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Hands-on testing of last mile concepts

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Abstract

Since 1995 the freight transport performance within Europe has increased annually by 1.2% and is expected to grow further over the coming decades. Being the sources and sinks of transport activities, Europe's cities are strongly affected by the resulting undesirable effects of transportation. This applies in particular to North West Europe (NWE), one of the most urban regions in Europe. NWE therefore stands in urgent need of solutions for efficient urban freight logistics.

Focusing on the last mile of freight deliveries the INTERREG IVB NWE project LaMiLo (Last Mile Logistics) addressed this issue. The project promoted Urban Consolidation Centres (UCCs) as they allow and encourage transport consolidation as well as modal shift. Decoupling the last mile at the city borders, large vehicles are used for bundled, long haul transports outside the city whilst sustainable transport means are used inside.

In the knowledge that UCC attempts with huge government subsidies have been made several times before but rarely succeeded, the core of the LaMiLo project was to enable environment for UCC operations that accomplish a sustainable last mile and can as well be transformed in successful business models. Thereto, UCC concepts were operationalised and implemented in a number of pilots in metropolitan areas and cities all around NWE:

- Paris: A UCC was field-tested to which freight was brought by truck and afterwards delivered by cargo bikes.
- Netherlands: Central hubs were put into operation to streamline the home delivery of parcels. Thereto, a Freight Circle service was launched in the cities of Nijmegen and Maastricht which used e-bikes and enabled customer-specific delivery times.
- London: A UCC was set up to bundle goods for the public sector which were destined for the boroughs of Camden and its partners Enfield and Waltham.
- Brussels: A UCC was launched at the Port of Brussels offering warehouse services and deliveries to retailers in the city.

The key results gained from the studies primarily include the demonstration of UCCs as possible last mile solutions. Beyond their economic performance, their environmental effects as well as their social impacts were evaluated. Exemplary results include that

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all the pilots contributed towards emission reduction and total distance travelled through city centres and residential areas. Gained best practice and lessons learnt about the examined UCC concepts were discussed and shared at transnational level to encourage relating solutions for further cities.

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Keywords: LaMiLo project; City Logistics; Last-Mile; Sustainability; Urban Consolidation Centres

Nomenclature

B2A	business-to-administration
B2C	business-to-consumer
B2B	business-to-business
CNG	compressed natural gas
CO_2	carbon dioxide
GHG	greenhouse gas
ICT	information and communications technology
LPG	liquefied petroleum gas
LBCC	London Boroughs Consolidation Centre
NO_x	nitrogen oxides
NWE	North West Europe
PM	particulate matter
TGL	The Green Link
UCC	urban consolidation centre

1. Introduction

Since 1995 the freight transport performance within Europe annually grew by 1.2% including the lower levels during the years after the economic crisis (European Union 2014). Also for the coming years an increase in freight transport activity is expected amounting to 1.1% p.a. until 2050 (European Union 2013). From a long-term perspective the freight transport performance within Europe is thus steadily rising.

Being the sources and sinks of transport activities, Europe's cities are strongly affected by the resulting undesirable effects in the forms of GHG- and fine dust emissions, noise and congestion (Clausen and Geiger 2013; Thaller and Clausen 2013). This applies in particular to North West Europe (NWE), as it is – with over 250 Million inhabitants living in metropolises, large and medium cities – one of the most urban and densely populated regions in Europe. NWE therefore stands in urgent need of solutions for sustainable urban freight logistics.

Focusing on the last mile of freight deliveries the research project LaMiLo (Last Mile Logistics) addresses this issue. The 'last mile' of supply chains is the link to the doors of the final recipients as homes or shops. More often than not, many organisations extend their supply chains to retailers but do not focus on the last mile. This is largely because the last mile is lost sight of due to its distance to the place of planning. In stretched supply chains with many stages the final journey frequently takes place in a different country or region from that of the start. However, this negligence means that opportunities for financial, congestion and carbon savings are missed.

