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Innovative logistics model and containers solution for efficient last mile delivery

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Abstract

Urban goods distribution is important for the economy. However urban transport causes traffic, noise and pollution. The European Research project CityLog (part of Framework Programme 7) aims at increasing efficiency in urban distribution by proposing a logistics model based on two types of vehicles and containers solution in the context of parcel delivery. The urban delivery scheme currently consists of a number of vehicles that leave the hub and drive towards the city. The innovative logistics model for urban deliveries introduces a concept which make use of two types of vehicles: a Freight bus which is loaded at the depot with several load units that can carry generic parcels, and a Delivery van which is a light vehicle with high eco-compatible characteristics that make it very suitable to be used in the inner city Each load unit, when transferred from the Freight bus to the Delivery van, replaces the body of the van. These interoperable vehicles and containers form an improved logistics chain, reducing the number of vehicles entering the city, chilometers driven and pollutant emissions. Another source of unnecessary driven chilometers is unsuccessful deliveries when the receiver is not home during the delivery. The Modular BentoBox is the second concept introduced by the project. It allows to obtain a balance between optimisation of logistics and customers' interests by delivering goods to the bentobox, instead that to the customer location.. There parcels are stored in the bentobox until the customer picks them up. The Modular BentoBox System introduces the concept of removable modules that is trolleys with various size drawers. These trolleys and their drawers are filled in with parcels at the depot. The carrier transports the trolleys downtown and inserts them into the bentobox. As soon as the customer is notified, the parcel is ready at the bentobox. To access the parcel, the customer enters his special code on a user interface. The Modular BentoBox System can also be provided with a weighting and payment system and used for shipping parcels. The trolleys with shipments are taken back to the depot by the carrier. These CityLog concepts will be implemented and tested in 2012 in three European cities: Berlin, Lyon and Turin.

Keywords: city logistics; bentobox; urban delivery; last mile delivery.

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1. Introduction

In the context of the research project CityLog (co-funded by the European Commission under the Seventh Framework Program, Theme 7, Sustainable Surface Transport) the interoperability among vehicles is improved, especially in terms of load units handling, in order to let each vehicle support different types of mission and reduce the impact of parcel delivery in the urban area. In this paper we present two innovative solutions for urban logistics and we discuss their impact on the reduction of CO_2 and congestion. The first concept, described in section 2, targets the decoupling of transports in the inner city thanks to the introduction of two different vehicles sharing an interoperable load unit to be exchanged between the vehicles at a transshipment area. The second innovation, introduced in Section 3, define a system to decouple the transport and delivery phases of goods to final customers. Section 4 describes and compares four scenarios with a base scenario. The base scenario is referred to the actual distribution process, the other four scenarios simulate the innovative logistics distribution. The final objective is to show the savings that the new customer distribution allows to obtain in terms of kilometers traveled, pollutant emissions and costs for transport.

2. The innovative logistic distribution

Urban freight distribution is today performed by several vans that deliver shipments directly to the customers. The transport operator usually organizes deliveries by partitioning the delivery points in urban areas. Warehouses are usually located at the proximity, but outside the city center. In case of unsuccessful delivery, in general, the customer needs to go to the warehouse to pick his parcel up.

This chapter presents an innovative logistic distribution that consists in the introduction of two different vehicle types with the aim to optimize the distribution by lowering the transportation costs. More specifically the distribution model allows to reduce the number of km traveled in the urban area, thus immediately reducing pollutant emissions and congestion. Due to the shorter transport missions, vehicles with very small environmental impact, such as the Full Electrical Vehicles (FEVs) can be used.

The two vehicles of the distribution model are, respectively, a eurocargo truck and a small van (total load up to 3.5 tons), called in the sequel Freight bus and Delivery van. The Freight bus is loaded at the depot with several load units (LUs) that can carry generic parcels: the final scope of a LU is to replace the body of a Delivery van. The LUs are provided with legs applied to the box that can be extended or retracted so that the LU is raised or lowered to be loaded and unloaded from the Freight bus and the Delivery van. Load units are blocked over the vehicles with twist locks.

