solar panels and equipped with GPS and transmitters to facilitate real time tracking.

Figure 33. Cargocycles (DHL)

5.2 SHARED ECONOMY PRACTICES

5.2.1 Crowdsourcing Apps

Based on the concept of shared economy, startups are arising in logistics sector to supply digitally the demand by sharing of excess and underused assets. Systems are based in a courier service which leverages large groups of geographically dispersed individuals, disposed to carry out deliveries receiving remuneration in return.

Delivery are requested online by particulars. When the details are submitted the crowdsourced delivery platform sends them the order to be approved by couriers in the vicinity of the dispatch point. The first courier in the system to accept the delivery assignment secures the delivering task.

Advantages and disadvantages

It is a method that can help to cover the growing demand for e-commerce logistics. Besides being a flexible service in supply and with low investment requirements for parcel companies, it can provide employment opportunities for communities. Crowdsourcing Apps are also facing some cons to be definitely spread and used. Among them, the ones standing out are safety issues and legal and liability concerns.

Uber Rush App, crowdsourcing deliveries in North American cities

Uber is an app that was created in 2009 to connect individuals who need to take a ride with a vehicle driving the adequate path. Some years later, Uber RUSH was designed to follow the same model but with deliveries. Currently available in San Francisco, Chicago and some area of New York City, Uber Rush connects you

with a delivery partner when you need to send any kind of good from a specific point to another, and allows you to track all the process.

Every citizen can join as a carrier just signing up the application. Every order is associated with some costs which are paid from the receiver through the application. Receivers could ask for many kind of goods, but there are some exemptions involving food or animals, among others.

Glovo App, crowdsourcing deliveries in European cities

Glovo was created in Barcelona in 2015 and it is currently present in several Spanish cities, Paris and Milano. It is an application that allows customers buy stuff from local stores using their phone. Then an individual in the system deliver the packet delivered in less than 60 minutes with the possibility to follow its location in real time during the process.

Many kind of goods can be asked if these are located within the city in the system network. The package constrains are set in maximum 9 kg of weight and 40x40x30 cm of volume, since the carriers use bikes and motorbikes. The cost of the service is based in the distance from the pick-up point to the delivery point and can be paid through the application.

5.2.2 Collaborative information sources

In recent years, public administrations and other institutions have set systems to collect data from citizens and users of a service. Technology enables the communication between a service provider and a user providing the latter with a powerful tool. In New York City, a project called Smart Truck Management Plan is using information from operators, citizens, road users, etc. to map incidences that affect or cause the city logistics of the city.

Smart truck management plan in New York City (USA)

In NYC, 90% of all goods are delivered by truck. Freight is a critical part of the everyday experience for New York's residents and businesses, bringing the products consumed and produced on a daily basis.

Figure 34. Freight delivery in New York

The New York City Department of Transportation (NYCDOT) is developing a comprehensive citywide Smart Truck Management plan to better manage freight in New York City.

The data being collected and the public and private sector outreach efforts that are underway will provide a better understanding of truck route usage, the needs of shippers and receivers and community concerns. With the input from the public and private sector stakeholders the Department will recommend a series of strategies and actions to improve operations and enhance the economic vitality and quality of life for all New Yorkers.

Currently, the service offered by the project enables these stakeholders to upload any incidents detected with the following options:

- Deliveries in bike lane
- Confusing truck route signage
- Difficult truck turn
- Narrow roadway
- Observed cyclist and truck conflict
- Observed pedestrian and truck conflict
- Speeding trucks
- Truck double parked
- Truck hitting overpass/low bridge location
- Truck parked in bike lane
- Truck parked on sidewalk
- Truck in residential area

Figure 35 shows an example of confusing truck route signage. A user reported: *Signs indicate all trucks must take the tunnel, but truck route signs on 1st at 42nd also indicate that trucks can make a left turn there. Both can't be right.*

The citywide Smart Truck Management Plan will improve the understanding of truck route usage and compliance, movement of goods, needs of shoppers and receivers, and community concerns. With input from the community, the Department will then implement a series of strategies and actions to improve operations and enhance the economic vitality and quality of life for all New Yorkers.

Figure 35. Example of a confusing truck route signage.

5.2.3 Carsharing

Carsharing is a model of car rental oriented to businesses that needs a vehicle only for short periods of time. It reduce significantly the shipping costs and the freight vehicle fleet in the city. It is a good opportunity for small businesses who make only occasional use of a vehicle and for others who do not access to a vehicle day-to-day.

Vule Partagés, electric vehicle car sharing in Paris (France)

In 2017, the City of Paris has launched a pilot project to test an electric van carsharing system. The program is called Vule Partagés, it is operated by Paris municipality and uses electric vans from the PSA group: Citroën Berlingo y Peugeot Partner.

Tests are planned to run for a year with stablished prices for the service depending on the day time: 11 € an hour at the peak times (8:00-10:00 and 17:00-20:00), 5 € an hour between 22:00 at night and 5:00 in the morning, and 9 € an hour at all the other times.

It is oriented to small businesses, craftspeople and traders to leave their vehicles. It avoids the need to buy, maintain and house a vehicle. The service is further incentivized by a free parking permit at the Rungis International Market on the outskirts of town, which provides wholesale goods for the bulk of restaurant and catering businesses in Paris.

Figure 36. VULe Partages (Mairie de Paris)

5.3 INFORMATION PLATFORMS

To improve urban delivery services, besides having efficient strategies and strong regulatory measures, it is important to facilitate as much information as possible to the stakeholders involved in LMD. Moreover, it allows the operators to avoid penalties, improve the working conditions with less stress, and develop own strategies that can be positive for the city logistics.

There are many options to provide information to carriers. In the study it is already seen a case of parking information through an app (AreaDum in Barcelona). Besides apps, the information can be provided using other online platforms for its constant updates. Anyway, an extended option is to provide by time to time a document with global information of the legislation and street situation to carry out city deliveries, as the NYC case showed in addition.

Truck Route information in New York City (USA)

Urban mobility in NYC is administrated by the Department of Transportation (DOT). The administration publishes a city center map faced to drivers and operators. It is a full color, double-sided map featuring the City's comprehensive Truck Route network overlaid on top of the entire arterial street network, making it easier for drivers to locate specific streets and intersections.

As it is possible to see in Figure 37, the map include information about the enabled streets for freight transportation or the restrictions in bridges or tunnels. The map is constantly changed and adapted to current situation. There have been truck route changes since 2012 to the Truck Route Map.