At this point, the LaMiLo project aimed to create a step change in freight deliveries by ensuring that the last mile of a supply chain is fully considered and its potential exhausted. Thereto, the project promoted last mile practice for delivering goods to homes, shops, businesses and authorities that strike a balance between ecological sustainability, customer satisfaction and economic operational performance.

Within the LaMiLo project a combined scientific/hands-on approach was selected: Last mile concepts were tested in a number of pilots in metropolitan areas all around NWE with accompanying evaluation.

The paper on-hand reports on these trials. In the second chapter, the basic idea and objective that are equally associated with all the tested concepts are initially outlined. In the third chapter, the evaluation method of the pilots' impacts is explained. Based upon this the paper gives a detailed description and impact analysis of each pilot in chapter four. The final chapter draws a conclusion by summing up the results of the described pilots and making suggestions for future research.

2. Subject and goal of the UCC concept

Discussing concepts to achieve sustainable city logistics for the last mile the most evident actions are the consolidation of transports and the use of alternative modes of transport. Both options are enabled by transhipment in Urban Consolidation Centres (UCCs) (Allen et al. 2007).

As shown in Fig. 1, the idea of UCCs is to separate the distribution into activities inside and outside the city. One of the main arguments for such a transhipment point at the city borders is to benefit from the advantages of large vehicles for long haul transport outside the city without having their disadvantages in the urban area, such as pollution, inconvenience and traffic safety risks. Moreover, the transhipment at the consolidation centre allows the usage of more sustainable means of transport in the city, e.g. hybrid and electric vehicles or cargo bikes (McKinnon et al. 2015).

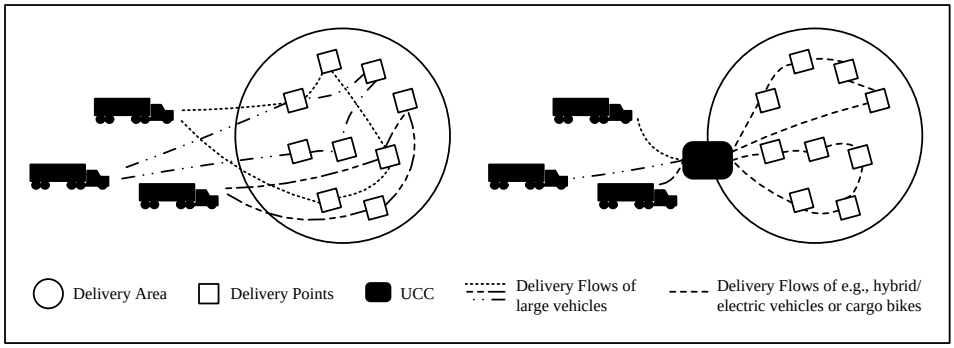

Fig. 1. Impact of the UCC concept on the distribution of goods.

Attempts to successfully implement UCC initiatives with huge government subsidies have been made several times before but rarely succeeded (van Rooijen and Quak 2010). The subject of the collaborative project LaMiLo was therefore to develop practical solutions which accomplish a sustainable last mile and can as well be transformed in successful business models. With this in mind, concepts were operationalised and implemented in four pilots in NWE.

3. Evaluation method

In order to control these four pilots as well as the embedding overall research project, all LaMiLo activities were evaluated throughout the project period following an evaluation plan (Goedicke 2014): A mid-term evaluation was scheduled to assess the progress of the project based on qualitative criteria, and an ex post evaluation which measured the final results based on quantitative analysis.

As part of this project management concerted indicators were identified and selected that assess the strengths and weaknesses of the four pilots. With respect to the projects subject to promote environment-friendly solutions that go along with economic and service interests the indicators cover the three dimensions of sustainability (LIST 2015d):

- The objective of the *economic dimension* was to give summary of the pilots' financial aspects. It shall outline what effects the UCC concepts have on the turnover and cost of the last mile, e.g. by reducing the number of deliveries or the kilometres travelled.

