

Consolidation strategies as a breakthrough on urban logistics

Stakeholder engagement strategies through
business and DAP modelling

Ciutat Vella, Barcelona

Roberto Rejano Arias
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Colophon

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Author	Roberto Rejano Arias
Student number	s1010013
E-mail	r.rejanoarias@student.ru.nl
Date	16 of July, 2019
Master thesis supervisor	Peter Ache
Internship supervisor	Miquel Estrada Romeu

Radboud University



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Roberto Rejano Arias

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Abstract

Urban areas constitute spaces where opportunities burst embodied in economic activities, which satisfy necessities of today's society. Thereby, urban freight transportation as a piece of a complex puzzle, it is the benefactor of an economic prosperity among states and within them. However, those beneficial streams that ease economic relations among bodies of any nature, they locally harm at urban spaces in form of traffic congestions, pollutants and space invasion among others negative externalities. Although urban freight distribution is as mighty as fragile, yet it remains unchanged due to the complex behaviour of supply chains. To fight off these anomalies, urban development concepts are showing up to make a transition to a more sustainable urban freight distribution in cities. That is the case of Barcelona, where according to the Urban Mobility Plan for 2013-2018 (PMU, 2014); it embraces consolidation strategies to turn from unsustainable independent deliveries, to a collaborative network through urban terminals. Hence, liveable urban spaces and logistic efficiency can fit together into neighbourhoods, being at the service of their own residents and visitors.

As a fact, Urban Consolidation Centre (UCC) and Urban Locker Area (ULA) are potential to make this reality to happen, since they tackle outcomes of interests of relevant stakeholders that participate in urban logistics, such as carriers, residents and visitors, and receivers.

On that behalf, this research intends to formulate strategic lines to engage carriers, being fundamental to overcome the launching phase as the main catcher of demand and a potential financial collaborator. Through analysing applicable strategies within a hypothetical scenario in Ciutat Vella district –Barcelona–, fruitful results are capture to assess positive impacts that may engage stakeholders, such as efficiency –carriers and eco-friendly operator–, sustainability –the municipality and residents– and operational cost savings –carriers–. Besides, this research proposes a business model based on an interrelation of dependence between the municipality and carriers, forcing them to collaborate to fulfil individual and global –local– achievements.

Key words

Urban freight distribution, Urban locker area (ULA), traffic congestions, Urban Consolidation Centre (UCC), Dynamic Adaptive Policymaking (DAP), environmental issues, externalities, carriers' contributions, cost savings, GIS analysis, Spatial Analyst, Network Analyst.

CHAPTER 1. INTRODUCTION

This new century characterizes by a trend of an unstoppable economic growth and the spent of finite resources, claimed by a tireless consumer society. In developed countries, governments operating along ideas of capitalism have enabled free trade, resulting a wide open market and a complex cooperative network that goes to a constant expansion of the economies.

That statement highlights the importance of the exchange of interest among stakeholders that participate in certain markets. Those realities are tangible thanks to the configuration of a freight transportation system, since it is where companies freely trade with common interests, forming at last a wide range of supply chains. Such a complex network performs from the extraction of raw materials, passing through manufacturing processes, ending to delivering services at shops and lastly, the final user. Then, it is logical to assume that freight transportation is a vital system that holds bridges between modern societies in a macro perspective (European Commission, 2018).

Nevertheless, macro indicators, which give an overview of countries' development, they are formed from micro-level structures. In that scale, the relationship relies on the interaction among local actors that deal inner and outer urban areas. Those influxes of goods fluctuate depending on the demand of products in a certain location through time, strongly bounded to final consumers. As a fact, it is certain that most of the demand concentrates at urban areas, due to the opportunities to prosper for citizens, as stated by UNDP/UNFPA, UNICEF and WFP *"Cities have much to offer their residents, from better access to services to greater economic and development potential"* (pp. 1. 2009). However, this trend is somehow worrisome to policy-makers because cities are already happening to be highly densified. As Eurostat compiled, roughly three quarters of the population allocate in urban areas, unchaining social disparities within them (Eurostat, 2016).

Despite that fact, Eurostat shows that freight transportation dropped around a 17% of thousand tonnes hauled for all European Union between 2008 and 2015 (2019). Such a fall is consequentially associated to the economic crisis that started in 2008, abruptly affecting southern countries such as Spain (Moschovou, T. & Tyrinopoulos, Y., 2018). For this reason, retailers seek methods to adapt within the market behaving with austerity in their business and finding alternative ways to subsist. Some of the logistic measures are associated to e-Commerce, which eases retailers to contact with any agent of a supply chain –suppliers, distributors and so on–, cost savings are generated thanks to outsourcing and streamlining the information transferred (Kaynak, E., Tatoglu, E. & Kula, V., 2005). In short, austerity together with an important reduction of the volume of freight hauled would seem that economic activities are being slowed by downturns, but nothing further from the truth. Urban logistics in Europe experimented an increasing of frequencies in delivering services, roughly 4% between 2012 and 2015 (Eurostat, 2019), and 20% of total routes correspond to empty mileage (Hezarkhani, B., 2018). On the other hand, retailers are extending the service time (closing business later) in favour of consumers (Euro-CASE, 2001). Other changes from retailers are associated to sharing warehouses and optimize stocks based on demand patterns (Euro-CASE, 2001).

What it refers to carriers in that concern, non-optimized hauling services are surprisingly still ongoing. That is seen in the current picture, where a competitive scenario takes place to gain more market share within cities, without developing smart strategies and without adapting fleets to highly densify urban areas. That is relevant since moving goods is pinpoint accuracy, whereby it implies a great risk when hauling due the countless impedances that might show up when delivering. Indeed,

impedances influence on timing (Suárez Falcón, H., Verano Tacoronte, D. & Sosa Cabrera, S., 2015), distances and carrying capacity (Estrada, M., Campos-Cacheda, J.M. & Robusté, F., 2017). For instance, a carrier who experiences a congestion during early shifts and far distances with low loading, would trigger over operative costs for him/her (Holguín-Veras, J., et al., 2015).

For this reason, freight management results to be a fragile ripple effect, easily to trigger adversely and consequently set off events hardly to mitigate. Even that, local administrations try to develop strategies to manage certain and uncertain situations, such as traffic congestions, roads temporarily closed, accidents and so on (Estrada, M. & Roca-Riu, M., 2017). These restrictions result to be negative in an annual balance sheet, but in addition, it economically affects directly and indirectly to the city and its residents. As stated by RPA (Regional Plan Association) & VREF (Volvo Research & Educational Foundations) *"Impeding the movement of goods impedes the economy"* (pp. 7. 2016), what in a micro-level would be; blocking the mobility of goods, precludes to the residents on covering their demands in their daily life.

In the meantime, these economic transactions that enable growth into modern societies, constitute negative externalities as payoffs that cities have to run with. Fortunately, governments from the European Union, United States, Mexico, Korea and Brazil among others, put that issue on the top of the agenda by including specific commitments regarding emission issues within the Paris Climate Agreement (NRDC, 2017). Thus, policy-makers are politically and legislatively endorsed to change the rules of the game in order to reduce particular events that harm the environment of cities (Mohajeri, N. Gudmundsson, A. & Louis Scartezzini, J. 2015). Pollution, congestion of roads and traffic noise are the main negative externalities that the cities are undergoing, where freight transportation contributes with approximately a 7% of gas emissions –CO₂, Nox and PM_{2.5}– globally (OECD, 2011). Moreover, in the OECD countries trucks and vans are the most contributors on CO₂ emissions within freight operator groups, forecasting a roughly 22% of the CO₂ emissions in 2050. Even then, currently the statistics between the years 2015-2020 point to a worrying prospect for trucks being a 23,4% and a 23,9% of CO₂ emissions respectively, whilst LDVs (Light Duty Vehicles) or vans positioned between 39,5% and 37,6% (OECD, 2011). What is more, the demand on freight transportation in EU grew a 2,4% by the years 2014-2015 (European Commission, 2017) and also was expected to be growing, at least a 3% yearly between 2016-2020, followed by a slightly expansion of the volume carried (Ti, 2017).

These statistics show that freight transportation has kept growing after the economic crisis in 2008, whose expansion sustains positive due to the fact of a huge demand on urban areas. That fact is in a very high concern, since CO₂ emissions reached roughly a 40% in urban areas (Navarro, C., Roca-Riu, M., Furió, S. & Estrada, M., 2015). Furthermore, these huge flows of goods heading to the metropolitan areas require a high coordination among companies, carriers and retailers. Such a coordination is based on delivering frequencies to different commerce, fleet capacity and volume capacity of vehicles, distances from O-D and intermodal terminals, unload/load parking spaces and so on.

Therefore, a clear framework of a vision as a city, ambitions, strategies and actions are essential to ensure a balance between efficiency/emissions and to develop engagement strategies to keep running the adequate business model. Rights must conduct such participation and duties, in other words, contribute on shrinking the negative externalities as much as they concentrate on maximizing the profitability of the service (Holguín Veras, Sánchez-Díaz, 2016).

Because of these inequalities in terms of efficiency and sustainability, this research intends to spotlight the relevance of consolidation strategies such as Urban Consolidation Centres (UCC) and Urban locker areas (ULA). Such concepts are key to convert the conventional urban logistic system to a greener and a more efficient model. As a result, reshaping the neighbourhoods as we know to a more liveable spaces for residents (Navarro, C., Roca-Riu, R., Furió, S. & Estrada, M., 2015). In terms of functionality, UCCs & ULA are urban terminals –with differentiated dimensions–, which work together with an extra operator that takes over the last-mile distribution. The differences relying between the conventional freight transportation in urban areas and the inclusion of these new transport operators, it is that e-bikes are zero fuel consumption and are adapted to the environment in a concurred district, whilst small and conventional operators do not (Leise Kelli de, O. et al., 2012; Roca-Riu, M. & Estrada, M., 2012). As an example of good practices, Barcelona run the SMILE pilot project in Ciutat Vella district, where a micro-distribution station received small packages from carriers and distributed them by an eco-friendly operator. The objectives for succeeding were clear and the participation was significant at the beginning, with an efficient operative calibration of the line haul distribution (Navarro, C., Roca-Riu, R., Furió, S. & Estrada, M., 2015). Nonetheless, this example among other cases failed, mainly because of finance and unwilling stakeholders.

In this research, alternative approaches intend to engage those unwilling carriers towards sustainable practices, with the final purpose to overcome bottlenecks in urban logistics. The motivation relies on designing a business model whose key players are carriers, which through financial contributions from their cost savings -once generated thanks to optimization of the line haul distribution through ULA terminals-, the third operator's operational costs are covered. For that commitment, Dynamic Adaptive Policy-Making (DAP) appears to be a policy framework where, strategies discussed in academia are transformed to policies, which –theoretically performing the regulatory role- on behalf of the municipality, those will be configure to generate as more costs savings as possible for carriers through ULA facilities. Besides, the methodology used also gives a practical approach by testing the policies into Ciutat Vella (Barcelona) as a case of study, capturing potential revenues of such strategies through Geographic Information System (GIS).

CHAPTER 2. STATE OF ART. UCC & ULA AS POTENTIAL CONSOLIDATION STRATEGIES FOR URBAN LOGISTICS

Consolidation strategies stand as the cornerstone that make possible to exist a balance between efficiency and sustainable public spaces against negative externalities. Hence, this chapter acts as an introduction to this concept, by defining and depicting its functionality through the following subchapters: a) defining consolidation strategies, b) stakeholder framework, c) the optimal location for UCC & ULA terminals, d) showing the successfulness of these urban logistic spaces and e) remark those barriers that have made consolidation strategies fail.

2.1. Definition of consolidation strategies

Consolidation strategies (CS) are innovative concepts in urban logistic's domain, which among their objectives include to tackle environmental issues within the city, transforming the conventional distribution of last-mile distribution in urban areas (see figure 1-2). From the conventional carriers' perspective, cost savings are substantial to be increased, and that is by reducing the number of trips destined per fleet for a coverage area (Estrada, M. & Roca-Riu, M., 2017). On the other hand, positive outputs for the city and its citizens are noticed, and that is by means of healthiness because of the shrinkage on traffic congestion. What is more, public spaces are protected from space invasion when unloading/loading goods (Triantafyllou, M, K., Cherrett, Tom, J & Browne, M., 2014). Hence, due to CS's positive outcomes from a theoretical perspective, Barcelona City Council approached this asset into Urban Mobility Plan, as a medium-term intervention plan between 2013 and 2018 (Ajuntament de Barcelona, 2014).

Thereby, consolidation strategies which bound spaces and freight flows are named by Estrada, M. and Roca-Riu as carried-led consolidation strategies (2017), well known as Urban Consolidation Centre (UCC) and Urban Lockers Areas (ULA). Both differentiate by their size and their capacity on market share, being ULA smart lockers and UCC warehouses. These facilities are optimally located to take over the last-mile distribution (van Heeswijk, W.J.A. et al., 2007; Simoni, M. et al., 2015), whose position are close to demand to guarantee cost savings and less emissions of pollutants within a given space and its surroundings (see figure 2). The role of both infrastructures, UCC&ULA, contemplate receiving, storing and dispatching of goods, being once shipped from depots to UCCs by carriers with more loading capacity, to be lastly distributed from UCCs to local customers by eco-friendly fleets.

Even seeing those consolidation strategies as improvements in urban logistics, their staging is questioned because of their complexity. That concern comes from a wide critical public of academics, private parties and public administration, being due to its organizational complexity, the significant dependence among stakeholders and its high budget (E. Nordtømme, M., Y. Bjerkan, K. & B. Sund, A., 2015). As a matter of fact, that last stands out, since the infrastructure needed and the level of investment to adapt operational parameters to meet with the demand, are significant (Danielis, R. et al., 2010; Gogas, A. & Nathanail, E., 2016). Due to that, resources –operators-, market share –retailers- and infrastructures –terminals- must be optimized in order to reduce excessive costs. On this basis, those issues will be treated further in 2.2.3. *Criteria for success and identified barriers in UCCs.*

Figure 1

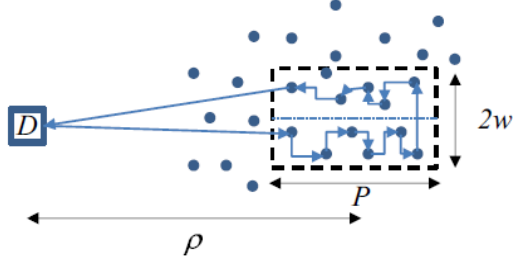


Figure 2

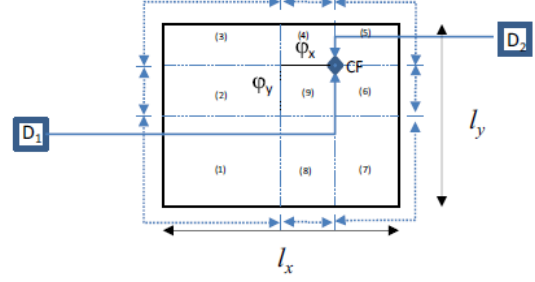


Figure 1. (Left) Scheme of the receiver partition in the regular distribution network of one carrier (Estrada, M & Roca-Riu, M. pp. 169. 2017)¹. **Figure 2. (Right)** Scheme of carriers' distribution through consolidation facility (Estrada, M & Roca-Riu, M., pp. 169. 2017)².

2.2. Issues on planning UCCs

UCCs and ULAs are presented as smart solutions, which have been already set in motion in some countries worldwide. However, as it has been mentioned previously, disparities and high difficulties for its applicability have been identified within the city (van Duin, J.h.r., Quak, H. & Muñuruzi, J., 2010). That is where, in the following sub-chapters, key elements are identify to be included into the consolidation model of Ciutat Vella district, such as: 1) Optimal location for terminals that may be appealing for relevant stakeholders, 2) Stakeholder framework for UCCs & ULAs and the criteria for success and 3) barriers that have been detected in other projects (BESTUFS, 2007).

2.2.1. Optimal location for UCCs and ULAs

UCCs and ULAs are at most, highly convenient for metropolitan areas, since cities concentrate roughly a 75% of the population in Europe (Gogas, M. & Nathanail, E., 2017), being highly densified followed by a huge demand that carriers cannot manage without failing on the service. Actually, worrisome realities are yet to come, as UNFPA confirms that the demand of products increase yearly as the population moves to where economic activities are (UNFPA, 2012). Moreover, that growth comes to more movement of goods, pushing carriers to run with high external costs when performing within cities. Monetarily, carriers spent in fuel six times higher and being at least two times noisier than a private car (Russo, F. & Comi, A., 2012).