The document also contains helpful information on truck route signage, weight limits and dimensions, overweight and dimensional permitting. Moreover, violation in behaviors related with parking, standing, and stopping rules, occupancies of bicycle or bus lines are specified. Finally it also provides city, regional and state truck-related resources.

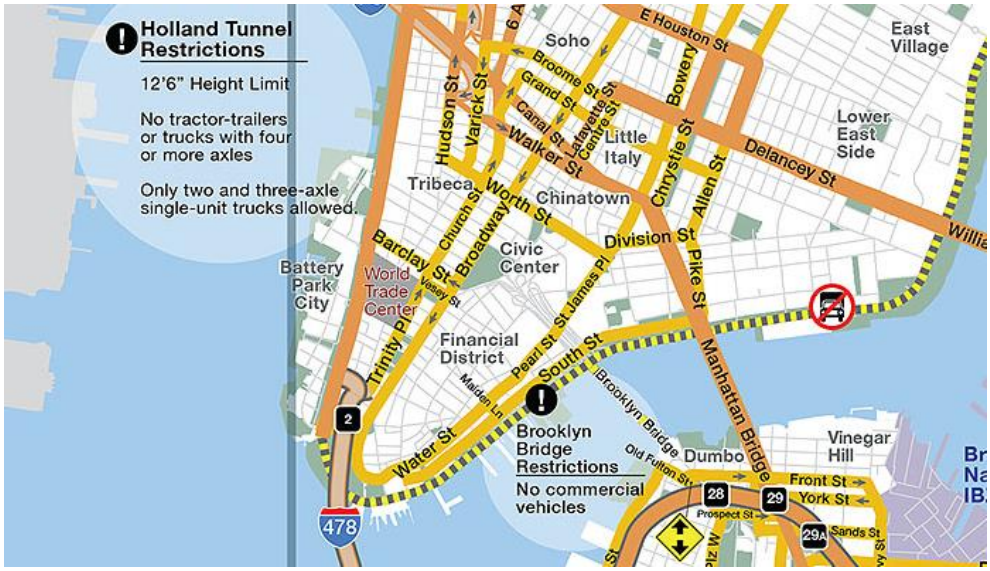

Figure 37. Cut of Manhattan Truck Map (DOT)

6 NEAR FUTURE INNOVATIONS

Nowadays, the ambitious options arising consider the delivery of parcels without any human intervention. These options involve different types of physical designs programed to carry out specific routes with packages. Customers are notified online about the exact arrival time and they are asked to pick up the parcel.

The reasons for autonomous vehicle growth are basically based in the potential savings in economic costs for the private companies. Thanks to the improvements in technology, more and more the shift to automation and digitalization is viable and becoming a reality.

Moreover, another of the drivers of the research in automated vehicles is also the increasing lack of personnel for the driving operation. In several countries such as Japan and Peru but also in Europe, transport companies struggle to fill job positions. The reputation of the truck driving job has fallen and it is not any more attractive for young people due to low income and physically hard job. Despite that the lack of employees is more concentrated in the long distance truck operation it is starting to affect also the last mile delivery sector.

Following on the list, there are practices based on autonomous delivery distribution. The diverse options of this group involve automated vehicles, droids, drones and even a cable rail system for distribution.

6.1 Automated vehicles

Automated vehicles are being considered to drive sharing space with other non-automated vehicles. There are many studies based on the substitution of passenger cars to self-driving, but also for city deliveries vehicles. Granted, such vehicles would need to be supervised.

Gateway project developed in London (UK)

In London, a research project named Gateway is being carried out to understand and overcome the possibilities of implementing automated vehicles for urban deliveries. It is led by TRL and the entire project include trials and validations of driverless shuttles and automated urban deliveries in the borough of Greenwich. The vehicle created runs with a combination of sensors, cameras, lasers and software to safely navigate in an urban area. Nevertheless, this research project in

not focused on developing vehicles, but the societal implications of this automated delivery model.

The first phase was based on knowing the people's hopes, fears and expectations of driverless vehicles. After that, it has been started a final phase of onsite validation and testing of a prototype automated vehicle. Road markings has been included around the Greenwich Peninsula and the prototype is currently over the final regime of safety evaluation. Once completed, public trials are planned to start.

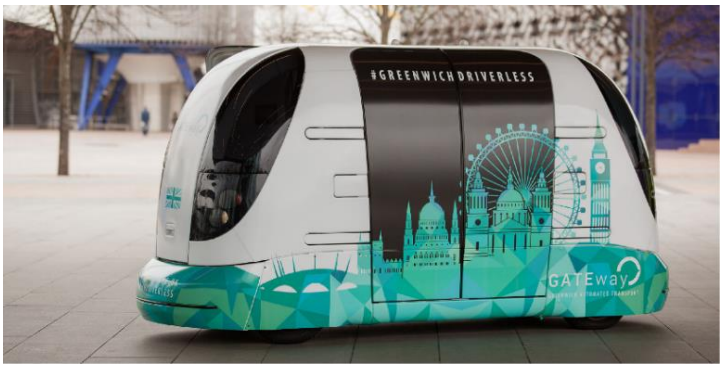

Figure 38. Gateway Automated vehicle (Gateway)

6.2 Droids

Delivery droids are small autonomous vehicles, only slightly larger than a regular parcel, created to deliver parcels to the doorstep. They are created to use the sidewalk rather than the street for the transportation to their destination. The reason to use that space is their small size and slow velocity, reaching from 5 to 10 kilometers per hour.

Private businesses and public services are starting to test droids for the possible benefices on their deliveries. Although it needs a supervision, many workers can be saved. Developers pointed out that a single supervisor could manage 50 to 100 droids. The robots navigate using a mixture of geolocation signals and visual recognition of the environment using multiple cameras. At awkward points and in cases of doubt, a remote operator takes control of the parcel robot from a distance.

Just Eat droids in London (UK)

The takeaway app tested a fleet of high-tech land-based drones in 2016. The robots belong to Starship Technologies and were launched in 2014 with their compartments able to contain two bags of shopping, Starship's drones aim to provide not just food delivery, but a complete personal courier service. The developers claim their little robots have already met over 400,000 people, driving over 50,000 miles between them, without a single incident or encountering any difficulties.

Droids used by Just Eat travel at about 4mph, and are planned to navigate their way to customers autonomously, using a toolkit of cameras and sensors which feed into a sophisticated obstacle avoidance system. Moreover, those are connected to Internet with 3G technologies all the time. In order to control them, a team of human operators will be at the ready in a remote command center.