- The *environmental dimension* takes a closer look at the surroundings and climate of the pilot. The emphasis is put particularly on emission savings. These include Carbon dioxide (CO_2) as it is – counting for 20% of the natural greenhouse effect – considered to be the most important greenhouse gas, as well as Nitrogen oxides (NO_x) and Particulate matter (PM) which are hazardous to human health (e.g. bronchoconstriction).
- The *social dimension* reflects the attractiveness of the pilots for recipients and suppliers. It shall provide information about the number of involved partners and a better understanding of how the UCC concepts are perceived.

4. Project pilots

Within the LaMiLo project four pilots were implemented, tested and evaluated. Each of them will be presented here following the same structure: After pointing out the underlying motivation, the operator of the pilot is introduced. Then, the prior delivery model and the last mile delivery concept of the pilot are explained. Last, the most essential results gained from the operational phase are stated.

4.1. Parisian pilot

With over 2.2 Million inhabitants, Paris is the second largest metropolitan region of the EU. Because of its comparatively small urban area Paris has a population density of 21,000 inhabitants per square meter, making it the most densely populated city in Europe (Insee 2015).

The goods supply and disposal of Paris is therefore associated with a high traffic volume. It is estimated that 20% of the vehicles circulating in Paris is dedicated to goods transport (LIST 2015a).

Aiming at reducing the goods transport volume and thus transport emissions The Green Link (TGL) initiated a pilot within the LaMiLo project. Founded in 2010, TGL is a private sector company performing pioneering work in the last-mile sector in Paris. Thereto, TGL operates a delivery model which consists of three logistics UCCs in Paris, so called Micro Distribution Centres (TGL 2015).

Basically, Micro Distribution Centres are small facilities held by only a single carrier. They serve as a transhipment platform to which the goods are delivered by large vehicles and where they are portioned into smaller loads. Finally, the goods are delivered to the dense urban zones using light vehicles (Gonzalez-Feliu et al. 2015).

Micro Distribution Centres are generally set up close to the urban area for which the goods are destined. This location enables to hold up the goods consolidation during the main haul as long as possible and to minimise the subsequent last mile. The Micro Distribution Centres of TGL are therefore situated in the 6th, 10th and 13th boroughs of Paris.

The fleet of TGL for onward delivery comprises two electric vans and thirty electrically assisted cargo tricycles (LIST 2015a). The tricycles are rear-loading having a range of more than 20 km at a speed of 20km/h (TGL 2015). Within the pilot, their offered capacity which in terms of weight amounts to 250 kg and in terms of volume to 2.5 m^3 was almost fully utilised (LIST 2015d).

An efficient operation of a delivery model that reverts on cargo bikes prerequisites an intelligent route planning for the last mile and a detailed guidance of the drivers. On this account TGL refers to a new ICT system supporting these functions. It calculates an optimal route while considering constraints affecting speed, service time, distance, weight and specific bike accessibility and directs the drivers accordingly using GPS.

The special feature of the ICT system is that it is tailored to non-motorised vehicles. For this purpose the system's map data includes information on both roads and cycle lanes. Thereby, it is ensured, that the system is accurate enough to allow providing precise routing and navigation instructions (Institute for Sustainability 2015a).

Before the delivery model was introduced, the goods were transported from the suppliers' depots which are situated outside of Paris into the Parisian boroughs and instantly delivered in roundtrips to the final recipients. The transports were carried out by express couriers using light vehicles.

Today, the couriers enter the boroughs only up to one of the Micro Distribution Centres. Actually, Heavy Goods Vehicles are in use for these transports. After sorting, TGL dispatches the goods within cycle roundtrips starting and

ending at the centre. Only when the deliveries are so large and/or so heavy that their bike transport would lead to technical difficulties TGL reverts to its electric vans (LIST 2015a).