Because of those issues, nowadays UCCs represents an alternative way into urban logistics' development plans. Even seeming to be a newly strategy, the criterion to its implementation it is similar to warehouses. That fact eases urban developers to find a suitable location that fits in the territory, always following a criterion where; socio-economic interests, operational safety and close distances to the demand areas, constitute the basis. However, those terminals are also subjected to environmental policies that move them away from densified urban areas (Janjevic, M. et al., 2013). Logistic terminals are classified by Gogas, M. & Nathanail, E. as it follows: freight villages, logistic

¹ Where 1) D and p is the line haul distribution distance from the distribution centre to the urban terminals in the last-mileage and 2) P and $2w$ are the dimensions of those zones where the demand is.

² Where 1) D_1 and D_2 are different carriers that plan to consolidate their freight in the urban terminals, 2) ux are the segments of different zonings and lr is the length of any segment.

parks and special logistic areas, all of them heterogeneous on size and their far location from urban areas (2017). Additionally, there is another category which is a close approach to UCCs, being city terminal, whose dimensions according to Gogas, M. & Nathanail, E. (2017) are large, located in the suburban areas, therefore well connected to interurban freight flows and to inner city.

The proximity of a city terminal to urban areas is essential for a greater success, otherwise controversial in a sense of generating new traffic flows where before there were not (Olson, J. & Woxenius, J., 2012). What is more, the more a terminal is close to the city, the more likely will have to run with excessive costs on land price and rental prices, indeed unappealing for developers and municipality (Olson, J. & Woxenius, J., 2013). On the contrary, not facilitating the proximity to high densified demand areas, it would drive to larger distances and then, as Gogas, M. & Nathanail, E. state, “lead times may be too long” (pp. 28, 2017).

Those issues are by means, principle to sort out inequalities. Seeing how problematic is to set CS framework, a combination of location proximity, optimization of investment and a robust and adaptive policy framework (see in this research chapter 5.5. *Dynamic Adaptive Policy-making*, pp. 26), it will help at least; to give some approaches to that matter. The location analysis is explained at sub-chapter 7.1. *Optimal location for ULA terminals in Ciutat Vella* (pp. 40).

2.2.2. Stakeholder framework for UCCs & ULAs

As it has been seen, UCC & ULA stand as smart solutions in city logistics shorting time spent to carriers in the neighbourhoods, obtaining savings for them, while preserving the liveability of public spaces (Johansson, H., 2018). Although those interests seem substantial as a starting point for establishing a strong partnership between private-public, the collaboration and thus the interdependence, drive to complex relations.

Thus, looking at figure 3, the conventional relation between regional and interurban freight transportation principally, it comes from the economical link between the supplier and the receiver. At a first sight, operative measures seem as simple as its physical relation transporting-delivering does, but nothing could be further from the truth. The main economic elements in freight transportation has to be with the amount of goods hauled, the frequency of route delivering, unloading/loading timing and lastly, a time horizon compromise which a carrier agrees on fulfilling (Estrada, M. & Roca-Riu, M., 2017). In all, the physical layer takes places whilst the local administration plays the role in the regulatory layer, where its concern relies on controlling unpopular effects in the city (see figure 3).

As a fact, uncertain events may prompt, for instance, new opening of shops producing a higher demand, where a limited fleet needs to expand, thus increasing costs. However, demand may fluctuates in a lifetime and by that, converting a necessary medium investment as a van is –it depends of the company’s size–) to an expensive variable cost. In other words, more pick-up/delivery time and larger distances among retails, unfortunately it drives to risky scenarios of uncertainty, starting for delays and finishing for monetary losses.

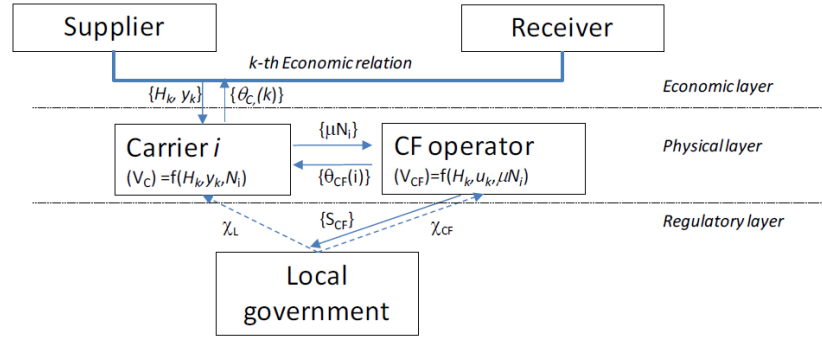


Figure. 3. Economic and physical relationship among stakeholders. Literature review from ‘Stakeholder’s profitability of carried-led consolidation strategies in urban goods distribution’ (Estrada, M & Roca-Riu, M. pp. 167. 2017)³.

UCCs and ULAs manage that last-mile distribution, then, ensuring a fair delivering to retailers into reachable distances, preserving a high quality service in terms of timing, sustainability and logistical performance -schedule, unloading/loading spaces-. Followed by van Duin, J.h.r., Quak, H. & Muñuruzi, J., the importance on success and failure for UCCs operatively, rely on how the UCCs are managed and by whom those initiatives were started (2010).

Some examples like in Leiden, Nijmegen, Bristol, Kassel, La Rochelle and Málaga demonstrated different strategies for launching UCCs as med-term initiatives, not only in terms of financing, but also in terms of integrating free space facilitating actions. Mostly, those projects started by municipalities, which three out of four projects failed. Based on the statement of Duin, J.h.r., Quak, H. & Muñuruzi, J. (2010), most of the projects of UCCs that failed, they contained a strong financial support from subsidies. On the contrary, private contribution stand as a primordial source of success on these initiatives.

These notorious differences have their own trade-off, which are essential for a win-win scenario. For example, in the hypothetical case where carriers are the leading actor of the UCCs, that is exemplified to tilt the balance positively to efficiency, but against environment parameters (Browne, M. et al., 2005). Nonetheless, being the municipality as a standalone player, it brings the whole UCC or ULA supply chain to be under a dependent position according to the political context, since a change of the mandate means a shift of the policy agenda and by that, the withdrawal of funds (Johansson, H., 2018). What is more, this public authority actions may drive to monopolistic scenarios like happened in Maastricht (the Netherlands), Barnsley (U.K.), Bradford (U.K.), Camberley (U.K.), Chichester (U.K.), Hammersmith (U.K.), Hull (U.K.), Swindon, (U.K.), where private parties are leery to participate because of lacking competitiveness (Browne, M. et al., 2005). On the contrary, companies may take urban logistics as a market niche to fill in with operational and cost saving purposes, favouring a fierce competition of the prices. That fact could drive to lower-quality services for the city and non-profitable revenues to keep on the UCC (Browne, M. et al., 2005; Duin, J.h.r., Quak, H. & Muñuruzi, J., 2010).

³ Where 1) k is each economic activity among suppliers and retailers, 2) y_k is the amount of goods, 3) H_k is the time horizon or the time limit of time to accomplish the order, 4) $\theta_c(k)$ represents the transportation fair to drive through the network, 5) V_C adapt their vehicles to demand’s conditions, 6) N_i the number of visits locations, 7) V_{CF} being the fleet that distributes from the consolidation facility to receivers and 8) X_{CF} regulations imposed by the municipality in the last-mileage.

That is why, a third party is essential as a neutral operator, assuring the correct functionality of terminals in order to achieve carriers and retailers' expectation. That new agent is a relevant gear within the supply chain, since is the one who models the optimal functionality of the terminals and it facilitates feedback to exploit opportunities for a better service. That argument is supported by Estrada, M. and Roca-Riu's model (2017), where the CF operator or UCC manager play the role of being responsible for running physical or operational tasks of the inbound goods shipped by the carrier to shops, saving a huge time and resources to carriers to perform that role –as a transport planner-. In short, it is clear that a neutral actor is key to consolidate a robust operational relation between the carrier, the receiver, the terminal and the new operator.

Then, UCC & ULA freight distribution relies between the CF manager and a new key actor who carry out the last-mile distribution with eco-friendly vehicles. These last are characterized by their zero emission of pollutants, since their engine is electric, perfectly matched to consolidation strategy requirements. In addition, the dimensions of such vehicles perfectly fits in the urban morphology of streets into the city, but also cargo-bikes make easier the unloading/loading process. What is more, with that operator, deliveries are increasing in frequency but reducing in volume per ride, fitting to an upcoming new trend of demand such as just-in-time delivery and fragmentation of loads (Faccio, M. & Gamberi, M., 2015), which is unsustainable since carriers have to do empty rides (Faccio, M. & Gamberi, M., 2015; Islam, S., 2017; Savelsbergh, M & Van Woensel. T., 2016). Although it stands out due to sustainable and efficient principles, the existence of adaptive and compacted financing model must take place, since these vehicles implies a high-cost on urban goods distribution (Lebeau, P., 2016). After putting several examples and having depicted stakeholders' role on UCC & ULA supply chain, it is clear that the beginning of a transition is happening. A wide range of literature exists but also the fact of sharpening those roles. Definitions of roles and tasks that relates to each stakeholder have been shown but deeper approaches remain to be unclear, for instance, rights and duties within the supply chain modelled by an adaptive policy-framework. This duality drives to even more complex scenarios, above all, building up the architecture of consolidation strategies, and then, the challenging process of engaging those traditional players. However, without strong bonds that hold a collaboration and a consensus among counterparts, it is impossible to make a leap to a more sustainable freight distribution reality.

2.2.3. Criteria for success and identified barriers in UCCs

In the last section, UCC and ULA concepts have been defined, but also it has been considered the elements for locating those facilities. In this case, a criterion for succeeding in UCCs performance is developed -adaptable to ULA applicability-, above all, for fulfilling on its feasibility and overcoming the pilot phase. Thereupon, barriers are analyzed by identifying pillars that impede success of consolidation strategies in urban distribution.

Keys to success

What concerns to UCC successfulness, some significant elements are depicted by BESTUFS at table 1 (pp. 74, 2007).

Circumstances	Elements needed
Lacking of transport infrastructures or policies that adapt to the increase demand of freight flows.	Analysis and planning to formulate new sustainable unloading/ loading policies based on stated preference model of carriers and retailers (<i>Apolda surveys</i>).
Traffic congestion when hauling freights.	Common interests on implementing measures for improving the environment of the streets.
Disruptions on mobility and accessibility for freight distribution vehicles in urban areas.	Include in the fleet smaller vehicles that can drive through narrow streets where the demand is located.
Densified areas of small retailers that are not part of a national business with a solid supply chain.	Design an appealing business model where retailers form part of the UCC and ULA model.
The existence of certain retails where the demand is consolidated into UCC or ULA supply chains.	Focus in a certain typology of retails in each phase of the UCC and ULA development.
Optimal infrastructure that can ensure an organized flow of freight.	Establish the terminals in suitable locations at last-mile in terms of operability.
Bottom up pressures from a consolidated group of business/users that claim solutions for urban good distribution.	Seeking those small businesses and look for a competitive edge.
Availability of funding for UCC and ULA maintenance and the existence of a strong regulatory framework, which enables a strong private-public partnership.	➤ Creation of a private-public funding. ➤ Pursuit local, regional, national and European funding for sustainable mobility projects. ➤ Municipality of Barcelona as the space facilitator for ULA manager. ➤ Cooperation from carriers through contributions that can help to keep on the ULA model.
Stronger policy measures against those carriers that are not included in the UCC and ULA scheme and haul small-medium packages.	Formulate adaptive policies on freight transport according to what is needed to maintain the functionality of the supply chain. That includes to conduct those measures that give room to ULA model, forcing independent deliverers that load small packages –through restrictions- to join the supply chain by showing what are the beneficial alternatives from the conventional situation (ERTRAC, 2011; McKinnon, A., 2010).
Strong presence and influence from the CF manager among all the players.	The CF manager is the one who knows the typology of products, capacity, storing and dispatching schedule of goods in the terminal. At the same time, keep a strong communicative canal with the retailers and eco-friendly transports for goods distribution and reports to municipality.

Table 1. Criteria for UCC's success and elements needed for Ciutat Vella model (BESTUFS, 2007)

Among the circumstances shown above, are identified some elements where UCC and ULA are only applicable when the city shows negative symptoms, because of conventional freight deliveries' practices. Those facts relates to, as mentioned previously, environmental disturbances and unbalanced stakeholder power within the supply chain. More accurately, public authorities have less control on micro-economic activities comparing to the private sector, but at the same time, private parties are subjected to urban regulations. These weak points must turn as potential opportunities for UCC an ULA performance.

Identified barriers

As a fact, the model needs to consolidate a potential demand in Ciutat Vella to succeed. That requires great efforts aimed to overcome identified barriers from unsuccessful UCC pilots on the last years (Browne, et al., 2005). Majorly, the barriers that are associated to UCCs failure relate to financial viability (van Duin, R., et al., 2016; Duin, J.h.r., Quak, H. & Muñuruzi, J., 2010). That is strongly bounded to UCCs' location (Olson, J. & Woxenius, J., 2012) and the fact of a lacking stakeholder collaborative participation, driving to short-durability of consolidation facilities like in Leiden (Duin, J.h.r., Quak, H. & Muñuruzi, J., 2010), already mentioned at section 2.2.2. *Stakeholder framework for UCCs & ULAs*.

According to May, A.D., Kelly, C. and Shepherd, S. (pp, 5. 2006) four fundamental barriers intervene when trying to develop consolidation strategies. **Nothing could be further from the truth,** but by identifying the following barriers, has to help to overcome bottlenecks regarding UCCs or ULAs performance at the last-mile distribution:

- *Legal and institutional barriers:* Develop shared spaces at public facilities, thus consolidation terminals can be optimally located. Therefore, restrictions have to be formulated to regulate independent deliveries of small-medium packages at regular distribution time. In the meantime, local authorities steer policy-making in favour of sustainable concepts like UCC or ULA. By doing so, the presence of both systems may balance to collaboration through urban facilities, as the model optimizes the line haul distributions. In fact, that may be appealing for carriers as the model contributes to fulfil their interests.
- *Financial barriers:* Budgeting restrictions due to limited public contributions and high pressure of big competitors towards the eco-friendly operator. Because of this current situation, a private-public partnership framework must be configured in order to overcome the launching phase.
- *Political and cultural barriers:* The acceptance of UCC and ULA concepts from the political and the public sphere is highly relevant. That is why, UCC and ULA ought to be in harmony with the sense of community. Hence, residents' concerns have to be included in the formula, thus civil society could endorse consolidation concepts as a way to maintain a clean environment in their neighbourhoods. Perhaps, that might keep UCC and ULA in the long-term (E. Nordtømme, M., Kristin Y. Bjerkan, K. & B. Sund, A., 2015).
- *Practical and technological barriers:* As the consolidated demand of UCC or ULA supply chains grow, the capacity of the third operator's fleet must do as well. That is

a concern, since vehicles with more capacity –such as electric vans– may be unaffordable for the time being, which is just subjected to society’s demand as a whole. Nonetheless, somehow the eco-friendly operator has to put efforts on deploying as many vehicles –whether e-bikes or vans– as possible to meet the demand from retailers. Such a compromise could be costly in the launching phase, that is why cargo-bikes seem feasible as the first transport mode of UCC or ULA, being furtherly upgraded to electric vans.

In all, UCC and ULA face financial barriers conditioned by non-collaborative actors –private parties or public authorities’ standalone– in terms of sharing contributions. This fact comes together with lacking efforts on developing engagement strategies for stakeholders, lacking of strong policies onto conventional urban freight transportation and as a key element, lacking of strategies to meet with an optimal market share. These aspects are key factors to consider for the strategies in chapter 5.4. *Operational strategies for Ciutat Vella model*, since the business model is designed according to key success elements and barriers mentioned above.

CHAPTER 3. PROBLEM STATEMENT

In daily basis, freight transportation is the facilitator of inflow of goods that enables economic activities to keep in motion within the cities. In fact, freight transportation is a growing market in EU (European Commission, 2017); however, empty rides represent a significant share of all routes made at cities. In fact, this tendency provokes negative externalities that undermine the quality of life of those districts, being areas of high demand.

In that respect, Barcelona is tackling these externalities by pursuing and formulating strategies in order to fulfil the vision of a modern, smart, sustainable and consolidated city. Different approaches have been made from municipality, universities and consultancies to put in practice consolidation strategies on regards of the last-mile distribution in Ciutat Vella district, although those have been put in doubt due to: financial aspects and unwillingness to collaborate. Yet, Urban Consolidation Centre (UCC) and Urban Locker Area (ULA) are valued as smart concepts, whereby are beneficial for carriers and municipalities in terms of cost savings, operationally and sustainability. Actually, multiple attempts have been made to overcome the pilots' phase in different cases of study. Regardless most of them have not succeeded, are still operational in countries such as Germany, the Netherlands, France, Japan, Spain, Sweden, etc. (Allen, J. et al. 2012). For that reason, thanks of previous researches on UCCs, some key aspects have been identified in order to succeed, which are depicted as follows⁴:

- Ineffective incentive strategies for engaging retailers and carriers into UCC supply chain.
- Poor involvement on adaptive policies when a service disruption might occur. Therefore, the conventional freight transportation remains unchanged on larger vehicles with small-medium packages regulation.
- A call for a private-public partnership that ensures a fair business model to all parts involved in the UCC's supply chain.
- Abusive price competition from bigger supply chains onto eco-friendly operators.
- The necessity of evaluating new formulas to locate UCCs at public spaces –as mixed-use functionality– with clearer purposes.