Swiss Post delivery robots

As an additional delivery solution to complement parcel delivery, from September 2016, Swiss Post is testing delivery droids in Bern, Köniz and Biberist. The post services envisages to use that solution for flexible, quick and inexpensive LMD. However, Swiss Post does not expect to introduce the model in few, but if the results are positive their commercial applications with droids could start in three years' time.

Despite droids are designed to be autonomous, for the current test journey the robots are always accompanied and monitored by a person. The only task assigned to that worker is to collect as much information as possible about its operation.

Figure 39. Droid prototype (Swiss Post)

Hermes testing droids

This logistic private company is trying to develop a system of deliveries with droids. Hermes has already carried out tests in the suburbs of Hamburg (Germany) and more tests are planned in the London district of Southwark (UK).

The trials are in partnership with Starship Technologies, developer of that kind of droids, and the main aim for Hermes is to understand how the robots could enhance the company's offering. The delivery firm expects that results let they offer limited 30 minute time slots for the collection of parcels, either for items being returned to retailers, or for items being sent by small businesses or consumers. They also expect to gain in the possibility to have greater scheduling and tracking capabilities.

6.3 Drones

Another kind of autonomous robots with delivery purposes can be designed to work in the air. Drones are autonomous aircrafts that can carry parcels up to 15 kg to a destination along a direct route and at relatively high average speed. As the other autonomous vehicles considered, human resources are needed just for its supervision.

The most important difference compared to other autonomous systems is that drones do not make sense for urban environments. They are designs to cover LMD in rural areas, covering larger distances and delivering parcels in the house gardens.

UPS testing drones

The big delivery company carried out a drone delivery test to assert its interest in using new technologies to improve deliveries. It was carried out in a rural place of Florida (USA) using an electric delivery truck fitted to operate as a drone hub. The drone was loaded in the truck and then it took off to the destination. For the current models, batteries lasts for about 30 minutes and are planned to be recharged between flights. Fuel savings are the most important point considered by UPS, who says that if every UPS driver had to cover one less mile per day, it is possible to save up to $50 million per year.

Although several positive points are considered with the drone introduction, there are no guarantees that UPS will ever deliver a service package with a drone. Among other questions, one to be treated deeply is the deliver safety. Other questions are related with policy terms, for example, it's not legal to run a fully automated drone delivery service in USA.

Amazon testing drones

Amazon is the largest Internet based retailer in the world. One of the purposes to reach in few years is to carry out their own deliveries and no subcontract a distribution company. To do so, Amazon became a pioneer on looking for new models and strategies of LMD, one of the options contemplated is the introduction of delivery drones.

The multinational firm developed a drone delivery system, called Prime Air, and a trial of this service is already ongoing in UK. It is in the first phase only involving two customers, but it is planned to be extended. Delivering parcels are carried out in less than 30 minutes at no extra costs, the trial is limited to daytime during suitable weather in specific places.

Figure 40. Delivery drone prototype (Amazon)

JD drones in China

China's second largest e-commerce giant developed a drone model that can deliver packages weighing as much as one metric ton throughout rural areas of the country. The company has drones that can fly up to 100km per hour, delivering packages weighing from 5 to 30 kilograms, and is testing drones which can carry as much as 1,000 kilograms. The maximum distance they can travel is approximately 100 kilometers before recharging.

Air space of Chinese cities is highly restricted and drones are completely banned. It is the reason why the use of JD drones is limited on rural areas and by June 2017

JD only had permission to carry out the service in four administration divisions of thirteen. The service does not allow the customer private home as final destination for now, it is working with destination to a service place in the destination locality where the customer lives or near it.

6.4 Cable rail

A cable rail system is an idea raised recently for automatic LMD. It is still not spread and it only has been tried in China. The idea is based on low-altitude static cable rails, with an express way in the air to carry unmanned shuttle robots loaded with small amount of goods. It could make possible to deliver the parcels to their destinations rapidly, with low energy consumption and low cost.

iBosst cable rail in Huizhou (China)

Cable rails have been developed in China and purposed to try on Huizhou (China). On May 2017 Guangdong iBosst Ltd completed a 15 kilometers cable network suspended at street lamp height on which small robot containers of 100kg capacity can travel. A pilot test is being carried out to test how the robots make turns and shunt. The current construction cost of the smart logistics express is RMB150.000 (20,500 €) per kilometer, and less than RMB100.000 (13.500 €) per kilometer after mass production.

After launching the first smart express system, on July 2017, the same operators announced a project aimed to build a smart logistics express cable rail system covering the urban and rural areas of China, aiming to achieve same day delivery of goods nationwide and one hour delivery city wide, and halve the cost through the cable rail plus shuttle robot.

7 GENERAL CONCLUSIONS AND MAIN FINDINGS

The complexity of freight distribution considering the most remarkable strategies and innovations in LMD has been analyzed. Different variables have been considered to compare different practices carried out in Europe for each strategy in order to characterize its tendencies. Considering a global overview of the situation of all the strategies and measures examined it is possible to point out the main findings.

LMD overall interests

In the next years, the distribution in the last mile will keep under development and it will be a topic treated and discussed frequently among investors and media. It is affirmed for its significant costs in both economic and environmental terms.

From an economic point of view, the costs vary depending on the complexity of the product, but LMD costs represent 1% - 20% of the cost of selling the products. The investments in strategy and infrastructure to reduce selling costs are expected to be high. In environmental terms, the impact is directly related with the type of vehicle that distributes the product, but as it is proved, it can be reduced with adequate logistic strategies.

Besides reducing pollution and improving the environment in general, the leading practices in LMD worldwide favor the delivery on time and the efficient service. Moreover, the reduction of emissions is related with an improvement of the vehicular flow and urban roads capacity, which can be even more promoted by the development and introduction of different kinds of autonomous and small vehicles.

Key considerations its development

One of the key points of analysis has been to take into account the multiple stakeholders taking part in LMD processes. It has been proven the necessity of cooperation and understanding among the private and the public sector.

Private sector will keep on investing in strategies and vehicles for the growth tendency of urban deliveries and its potential benefits. The public sector, in turn, should keep on working and innovate in public policies. For LMD progress potential benefits, local governments should not lose sight of consider infrastructure as a part of the LMD System. They also need to adapt regulations to new demands and technology, and expand merchandise delivery time windows including distribution at night if it is possible. However, for any strategy or measure implemented, certifications and training along the chains should be

considered for an efficient LMD. Finally, the possibility of devoting public funds to promote the preventive maintenance and fleet renovation could be crucial for a fast progress.