In order to evaluate the economic, environmental and social impact of the pilot relative to the previous delivery a set of data was collected describing the operational activities of 19 working days in the Micro Distribution Centre localised in the 10th borough of Paris. The activities comprise 8,519 deliveries of overall 8,559 items performed by TGL on behalf of two suppliers (LIST 2015a):

Concerning the economic dimension it must be noted that the number of roundtrips rose whereas their respective travel length decreased. While 6.5 roundtrips per day with an average length of 49.85 km would have been necessary in the conventional delivery, 9.6 roundtrips per day with an average length of 19.51 km were executed in the pilot, plus 734 km for the flow from the suppliers to the Micro Distribution Centre. The modified number of trips is due to the limited capacity and range of the tricycles in comparison to light vehicles necessitating a higher number of bikes and employees to deliver the goods. However, the closeness of the Micro Distribution Centre to its delivery area as well as the optimised delivery routes led to a sharp reduction of the trips' length, so that the total distance travelled was reduced by 30%.

As regards the environmental dimension it is crucial that the distance was not only reduced but also covered to a large extent by cargo bikes. Being an electric and human powered vehicle the tricycles contribute to a noise reduction of the urban traffic. Moreover, they are much cleaner than the previously used light vehicles. In consequence, emissions were lowered: CO_2 and PM by 82% each and NO_x by 80%.

The impacts of the social dimension are primarily related to the tricycle drivers. They benefit from the rise of manpower requirements and the associated higher employment rate. Thanks to TGL's new ICT system the introductory effort can be kept small when hiring new drivers. Also inexperienced drivers can easily follow the route predefined by the system achieving the same service level as old stagers. In addition, the tricycle drivers are not subject to parking restrictions as drivers of trucks and other motorised vehicles (Institute for Sustainability 2015a) and thus profit from relaxed working conditions.

However, a social impact on the final recipients could not be determined. As the recipients were not informed about the pilot they did not necessarily perceive the shift to the new delivery model as well as its benefits.

4.2. Nijmegen pilot

Nijmegen is situated in the east of the Netherlands in the province of Gelderland. At the sight of its history reaching back to the settlements of the Romans during the period from 20 B.C. to 400 A.D. Nijmegen considers itself as the oldest city in the Netherlands (Gemeente Nijmegen 2007). Still today, Nijmegen's long past is mirrored in its historic buildings, parks and museums and numerous little shops (Regional Tourist Board Arnhem Nijmegen 2013).

For Nijmegen's economy, especially the health and education sectors are vital parts. Nijmegen gives home to 166,000 citizens, of which the majority is employed in healthcare. Amounting to around 23%, the employment rate of the city's health sector is by far the highest (Gardenier and van Rijn 2013). Further 20% of the Nijmegen's inhabitants are studying (Border Concepts NN). The sectors' importance is moreover demonstrated by Health Valley, a network uniting about 700 universities, institutions, companies and governmental authorities in the region that are involved in health care in some way or another (Health Valley 2015).

The strength in which the health and education sectors are represented confers a distinct pioneering spirit to Nijmegen, boosting innovation und sustainability in the cities development and thus also in city logistics.

A Nijmegen foundation which invents and implements new green freight concepts in city logistics is Eco2City. Eco2City was established in 2008 aiming at reducing freight traffic in urban areas (Binnenstadservice Nederland 2015). Therefore, Eco2city started a new urban freight circle concept together with Binnenstadservice (Institute for Sustainability 2014).

Binnenstadservice operates a distribution centre in Midden at a distance of 1.5 km from the inner city of Nijmegen. The centre functions as a decoupling point in B2B shipments. Goods that are destined for retailers located in the city are dropped at the centre by freight operators. At the centre, the goods are bundled and delivered using clean transport vehicles at the time the shop-owner wishes (Institute for Sustainability 2015b).