These facts are the targets that this research is intended to tackle. The idea is to reformulate the current strategies for a better applicability and feasibility of consolidation strategies in Ciutat Vella district, Barcelona. For it, the accuracy of this research relies on testing new strategies in form of policies in Ciutat Vella district, thus a fair economic balance is expected for all operators involved. Moreover, defining clear roles for the municipality, carriers, the CF manager and the eco-friendly operator, may help on having some approaches from those relevant players that are key for the UCC or ULA supply chains.

⁴ The outcome after the analysis of this process can be found in section 5.4 *Dynamic Analysis Policy-Making (DAP)*, pp. 32, 33, 34.

CHAPTER 4. RESEARCH OBJECTIVES

Once the problem statement spotlighted main issues on consolidation strategies, this chapter serves the focus of this research. The main ambition is to tackle the non-collaboration issue among stakeholders through basic policies –resulting ineffective business models for UCCs or ULAs–, which are not tailored for those potential benefactors for the supply chain. In that regard, this research seeks to formulate a model, where financial aspects and operational tasks are overcome. In order to achieve that, strategies raised by academia are gathered into Dynamic Adaptive Policy-Making (DAP), which is tailored to cover the necessities of those key stakeholders during the launching phase. Eventually, DAP framework is tested to assess whether those concerning outcomes of interest could be covered or not. Then, the research question is formulated as it follows:

To what extend Ciutat Vella's business model, could be appealing to engage and to keep on board those operators in the last-mile distribution?

4.1. Research sub-questions

In addition, the research question is followed by disaggregated sub-questions that will help addressing issues from a more technical and operational approach. As a fact, with the aim of keeping relevant stakeholders on board, engagement strategies must be stated by policy, whereby real compromises between the local administrations and private parties could be set. With the main ambition of configuring the basis of a business model for Ciutat Vella, the following question is set:

1. *What are those potential engagement strategies to be raised and for whom those might be steered?*

Thereupon, the effectiveness of the policy framework relies on assuring fair revenues to all players but also, demonstrating what improvements certain consolidation strategies would enable to engage and to keep stakeholders in the long term. Hence, all operators might benefit, thus, they may continue joining the supply chain. In order to see those improvements, Ciutat Vella model contemplates key indicators that affect all stakeholders involved within that scenario:

2. *To what extend ULA model improves the conventional freight distribution in Ciutat Vella, in terms of operational efficiency, environmental standards and cost optimization?*

By answering through all these three questions, this research hereby constitute the basis of Ciutat Vella model. At the end of this research, not only these questions will be solved constituting a robust business model for this hypothetical case. Besides, those insights of what measures must be applied and for whom will be reflected, as being potential facilitators of the workability of such consolidation strategies at last-mile. Last but not least, some recommendations will be depicted after analysing the Ciutat Vella scenario, as further steps to take in that line of thought.

CHAPTER 5. CONCEPTUAL FRAMEWORK

URBAN LOGISTICS SOLUTIONS & DAP FRAMEWORK FOR CIUTAT VELLA DISTRICT

In this chapter, Ciutat Vella is presented as the case of study to assess the competences of such consolidation strategies. Firstly, the spatial conditions and the socio-economic realities of Ciutat Vella district are depicted, with the final purpose of identifying what key aspects make UCC and ULA concepts to fit in the territory. Furthermore, obeying the duality of preserving liveable and efficiency spaces, Oriented Development approaches constitute the basis of what infrastructures would be needed –whether UCC or ULA– to be included and in what way–locations and conditions–. Thereupon, operational strategies regarding carriers’ performance are proposed to be included within the business model. Once these three steps are made, finally the Dynamic Adaptive Policymaking framework can be configure, conforming a set of tailored basic policies to be constituted. Finally yet importantly, the conceptual framework of Ciutat Vella explains the logic of the business model proposed to, hereafter, put it in practice through GIS analysis.

5.1. Case of study: Ciutat Vella district, Barcelona, Spain

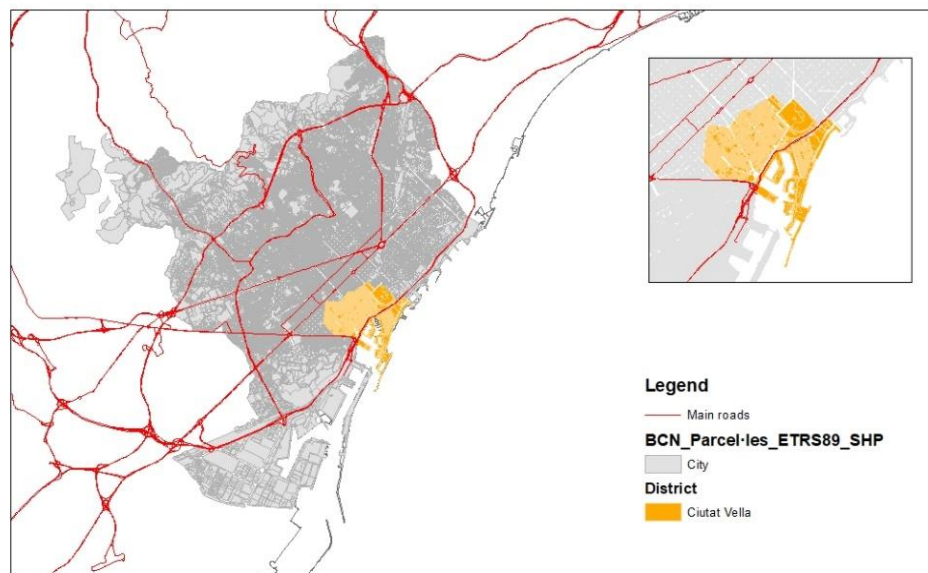


Figure 4. Ciutat Vella’s location. Own design out of CartoBCN data source.

Ciutat Vella district outstands as being a particular case among other areas in Barcelona, due to its attractiveness from a wide and differentiated public. Its location is at the core of Barcelona itself, – historical downtown– close to the harbour and the main roads that connects the inner city with other central infrastructures –airport, freight hub and so on– and other cities from the AMB (Àrea Metropolitana de Barcelona). Internationally, Ciutat Vella district is well known as being the most attractive tourism spot in Barcelona, since it gathers most of the tourist attraction. For instance, Plaça Catalunya being a meeting point, walking through la Rambla as the main boulevard, ending at Colon monument and continuing the walk throughout Barceloneta. Hence, hotel establishments and

commerce see that as a huge opportunity of dynamism, where economic activities develop greatly strategically located on the surroundings along the corridors, such as la Rambla, el Portal de l'Àngel and the commercial axis of el Raval (see figure 5).

As a fact, since last registry in Ciutat Vella made in 2016, almost a 40% of its territory is designated to economic activities, which at least a 24% is composed by offices, followed by a 21,4% designated to commerce (Barcelona City Council, 2016). Hence, this district presents as being an appealing territory for developing economic activities, mainly designated to tourism and commerce. According to Idescat (Statistical institute of Catalonia) figures (2018), the grade of accommodation occupancy in Barcelona has raised 11 points from 2009 until 2018 , but more precisely, Ciutat Vella collected at least a 27% of accommodation offer of the whole Barcelona in 2017 (Barcelona Activa, 2017) (see figure 5)⁵. These numbers are strongly linked to demand growth of products such as food products -34.6%-, personal equipment -31.8%- , others -14.9%- and leisure & cultural -7.1%- (Barcelona Activa, 2017), so does the demand of hauling services. As stated by Estrada, M. & Magín Campos, J. (2015), between 10%-25% of traffic in a city as a whole, is generated by freight transportation. In that concern, Barcelona has grown its goods distribution -interns and connections- in recent years after getting through the economic crisis, comprehended between 2015 -117.219 tonnes- and 2018 -172.940 tonnes- around 32% respectively (Ajuntament de Barcelona, 2018).

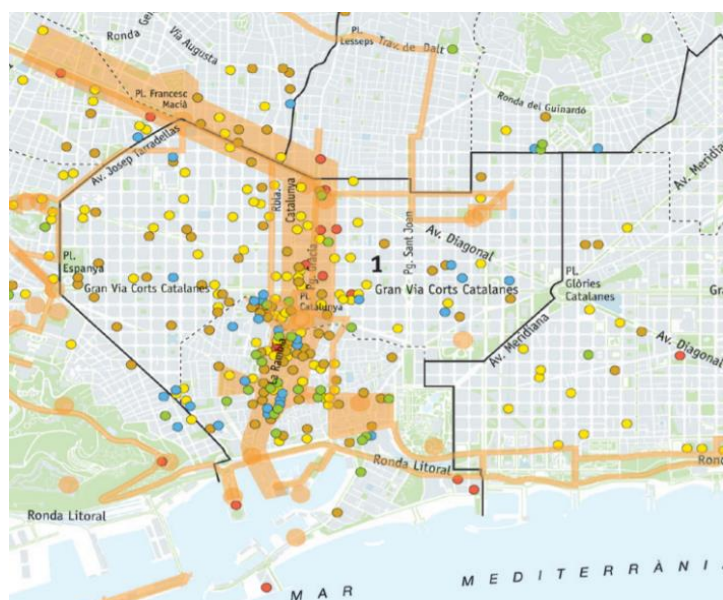


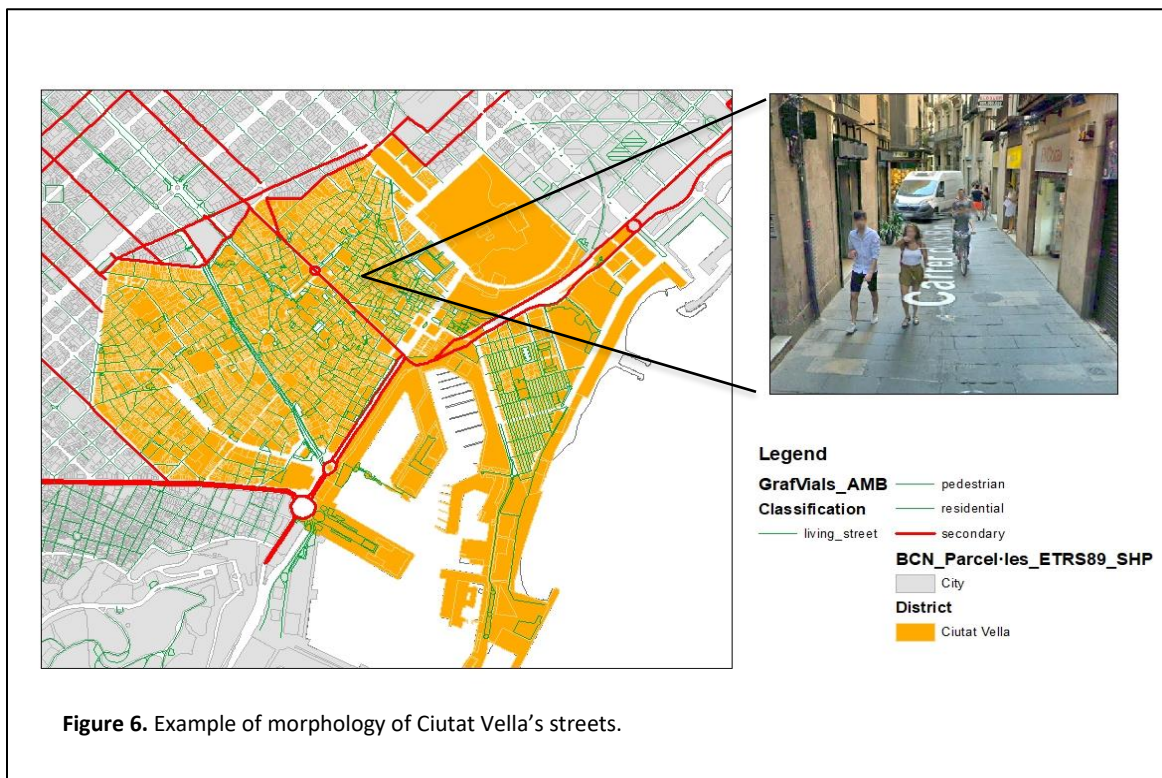
Figure 5. Hotel map Ciutat Vella (Barcelona turisme, 2011).

In spite of these positive figures, there exists efforts to tackle negative externalities that affect the quality of life of its residents. That is an unresolved issue, whose resolution must be intervened by the city council and policy-makers. The main evidences point to an increasing demand, the typology of fleets and above all, the accessibility conditions of streets. For instance, narrow streets and alleys characterize Ciutat Vella, where many retailing shops positioned along them. That fact

⁵ This map is originally from Hotel Map Barcelona “Oferta Hotelera a Barcelona (31/12/2011)”. It has been cropped to spotlight the main affluences of tourism -orange buffers- and hotel accommodation -points organized hierarchically-.

hinders freight distributors to pass through (Estrada, M. & Magín Campos, J., 2015), plus restrictions on time windows stipulated by policy and retailers' demand –that will be seen in the subchapter 5.4. *Operational strategies for Ciutat Vella model*–. As seen at the map below (see figure 6), green lines represent living streets, pedestrians and residential areas within Raval and Gòtic neighbourhoods. Actually, most of retails Ciutat Vella are located along these streets, making the manoeuvres problematic and costly, in terms of timing, when hauling freight by carriers (see picture at figure 6). On the other hand, red lines are those that are in a higher grade of hierarchy network, being Via Laietana, la Rambla and Passeig de Colón as the main road connectors with the primary and motorway network (see figure 6).

On this basis, Ciutat Vella shows to be overwhelmed due to the combination of the environment of the district and its capacity to attract a huge market as tourism rates present. In short, whilst economic indicators keep growing, urban logistic operators' performance are being undermined. That gives a clear picture of lacking of efficient strategies on freight distribution plans, making stakeholders distrustful. Thus, supply chains are less mouldable to adapt them into more sustainable realities.



This reality comes along with some identified barriers. Despite the fact of some pilots' failings, that have to be seen as an opportunity to explore and identify key elements, whereby match with the best conditions for succeeding through consolidation concepts, such as UCC and ULA. In that sense; traffic congestion when hauling, disruptions on mobility and accessibility for vehicles, small retailers that are not part of a national business with a solid supply chain and optimal infrastructures that can

ensure an organized flow of freight (Best Urban Freight Solutions, 2007)⁶, are the circumstances that meet with Ciutat Vella scenario. However, what are the ambitions of Barcelona City Council in that respect? Before depicting and proposing operational strategies for DAP framework, the following section shows what the interventions of Barcelona City Council, regarding on urban logistics, were and are.

5.2. Barcelona City Council: ambitions, strategies and actions

What regards to Barcelona City Council's actions on DUM issues (Distribució Urbana de Mercaderies - Freight Urban Distribution), have been notorious on the last years by making researches on freight distribution at different scales of the city and running pilots as the SMILE project. Results show that there has not been a significant change to a more collaborative supply chains from a top-down approach as such, where operators remain suspicious on sharing any kind of data to administration at any scale (Nuzzolo, A. et al. 2016). That is, perhaps, because private parties would loss competencies on freight transportation.

Hence, that lack of understanding among counterparts might drive administrations to fail when implementing assets, always based on freight mobility patterns' estimation within urban areas, ending to unleash chaotic situations. For instance, while Barcelona City Council makes more unloading/loading parking spots –increasing a 42% from 1998 to 2011–, there is a growing tendency of a 35% of carriers that park illegally on unloading/loading spots –sidewalks–, mostly at door-to-door distances (PMU, 2015). Without any doubt, these facts surprisingly glimpse an absence of a deep understanding of how to reduce certain behaviours effectively. Carriers look for minimizing the simple equation of operational cost= unitary time and distance –which involves many variables– as a matter of efficiency, whilst retailers want to meet the demand on a certain area and residents want to enjoy freely the public space. Indeed, there still exists lacking of appealing strategies that succeeded when constructing strong consensus among counterparts.