Considering all the strategies, the future fleet distribution has been defined. It is changing in order to win efficiency, to reduce the consumption, to decrease the distribution time and to reduce the emissions to the environment.

Future fleet distribution in supply chain logistics

In Figure 38 is possible to observe that large vehicles are only located outside of the city limits, and with a proper technology advancement, these could be autonomous. Concerning the urban environments, a first vehicle is used to deliver goods at urban consolidation centers and the final distribution to home is carried out by cargocycles and alternative fuel vehicles. Nevertheless, it is already contemplated that in a near future this step could be basically automatized by robots and lockers.

Potentialities of each strategy and measure for a further development

Regarding the strategies and measures studied, all of them are contemplated in a future situation. However, the ones depending on the technological progress have more potentialities than the others for its fast advancements. Hence, OHD will be an increasing solution for the improvements in silent equipment. Also, the use of lockers and robotization will be extended for its gains in efficiency.

In contrast, the innovation in UCC could be stablished. Their expansion could be limited for the lack of understanding, UCCs tend to be privatized with each operator having its own urban terminal. Operators will share more and more a competitive LMD market.

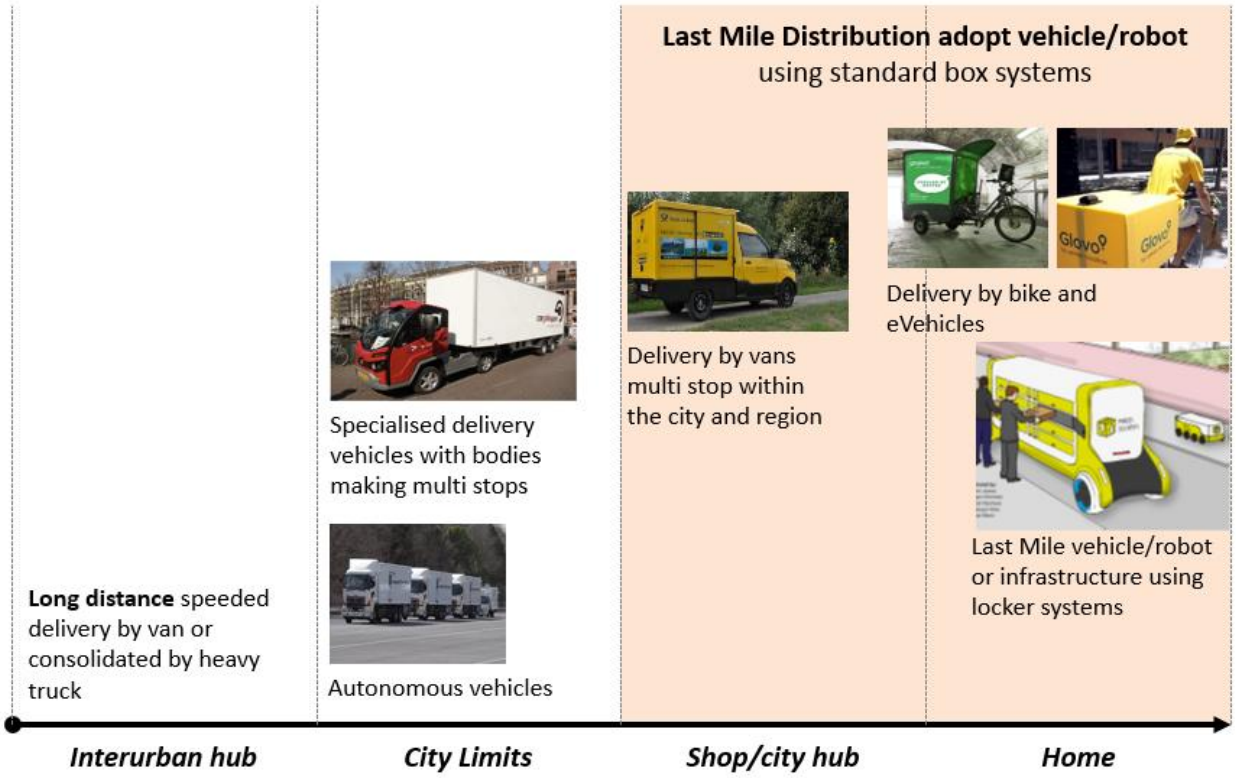

Figure 41. Future fleet distribution

Finally and to complete the analysis of tendencies, it is resumed the impact of the influencers in the future. The closer and most significant influencers, e-commerce and the digitalization of delivery infrastructure, are already affecting the present situation.

Future impact forecast of LMD influencers

The establishment of regulations and urban policies, related to each city context, will keep being relevant, but it is not expected to be an important influencing factor neither impose impacting restrictions for LMD progress. Administration will supervise new strategies, but it will tend to be opened to technological innovations because those tend to be developed taking into account the wills of the public sector.

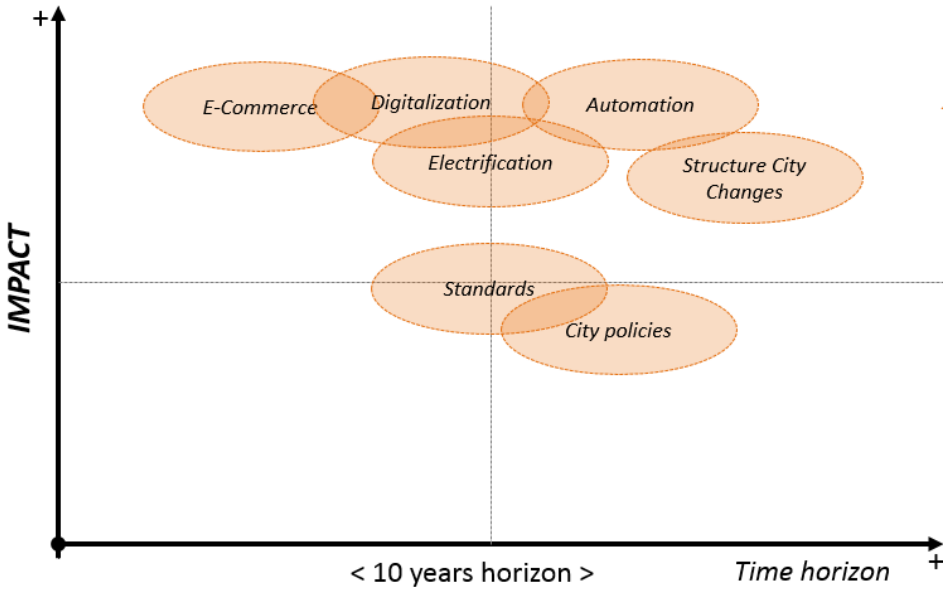

Figure 42. Impact and timeline assessment of LMD influences

8 GLOSSARY

OHD – Off-hour distribution

UCC – Urban Consolidation Centre

UFD – Urban Freight Distribution

UFT – Urban Freight Transport

LEZ – Low Emission Zone

EV – Electric Vehicle

CCZ – Consolidation Charging Zone

GVW – Gross Vehicle Weight

SUMP – Sustainable Urban Mobility Plan

HDV – Heavy Duty Vehicle

IT – Information Technology

CBA – Cost Benefit Analysis

B2B – Business to Business

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ANNEX I: INTERVIEWS TO CITIES

A series of interviews have been carried out in order to better understand the views of cities in what regards to urban freight distribution as well as obtaining more information on the projects that cities are carrying out and how are they tackling the measures that have been explained in this document.