Binnenstadservice distinguishes from previous consolidation centres by envisaging retailers that are not part of retail chains. Most retail chains organise the transports to their embedded stores via a distribution centre where the goods of several suppliers are bundled and exclusively brought to the chain's shops in roundtrips. Through this consolidation the deliveries are solely optimised from the origin perspective in the retail chains' favour. Binnenstadservice, however, intends to arrange the shops deliveries from a destination perspective and to create value for the cities by bundling its inner transports. Thereto, Binnenstadservice focuses on the many small retailers located in the city of Nijmegen. Due to their independence, their deliveries are generally not as streamlined as those of retail chains and hence offer great optimizing potential. To get access to the consolidation services including the timed deliveries the retailers have to sign up to Binnenstadservice and to notify their suppliers of a change in shipping address from the shop's to the centre's address (Van Rooijen and Quak 2010).

Within the LaMiLo project, the depicted concept was transferred to B2C shipments. The motivation behind is that end consumers are increasingly ordering products online. In 2013, for example, the European online revenue of B2C goods and services grew by 16.3% (Ecommerce Europe 2014). In consequence, multiple small-sized shipments are delivered to homes through the unaligned networks of the diverse couriers every day. This inefficiency is amplified further by cases in which the initial delivery was unsuccessful with the result that the carrier has to undertake a second or even further attempt. To raise the rationality of residential deliveries, a Freight Circle service was launched in March 2014 in Nijmegen and June 2014 in Maastricht.

After becoming member of the Freight Circle service, online shoppers choose the distribution centre as their final address when ordering goods. Now, the suppliers deliver the parcels to this single node rather than directly to the shoppers' homes. The subsequent last mile is contracted out to bike couriers. This way no permanent staff has to be provided as well as the neutrality of the platform manager is ensured. The couriers deliver the parcels in one roundtrip per day taking into consideration the time (between 5 to 9 pm) which is requested by the end customer. They exclusively use cargo bikes which possess a load capacity of 100 kg. Alternatively, the shoppers can waive the residential deliveries by the logistics carriers and collect their goods from the centre by themselves. In addition, the members of the Freight Circle can take up waste disposal services. Thereto, the bike couriers retrieve waste in the same roundtrip in which the parcels are delivered. (LIST 2015b)

The Freight Circle was still at an early development stage when the data collection for the evaluation took place. Therefore, at this point merely first indicators of the economic, environmental and social impact of the pilot were recorded rather than a full-scope analysis (LIST 2015b):

Looking at the economic aspects of the pilot it should be noted that the running costs amount to around 2€ per delivery and are covered by the end users. Thanks to the existing infrastructure and human resources that were already available from Binnenstadservice, the investments required for initiating the Freight Circle service were relatively small.

Concerning the environmental impacts it can be concluded that less emissions are emitted in the delivery area because of the shift to cargo bikes. Moreover, the service option of scheduling the deliveries according to the customers' wishes lead to a reduced number of failed deliveries.

From the social perspective it is worth mentioning that, despite the ecological and service advantages, the Freight Circle has only a small group of participants. Since the start of the pilot, it was joined by 36 recipients in Nijmegen and 23 in Maastricht. A probable explanation for this is that the residents do not realise the added value of the Freight Circle services and are therefore unwilling to pay for it.

On this account, one key lesson learnt from the pilot is the understanding that the implementation of such a service requires intensive mediation work. A regular dialog has to be held with potential consumers in order to convince them of the benefits, to explain the underlying cost structures and to motivate their usage.

Nijmegen and Maastricht are intending to do so and to gain new members also after the project's lifetime. Thereto, the 'City Logistics Network' was established to create connections with city initiatives at European level.

4.3. London pilot

In view of tens of thousands deliveries every year and of the own limited resources in the goods-receipt (e.g. number of loading bays) Camden Council and its partners, Enfield and Waltham Forest Councils, felt a strong need to re-organise the delivery traffic to their own buildings (Camden 2015).