Each LU is loaded at the warehouse with the parcels to be delivered by a single vehicle. The LUs are designed with appropriate width and length so that three LUs can be loaded on a single Freight bus which transports them to an intermediate transshipment area which is close to the inner city, but outside of it. In this area the LUs are stored (on their legs) until a Delivery van, with a bare chassis, arrives and loads one LU that becomes its body. A transport of a Freight bus is than coupled with three missions of the vans.

The underlying idea is that the vans are small vehicles, possibly with full electric traction, that are very respectable of the environment and have a small impact when enter sensitive areas as the very center of old cities. But very important is the fact that the decoupling of the transport phase has a direct effect on the reduction of economical end environmental costs. We will analyze this aspect in the next Section 4.

3. Modular BentoBox System (M-BBX)

The Modular Bento Box System (M-BBX) is a solution for efficient last mile deliveries. The objective of this solution is to address the “last mile problem” by delivering goods to *bentobox* where they are stored until the customer picks them up. The bentobox may be located in residential districts, inside shopping malls, in central squares surrounded by offices, i.e., in a place where several customers can access it with small travelling distances. A similar idea has been already adopted by some logistic operator such as DHL that in 2002 introduced the Packstation system for home deliveries, the Austrian Post that introduced the Post.24 Parcel Machines to collect and mail parcels at any time of the day and of the night or the Estonian SmartPOST parcel terminal.

The M-BBX idea improves upon these systems by introducing the concept of removable modules. The bentobox has a fixed part, called *dockstation,* consisting of a user interface and a control unit (to be described later) and a chassis subdivided in a few modules (six in the CityLog implementation). In each module we can insert a trolley that is subdivided in several drawers of different sizes. At the depot, the drawers are filled with parcels. The logistic operator transports full trolleys to the bentobox and inserts each of them in a module, possibly removing empty trolleys. A customer is informed by a messaging system that his goods have been placed in the bentobox and he/she can go to pick them when it is more appropriate for him.

From a technical point of view the drawer doors of a trolley are closed by electric locker controlled by a specifically designed hardware installed on the trolley. The lockers can be opened only when a proper voltage is applied, i.e., they are in a stable position “close” when no energy is supplied. Moreover the drawers are equipped with a sensor that informs the controller when the drawer is open. The trolley has no batteries on board, but when it is plugged on the dockstation it is connected to a power supply and to a can-bus to exchange information and commands with the control unit. An automatic handshake technique allows the control unit to recognize the insertion of a new trolley and to send commands to manage the correct doors opening. The user identifies himself at the user interface and the control unit automatically opens the door corresponding to his parcel. The user interface implemented in the CityLog test case is a touch screen with a multilingual menu, but several other interfaces are devised as smart-card readers, bar-code readers, voice recognizers, smart-phones etc.

In order to have a complete remote control and monitoring of all operations the control unit is connected to a data network (Wi-Fi, UMTS, wired networks, etc., are possible in different implementations) so that it can transmit to the information system of the logistics operator real time information on the use of the bentobox, including some alarm when drawers are left open.

The M-BBX allows to obtain a balance between optimisation of logistics and customers’ interests and improve upon environmental impact. The total number of operations performed by the logistic operator is smaller, compared to a traditional delivery. Indeed in the traditional system the parcels to be delivered are loaded on the van at the warehouse and the driver has to perform has many stops and deliveries as the number of parcels. With the M-BBX the parcels are loaded in the drawers of the trolleys at the warehouse (which requires a slightly greater time than in an unsorted van body) and the driver performs a single stop and a single delivery for all the parcels contained in a trolley. Furthermore the number of successful deliveries is expected to increase because the customer does not need to pick up parcels at the same time as the operator delivers them. Deliveries might not succeed if the receiver is absent at the address where the shipment has been sent or he was relocated to another address. Unsuccessful deliveries are costly and time consuming. Recently Edwards et al., 2009 modeled CO_2 emissions for failed deliveries. For a failure rate of 10% the results show an increase of 15% of CO_2 emissions, for 30% failure rate there is an increase of 45% while for a 50% failure deliveries an increase of 75% of CO_2 emissions can be expected.