Despite the complexity of urban freight distribution, Barcelona City Council did not give up on testing different pilots such as; CDUs –Centre de Distribució Urbana or UCC–, telematics access to pedestrian zones through special cards monitored by cameras, time windows and so on (PMU, 2015). Perhaps, these strategies displayed were not mistaken at the operational level, but within the stakeholder structure itself, lacking of solid interdependences among players. That can be easily noticed at the last PMU report for the coming years 2019-2024 (Ajuntament de Barcelona, 2019), where the degree of the proposals are in a half-way to be consensual, marked by the low degree of support, thus doubtful for its complexity seeing how dull freight transportation is. Those measures proposed are; a) designate different action plans according to DUM typology –typology of freight carried– such as time windows and unloading/loading facilities –or free spaces–, b) deploy distribution centres –UCC and ULA–, and c) use zero emission vehicles and connect them to superblock plans (Ajuntament de Barcelona, 2019)⁷.

⁶ Those keys of success are compiled within Keys to success within “5.2.1.3. Criteria for success and identified barriers in UCCs”

⁷ Superblock definition base on “Let's fill streets with life, establishing superblocks in Barcelona”: “*The superblock model is a way of organising the city based on reversing the distribution of public space among vehicles and people, giving priority to the citizens, to improve environmental conditions and people's quality of life*”...“*the Superblock model's implementation will have to be accompanied by a 21% reduction in private-vehicle traffic in the city*” (pp. 17., 2016).

Because of lacking of consensus and resources, the prioritization has turned from the PMU 2013-2018 to 2019-2024, changing from DUM to Mobility as a Service (MaaS). That fact is remarkable, since freight transportation is not at the top of the agenda on that last PMU, otherwise smart mobility for commuters stands as a breakthrough into Barcelona society (see table 2). That change, of course, could be given because of sharing data issues, which diminishes the possibilities to make precise studies regarding mobility patterns of carriers, then formulating tailored strategies and plans of action. Although new growing business models, such as MaaS, imply to have great dependences from data traffic and infrastructures, the role-play works differently. For instances, even sharing data is problematic, an increasing trend of tech developers focusing on this part of business is happening. In addition, public administration has vast quantities of mobility data, has the infrastructures and has a great market share. These elements in fact, as stated by Matyas, M. & Kamargianni, M., enable MaaS's launching phase *"These positive coefficients support the theory that public transport needs to be the backbone of MaaS systems as it is a core part of individuals' travel preferences"* (pp. 14. 2018).

PMU 2013-2018	Ambitions	PMU 2019-2024	Ambitions
Safe mobility	Diminish accident rate.	Safe mobility	Diminish accident rate.
Sustainable mobility	Accomplish EU rates regarding NO2 and PM10 emissions.	Healthful mobility	Reduce emissions and acoustic pollution. Foster active mobility.
Equitable mobility	Augment frequency of public transport.	Sustainable mobility	Moderate energy consumption and foster renewal and clean energies.
Efficient mobility	Improve urban logistic distribution. Implementation of logistic micro-platforms.	Equitable mobility	Make accessible public transport and foster inclusivity widely to any age, gender, physical condition, income and neighborhood.
		Smart mobility	Increase car sharing, efficiency of transport, incorporate tech breakthroughs and make room for MaaS.

Table 2. Comparison of ambitions and strategies between PMU 2013-2018 and PMU 2019-2024.

Extrapolating this example back to freight transportation domain, a solid exchange network between the public administration –as the space facilitator– and operators –who consolidates a market share– have to be set. To reach that point, compromises and strategies have to be stipulated in form of tailored policies for those stakeholders that are key for the supply chain. In other words, those policies must be under conditions that, are mainly appealing for carriers, but at the same time compromise them to have some duties to ensure the system in the long-term. This system could push institutions, companies and civil society of Barcelona to work together to make more liveable and efficient public spaces.

5.3. Oriented Development concepts for consolidation facilities at last-mile distribution

The awareness on environmental issues is rising as promptly as the increasing demand of products from society increase. That is a homogeneous global concern, but adding the fact that the core of this duality remains at metropolitan areas (Renne, 2016). Freight transportation network contributes greatly at those areas where the demand is, producing traffic congestion, pollution, noise and free space competition (Roca-Riu, M., Estrada, M. & Fernández, E., 2016). As a fact, the fuel used for vehicles are non-renewable, unleashing a wide range of externalities whose effects go directly into neighbourhoods, meddling in citizens' daily activity and therefore, undermining their quality of live.

However, line haul distribution is not the only responsible of these inequalities, but it also invites land use to this open discussion, concerning strategic location of consolidation facilities into last-mile distances (Curtis, C. & Olaru, D., 2010; Papa, E. & Bertolini, L., 2015).

As an example, a carrier comes daily out of the city to supply shops several times per day within urban areas. The transport system of the city appeals to ensure a coexistence among different agents and by that, there exists transit rules, those translated to time impedances for carriers –traffic lights, lack of unloading/loading parking lots, etc.–. Moreover, cities present heterogeneous urban configurations, geographically differentiated and followed by structural transformation processes through time –avenues, narrow streets, alleys and so on–. In addition, clusters of demand do not remain in the same location as past times, neither the same land use nor its weight in the territory. That could alter the outcomes of the final formula when hauling goods. For instance, Ciutat Vella majorly has pedestrian streets where retailers spread along the path. Besides, those streets are poorly accessible because of narrowed streets or lacking of unloading/loading spaces that fit with larger-vehicles. That provokes significant routing delays, followed by not meeting the objectives based on demand, rescheduling routings for the following days, low quality of the service and so on. At the last point of this ripple effect, those externalities outline to monetary losses for private parties –carriers and retailers– and on the other hand, residents protest due an invasion of private forces onto public spaces. This example renders a reality that happens daily in urban areas, which these unstoppable interactions undermine the activities of carriers but also the liveability of urban spaces. That is why, oriented development concepts are key for starting to build up the criterion of where to locate consolidation facilities at the last-mileage.

Hereby, one of these approaches among others, points to Transit Oriented Development (TOD), which captures the existing ties between the land use, the growth of economic activities and the travel behaviour effects of commuters. This strategy tackles the fact of developing more compacted neighbourhoods, where necessities are supplied by allocating any kind of services and jobs into reachable distances for their residents and transit stations (Curtis, C. & Olaru, D., 2010). In terms of transportation, TOD facilitates citizens to swap from individual car usage to a more sustainable transport mode, such as biking, walking and using public transport. Indeed, the environment provides these transport modalities (Bishop, Z., 2015), firstly configured by policy-makers. This concept is supported by academia as a tool of mitigation against market forces that generate socio-spatial divisions along economic lines (A. Ratner, K. & R. Goetz, A., 2012), preserving the sense of community (Curtis, C. & Olaru, D., 2010), but at the same time not leaving out the efficiency and the functionality of these spaces. Nuzzolo, A., Comi, A., Ibeas, A & L. Moura, J draw a vision of these pillars, where all stakeholders involved in a geographical space are perfectly

compacted all together, performing their functionality endorsed by policies that protect the public space:

“For example, end consumers (i.e., residents, visitors) and public authorities (e.g., public planners) want to reduce transport impacts in order to have an attractive city for residents and visitors alike (mainly environmental and social sustainability such as a reduction in congestion, pollutants, and accidents) while retailers (or producers) and private companies (e.g., carriers) seek to deliver and pick up goods at the lowest cost, while performing high-quality transport operations and achieving short lead times in order to fulfil user expectations (mainly economic sustainability)” (pp. 552. 2016).

Regardless it is a utopian assumption; there are efforts on reducing negative externalities made by policy-makers, whilst trying to not harming hauling efficiency. Therefore, institutions boosts pilots’ initiatives to enhance logistics operability and to jump to wiser strategies for smart cities. Nonetheless, there still exists a gap on going deeper on that topic, whilst there are endless theories and simulations on urban mobility for normal travellers, as stated by Russo, F. and Comi, A. (2018).

The lack of a strong theoretical basis of freight transportation in the last-mile influence area, calls to lean onto others theories such as Cargo-Oriented Development (COD). COD represents an approximate theoretical approach to freight transport and to intermodal terminals. This concept spotlights the linkage of industry and logistics, and the closing distances to ease the efficiently movements of cargos (CNT, 2012). In the case of Ciutat Vella district, although this district does not have a harbour within its boundaries, it is well connected to Zona Franca –logistic park– through Ronda del Litoral –relevant ring road at the outskirts of Barcelona– at a reachable distances. Nonetheless, as it has been explained in ‘5.1. Case of study: Ciutat Vella district, Barcelona’, this area attracts visitors and residents of the city, through economic activities. However, a chaotic picture is revealed in the district because of the huge interests of retailers to establish there and the lacking of strategies in urban logistics, which in the end, the sense of neighbourhood results to be harmed. To solve that, a combination of COD and TOD approaches would be convenient by deploying those urban terminals infrastructural adapted based on: a) a real demand and b) preserving the sense of community for residents.

In addition, Ciutat Vella district frames all the downtown, being a problematic area for delivering, since narrow streets and alleys configure its environment. In terms of accessibility, it is noticed that the characteristic of vehicles and the streets do not match to perform an efficient distribution of goods. That is why, as consolidation concepts propose, a third operator is key to make goods more accessible in the last-mile distribution. In fact, Accessibility-Oriented Development (AOD) concept steers consolidation facilities development to consider the relation between the land use and the line haul distribution, and the grade of difficulty among origins and destinies (Deboosere, R., M. El-Geneidy, A. & Levinson, D., 2018).

To sum up, each oriented development concept have spotlighted relevant aspects to take into account when planning consolidation facilities: where to allocate them and how they ought to be. In that respect, those facilities have to be configured in a way that; do not change the surroundings with big infrastructures, thus the sense of community remains for residents (TOD), locating intermodal terminals nearby other participatory agents in the supply chain (COD), and enabling the presence of a third operator to ease the accessibility of goods to commercial axis (AOD).

5.4. Operational strategies for Ciutat Vella model

In the previous section, SMILE project was mentioned as being a pilot in Barcelona, where a micro-distribution terminal was operative at regular hours delivery taking over last-mile distribution (Navarro, C., Roca-Riu, R., Furió, S. & Estrada, M., 2015). Goals were achieved at the very beginning, but the project failed due to lack of collaboration and trust on the project itself at the mid-term. Thanks to these attempts –among others–, some behavioural patterns from carriers in the city of Barcelona were extracted and analysed (Ajuntament de Barcelona, 2015):

- Mostly, small and medium vehicles –vans and cars– are predominant in the last-mile area.
- On average, carriers visit thirty-four retailers per day.
- In order to minimize service time violation, carriers park door-to-door occupying illegally the public space.
- Time windows are distributed on RHD basis from 9 am to 12 pm and 16 pm to 20 pm.

These facts make Ciutat Vella widely chaotic, above all during mornings because of overwhelmed public spaces shared among visitors, traffic –including carriers and commuters– and economic activities. Although local authorities insist to redirect some misconducts from carriers by implementing specific rules, those seem ineffective. Then, it is reasonable to question why these actions are a tendency in Ciutat Vella's surroundings. A powerful argument relies on the disposal of an important number of retailers along crowded and narrowed streets, which is an element why UCC concept originates (Browne, M. et al. 2005). This problem brings carriers to make their way to meet with efficiency terms, even not respecting traffic rules. Nonetheless, a carrier either does correctly its job with good practices or not, will be penalized through delays, or punished in form of fines (Ajuntament de Barcelona, 2014).

These bottlenecks must pressure policy-makers to propose strategies to reduce unsustainable scenarios. In the end, understanding all individual problems when performing their work, engagement strategies have to arise to make stakeholders collaborate in urban logistics. Some of them are identified and are discussed in academia, being those potential strategies tailored for carriers.

5.4.1. Time windows

According to Deflorio, P. et al. (2013) the most value in freight transportation, it regards efficiency without violating the quality service claimed by the client. The service quality relates to the product status if the client is an ordinary consumer. Otherwise, retailers claim to meet with time windows, which are the indicators to determine a certain time to supply, therefore running the risk of being penalized by constraints when servicing. Deflorio, P., Gonzalez-Feliu, J., Perboli, G. & Tadei, R. confirm that aspect “...service quality is often related to travel time, and can vary according to both socio-economic and trip characteristics” (pp. 556. 2013).

Looking at the current picture, retailers expect different providers to come to their business, during the day and along the week. Then, retailers determine time windows, being those conditioned by policies and above all, being the best time for retailers to attend when carriers unload goods (Holguín Veras, J., et al. 2016). The controversial thing is when, for instance, carriers have to deal with other time windows of other retailers, which might drive to time violations. Then, it is logical to

thing that a growing tendency of services in a city demands more products, so carriers concentrate more market share, leading to work overloads and ending up to economic losses and a waste of resources. On the other hand, also delays are troublesome for retailers since are the ones who must invest time and personnel to receive the goods, consisting on more or less time depending on what sort of freight is. Moreover, in Ciutat Vella unloading/loading time slots perform between 9 am to 12 pm by policy, which totally undermines the efficiency and the quality service. Indeed, those facts result problematic to retailers and to carriers, forcing themselves to obtain the best results individually. At the end, retailers are not flexible on time windows by being on a dominant position and carriers do not optimize their market share capacity trying to get more benefits.

One of the potential strategies to fight off this puzzle, regards testing the effects –also strengths and weak points– by modifying unloading/loading policies from RHD (regular-hour-delivery) to not that frequent time slots (Holguín Veras, J. et al., 2016). As noticed, RHD brings along unsustainable and suboptimal number of routes widely in a city, affecting all stakeholders. In contrast, academia, decision-makers and companies have given a chance to OHD (off-hours-delivery), whose frame in practice goes from 7 pm to 6 am, lately in the night-morning (Holguín Veras, J., 2016).

OHD strategy generates greatly cost savings on operational basis –avoiding traffic jams, unloading/loading problem and so on– and provokes much less emission of pollutants. In *“Direct impacts of off-hour deliveries on urban freight emissions”* (Holguín Veras, J., 2016) emissions produced by daily delivery activity was analysed. New York City, among others, showed that during RHD shorter distances substantially emit more emissions –in total 77.60 kg of pollutants in 50 kilometres–⁸ than larger distances in OHD –in total 69.58 kg in 100 kilometres⁹–. That is because of traffic congestions at certain times in Hudson River, being one of the entrance to Manhattan Island (Holguín Veras, J., 2016).

It seems that OHD strategies would likely reduce abruptly operational costs and favour a better liveability of a city. Although this policy is appealing towards carriers and citizens, receivers might disagree on this due intern-logistic reasons such as ‘who is going to receive those deliveries?’ (Estrada, M. Campos-Cacheda, J.M. & Robusté F., 2017). What is more, as stated by Estrada, M. Campos-Cacheda, J.M. & Robusté F., receivers would have to run the risk *“of property damage or theft at the shop where supplies are delivered...”* (pp. 3. 2017). Therefore, financial support for retailers would be needed, on the contrary *“...big department stores may have personnel responsible for store replenishment that would receive the shipments out of the commercial hours”* (pp. 3. 2017).

a) Issues on OHD policy applicability

Retailers are a challenging player to get into OHD policy, due to operational extra costs and risk of damages on goods. On the contrary, bigger receivers such as supermarkets or malls might be beneficiaries, because they have resources to do it (Estrada, M. Campos-Cacheda, J.M. & Robusté F., 2017). However, receiver-led consolidation strategies are not suitable for ULA framework, since that

⁸ Average city regular-hour emissions per kilometer (g/km): reactive organic gases (ROG) – 0.247, total organic gases (TOG)-0.281, carbon monoxide gas (CO)-3.607, carbon dioxide gas (CO₂)-1548.156, nitrogen oxides gas (NO_x)-0.581, particulate matter of 10 aerodynamic diameters (PM₁₀)-0.086, particulate matter of 25 aerodynamic diameters (PM₂₅)-0.083.

⁹ Average city off-hour emissions per kilometer (g/km): reactive organic gases (ROG) – 0.081, total organic gases (TOG)-0.092, carbon monoxide gas (CO)-1.190, carbon dioxide gas (CO₂)-694.450, nitrogen gas (NO_x)-0.236, particulate matter of 10 aerodynamic diameters (PM₁₀)-0.030, particulate matter of 25 aerodynamic diameters (PM₂₅)-0.028.

supply chain must be a collaborative pool of small carriers and retailers, managed by an independent operator and ruled by a local administration. In fact, BESTUFS endorse that statement in criteria of success in UCCs *“Areas with a high incidence of independent small traders/ outlets who are not part of a regional/ national business with a dedicated and sophisticated supply chain and who are looking for a competitive edge”* (pp. 74. 2007), compiled at section 2.2.2.3. *Criteria for success and identified barriers in UCCs*¹⁰.