As part of the LaMiLo project the three Councils therefore tested a new method of managing B2A-deliveries within the boroughs, all in all representing a delivery area of 143 square kilometres. The heart of the pilot is the London Borough Consolidation Centre (LBCC) placed in Edmonton, North London, close to the border to Waltham Forest. During the pilot the 2,000 square feet centre is dedicated to the consolidation of goods for the public sector such as cleaning and office products. After appointing DHL Supply Chain UK Ltd as logistics partner the LBCC opened in January 2014. During its starting phase it served to channel the deliveries of four council's suppliers (Banner, Bunzl Greenham, Janitorial Express and Office Depot) (LIST 2015c).

However, going beyond the London Councils' self-interest, the aim of the pilot was further to generally counter traffic growth and its negative effects in London.

88% of London's freight is currently transported on the street. This equates to 132 Million tonnes which are annually moved to, from and within London by road (Allen et al. 2013). Every day, London is faced by a high traffic density, which reaches 7,300 vans per hour during the morning peak (London Assembly 2015). Looking at the years ahead, London is expecting a rise of freight transport demand. Main drivers are London's population which is projected to grow by 13% by the mid-2020s (Office for National Statistics 2014), and of its economy, as the GVA is forecast to rise by more than 30% during the same time (City of London Corporation 2015).

By piloting the consolidation method and demonstrating its effectiveness on freight traffic Camden and its partners serve as an example and spur the adoption by other authorities and local companies.

Before the pilot, the four suppliers instantly delivered the goods to the three councils' buildings. These flows were not coordinated with one another leading to several goods receipts that had to be handled per day.

Within the pilot, these direct deliveries are replaced by integrating the LBCC. The goods arrive at the centre from Monday to Friday at pre-agreed time slots (6.30 am – 8.30 pm). Then the goods are grouped together and finally driven to the councils' buildings by DHL with collections returned to the LBCC. The roundtrips start in the morning (8.30 – 9.30 am) and arrive during the course of the day (9.30 am – 4.00 pm). The fill rate of the delivery vehicles is 71.3% on average (LIST 2015c).

The inbound flow of goods to the LBCC, however, is not uniform. One of the four suppliers brings his goods to the LBCC as part of a round-trip with further stops at other customers in the area. Another supplier drops his goods at the LBCC as well, but does not continue his tour. The remaining two suppliers do not deliver actively. Instead, DHL collects the goods by including these two into its round-trips as front- and back-haul (LIST 2015c).

To assess the economic, environmental and social impact of the pilot by comparing it to the prior delivery model two datasets were collected. The first dataset represents the baseline containing delivery data of one week for each supplier without the LBCC. The second dataset describes the operations of four weeks mainly gathered in June 2014. They encompass 39 delivery roundtrips and 48 supply roundtrips (LIST 2015c):

With the introduction of the LBCC into the supply chain the total number of deliveries and pick-ups which includes those of the suppliers as well as of DHL was slightly reduced from 3,069 to 3,021 during the period of observation. Similarly, the total distance travelled diminished by less than 1% from 6,317 km to 6,284 km.

Closely linked with that, the emissions were influenced:

- CO_2 emissions were reduced by 7% to 1.33 kg per delivery/pick-up,
- the amount of PM by 5% to 0.35 g per delivery/pick-up and
- NO_x emissions by 6% to 35.7 g per delivery/pick-up.

The calculations above led to the realization that the economic and environmental impact of a UCC is – at least under the circumstances in the present place – marginal and therefore not obvious. The main reason lies in the service demand. To offer high product availability the transit time is kept low. It averages 4:25 hours by parcel delivered with exception of Fridays when 05:00 hours were needed due to higher traffic congestion in Central London. To the disadvantage of consolidation the goods arriving at the LBCC are delivered at the same day. To increase consolidation and thus decrease the number of deliveries the LBCC should take on a warehousing function by storing goods.