3.1. The use of the M-BBX

This paragraph compares the average time needed to consign 38 parcels with the standard delivery and with the M-BBX in order to estimate the potential time savings (38 is the potential number of parcels in the M-BBX configuration that will be tested by the CityLog project). The comparison of the two distribution models, assumes that customers are settled in an area which is at a reasonable distance from the bentobox to be reached on foot (at most 250 m).

In the standard delivery, the time needed to serve a customer is about 2 minutes, that is 76 minutes are needed to serve 38 customers. Supposing that the driver stops two times in the delivery area, taking each time 5 minutes to find a place where to stop the van. Indeed the total time to deliver the parcels to the 38 customers from two different positions with the standard delivery model is about 1 hour and 26 minutes.

The M-BBX consists in delivering goods to a bentobox by replacing trolleys. In our preliminary experiment we measured 5 minutes on average which are necessary to unload a trolley, insert it in to the module of the chassis, fix it to the dockstation and load the empty trolley on the Delivery van. Therefore, it takes 30 minutes in order to replace 6 trolleys containing 38 parcels.

Beyond the time savings, the cost that the customer pays for the service can be decreased due to the possibility for the logistics operator to overturn on the customer the advantages obtained by the use of M-BBX.

4. Comparison of scenarios

This paragraph compares four alternative scenarios to a base scenario in terms of chilometers traveled and pollutant emissions. All scenarios suppose that the density of an urban area is a proxy of an adequate market density. This is supposed to offer opportunities for significant efficiency improvements in the urban environments (Gevaers et al., 2011). The scenarios are set in Lyon that is one of the three cities where the CityLog project will be tested in 2012. In Lyon, the depot is located at Pierre Benite in the South of the city.

The base scenario represents the actual delivery process that consists in several Delivery vans performing the standard urban distribution. The other four scenarios are a representation of the innovative distribution process (Fig. 1). The difference between the four scenarios relates to the distance between the depot and the transshipment area. The objective is to assess the impact of the position of the transshipment area in terms of chilometers travelled, travelling time and pollution.

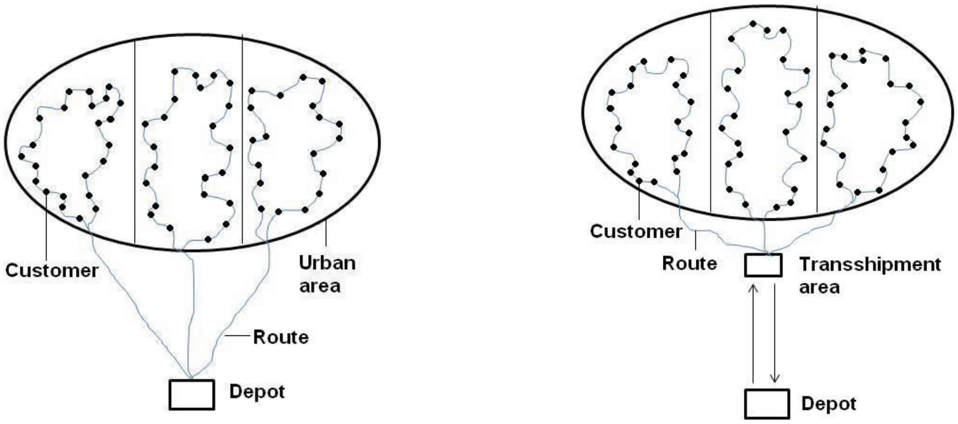

Fig. 1. (a) Standard urban distribution; (b) Innovative urban logistics system

4.1. Base scenario

The base scenario for urban freight distribution consists in several vans loaded at the depot. Each van delivers parcels directly to the customer. The strategy of the logistic operator is to identify several urban areas by clustering clients based on their distances. Each urban area, here identified by three Lyon's districts (3eme, 6eme and 7eme), includes 20 customers. This scenario estimates the total chilometers traveled by the three Delivery vans and their environmental impact. The environmental impact of the three routes is computed by means of the environmental calculator Ecological Transport Information Tool (EcoTransiIT) that quantifies emissions from freight transport.