Another relevant point to add is the grade of willingness coming from retailers to accept OHD, as reported in the city of Manhattan with a sample of 263 contestants (Holguín Veras, J., et al., 2017). There exists remarkable outcomes where its fulfilment depends on the business typology, delivery times per week, one-time incentives and carrier discount. The results showed that the most willingness to participate would be other services –laundry, pharmacy and so on–, followed by accommodation, services and retailers, being between 1 and 15 delivers per week. Lastly, the optimal financial support experiments an increasing growth from 1000 to 4000 dollars as one-time incentives, followed by a substantial discount of a 20% on carrier services. In short, that points to study a financial support to retailers in form of incentives by adopting consolidation strategies.

b) Proposed action

Draw from the premise that retailers are suspicious on OHD policy, a sort of combined policy might underline a solid canal between carriers and retailers. Despite the fact that OHD policy affects considerable to retailers, measures must be steered to incentive their participation, rather than their disapproval within the supply chain.

This research presents a solution combining OHD policies together with the deployment of ULA terminals. These consolidation centres would store small packages at OHD, being those protected in a secured area –no matter whether a retailer is 24 hours operative or not–. Continuously, a third operator will haul those goods early at morning. In terms of efficiency, this third operator contains a fleet of e-bikes, smaller than light vehicles perfectly adapted to public spaces, concretely narrowed streets. This characteristic enables to shrink restrictions significantly, where time windows may be positively affected. In the end, the combination of OHD, ULA terminals and a third operator could reduce the total cost of a line hauling distribution. The outcome of that operation would generate savings to all stakeholders:

- 1) Carriers on operability cost by avoiding traffic jams, inaccessible streets and space competition.
- 2) Retailers in means of paying delivery services and staff to attend goods.
- 3) Residents, by preserving a better environment in public spaces.
- 4) Infrastructural optimization by deploying ULA terminals or smart lockers, instead of costly consolidation facilities such as UCC.

5.4.2. *Optimization of hauling service through horizontal collaboration*

This particular strategy calls to build a collaborative network among carriers, when the demand is that low that the unitary cost per package is lower than the hauling operational costs. By fortifying

¹⁰ Table 1. *Criteria for UCC's success and elements needed for Ciutat Vella model.*

the robustness of this strategy, there must be an exhaustive and a continuous feedback of planned routes at OHD, since actions must be taken at short notice. Thus, the horizontal collaboration strategy asks carriers to collaborate among them, first to maximize cost savings and second, to minimize resources to perform the service at off-hour distribution.

For instance, a carrier located at point A delivers goods to B, C and D during RHD weekly in Ciutat Vella, though it doubts to join ULA supply chain, and by that swapping to OHD shift. If distances are such small and, in a certain day of the week only delivers to B, it might be unfeasible to do the service during OHD, due extra costs. In that sense, that carrier may consider to stop thinking about joining ULA model and staying into an unwilling position.

On the contrary, if a carrier comes from out of the city and distances are considerable, goods would be hauled to its closest collaborator, always considering the shortest path towards ULA terminals. Technically, the operability may be simple, but nothing further from the truth. The horizontal participation must be optimal, whose efficiency is based on; 1) the relation between quantity of orders, 2) loading distances, 3) drop-off distances and 4) the size of collaborative pool of carriers (Cruijssen, F., Dullaert, W. & Joro, T., 2010). The purpose of that commitment not only tackles reducing inter-drop distances and empty mileage. In addition, that strategy seeks to create a connected and transparent network, so further studies could be done for giving rise to improvements on ULA supply chain.

There are some examples already happening at western countries such as Belgium and Netherlands, where nowadays at least 50 logistic partnership exist as stated by Cruijssen, F. et al (2007). That is the example of Flanders where road truck companies (RTC) are formed and do collaboration for avoiding empty last-mileage, where the operational costs are *“unacceptably low efficiency”* (pp. 161. 2010). What is more, that participatory process among carriers of different companies, help themselves in physical assets and knowledge to improve, sharpening their operational methodology in order to become more efficient (Gibson, et al., 2002).

a) Issues on the optimization of hauling service through horizontal collaboration

There is a difficulty on this strategy, which concerns the share contributions among those who collaborate (Verstrepen, et al. 2009). Another fact is that there must be a deep confidentiality and adaptive capacity to ICTs among carriers. If the objective is to create a workable collaborative network, avoiding operability setbacks translated to delays, etc., an independent ULA operator has to have the competences of scheduling line haul distribution towards urban terminals. However, according to Cruijssen, F., Dullaert, W. & Joro, T (2010), the more complex is the network, the less profitable and less confident carriers will be joining consolidation supply chain.

b) Proposed action

As a result, cost savings will be generated for those carriers in need of horizontal collaboration. However, in exchange some contributions are steered towards ULA model, also some indirectly benefits are given towards the operator who helped on this strategy. In order to distribute fair shares towards those collaborators –carriers– in Ciutat Vella, a compromise from carriers is necessary. That comes along to what it is said by Cruijssen, F., Dullaert, W. & Joro, T. (2010) at the research on Flemish road transportation. The survey created, it raised different hypothesis concerning small companies' acceptability of horizontal collaboration, among others. One of the hypothesis remarks that *“Larger*

companies cooperate more often than smaller ones” and “Less efficient companies value the opportunities for cooperating more highly than more efficient companies do” (pp. 174-175. 2010). The conclusions of the study do confirm that collaboration does not take place among smaller companies and that is due to the lack of time and budget to study the possibilities (Cruijsen, 2010).

In fact, those problems must be sort out to give room to the existence of collaboration. For this reason, the combination of OHD policy, the horizontal collaboration, deployment of consolidation facilities –ULA terminals– and the existence of a ULA manager, it assures that the capability of fleets will be operable. This strategy will trigger based on estimations; 1) when cost savings are negative individually to each carrier and 2) those are not compensatory, according to carriers’ optimized revenues scale. Then, is there any strategy that compensates carriers that collaborate? Indeed, those carriers that perform horizontal collaboration –mandatory by joining the supply chain– will experience some benefits, those depicted within the conceptual framework.

5.5. Dynamic Analysis Policymaking (DAP)

Through this research, consolidation concepts such as UCC and ULA have been studied to understand what particularities made fail some attempts worldwide. In addition to that, characteristics of the case of study and the overlay of strategies proposed to optimize the conventional line haul distribution at RHD, have been positioned to conform the Ciutat Vella model. **Even seeming puzzling and complex, this is just a process to give correspondent roles to stakeholders, and to give certain rights and duties to each of them. These facts call for applying methodologies where the necessities of all players must be identified to maintain them in the negotiating table, since are the ones who uphold the whole architecture of the consolidation model.**

Therefore, the model has to be adaptable to uncertain scenarios potentially harmful, which until now most of the cases shown, remain into static collaborative models. For instance, in SMILE project in Barcelona (Navarro, C., Roca-Riu, R., Furió, S. & Estrada, M., 2015), where there is not a contingency plan when, for example, retailers withdraw from the supply chain due to a lack of appealing engagement strategies established. Drawn from this premise, consolidation strategies call for a robust policy framework to assure a participatory project, but also for assessing the reactions of other relevant stakeholders, resulted from the conventional urban freight distribution transition to a –progressively– greener urban freight distribution.

That argument refers to Dynamic Adaptive Policy-Making method (DAP), which optimally matches to accomplish the objectives of Ciutat Vella model through tailored and adaptable policy-making. More precisely, it is defined as a scheme where uncertainty is treated, whose objective is to glimpse multiple near futures with adaptive and flexible policies, that tackles formulas of success for a project (Jittrapirom, P. et al. 2018; E. Walker, W. et al. 2001; Marchau, V., E. Walker, W., & van Wee, G., 2009). **DAP is structuralized by a set of elements wisely organized for ideas extraction, from the identification of the problem, passing to taken-action policies at time zero and after when some events trigger.**

Even so, before approaching on DAP theory, it has to be asked where and when UCCs may go wrong. As it has been already mentioned, the turning point is identified in the short-term. In the case of DAP Ciutat Vella modelling, a first approach gives an approximation of the core of the issue regarding freight urban distribution in public spaces.

Stage setting

Neighbourhoods of Ciutat Vella are overexposed by traffic congestions, mostly caused by freight transportation. That trend does not decrease; on the contrary, flows of freight transport are increasing as the demand of goods grow, caused by tourism and residents. That is why Barcelona City Council has already put in action some sustainable strategies in order to cutback those unsustainable dynamics.

On the other hand, carriers run stressfully to meet with the demand in Ciutat Vella, where the urban morphology characterizes by its narrowness and crowded streets and policies, struggles to meet with an adequate quality services to retailers. Moreover, municipality restricts their activity at regular hour distribution, when most of the people are at the streets, majorly tourist, since mostly tourist attractions remain in Ciutat Vella district.

The strategy proposed is to tackle last-mile distribution by deploying terminals at the surroundings of the district. Actually, SMILE project initiated a micro-distribution terminal or UCC as a pilot. Nonetheless, SMILE project detected some particularities within the business model itself. Those elements that made the project stagger, regards to unwilling and suspicious stakeholders, precisely retailers, whose benefit involving the pilot seems unclear. Consequently, without a minimum market share, there are not revenues and the whole structure of the UCC collapses.

This current situation affects to particular stakeholders with their complexities, which calls to operate at different realities at the same time. Thought, that relies much complexity onto the supply chain at the very beginning of the model. That is why, DAP reduces to the most basic idea narrowing down by depicting: definition of the objectives, definition of success, constraints and options sets (see figure 7).

The objective of this research tackles the financial issue that consolidation strategies fail at the launching phase. The important thing is to extract how to get there, in other words, have a clear definition of success based on the possibilities given by spotlighting the main constraints and the capabilities of Ciutat Vella scenario. In that respect, the basis of this model is that there is an exchange of interest between the municipality and carriers. The municipality facilitates the deployment of terminals at protected areas, whose characteristics correspond to ULAs as being much less costly for the administration. While, on the other hand, carriers put in practice those strategies compiled at '5.4. Operational strategies for Ciutat Vella model' –carrying goods towards ULA terminals at OHD and making horizontal collaborations when it is needed–. Besides, the third operator takes place into the negotiating table, since its fleet will have to delivering at RHD the day after. That basic structure at least, has to meet the first premise of definition of success, having to cover all financial cost and ease the operability of the last-mile distribution for the operators.

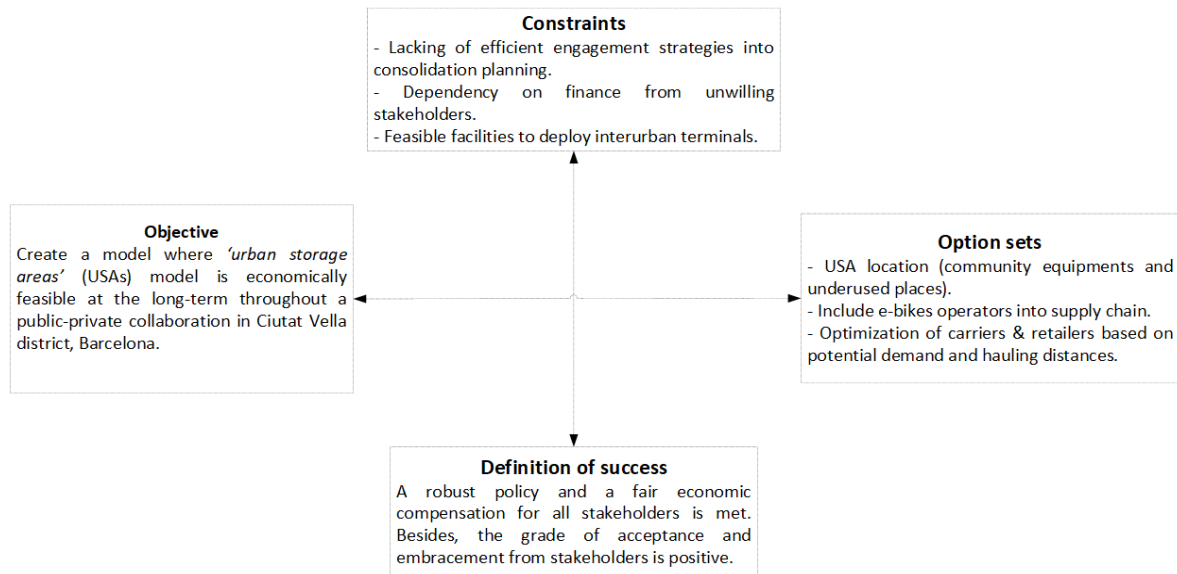


Figure. 7. Stage settings for consolidation strategies performance. Own creation based on “*Dynamic adaptive policymaking for implementing Mobility As a Service (MaaS)*”, (Jittirapirom, P., Marchau, V., van der Heijden, R. & Meurs, H., 2017).

These two issues concern UCCs’ performance, principally at the very beginning of the project, since there exist a lack of tailored policy framework that likely make business models fail. Beyond that aspect, external forces intervene within the disruption of completing consolidation concepts as palpable realities (see figure 8). For instance, competence of shared spaces for locating consolidation facilities, depending of the context, can end up to disagreements between the public administration and the owner of a plot, or disadvantage conditions for urban terminals –legal and institutional–. Another worrying scenario is; a) the lacking of participatory contributions that can financially supply the operability of a more sustainable supply chain, and b) the fierce competitors on the unitary cost per package at last-mileage. This idea links to the current context of a current territory administratively speaking, which may give prevalence or not to the budgeting destined to the project –political and cultural–. At last, the most unpredictable and contentious are clean energies, being e-bikes the most affordable but with less hauling capacity –practical and technological–. In short, as stated by E. Nordtømme, M., Kristin Y. Bjerkan, K. & B. Sund, A. ‘*objectives of the UCC, physical and locational terms, financial issues, the nature of the service and political and administrative support*’ (pp. 181, 2015), are the main concerns that the DAP ought to include in its framework.

These externalities, even though are highly difficult to predict, it helps to indicate key actors and their concerns. Following the structure of DAP framework (see figure 9), both elements are connected to conform appealing policies. In that case, the motivation falls into the worrying issue of engaging operators within the supply chain, being the basic policies focused on achieving that.

On the background, thanks to stability with the operators, less emission of pollutants and collaborative networks could remain in the long-term basis. Furthermore, figure 9 shows that DAP framework goes beyond identifying and classifying relevant aspects from key stakeholders. Once the stage setting is configured, further steps are essential for assembling an adaptive and mouldable system for further enhancements (E. Walker, W. & A.W.J. Marchau, V., 2009).

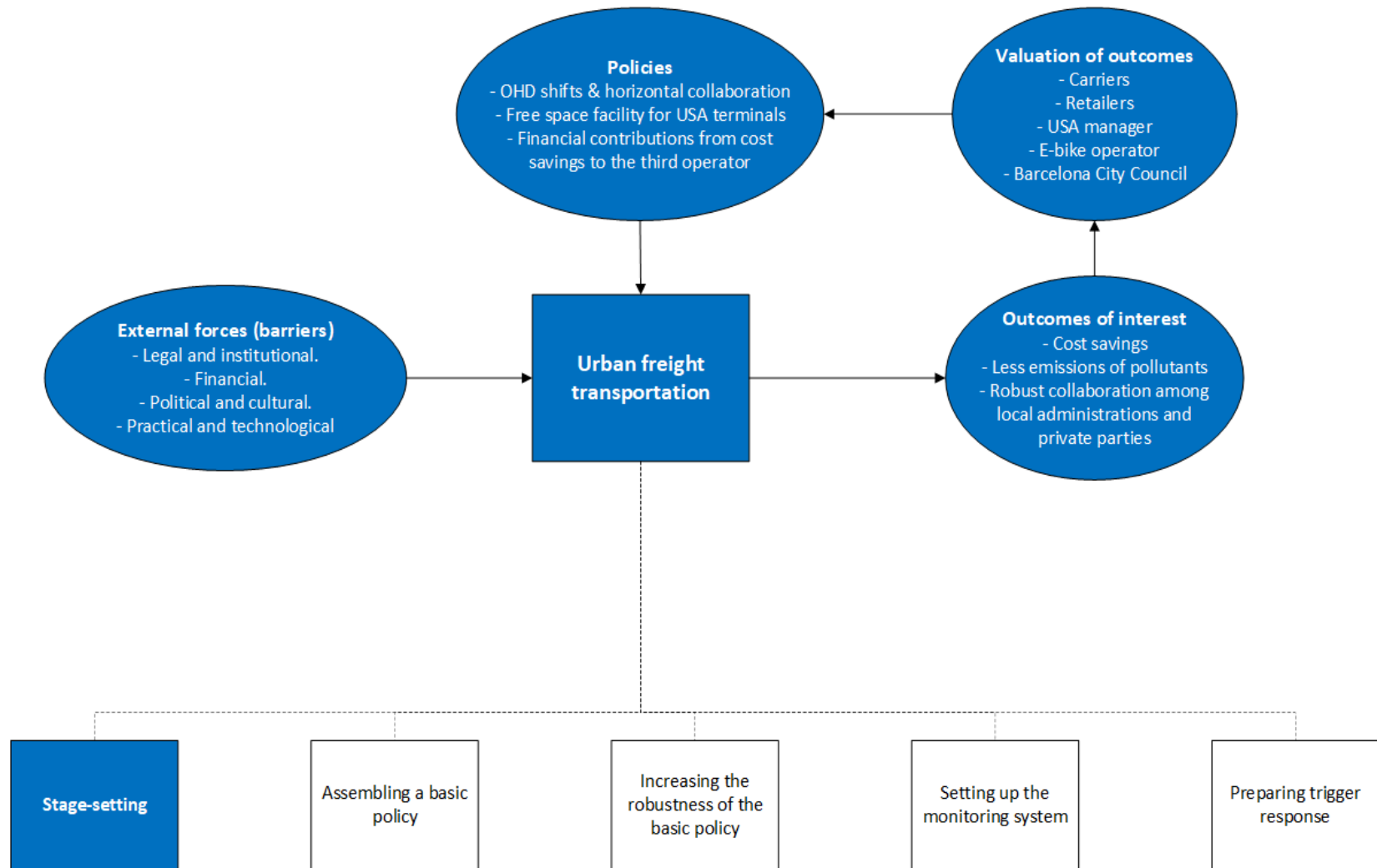


Figure. 8. Overview of UCC's DAP Ciutat Vella model. Own creation based on *"Dynamic adaptive policymaking for the sustainable city: The case of automated taxis"*. (E. Walker, W. & A.W.J. Marchau, V., 2017).