Significant emission savings can as well be made by operating the LBCC with "greener" vehicles. During the evaluation phase two Heavy Goods Vehicles running on Diesel were used (LIST 2015c). However, electric vehicles

or alternative fuel vehicles (CNG, LPG) are more environmental friendly. Therefore it is envisaged that an electric Nissan commercial vehicle will be introduced (Institute for Sustainability 2015c).

Further potential for improvement lies in the social dimension and consists of extending the user circle. By involving additional partners (suppliers) and other customers a higher consolidation rate as well as fewer trips into the delivery area can be achieved. Indeed, the LBCC was not open to other customers than council buildings during the trial. However, now efforts are made to attract partners and receivers from the wider public sector and the private sector in the long term (LIST 2015c).

After the evaluation phase the pilot already began to grow and included the borough of Islington. Apart from that, a number of new partners as Business Improving Districts, schools, universities, retails and other London borough councils are interested joining the service (Camden 2015).

4.4. Brussels pilot

The city of Brussels is located in the capital region Brussels which has a population density of 6,850 persons per square kilometres. It is currently the fastest growing region of Belgium with a total of 1,175,173 inhabitants in 2015 (BISA 2015). Due to growing population Brussels is challenged by increasing volumes of goods delivered and therefore a rising number of delivery vehicles. With one vehicle for less than two inhabitants, Brussels has one of the highest motorisation rates in Europe. Road transport represents by far the primary means to supply Brussels with goods and merchandise and the share continues to grow (List 2015e).

In order to face urban logistics issues Brussels authorities launched a strategic plan for the transport of goods in Brussels for 2015–2020. The plan includes a commitment by the region to encourage the use of alternative transport and delivery modes (Brussels 2015).

To realize that intention Brussels launched a pilot as part of the LaMiLo project. In preparation for that pilot a freight flow survey was conducted with over 3,000 participants to create a freight flow model of the city to understand its inner freight movements. Based on the model, the concept of the Brussels UCC was created. The initiative was strongly supported by Brussels Mobility which selected the consortium of the demonstrator partner CityDepot and TRI-VIZOR for the operation of the UCC. The consortium started operation in September 2014. Initially, the trial was scheduled for a period of six months. For the UCC a warehouse in the TIR centre at the Brussels was rented from which is located near the city centre.

The UCC concept envisages the consolidation of goods in the warehouse which provides temporary stock capacities. After an inbound phase in the morning from 6 to 9 am consolidated goods are delivered onward to shops inside the city where they arrive between 10 am and 3 pm on the same day. Thereto, low emission vehicles, such as CNG and small EURO V Diesel trucks, are used. Electric cars and cargo bikes were considered as well. However, after an extensive search the capacities of these vehicles turned out to be too low for the structure of the UCC's shipments.

During the trial phase the UCC performance was evaluated in a period covering four weeks of operation in February and March 2015. Additional data regarding the vehicles used by the suppliers before and after the introduction of the UCC were collected and factored into the calculation. With these data the delivery points were identified using the delivery addresses. Thereto, a model of the UCC operations was created based on a Traveling Sales Person Algorithm to setup the roundtrips and a Dijkstra Algorithm to calculate the shortest distance between delivery points. The results were computed and compared with the distribution structure before the implementation of the UCC (LIST 2015e).

Within the considered four weeks about 1,200 deliveries with over 2,400 goods were collected and delivered in 78 roundtrips. The introduction of the UCC reduced the number of deliveries by 6.3%. This reduced the total distance travelled from 15,924 km to 8,269 km (-48%). Furthermore, carriers changed their operation patterns using bigger vehicles on long haul to load off goods at the platform. Within the urban area, the travelled distance was reduced from 4,234 km to 3,328 km (-21%) (LIST 2015e). Through consolidation a total vehicle fill rate of 84.4% was achieved and emissions were considerably reduced:

- CO_2 emissions were reduced by 15% to 5.1 kg per delivery/pick-up,
- the amount of PM by 22% to 0.2 g per delivery/pick-up and
- NO_x emissions by 24% to 14 g per delivery/pick-up.