4.2. The four scenarios

The four scenarios differ from each other by the position of the transshipment area.

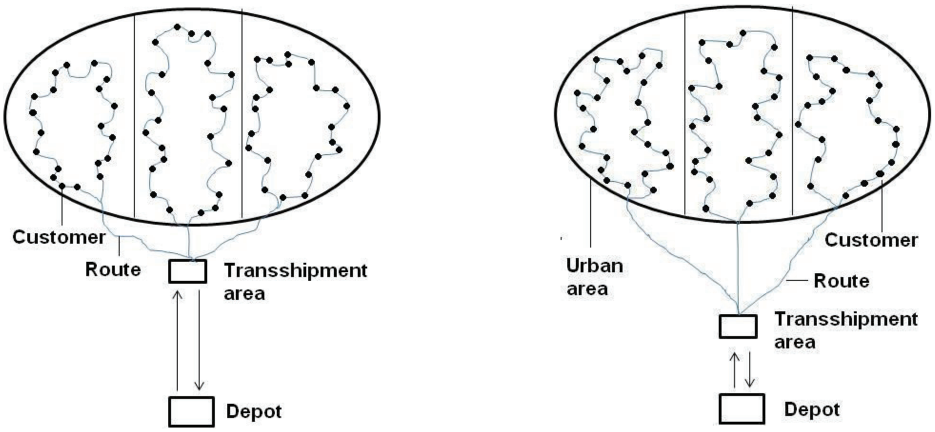

Fig. 2. (a) Scenario I; (b) Scenario II

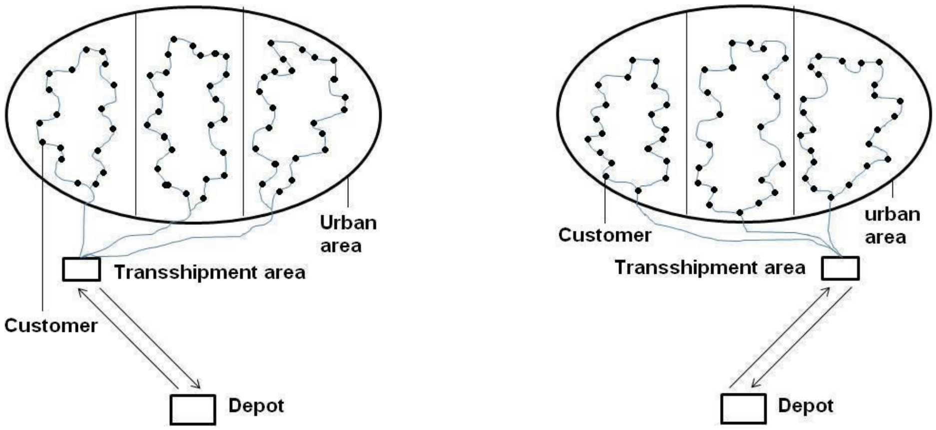

Fig. 3. (a) Scenario III; (b) Scenario IV

Figure 2 shows the transshipment area placed at the proximity of the urban center (scenario I); and next to the depot (scenario II). In Figure 3 the transshipment area is placed respectively on the left and on right side of the urban center (scenarios III and IV).