Those are the following ones: 1) Assembling basic policy, 2) Increasing the robustness of the basic policy, 3) Setting up the monitoring system and 4) Preparing trigger responses scheme where the model is into a constant assessment.

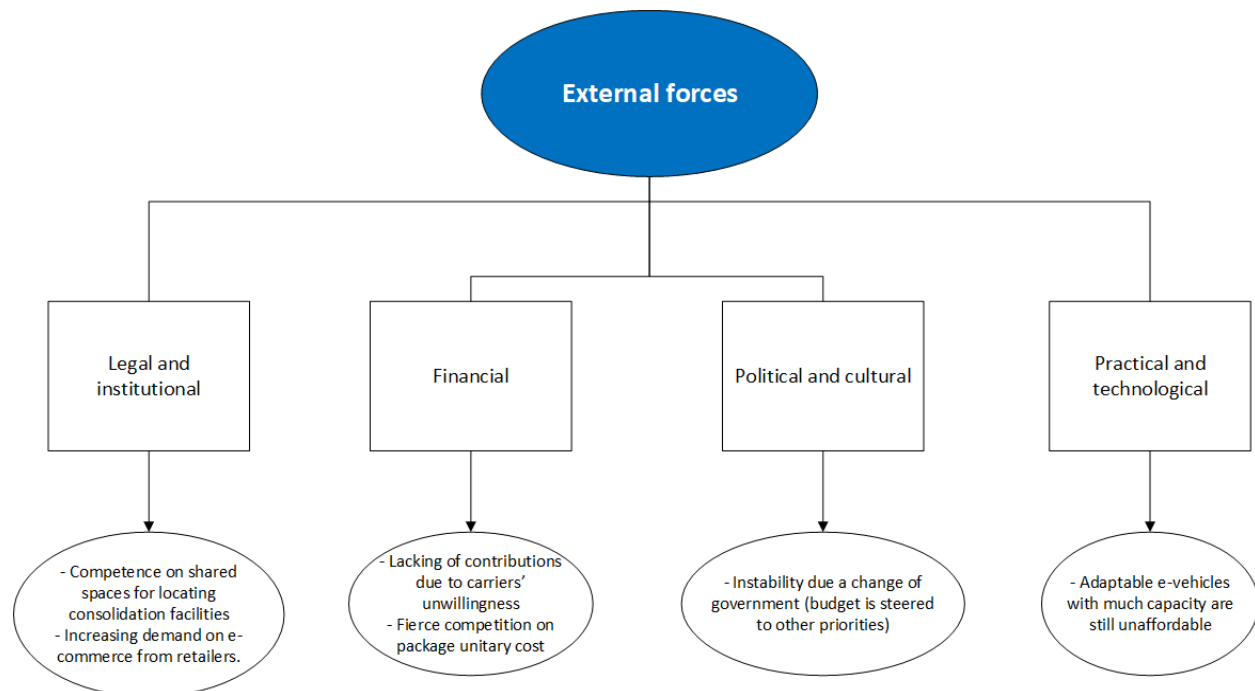


Figure. 9. Overview of external forces in the UCC's DAP model for Ciutat Vella. Own creation based on *"Barriers to urban freight policy implementation: The case of urban consolidation center in Oslo"*. (E. Nordtømme, M., Kristin Y. Bjerkan, K. & B. Sund.

These bottlenecks are unpredictable, that is why DAP contemplates sort of strategies thought to mitigate, defence and react against such effects. These strategies intervene as direct actions in form of basic policy (see table 3). These policies are compiled as follows:

Table 3. Selection of basic policy measures to implement ULA framework.

<u>Planning and policy</u> ➤ Develop <u>inclusive policies on land use</u> for sustainable freight urban distribution adaptability. ➤ Enable physical infrastructure that can ensure efficiency and security goods. In that sense, <u>a suitable geographical location for the terminal is essential to meet with the maximum market share, shorting distances travelled in the last-mile distribution</u>. That together with a close monitoring onto small terminals distributed in Ciutat Vella, would make retailers less suspicious on new consolidation strategies.
<u>Governance and regulation</u> ➤ Make available the role of ULA manager as a transport planner: controlling unloading/loading –carriers and eco-friendly operators–, time windows –retailers' expectation–.

- ULA manager must have a close relation with the whole supply chain –municipality, retailers and carriers–. Above all, updated reports directed to municipality, being that last the evaluator of the whole system, and the policy-maker as the facilitator of adaptive policies that satisfy all the stakeholders.

Private-Public partnership on cost sharing contribution

- A strong linkage has to be conformed among all the stakeholders at the supply chain. For that commitment, municipality has to compromise to accomplish and assess rights/duties for all counterparts.
- Rights consist on assuring costs savings for carriers that join ULAs supply chain. On the other hand, duties regard contributions that have to be steered to municipality, whose commitment will be to redistribute these shares to finance the third eco-friendly operator in the launching phase.
- Moreover, stakeholders have to be willing to collaborate in order to fulfil in their own outcome of interest for the short and long term. That means that, carriers compromise to swap from RHD to OHD shifts and being able to do horizontal collaboration when is necessary.

In order to have a better response to uncertain scenarios, adaptive actions and trigger responses are raised, to receive feedback and to reformulate policies. As stated by Jittrapirom, P., Meurs, H., van der Heijden. & Marchau, V. *"This scheme enables policymakers to deal with the uncertainties surrounding the policy formulation process right away, instead of waiting for information to become available"* (pp. 7.2018). For such accuracy, the DAP concept shows at *II. Assembling basic policy* (pp. 7.2018), which compiles the basic policy formulated and it specify the promising policy –necessary conditions for success– and terms and conditions –policy actions– for developing a solid plan (E. Walker, W. & A.W.J. Marchau, V., 2009). Thirdly, *III. Increasing the robustness of the basic policy* (pp. 7.2018) filters the policies by spotlighting their vulnerabilities, classifying certain and uncertain vulnerabilities in a near future. Thus, mitigation actions –actions taken in advance at time = 0– and hedging actions –actions taken in advance for uncertain effects of a policy at time = 0–. As a fact, these actions would trigger when some parameters reach red lines, known as *IV. Setting up the monitoring system* (pp. 7.2018). Indeed, signposts monitor those interventions during UCC or ULA performance. Last but not least, *V. Preparing the trigger responses* (pp. 7.2018), which manages to deal with defensive, corrective and reassessment responds when the basic filtered policy is altered and the triggers are activated, so the benefits of the policy are unaffected or meet with some adjustments due some challenges (E. Walker, W. & A.W.J. Marchau, V., 2009).

Hence, these set of strict policy measures may be unpopular for some actors. Nonetheless, those could conform their robustness, if the level of applicability remains acceptable for unwilling players at the first place. What is more, stakeholders, under the condition that policies are open to future reformulation, might embrace the acknowledgement of these policies. What represents table 4 is the DAP framework for Ciutat Vella district, whose policies are depicted precisely by distinguishing their vulnerabilities and opportunities, certainties and uncertainties, actions taken at time zero, their control and the actions taken as a response of some events. Ultimately, substantial and continuous exchange of commitments among players to keep running the first phase of ULA as a business model.

Table 4. Potential dynamic adaptive policies (DAP) to launch ULA supply chain. Better practices in urban logistics for Ciutat Vella district, Barcelona (I).

Conditions of success	Vulnerability (V) Opportunity (O)	Certain Uncertain	Actions are taken at time = 0 (Increase Basic Policy Robustness)	Signpost monitoring (begins at time = 0) and trigger events	Actions taken at time > 0 (Adaptive actions)
a) Free space location for ULA terminals at parking facilities.	O Erase the implementation of ULA terminals needed by reducing final cost.	Certain	SH: Terminals' location at parking facilities, sharing the space with other functionalities (parking lot of commuters). M: Public parking are potential. Smart lockers mean less infrastructural cost and easily deployment, less dependence on	Monitor: Optimization of terminals needed at certain locations. Trigger: Demand increases/reduces on ULA supply chain above/below terminal capacity.	DA: Capacity of terminals and daily activity are under day-to-day assessment. CA: Optimize the number of lockers needed based on feedback.
	O Reduce traffic congestions. OHD meets with time windows and it is appealing for carriers because of operational cost savings.	Certain	SH: OHD distributes from 7 pm to 6 am, when off-peak hours of traffic congestion. SA: There is a specific control on hauling distribution to ULA at OHD. ULA manager playing the role as transport planner.	Monitor: Emissions and cost savings estimation to plan efficient routes towards terminals. Trigger: At least 20% of designed routes are unbeneficial for carriers and ULA.	DA: Optimize number of carriers on the supply chain. CA: Reshape criterion for carriers joining ULA based on demand and number of terminals deployed in Ciutat Vella.
b) OHD distribution to ULA & horizontal collaboration approach.	V Overlaps with other carriers might extend unloading activity time.	Certain	M: Schedule inflows to terminals in order to reduce wait times to 0.	Monitor: Optimal number of carriers according to terminals' capacity. Trigger: At least a 10% of carriers overlap when unloading at terminals.	DA: Determine timeslot of hauling distribution services appealing to carriers. CA: Reschedule inflows on ULAs when overlapping with other carriers.
	V Carriers that handle few routes within Ciutat Vella would result economic losses on their cost savings.	Certain	M: Creating a horizontal collaboration network among carriers that join ULA's supply chain.	Monitor: Optimization of hauling line distribution at OHD. Trigger: When cost savings register as unbeneficial for a carrier.	DA: Make a robust communicative canal between carriers and ULA manager. CA: ULA manager performs alternative routes based on share hauling distribution.

Note: (O): Opportunities; (V): Vulnerabilities; (SH): Shaping action; (M): Mitigation action; (SZ): Seizing action; (CA): Corrective action; (DA): Defensive action; (R): Reassessment.

Table 4. Potential dynamic adaptive policies (DAP) to launch ULA supply chain. Better practices in urban logistics for Ciutat Vella district, Barcelona (II).

Conditions of success	Vulnerability (V) Opportunity (O)	Certain Uncertain	Actions are taken at time = 0 (Increase Basic Policy Robustness)	Signpost monitoring (begins at time = 0) and trigger events	Actions taken at time > 0 (Adaptive actions)
c) Cost sharing contribution	V Competitors of smart lockers (ULA) might compete on pricing for small packages delivering.	Uncertain	H: Freight distribution of small packages through smart lockers for business, is municipality competence.	Monitor: Small packages for business have to be stored within ULAs managed by the public administration. Trigger: A relevant number of carriers unjoin the supply chain due excessive pressures from potential competitors.	CA: Municipality enables developers to deploy a controlled number of smart lockers (for business). However, developers have to join ULA supply chain as collaborators, contributing as financial support.
	O Another influx for maintaining ULA system based on cost savings (time/distance) is met. Besides, those carriers willing to join ULA supply chain might contribute by expanding their market share due common interests.	Uncertain	SH: Carriers' contribution model is designed according to: distances hauled, number of retailers to be supplied and grade of horizontal collaboration approach at OHD.	Monitor: Fair share contribution from carriers towards ULA terminals. Trigger: A 10% of carriers unjoin ULA supply chain due excessive mandatory contributions.	DA: Design appealing grades of contribution in accordance to carriers' expectation. CA: Reshape the original policy by keeping out more cost savings to carriers.
d) Retailers horizontal collaboration network	O An optimal number of retailers is set per terminal. Being ULA appealing for new retailers, there exist some restrictions for new adopters regarding their degree of isolation. For instances, how this new adopter is at close distances to potential adopters and retailers already joining the supply chain.	Certain	M: Experiences from ULA's retailer members are part of the campaign to engage potential retailers. SH: Model optimal conditions to enable the maximum of retailers joining supply chain. That ensures a solid and optimized structure with relevant stakeholders, thus cost savings on e-bike hauling distances.	Monitor: Acceptance of conditions from retailers and grade of collaboration among them, by relating positive experiences of the model. Trigger: Grade of collaboration within ULA is low.	DA: Create a solid network of collaborators and conversation tables. CA: Redesign optimal conditions for joining ULA. Besides, compile feedbacks and try to adapt them into the chain.

Note: (O): Opportunities; (V): Vulnerabilities; (SH): Shaping action; (M): Mitigation action; (SZ): Seizing action; (CA): Corrective action; (DA): Defensive action; (R): Reassessment.

Table 4. Potential dynamic adaptive policies (DAP) to launch ULA supply chain. Better practices in urban logistics for Ciutat Vella district, Barcelona (III).

Conditions of success	Vulnerability (V) Opportunity (O)	Certain Uncertain	Actions are taken at time = 0 (Increase Basic Policy Robustness)	Signpost monitoring (begins at time = 0) and trigger events	Actions taken at time > 0 (Adaptive actions)
e) Restriction on non-collaborative carriers that haul small packages on RHD	O	Uncertain	SH: Limiting unloading/loading plots to those carriers hauling small packages. Restrictions on timing when parking at RHD. SZ: Inform carriers about ULA system. Engagement strategies take place to transfer stakeholders from the conventional system to ULA system.	Monitor: Carriers' feedback on parking policies. Trigger: ULA solution interests drop below, likely unconformities from restrictions on parking policies.	DA: Develop a solid campaign and gain support from politics sphere. CA: Reformulate policies making them softer.
	V	Certain	SH: Share information about their market share area (carriers) and suppliers (retailers), in exchange letting them to join ULA supply chain.	Monitor: Grade level of acceptance about rights and conditions. Trigger: Potential shared demand is below than agents attracted to ULA.	DA: Explain accurately positive outcomes, issues and solid trigger responses to diminish setbacks. CA: Defuse sharing information condition as mandatory for joining ULA.
	O	Uncertain	M: Consolidation strategies need to be endorsed by academia and public administration. Therefore, small events are needed, where potential stakeholders (carriers and retailers) give relevance of ULA supply chain to all players invited	Monitor: Measure level of convincement and the effectiveness on these tailored meetings for unwilling actors. Trigger: A significant number of stakeholders are unconvinced on seeing ULA fruitful and trustworthy for them.	RE: Reassess engagement strategies and actions raised until now.
f) Zone congestion charge in Ciutat Vella	O	Uncertain	SH: This policy is made for all those carriers hauling small, medium and heavy packages whilst not joining ULA structure. M: Zoning charge mostly affects to those carriers whose loading is below 50% of total capacity, when entering at certain zones.	Monitor: Level of integration of new adopters of ULA from this policy. Trigger: When estimations point that demand exceeds terminals' capacity.	DA: This charge is applicable when peak hours happen during workdays at RHD. CA: Zoning charge is reduced based on the relation ULA's increasing members and conventional freight transportation.
	V	Certain	SH: Reduction on zoning charges in exchange of setting GPS devices and sharing vehicle technical information.	Monitor: Grade of acceptance and accurate reports from carriers' decision. Trigger: Either participation is too low or too high.	DA: Protocol on data security for carriers and showing benefits in the long-term as part of ULA supply chain. CA: Adjust zoning charge.

Note: (O): Opportunities; (V): Vulnerabilities; (SH): Shaping action; (M): Mitigation action; (SZ): Seizing action; (CA): Corrective action; (DA): Defensive action; (R): Reassessment.

5.6. Conceptual framework

Hereby, DAP framework may serve as a policy-making tool along the transition process towards sustainable urban logistical practices. Even that, the sense of the ULA supply chain relies on the role model of those particular players that put in motion a collaboration network. That is why, it is necessary to make an overview of how Ciutat Vella model works in the launching phase. The conceptual framework (see figure 10) is based on the original model of Estrada, M. & Roca-Riu, M. (pp. 167. 2017). As a matter of fact, the economic, the physical and the regulatory layers, classify all relevant players at their domain, according to their role within the model.