Stockholm

The interview was carried out with Märta Brolinson (Freight Programme Manager) and Robin Billsjö (Freight strategist in Trafikkontoret) at the Stockholm city council on the 7th of April 2017.

In our study we are analyzing several measures that could be taken by cities in order to reduce the effects of increasing trips in city logistics:

Urban Consolidation centers, night distribution, regulation and policy measures, alternative fuels, loading and unloading areas and lockers/convenient package drop off. Are you promoting any of these measures? Are they in your SUMP – Sustainable Urban Mobility Plan?

Most prioritized projects during the last 3-4 years in terms of freight distribution improvements were: off peak distribution and urban consolidation centers development. Focus is to improve accessibility and efficiency rather than environment and make it self-sustainable (without public funding involved).

Urban consolidation centers

Are there any? Public or privately financed? Was it promoted by the city? Or entirely by a private company? How does it work, how many companies are involved? Did it affect the number of trips in the city? Is it still working?

Do you –referring to the city- feel that consolidation centers can be part of the solution to city logistics problems in your city? Have you studied other cities that have implemented consolidations centers?

They started the first commercialized UCC in the city center at the beginning of 2017 being the first business model without public funds. It supposed a Real Estate Company – a waste management company and a delivery company working

together: Bring (transport company) is delivering to Ragn Sells (waste management and recycling company) which is based in a real states company facilities of parking place (Vasakronan). The waste management company does the “last mile” distribution and picks up waste (recycling) at the same time. To do so, they use two specific electric trucks.

It worked as a pilot but no results were recorded, since the numbers and funds belong to the private companies involved. The interest was mainly on the business model and to ensure that the system would stand without public funding required to maintain it.

The difficulty was to coordinate it. It had been on works for several years but political implication was needed to move on. There was no public funding involved beyond the development of the business model (around 70.000€ of effort for basic knowledge of the building model, they contracted a consultant to help them). The transporter pays the waste management company to do their work and the waste management company pays the Real Estate Company to use its space to do the service within the facility.

Moreover, Real Estate Company and waste company have signed an agreement to try this out on a national level due to this initiative. They also plan to expand it in Stockholm, involving more logistic companies and real estate companies aiming to reach this kind of agreements. Nevertheless, it is not transferable to the old quarter because there are too narrow streets for this kind of vehicles. However, there is another UCC in the city center.

Off-hour distribution

Do you promote night distribution? Do regulate by any means night distribution? (For example by certifying that the equipment used by the companies complies with noise regulations) If this measure is applied in the city, what type of retailer does deliver goods at night? (Supermarket, textile sector, etc.) What measures are taken if the retailer is not present in order to deliver the goods?

Currently, there is a night ban on delivery in Stockholm. Regardless, there was a project when the municipality extended the certificates allowing night delivery to transporters from 22pm to 6am. The project finished but now continues using project ECCENTRIC (led by Madrid) and now they plan to add few more trucks.

The project was centered in deliveries for hotels and groceries. The expanded project will include building materials and recycling waste. The transport company involved is highly strategic competitive. The owner of the company was involved in research before and it was easy to get onboard. As a city, the incentive was to give the transport company the possibility to add an extra shift to the truck. To make it possible, the transport company did the economic effort to adapt the trucks because the city did not have to invest.

Trucks were from two different vehicle providers and fuel system with PIEK certification (Dutch certification that rebuilds the truck to be quieter), an electric hybrid and a Scania gas truck. City council was not asking to have the latest environmentally advances but they have to be the quietest, noise wise. It is considered more important to change the flows (time) than on environmental standards. Stockholm does not have big issues in terms of environment, but accessibility. Especially considering that it is one of the fastest growing cities in Europe.

Robin Billsjö point out that during the pilot there were staffed and unstaffed receivers, both on ground and underground (especially for some hotels). At grocery stores the driver had the key of the door, brings in the cargo and closes. In some cases, for little stores they had a central location where all was delivered and from where they serve the grocery stores. For the hotel case the truck has many stops along the routes, allowing to reduce the number of trucks needed to do the deliveries.

Results showed improving in efficiency, shorter delivery times. Nevertheless, it was difficult to compare because planned routes during the day are different than night ones. For the day ones congestion is taken into account. Instead, night routes follows more direct patterns since no congestion is accounted. Results are that one truck was 31% quicker than morning peak and 59% quicker than afternoon peak. Efficiency depends on when you compare both systems.

The results are that positive that wholesalers do not want to go back to previous model, they consider it too stressful. They would like to keep the method because as they say it is less stressful and safer for the driver.

The only negative feedback was caused by inhabitant complains end up removing one store because of noise levels. Of the 3 delivery points one has to be withdraw. From political perspective they were saying you are living in the city you get to be used to noise, but ended to withdraw due to insisting complaints. Now are considering use a noise map to know where it is suitable to implant such deliveries noise wise.

From the City Council, night distribution is and will be one of the points over study because it is already proven that it produces more accessible and efficient logistics.

Regulation

What type of policies have been lately implemented, or are in process of implementation to tackle the issues generated by city logistics? (Examples of other cities are: multi use lanes, a law that forces retailers to have a minimum space for storage, green labelling, traffic light prioritization, road pricing, delivery windows, etc.)

In Stockholm, there is an environmental restriction in which freight vehicles need to meet specific environmental requirements. Moreover, there is a congestion charge to enter in the city center.

Besides that they are looking at other initiatives such as:

- An annual fee for delivery companies in Italy cities to enter to the city center.
- A Swedish city tried to divide city in 3 areas. One transport company was allowed to work in each area. The issue they reached was that it was not legal, nationally and also at EU level even, but it worked well.