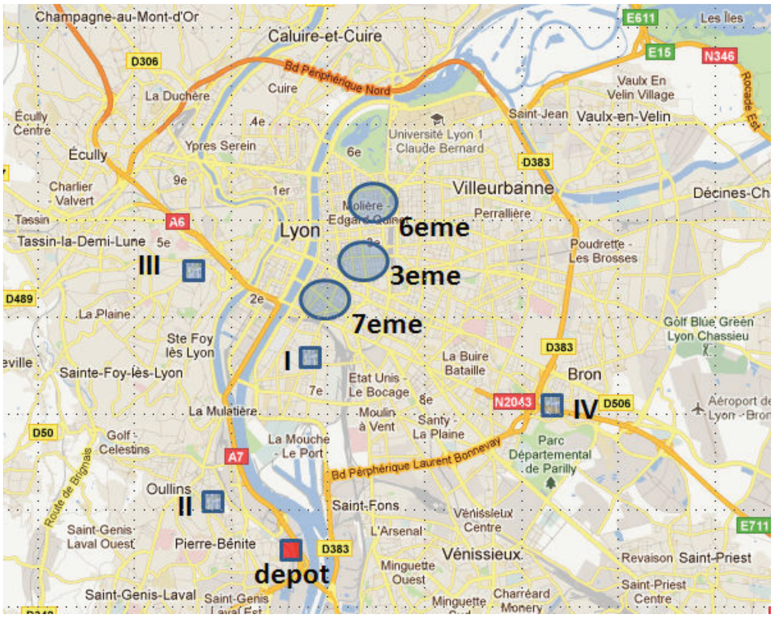

Fig. 4. City of Lyon: Position of depot, four transshipment areas and three urban areas

Figure 4 provides a graphical representation of the depot, the delivery areas and the four different positions of the transshipment area. While Table 1 reports the distances between the depot and the transshipment areas for each scenario based on the assumptions represented in Fig. 2 and Fig. 3. The farthest transshipment area are the ones of scenario III (11,3 Km) and scenario IV (10,9 Km). It has to be noticed that these transshipment areas are connected to the depot respectively though fast-flowing roads: the A7 *Autoroute du Soleil* and the *Laurent Bonnevay* ringroad thus allowing shorter travel times (8 and 9 minutes).

Table 1. Distance and travel time between the depot and the transshipment area

	Km	Travel time (minutes)
Scenario I	9,9	7
Scenario II	4,4	5
Scenario III	11,3	8
Scenario IV	10,9	9

Source: OpenRouteService.org

Tables 2 and 3 show the travel time and Km of the optimal route obtained by using the OpenRouteService. The largest reduction of travel time and chilometers is obtained in scenarios I (-23% and -28% respectively). Contrary, in scenario IV travel time and chilometers increase respectively of 16%

9%. This is explained by the longer distance between the depot and the transshipment area and between the transshipment area and each customer. Therefore savings in travel time and chilometers traveled are obtained only in the first three scenarios.

Table 2. Travel time and percentage of variation

	Minutes	Δ%
Base scenario	71	-
Scenario I	55	-22,5
Scenario II	63	-11,3
Scenario III	65	-8,5
Scenario IV	82	+15,5

Source: OpenRouteService.org

Table 3. Chilometers traveled and percentage of variation

	Km	Δ%
Base scenario	73,3	-
Scenario I	53,0	-27,7
Scenario II	60,6	-17,3
Scenario III	65,2	-11,1
Scenario IV	80,0	+9,1

Source: OpenRouteService.org

Table 4 shows CO_2 emissions computed using the EcoTransIT tool. Comparing to the base scenario, only scenario IV shows a small increase of CO_2 emissions (+1,2%) due to the longer average distance between the transshipment area and each customer.

Table 4. CO2 emissions and percentage of variation

	Tonnes	Δ%
Base scenario	1,10	-
Scenario I	0,98	-16,7
Scenario II	1,00	-9,0
Scenario III	1,08	-7,5
Scenario IV	1,22	+1,2

Source: EcoTransIT

However, it must be noticed that even a few percentage point can generate a significant CO_2 reduction because each trip is sistematically repeated every day. For instance, for 0,1 t saved in scenario II, in a year of 220 working days, there would be an annual reduction of 22 t of CO_2. Accordingly, scenario I would allow to save 40 t of CO_2 a year.

Moreover, previous assumptions highlight that the savings in terms of kilometers traveled, travelling time and pollution depend on the distance between the depot and the transshipment area but also on the average distances between the transshipment area and each customer. Furthermore the introduction of the transshipment area can bring other advantages related, for instance, to the possibility to use less polluting vehicles such as the electric ones.

Finally, the four scenarios are compared to the base scenario considering the additional time needed for handling operations at the transshipment area. Supposing that the time needed to unload a LU from the Freight bus, load it and lock it on to the delivery van is on average 4 minutes, three delivery vans are loaded in 12 minutes.