Looking into the physical layer, the ULA manager is positioned in the centre as the one who controls and ease all inbound and outbound operability. In that way, carriers may be satisfy because its responsibility just relies on hauling goods to the terminal at OHD, being hauled afterwards by the third operator at RHD. As it is seen at figure 10, that gives positive outcomes that likely cover the necessities of all direct participatory players, but also to those who indirectly participate or share the urban space. In that sense, cost savings are generated for carriers, which at the same time benefits the third operator by enabling it to take part of the last-mile distribution as a key operator. By giving that share, quality service is likely to grow greatly, since delays may significantly reduce as being close to retailers and having a large bike lanes network. Besides, spill over effects have the potential emitting zero emission of pollutants at RHD and provoking much less space invasion for Ciutat Vella's residents.

The economical layer is essential because it maintains the model in motion. Seeing that consolidation strategies are not feasible by standalone players, neither the operators nor the public administration, this research have pointed to an interrelation of dependency. Looking to carriers domain at this layer, fair contributions are part of their duties, which come from the cost savings generated thanks to hauling towards ULA terminals at OHD and doing horizontal collaboration when needed. Indirectly effects, perhaps, have to make with the reduction of transport costs in benefit of the retailers that form part of Ciutat Vella model, however, studies ought to be made to assess the pay-offs of such model. On the other hand, the municipality as the space facilitator of consolidation facilities, it also share the responsibility by financing the ULA manager and the many terminals as needed. Hence, in terms of budgeting costs and being the first phase of the model, costs are thought to be minimum, so in that respect ULAs or smart lockers seem the most adequate infrastructure.

Finally, the regulatory domain corresponds to administrations and consultancies, whose policy is thought to endorse carriers' conditions as being the main investor of the third operator, being the last-mile distributor in RHD. That commitment would not be possible without the strong compromise of the physical layer, being carriers willing to report routing data to the ULA manager, whereby it is facilitated to the municipality. The logic of this strategy is to pull carriers to trust in the model, as the administration support their role by optimizing their services and generating cost saving for them. The more adequate policies are applicable for carriers' performance, the more cost savings are generated, the more data is received and the more contributions are steered towards the third operator. In the end, the model configures a circle of interdependencies and trust among public and private players, forming a solid collaboration network that makes a step into more sustainable and efficient space.

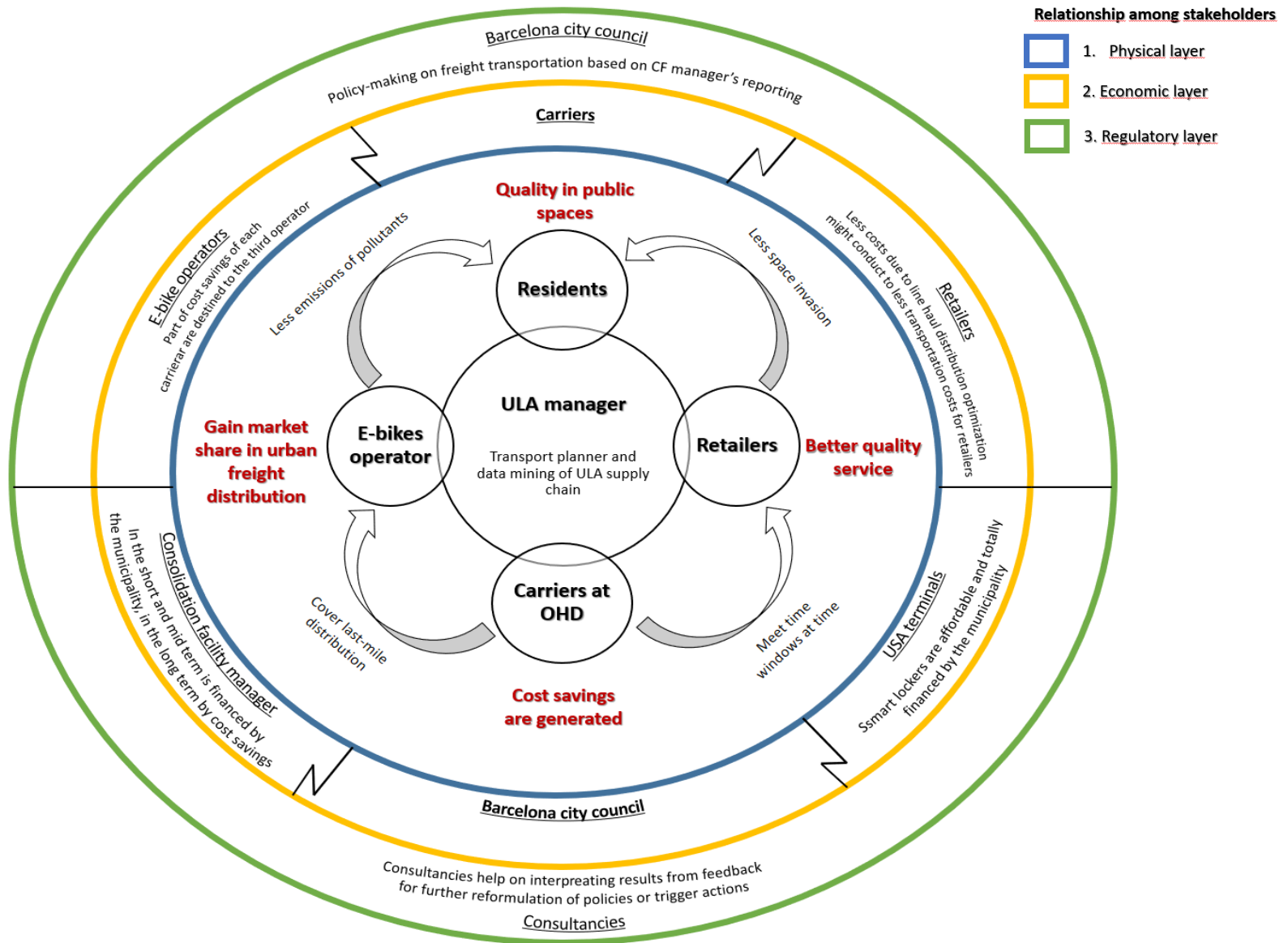


Figure 10. Conceptual framework of Ciutat Vella model, based on 'Stakeholder's profitability of carrier-led consolidation strategies in urban goods distribution' (Estrada, M & Roca-Riu, M.pp. 167. 2017).

CHAPTER 6. METHODOLOGY

Hereby, the methodology used along the research consists in a theoretical or qualitative approach – first part– and a practical or quantitative approach –second part–. The first part corresponds to the literature extraction of urban development strategies and cases of study regarding urban logistics (see chapter 5. *Conceptual framework. Urban logistics solutions & DAP framework for Ciutat Vella district*). That have been necessary to configure a solid base to start thinking about sustainable practice in the last-mile distribution. Thereupon, that have generated the Ciutat Vella business model, based on the DAP and the conceptual framework.

Instead, the second part have focused on testing those measures through GIS analysis, using geospatial tools to assess the hypothesis established of this research. Those geospatial tools have configured: 1) ULAs' optimal locations and their characteristics, corresponding to Oriented Development approaches, and 2) the freight transportation network through consolidation facilities at last-mileage (see Figure 11).

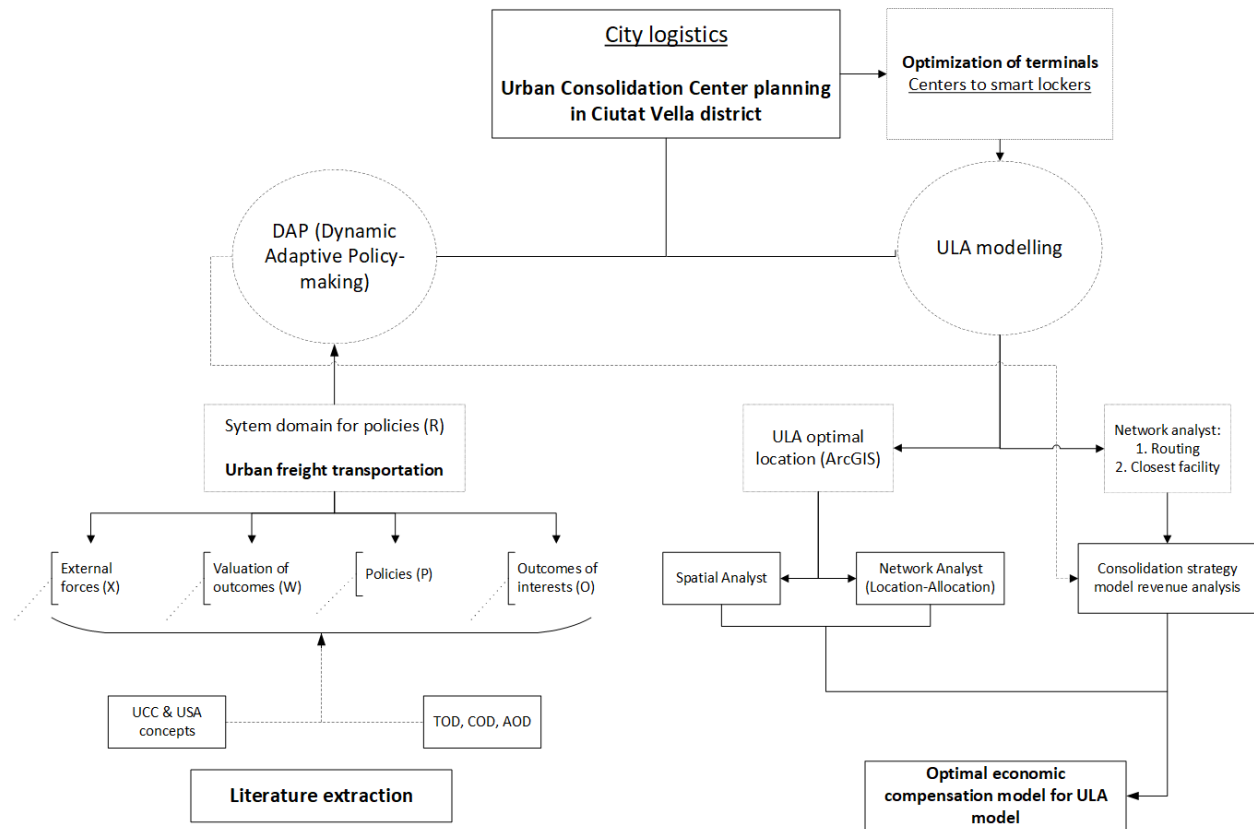


Figure. 11. Own design representing the methodology process used for this research.

In fact, the scheme differentiates both approaches –theoretical at the left side and practical at the right side–, as the two research sub-questions correspond to each of them. What refers to the theoretical approach –or literature extraction–, may answer the following one:

1. *What are those potential engagement strategies to be raised and for whom those might be steered?*

The second sub-question regards the outcomes of such business model in a hypothetical scenario in Ciutat Vella district –practical approach or GIS analysis–, shall answer the following question:

2. *To what extend ULA model improves the conventional freight distribution in Ciutat Vella, in terms of operational efficiency, environmental standards and cost optimization?*

Hence, in order to make the comparative analysis between independent deliveries and collaboration through ULA terminals, the environment has to be constructed beforehand. That implies to go through a data mining process from different sources such as; CartoBCN, statistics from INE (National Statistic Institute) and Barcelona City Council and lastly, surveys made to carriers and retailers provided by CENIT –see CENIT surveys reference at '10.2. Database' section–from the SMILE pilot (see figure 12). These data serves to:

- 1) Find suitable locations for ULA terminals through Spatial Analyst toolbox (Kopp, S., et al., 2001), in ArcGIS 10.5.
- 2) Estimate a potential demand for each retailer surveyed.
- 3) Determine the market share of each terminal by linking them to retailers.
- 4) Build up the environment of road networks for LDV and cars at independent deliveries and collaboration through ULA facilities and also for e-bikes modelling.

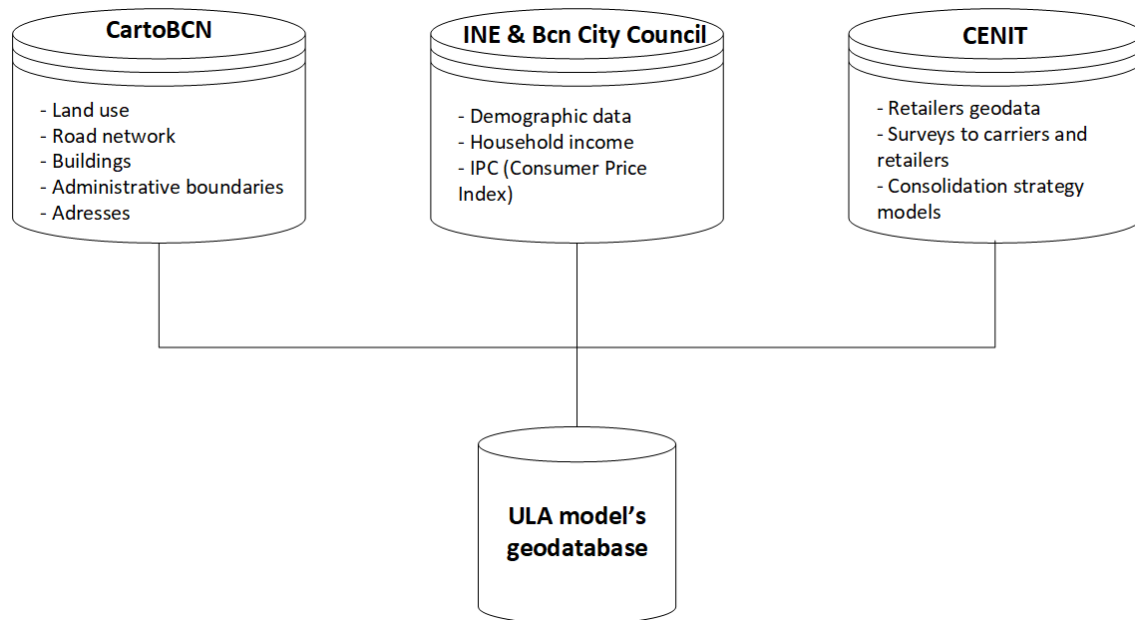


Figure. 12. Own design. Representation of sources used on GIS analysis.

In all, this process helps to answer the main question, whereby it assesses the impact of Ciutat Vella model into the hypothetical scenario:

1. *To what extent Ciutat Vella's business model, could be appealing to engage and to keep on board those operators in the last-mile distribution?*

Once the outcomes and insights are raised, further recommendations will be depicted as a follow up of the model set, being the carrier's role as the facilitator of a transition to more sustainable practices in urban logistics. It is true that by including the DAP framework, the model developed in this research could fit better being a simulation, where the basic policy would be reformulated as the analysis get responses from stakeholders. Nonetheless, this effort have served to spotlight likely measures that may attract those stakeholders involved in the last-mileage.

Although tailored policies to engage relevant stakeholders are still missing in ULA performance, the robustness of Ciutat Vella model relies on the financing compromises from operators. Indeed, the model of this research characterizes by being static and not dynamic, since the focus is on designing tailored conditions for carriers. As an overview, figure 13 shows a representative scheme of the appearance of Ciutat Vella model.