They are aware of the topic of regulations but there is a real discussion regarding it. Another issue is how to enforce the measures, since it has to come from a national level due to police is not hanging from the municipality.

- *Alternative fuels:*

Is the city promoting in any way the use of electric /LNG vehicles in the urban freight sector? Are you aware if any operator in the city is already using electric/gas fueled vehicles? Does the city have in its plans (SUMP) plans to install

charging points devoted to the charging of freight electric vehicles? Do you think that the shift to alternative fuels will occur soon in the city? [Are there any public funds to help transport operators to shift to electric/gas vehicles?

From a city point of view they are working on it but it comes from the environmental department and not the traffic one. It is that department who manage specially the procurements. It is common for municipalities in Sweden to have their own environmental department.

Load parking

Do you have dedicated spaces in the city? Is there a limited time for delivery? Is there enforcement pressure? How do you control parking time of each vehicle? Is there any experience in reserving parking spots? Do you think that an efficient management of parking spaces for loading/unloading operations could improve the efficiency of the delivery system?

Stockholm has around 2.000 loading bays for load parking, 70 of them are dedicated just for heavy vehicles. They allow carriers to be parked for the loading processes during 10 minutes. Currently, they are studying how to modify it because they see that 10 minutes is not enough time, especially for heavy loads.

Moreover they are analyzing the possibility to reduce parking places in the city and to increase the number of spaces for loading and unloading freight, especially for the large ones. They are thinking about give incentives to have less cars but larger to increase use of heavy spots. Hence, that spaces could be more constantly used and the demand for the other kind of loading bays reduced.

Pick-up points

Has the municipality promoted the installation and use of lockers or convenient stores? Is this delivery system common in the city? Has the city participated (financially or by providing public space) in the creation of lockers? Does the city believe that this solution could minimize the number of trips of the increasing deliveries of ecommerce?

Drop off and pick up points are common in grocery stores all over the city. Small kiosks are gradually replacing the old post offices. They have enough storage space for residents in the area to pick up the parcels if the delivery does not find the receiver at home.

To promote this concept and save trips, certain logistic companies would have agreements with certain chains. Similar with this concept, delivering installations are promoted by a transport company as a locker system, all of them private.

Turin

The interview was carried out with Mr. Giuseppe Estivo (division of infrastructure and mobility of the city council of Turin) on the 5th of April 2017

Do you -and the city of Turin- feel that city Logistics is currently a problem in the city?

The logistics sector is a complicated sector in Italy since it is widely unionized. It is very difficult to come to terms involving all sectors and shop categories. Logistics in Italy is divided in two separate groups: one which produces goods and the company carries out itself the logistics and transportation, and the other group which contracts a logistics company to perform this duty. The first group represents in Italy around 70% of the city of Turin logistics so that transport is not its first activity, but a secondary task in which the business is not focused on. It is a cost of these companies, they are not interested in investing in this side of the business. The resting 30% of transport is done by professional companies whose core business is logistics and transportation. This value is increasing with the deliveries of ecommerce. Mr. Estivo stresses that the first group needs to be motivated to shift to the second and professionalize the logistics side. In Italy, companies that do transportation of goods require a license which can be of two different types, *conto propio* and *conto terzi*, which are the two groups mentioned before.

Five years ago, the new administration of the city wanted to activate a dialogue with the transport sector in order to reduce the problems generated by these despite the economic recession. The *conto terzi* was interested since one of the aims was to specify loads and make more efficient the delivery trips. This required the reduction of the *conto propio* in favor of the professional sector.

The city of Turin did not have resource to tackle this issue and used tools such as policy and regulation to incentivize the improvement of the logistics sector. Subsidies could be awarded to incentivize changes or through regulation and policy measures. Projects such as PUMAS in which a license is given to clean vehicles for accessing city center and parking are solutions that favor sustainability in the city logistics.

Mr. Estivo also pointed out that in the city of Turin, around 10-12% of vehicles belong to the logistics sector.

How do you feel about the near future about this topic? What projects do you currently have in order to mitigate the effects of city logistics?

Turin is currently running a pilot within the Novelog project (Horizon 2020 program) in which is testing new policy measures to incentivize logistic operators to shift to more sustainable fuels and cleaner vehicles. Currently only the cleanest vehicles have access to the ZTL (low emission zone) and are allowed to use the bus and tram lanes to circulate inside the LEZ. In addition, these vehicles can park during the day unlimited time whereas without the special certification they are only allowed to park for two hours. The permit is valued in 10.000-15.000€

because vehicles that have it are much more efficient in reaching the delivery points to be much more competitive. This permit is the way to incentivize logistic operators to shift to sustainable vehicles. Similar policies started to be applied ten years ago within the PUMAS project.

Currently, 95% of logistics vehicles are fueled with diesel, being the average certification of EURO 3 and 4 (75% of the diesel). There are between 4 and 5 logistic operators that fuel their vehicles with methane.

The Urbelog project is an Italian national project that is more focused on technology. By using the information given by sensors installed in the logistic vehicles the traffic state can be inferred.

Turin is also in the process of implementing a system to control through an app the use of the parking loading areas which will facilitate the city council to control the use of these spaces and its management.

In our study we are analyzing several measures that could be taken by cities in order to reduce the effects of increasing trips in city logistics:

Urban consolidation centers

Are there any? Public or privately financed? Was it promoted by the city? Or entirely by a private company? How does it work, how many companies are involved? Did it affect the number of trips in the city? Is it still working?

Do you –referring to the city- feel that consolidation centers can be part of the solution to city logistics problems in your city? Have you studied other cities that have implemented consolidations centers?

The Turin city council decided not to build public urban consolidation centers. Currently, in the Turin outskirts there are 2 private UCC's one in the north and the other in the South. The city of Turin managed the policy (through incentives) of the lots so that logistic companies would have interest in building their distribution locations there. For this reason, after this policies were implemented, it wasn´t thought as necessary to create a public company to try and consolidate further the goods to the city. Consolidation of goods was already being carried out by private companies and the city council thought that it wasn't a good idea to enter a private market.

As logistic companies were big enough so as to concentrate goods and be efficient, it had no sense to add a company to consolidate the goods from the different operators because this wouldn´t have brought more benefits to the city. This decision was taken 10 years ago.

In the city of Padova, the Company City Porto was created 10 years ago when the quantity of goods delivered was not very high and it was justified to create a public company to consolidate goods. Now, with the ecommerce deliveries there are much more goods to be sent and the public company is less needed since logistic operators have now sufficient load to consolidate goods by themselves.