Table 5. Total delivery time

	Minutes	Δ%
Base scenario	71	-
Scenario I	67	-5,6%
Scenario II	75	+5,6%
Scenario III	77	+8,5%
Scenario IV	94	+32,4%

Table 5 shows that the delivery time of the standard model is 1 hour and 11 minutes. Even if the transshipment introduces an additional operation comparing to the base scenario, scenario I allows for a reduction of delivery time. The reason of this reduction is related to the position of the transshipment area, that is to the shorter travel time needed to reach it from the depot passing thorough the A7 Autoroute du Soleil (Fig. 4). Contrary, scenario IV has the longest delivery time that is 1 hour and 34 minutes due to the distance between the transshipment area and the customers. It must be noticed that this example considers only 20 parcels included in a LU of about 10 m^3 load capacity. Therefore the innovative logistics model would be strongly competitive with the base scenario if LUs are fully loaded.

4.3. Financial considerations

This last section presents some financial consideration regarding the implementation and management of the four above scenarios. The first financial aspect to be taken into account relates to the cost of the introduction of a transshipment area which is part of the innovative logistics model. The costs and benefits of different Urban Consolidation Centers (UCC) have been broadly analyzed by Browne et al. (2007). One conclusion of this work is that "*the successful of UCC depends on the nature and volume of traffic and on the possibility to introduce financial support to operation and to enhance the service offering to attract greater throughput*". In any case, if the logistics operator has to pay for the acquisition or the rent of an area where transshipment operations take place, the innovative logistics model could become disadvantageous. A possible solution is to involve a Local Authority (LA) in the process The LA may decide to invest in sustainable transport by finding an appropriate site to be conceded to the logistic operator with a small or null cost. In this case the financial effort of the logistic operator is very small, since it has just to provide to something like a fence, the lighting and possibly a surveillance systems.

If the transshipment area is provided by the LA, the costs for transport in the base and innovative logistics distribution models can be compared. TNT (one of the partner of CityLog project) estimates that the costs for transport with a small truck (< 3,5 ton) and with a medium truck (between 7,5 and 11,5 ton) are respectively 0,9 €/Km and 1,20 €/Km. These costs per Km include: the fixed costs (cost for the truck and the insurance), maintenance (including tires), cost for the driver and fuels costs.

Table 6. Comparison of the transport costs for different scenarios

	Depot - Transshipment area (Km)	Transshipment area - customers (Km)	Total cost €	Δ%
Base Scenario	73,3		65,97	-
Scenario I	19,8	33,2	53,64	-18,7
Scenario II	8,8	51,8	70,08	+6,2
Scenario III	22,6	42,60	71,46	+8,3
Scenario IV	21,8	58,20	89,46	+35,6

Table 6 provides the results of the comparison of costs in the four scenarios and it shows that Scenario I allows for a direct and significant reduction of costs for transport (about -19%). These results confirm that if the transshipment area is positioned in a convenient location, the innovative logistics model provides immediate financial advantages to the logistics operator. But we have not to forget the environmental benefits associated with the new model. If we translate in monetary terms these benefits, also scenarios II and III could become advantages. However this implies some political decision on the repartition of the social costs of the pollution, which is subject of many debates in the last decade. It is not the aim of this paper to enter this complex theme, but our results show that a proper design and a small contribution of the Local Authorities may determine a solution with immediate financial gains which could be immediately implementable.

5. Conclusion

The logistic models here proposed consist of two innovative concepts developed in the context of the CityLog project the M-BBX and the introduction of two vehicles and the transshipment area. The comparison of the standard distribution model with the distribution using the M-BBX showed a reduction of delivery time and unsuccessful deliveries, thus improving global pollution and congestion. The comparison of the traditional delivery with the use of the transshipment area showed the impact in terms of travel time, km traveled, environmental emissions and costs for transport. We have shown that the choice of the position of the transhipment area is crucial, but overall benefits can be obtained.

The combination of the M-BBX with the innovative logistics model is expected to further reduce delivery time, km traveled, environmental emissions and costs for transport. Furthermore, the innovative logistics system, implemented with an involvement of the Local Authorities, reduces the costs for the logistics operator who can decide to share the advantages with the customer thus allowing for global benefits.

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