The UCC allows carriers to consolidate their goods in one full truckload on long haul instead of using several small vehicles to cover deliveries in the Brussels capital region. The use of small Euro V Diesel vehicles reduced the pollution slightly. However, a technology change to CNG or electric vehicles is supposed to result in an even more positive CO_2 impact but with economic disadvantages (LIST 2015e).

As the trial was successful it continued operation beyond the six months trial phase. The Brussels-Capital region has put everything in place to support the UCC as a sustainable solution for the city which can be replicated in the form of a multi-centre structure in Brussels.

5. Conclusion

The collaborative project LaMiLo studied UCCs for balancing environmental and economic performance in last mile logistics. To this end, UCCs were piloted and evaluated in four urban areas in NWE: Paris, Nijmegen, London and Brussels. This chapter reports on the projects' key results and next steps.

By combining consolidation and mode shift a UCC is a promising approach towards sustainable city logistics. As shown by the environmental indicators measured during the pilot phases, the effectiveness of this approach was affirmed. Although the environmental impacts significantly differ from pilot to pilot, they all contributed towards emission reduction.

Due to unavailable or opaque data it could not be derived whether or not the UCCs are economically viable and can remain in the long run. However, some indicators suggest an efficiency increase of the last mile activities. For example, all the pilots succeeded in decreasing the total distance travelled through the delivery area as well as they all have a vehicle fill rate of more than 70%, demonstrating a good capacity utilisation.

However, implementing a UCC alone does not guarantee a positive environmental impact. Instead, the change to cleaner vehicles was determined to be a key setscrew for emission reduction. Moreover, a high participation of suppliers and/or recipients is needed in order to capture enough volume (critical mass) to achieve high capacity utilisation of the delivery vehicles and less journeys in the urban area. This in turn requires actively promoting the UCC concept. Only if the UCC benefits are firmly anchored in the minds of all private companies, the public sector and consumers will be willing to use and to pay for it where necessary.

The UCC concept shall become useful and reproducible for further cities. Therefore, the project team extensively communicates the gained best practice and lessons learnt. E. g. a European Conference on the future of last mile logistics was organised in June 2015. Furthermore, a web-based knowledge hub was established at which the pilots and their results are documented and published.

Going beyond the LaMiLo project, the next necessary step towards sustainable last mile logistics is to extend the gained experiences. Thereto, the pictured results will be incorporated into the project Urban Factory which investigates and optimises the development of resource efficient factories in the city. The central question is how resource efficient factories can be interwoven with their urban environment in order to become even more resource efficient. The answer may be found in many approaches, e.g. the energetic integration of buildings by local or district heating concepts or the social exchange with the neighbourhood by participatory processes. Also and especially in freight logistics further approaches can be found, in addition to those mentioned, as the use of cargo bikes for transports that are generated by an urban factory and run through its neighbourhood. For this reason, the multitude of those approaches will be compiled, analysed and enhanced by an interdisciplinary research team. To set an example and incentive for the industry – and this way to support the transfer – selected approaches will be implemented in model projects.

Within the project U-TURN the findings of LaMiLo will be exploited in an international collaboration. The project addresses urban freight distribution focusing on food logistics. The project will suggest innovative collaboration practices and tools towards achieving more efficient operations from both an environmental and cost perspective whilst considering the special requirements and needs of food transportation. The starting point is an analysis of existing transport flows of food products. In this course, different urban areas will be considered by selecting data from representative cities across Europe (e.g. Milan, London and Athens) in order to identify opportunities for consolidation. The impact of identified practices and strategies will be analysed using simulation experimentation. Special emphasis will be placed on what-if scenarios simulating the consolidation of flows considering products with complementary characteristics (in terms of volume, weight and stacking capabilities) and the use of UCCs.

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