The example of the Company City Porto Padova is the one of a public company that works for several logistic companies. Only the city of Vicenza has a similar company, but, as in Padova, it hasn´t succeed.

Off-hour distribution	*Do you promote night distribution? Do regulate by any means night distribution? (For example by certifying that the equipment used by the companies complies with noise regulations) If this measure is applied in the city, what type of retailer does deliver goods at night? (Supermarket, textile sector, etc.) What measures are taken if the retailer is not present in order to deliver the goods?* Night distribution is not regulated in the city of Turin. If an operator agrees with its client to deliver goods at night, this can be done. Despite of that the ZTL does not allow night distribution as deliveries can be done up to 20h. The access regulation to the city is done through the weight of vehicles. The city of Turin is built on a surface that has underground water and has archaeological sites and trucks admitted cannot be very heavy. Commercial malls and big supermarkets are located outside the ZTL and most of them receive goods at night.
Regulation	*What type of policies have been lately implemented, or are in process of implementation to tackle the issues generated by city logistics? (Examples of other cities are: multi use lanes, a law that forces retailers to have a minimum space for storage, green labelling, traffic light prioritization, road pricing, delivery windows, etc.)* Aside from the regulations of access zones already explained, the city also want to tackle the issue of the loading parking areas. The regulation of the loading parking areas is national and not at municipality level. There are loading areas but insufficient for the number of operations carried out in the city of Turin. These are parking spaces not reserved for this purpose but for anyone doing loading/unloading operations (which include citizens loading their vehicle). Trucks and van park in the end where they can, trying not to collapse the streets. In the city center there are 200 places for loading operations and soon a new IT system will be implemented to control de use of this areas (just like the app used in Barcelona called AreaDUM). This system, though, will not be implemented in all the city but only in the city center (ZTL). This project is called SETA; further information can be searched at (http://setamobility.eu/)
Alternative fuels	*Is the city promoting in any way the use of electric /LNG vehicles in the urban freight sector? Are you aware if any operator in the city is already using electric/gas fueled vehicles? Does the city have in its plans (SUMP) plans to install charging points devoted to the charging of freight electric vehicles? Do you think that the shift to alternative fuels will occur soon in the city? [Are there any public funds to help transport operators to shift to electric/gas vehicles?* There is currently a project of a car sharing service with over 400 vehicles that will be electric. In the city there are over 700 electric charging points where around 10% can be used by any vehicle including the logistics.
Pick-up points	*Has the municipality promoted the installation and use of lockers or convenient stores? Is this delivery system common in the city? Has the city participated (financially or by providing public space) in the creation of lockers? Does the city believe that this solution could minimize the number of trips of the increasing deliveries of ecommerce?* All pick up points in the city are private and are located in privately owned land. These services are not being promoted within the city council. It is very difficult to promote these services from the administration. It is found as a good solution to reduce the number of trips but the municipality is a mere observer.

Brussels

The interview was carried out with Charlotte De Broux (Bruxelles Mobilité) on the 7th of September 2017.

Do you -and the city of Brussels- feel that city Logistics is currently a problem in the city?

Charlotte De Broux thinks that city logistics is a problem in Brussels Region in general, composed by 19 municipalities. Brussels Mobility is working on it with different measures, based on their sustainable urban freight plan. They started to write it having very little relevant data. At the moment they are trying to get more and more data as a support to complete it.

To quantify the % of vehicle kilometers that city logistics represents over the totality of trips they use a French model based in surveys in the cities called Freturb. Moreover, in Belgium all the trucks above 3,5 tones must have an on board unit to make possible its tracking. It allows to know in every moment where the trucks are in Brussels.

How do you feel about the near future about this topic? What projects do you currently have in order to mitigate the effects of city logistics?

Charlotte De Broux state that they do not have any scientific theory to say what will happen in the future, but for Brussels case they expect a growth of population, which means that goods transportation and logistics will increase as well.

In the other hand, there is no reason for e-commerce to stop its growth and it leads to more and more deliveries. These are mostly composed of small packages, so more vehicles will be needed to complete numerous trips.

From the point of view of the administration, they contemplate that one of their jobs is to make people aware that city logistics problem is important and affects to every citizen. If the Brussels inhabitants make easier the work of transport workers, this would bring positive feedback for them. Charlotte De Broux's team is working to spread these ideas and thus, change the behavior of people.

Apart of that, it is wondered to carry out a project to differentiate vehicles according their characteristics by labels, but there is nothing ongoing yet. It can help Brussels, as other big cities do, to recognize and promote good practices in city logistics.

In our study we are analyzing several measures that could be taken by cities in order to reduce the effects of increasing trips in city logistics:

Urban consolidation centers

Are there any? Public or privately financed? Was it promoted by the city? Or entirely by a private company? How does it work, how many companies are involved? Did it affect the number of trips in the city? Is it still working?

Do you –referring to the city- feel that consolidation centers can be part of the solution to city logistics problems in your city? Have you studied other cities that have implemented consolidations centers?

They supported initiatives within the framework of the European project LaMiLo (Last Mile Logistics). They are interested in implementing an UCC but to do so they consider the necessity to have a private partner. A pilot was put in 2014 into practice and the results were very positive on a logistics point of view. They had a 200.000 euros budget and they offered it to City Depot for the UCC implementation. Hence, City Depot was the responsible to complete these tests with its resources and IT solutions. The financial support was only for 6 month, and from then on it was planned to continue the practice without money from the administration. 3 years later, the financial situation of the UCC is however still not very easy.

The results showed a great success. The initiative was then taken over by B-post (Belgium post), who invested a lot in it. At the moment they are reviewing the financial model because they wanted to earn money with this kind of consolidation. Nowadays, the UCCs in Brussels are being studied in order to improve the conditions for transporters and shop keepers. Even so, work with shop keepers is very difficult and the changes for them with an UCC are not so easy to start even when it is relevant. Hence the main approach is faced basically for carriers. Moreover, they are trying to think the changes that the city suffered because the pilot was carried out 3 years ago, and some results could vary.

Even the good feedback with the UCC, city logistic managers are conscious that it is not the only solution or measure to carry out. The problem with such big UCCs is that people expect this as a unique solution. Once showed their efficiency, the different stakeholders think that building three big UCCs around the city will solve all the city logistic problem. This measure is positive but it needs to be complemented with other practices.

Brussels is looking to other cities with similar characteristics in order to learn about good practices. In the interview it is highlighted Paris where new urbanism concepts are being implemented. They are renewing the urbanism plan, and for example there is a regulation that force to have a specific number of square meters dedicated for city logistics in specific new developments in order to offer a good coverage of the city by logistics real estate. Furthermore, they are working in the optimization of vehicles used (which can lead to more vehicles if you replace a diesel by electric vans) and they are using old parking places for instance as logistic spaces.

These ideas, among others, are target points to treat and promote in Brussels. But also having in mind that there is no only one solution to solve the problem, it is about a set of measures different for every city, according different urbanisms and characteristics.

Off-hour distribution

Do you promote night distribution? Do regulate by any means night distribution? (For example by certifying that the equipment used by the companies complies with noise regulations) If this measure is applied in the city, what type of retailer does deliver goods at night? (Supermarket, textile sector, etc.) What measures are taken if the retailer is not present in order to deliver the goods?

Brussels is taking attention in night distribution considering it as a very interesting point for city logistics. It is wondered to promote this kind of distribution for its positive benefits. They explain that night deliveries are cheaper than day deliveries and they are considering a great chance to have more deliveries at moments when

there is less cars on the streets. But at the same moment there are some problems related with the noise levels. In accordance there are strong regulations stablishing that it is not possible to deliver at night. It causes controversy.

A trial was carried out in the city involving two supermarket brands. The period of demonstration took time enough to register noise levels in different points of the street. The noise level proof that truck nuisance was normally lower than the noise of other vehicles driving on the streets but above limits stablished by the City Council. But still the conclusion was that these kind of deliveries are difficult to carry out because of the very restrictive norms and because of the density of certain parts of the city where the noise levels were too high in the buildings next to the supermarkets.

To avoid noise problems, out of this trials the administration stablished a time period when operators are not allowed to deliver on street. It is decided by the 19 Brussels Region municipalities and it is stablished between 10 pm and 7 am.

Charlotte De Broux points out that as far as she knows many companies carry out deliveries at night even if it is illegal. Nonetheless, they are not planning to complain about it because there are no complaints from inhabitants. In case some inhabitant complains they should stop it to avoid paying a fee. During the mentioned trial, there was only a reaction from one inhabitant, but curiously, it was to express how brilliant the idea was and nothing to do with noise problems.

Regulation

What type of policies have been lately implemented, or are in process of implementation to tackle the issues generated by city logistics? (Examples of other cities are: multi use lanes, a law that forces retailers to have a minimum space for storage, green labelling, traffic light prioritization, road pricing, delivery windows, etc.)

Unlike other European capitals, Brussels have no system to differentiate the cars according their emissions yet. Despite the situation, city logistic administration is wondering to apply labelling system but there is no political agreement yet. To propose and develop this practice well they are looking at the example of London because it looks very efficient. The initial idea they have with labeling is to give facilities to greener trucks and vans.

A LEZ will be implemented in 2018 but will tackle only vehicle < 3,5t. They are studying another measure specific for distribution sector, the possibility that only trucks specially labelled could be able to deliver goods for administration and public organisms.

Regarding charging regulations, in Belgium there is no charge to enter the cities and trucks above 3,5 tones must pay only to use highways in Flanders and Wallonia but all the roads in Brussels. There is a road charging scheme that they should pay for kilometer driven depending on the vehicle size, emission class and road type. The system of paying is supported with an on board unit working through satellite.

Alternative fuels

Is the city promoting in any way the use of electric /LNG vehicles in the urban freight sector? Are you aware if any operator in the city is already using electric/gas fueled vehicles? Does the city have in its plans (SUMP) plans to install charging points devoted to the charging of freight electric vehicles? Do you think

that the shift to alternative fuels will occur soon in the city? [Are there any public funds to help transport operators to shift to electric/gas vehicles?

Charlotte De Broux explains that it is a topic in which she cannot explain many things because it depends more on other administration called Brussels Environment. She just say that Brussels Environment is trying to promote electric cars and there is a plan to increase the number of charging points in the city.

Load parking

Do you have dedicated spaces in the city? Is there a limited time for delivery? Is there enforcement pressure? How do you control parking time of each vehicle? Is there any experience in reserving parking spots? Do you think that an efficient management of parking spaces for loading/unloading operations could improve the efficiency of the delivery system?

Regarding loading and unloading areas they consider Brussels situation like most of big European cities. There are specific areas for the loading and unloading operations but they have the same problems as other cities, cars take these spots.

Sometimes they try to go with a transporter for a morning and see what is really happening in the streets. They indicate with emphasis that in a whole morning, the carrier could only stop once on a loading bay in front of the place. The rest of stops it was not in a loading bay because it was not free or these were occupied by cars. In one occasion, there was a loading bay quite far away from where the transporter was going and he did not even think about go there. It was easier for the carrier to stop in front of the door and turn on the warmings.

City logistic consider it as an important problem, their intentions are to enforce this by penalizing infractions. Normally it is the police who has to control it. But they have more important things to do, with a depenalization the control can be done by steward already controlling parking (any vehicle can stop on a loading bay but must pay 100€ except if this is for a delivery).

Pick-up points

Has the municipality promoted the installation and use of lockers or convenient stores? Is this delivery system common in the city? Has the city participated (financially or by providing public space) in the creation of lockers? Does the city believe that this solution could minimize the number of trips of the increasing deliveries of ecommerce?

Despite they think that lockers could suppose remarkable improvements, for the moment the ones installed in Brussels are managed by private companies. Among the companies working with lockers there is B-post and several small initiatives.

There was a study about how to reduce the impacts on environment and the cost of deliveries coming from the e-commerce. It was conducted by Flemish Cluster on logistics and they used DHL data. One of the remarkable solutions was that deliveries become to be much more efficient using convenient stores instead to deliver parcels at home. If 70% of e-commerce deliveries in cities use convenient stores instead of home deliveries significant reductions of environmental and economic costs would be achieved. Charlotte De Broux points out the similarities in concept between convenient stores and lockers since the driver can consolidate deliveries in one place instead of having to drive to several different addresses.

City logistic plans for the future contemplate to work more in e-commerce and lockers. Even so, this topic does not figure out as priority because at this moment they do not have such a problem which carry the need to regulate this, but an extra.

- *Is the city currently promoting any other initiatives/measures aside from the already mentioned?*

They are working a lot in the sensibility and consciousness of the stakeholders involved in city deliveries.

Charlotte De Broux emphasizes in Delivery and Servicing Plans initiative. The idea is to contact with companies, and check all deliveries they receive and explain the necessity to optimize them. For example, a company receiving everyday frozen vegetables can optimize that service in a consolidate shipment per week. They work in this initiative giving support and conscience them, but data and decisions have to be taken by the pointed company