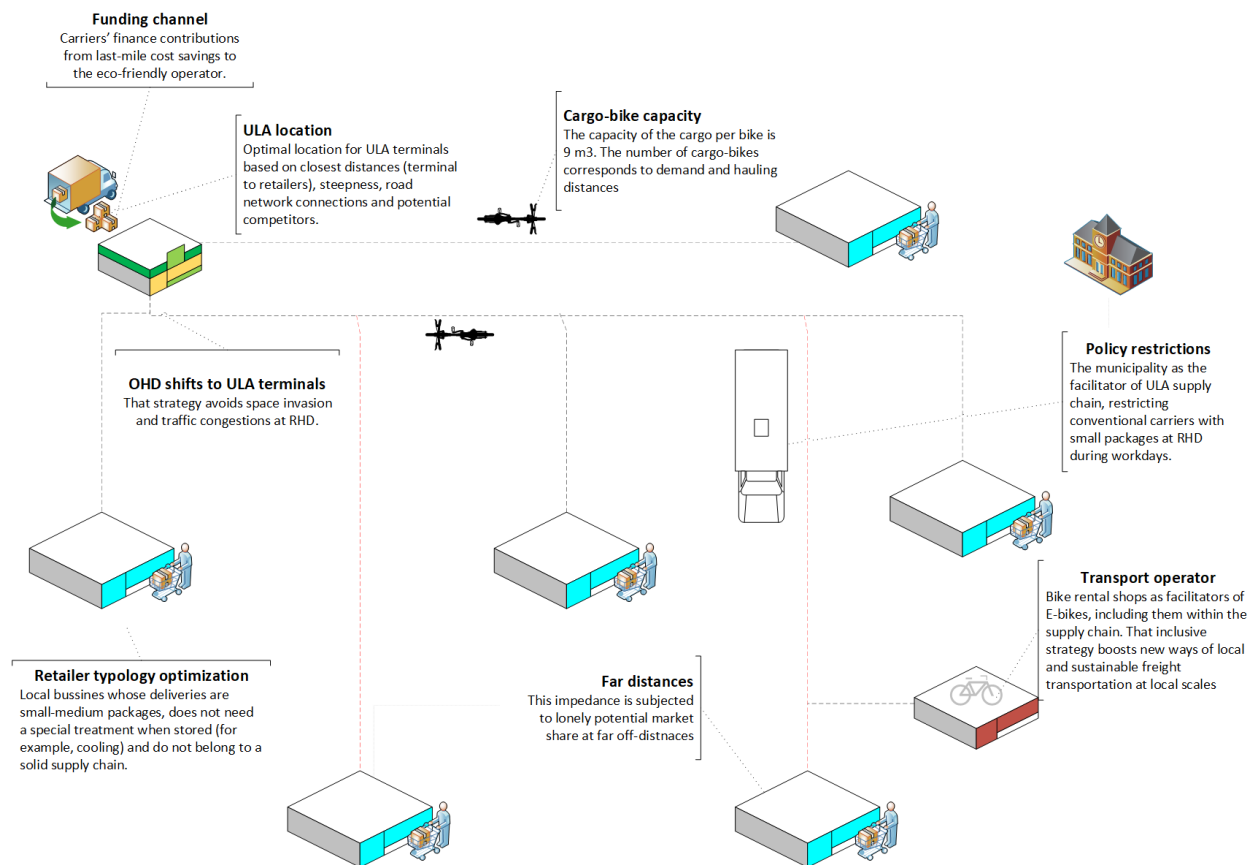


Figure. 13. Overview of UCC & ULA supply chain network and policies included within the model. Own design through Visio, strategies extracted from literature review.

CHAPTER 7. OPTIMAL LOCATION OF ULA TERMINALS AND DISTRIBUTION OF MARKET SHARE IN CIUTAT VELLA

The DAP model and the business model give rise to different stakeholders' roles that operate within the supply chain. Nevertheless, before going deep into the comparative strategic analysis, it is necessary to find optimal locations for a certain number of ULA terminals in Ciutat Vella district. Such locations are based on socio-economic and environment elements, where the effectiveness of the model may rely on distances, competitiveness and efficient hauling infrastructures –bike lanes and so on–. In all, this chapter intends to deploy the proxies that connect the demand and carriers –both players' patterns extracted from CENIT's survey–. Continuously make a comparative analysis of independent deliveries and collaboration through ULA terminals in Ciutat Vella district, which is depicted at "*Chapter 8. ULA freight distribution analysis*".

7.1. Optimal location for ULA terminals in Ciutat Vella

Thereby, the following elements for locating ULA terminals have been considered for Ciutat Vella district: nearby retailers, far from potential competitors, less of 3% steepness, community facilities & underuse and close to main roads.

Before explaining the spatial analyst process made through GIS tools, it is important to explain the main element that configures the quality of ULA performance. It is a fact that a huge number of business surrounds Ciutat Vella district and retailers. However, the scenario established just consider those retailers whose demand are small packages and those goods that do not need any maintenance when stored.

Code	Type of shops	Number of shops	Percentage
1	Bar / Restaurants/ Hotel	848	27,66
2	Fresh	68	2,22
3	Retailers	141	4,60
4	Supermarkets	83	2,71
5	Clothes/Complements	556	18,13
6	Shoe shops	99	3,23
7	Pharmacies	46	1,50
8	Hardware	18	0,59
9	Department store	5	0,16
10	Kiosc	21	0,68
11	Bookstore	31	1,01
12	Souvenir shops	147	4,79
13	Telecom shops	22	0,72
14	Post offices	13	0,42
99	Others	558	18,20
16	Watertight	36	1,17
17	Appliances	17	0,55
18	Jewellery shops	117	3,82
19	Bakeries	49	1,60
20	Hairdressers	64	2,09
21	Optics	20	0,65
22	Bank	44	1,44
23	Bike rental shop	22	0,72
24	Cosmetics	30	0,98
25	Tattoo shops	11	0,36
		3066	100,00

Table 5. Business in Ciutat Vella. Facilitated by Miquel Estrada Romeu

That fact helps to optimize the area covered for ULA supply chain and it avoids cost overruns. Thanks to the data provided by my supervisor of my internship at CARNET, Miquel Estrada Romeu – Doctorate in civil engineering–, the analysis have been realized. Table 5 shows the total number of

shops by typology in Ciutat Vella district. On the other hand, table 6 shows the sample extracted from the surveys that were made to retailers. As it is seen, the sample used for the analysis just represents a 4.77 % of shops out of 3066. Among them, there have been selected those that do correspond to small businesses, which are collected in '10.1. Database' section, typology of retailers (CENIT, 2011).

Code	Business typology	Percentage Ciutat Vella	Number	Percentage typology	Percentage sample
1	Hotels	0,16	4	0,47	3,36
3	Retailers	0,16	4	2,84	3,36
5	Clothes/Complements	1,68	42	7,55	35,29
7	Pharmacies	0,08	2	4,35	1,68
10	Kiosk	0,08	2	9,52	1,68
11	Bookstors	0,24	6	19,35	5,04
12	Souvenirs shops	0,32	8	5,44	6,72
13	Telecom shops	0,08	2	9,09	1,68
20	Hairdressing	0,04	1	1,56	0,84
24	Cosmetics	0,20	5	16,67	4,20
99	Others	1,72	43	7,71	36,13
		4,77	119		

Table 6. Sample used in Ciutat Vella scenario. Extracted from CENIT's surveys.

A total of 177 business were surveyed (see drivers surveyed reference at '10.1. Database' section), but just 119 were selected for this analysis (see retailers table reference at '10.1. Database' section). A data processing is performed, excluding those that are part of a chain store and those that corresponds to food & beverages, since there is specific maintenance for such products. After this, those retailers were processed –cleaning data phase¹¹– and geo-located into ArcGIS, prepared to be included within the spatial analyst phase. During this process, several sources were consulted and adapted to the same coordinate system ETRS 1989 UTM Zone 31 N (see table 7).

Layer	Description	Source
Slope	A certain number of terminals must be located at less of 3% of steepness – for e-bikes–.	ICGC (Institut cartogràfic i geològic de Catalunya), Vissir v3.26, Models d'elevacions 2x2 (DEM)
Land use	Community facilities or parking are required by policy –a) free space location for ULA terminals at parking facilities.	CartoBCN –open source–, ETRS89, Usos del sòl en format CAD/SHP/KMZ.
Retailers surveyed	ULA terminals must remain close to potential demand.	Surveys to retailers created by CENIT and provided by Miquel Estrada Romeu.
Potential competitors	Smart lockers for individual users could be potential competitors in a near future, thus far distances must be kept.	Extracted from Google Maps.
Road network	ULA terminals must keep close to primary, secondary and tertiary order.	CartoBCN –open source–.

Table 7. Database used to find optimal ULA terminal locations.

The extension used in ArcGIS 10.5 is Spatial Analyst, whose functionality, according to ESRI is to “*build complex site location analysis model as well as those users who are interested in conducting terrain and visibility modelling or who want to perform density mapping, overlay, distance analysis, or*

¹¹ Most of the addresses corresponding to businesses were misspelled or the GIS did not recognize them, so there were setbacks when trying to find UTM references.

interpolation“(pp. 2. 2016). Besides, it enables to find suitable locations for facilities of any kind, in that case urban terminals. In this model, basic tools are used to find suitable locations; Euclidian distances, Reclassify, Overlay, Conditional and Majority Filter (see figure 13).

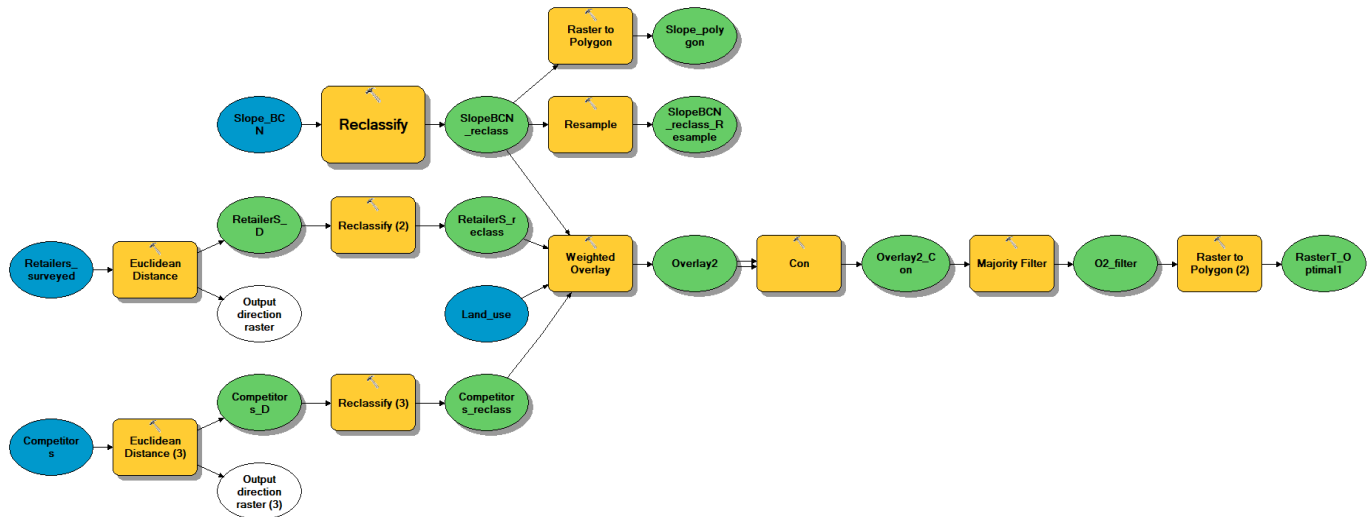


Figure. 14. Overview of ULA terminals' suitable location process. Scheme made through model builder, ArcGIS.

Looking at figure 14 it can be seen the process of configuring a weighted overlay of the layers, where the best results of the criterion merge into a single feature. Firstly, Euclidian distances were estimated in the case of the retailers surveyed and the potential competitors, creating buffer ranges of 1250 meters each¹².

Thereupon, a reclassification of the values from one to nine –being highest the best value and smallest the worst– were applied to retailers surveyed, competitors and slope. In the case of the retailers, worst values starting from 0 remained in a sequenced ordered, being 3 the best. On the contrary, further distances from competitors are captured, since it is thought to tackle the maximum market share in optimal conditions in Ciutat Vella district, thus the values are reversed, being the third buffer as the most suitable. This sequence repeats also in the case of the steepness, where values from 1% to 3% are the most adequate appreciating the characteristics of these sort of facilities. However, the relevance of this variable stays low, being Barcelona a coastal city –above all Ciutat Vella district–, but surrounded by an abrupt change on its terrain; Collserola mountains –orientated at the northwest– and Montjuic –facing southeast–. An overview of these processes are appreciated at figure 15 (see [spatial analyst](#) reference at '10.2. Geodatabase' section for better resolution).

Finally, these three last layers and the land use configure the overlay by giving a specific influence to all of them (see table 9), highly considering retailers and land use. Therefore, in some of the layers the reclassified values are restricted to simplify the outcomes of the overlay. Besides, land use values are restricted and ordered in table 8. The overlay layer (see figure 16) come together to form plausible range of solutions. As a fact, those areas with a value of six are the most suitable locations, excluding zero as being non-convenient on the solution. Consequently, the map seems dull, which impedes to come with a clear conclusion of the possibilities to locate the ULA terminals.

¹² This distance was estimated base on approximately 15 minutes spent by cycling through Google Maps.

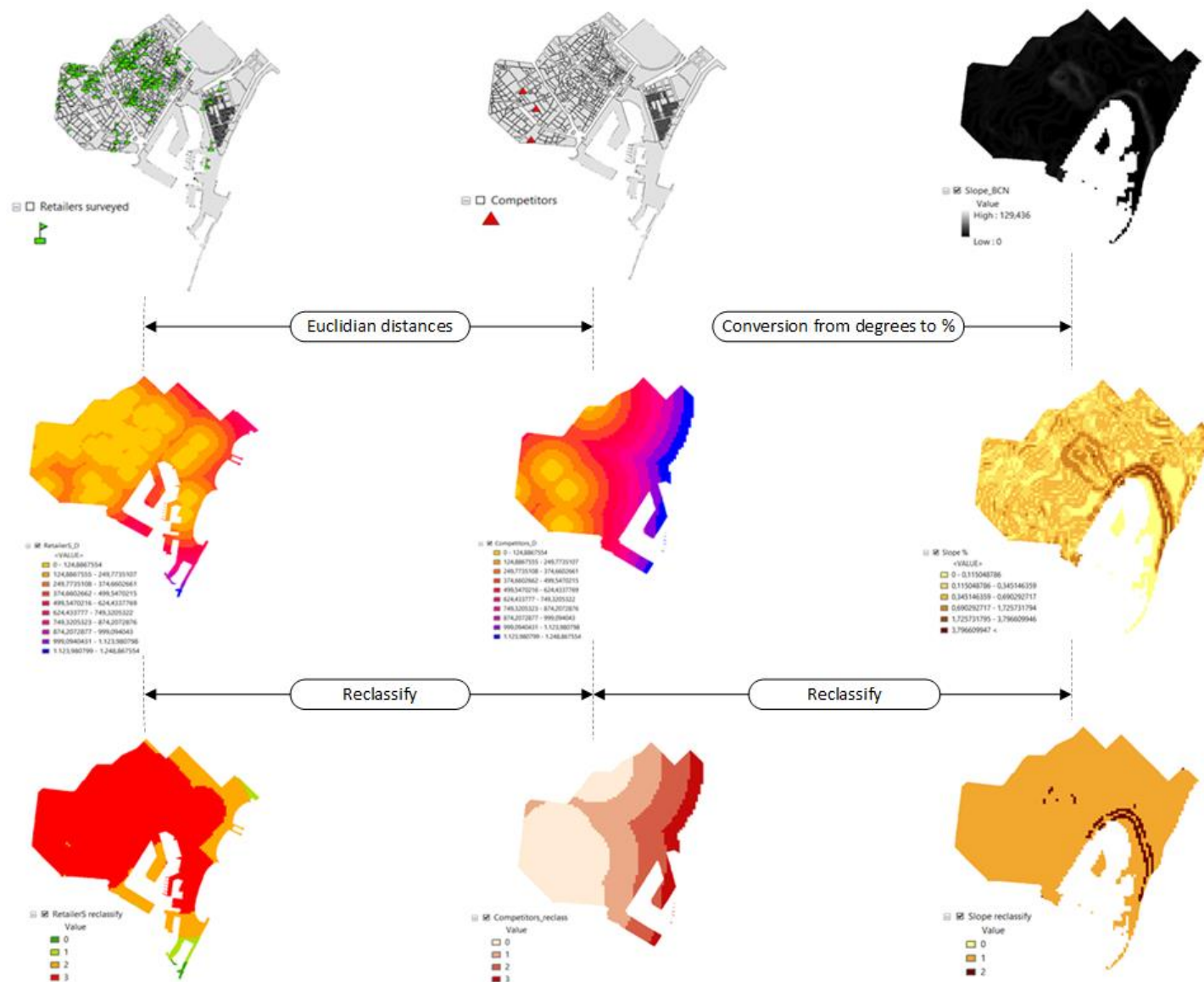


Figure 15. Spatial analyst overview. Euclidian distances and reclassify.

<i>Field</i>	<i>Scale values</i>
22@	Restricted
Downtown	2
Conservation of the urban structure	Restricted
Urban densification	Restricted
Isolated buildings and multi-family subareas	Restricted
Isolated construction and multi-family subareas	Restricted
Community equipment and endowment	4
Dwelling and social housing	Restricted
Industrial	Restricted
Specific volumetric sorting	Restricted
Forest park	Restricted
Parks and gardens	Restricted
Protection of road system	Restricted
Physical renovation	Restricted
Urban renovation: rehabilitation	5
System of technical services	Restricted
Railway system	1
Harbor facilities	3
Transformation of existing use (equipment)	6
Transformation of existing use (parks)	Restricted
Private green	Restricted

Table 8. Criterion on weighted overlay, Spatial Analyst (ArcGIS).

<i>Layer</i>	<i>Influence (%)</i>
Slope	10
Retailers surveyed	35
Competitors	25
Land use	30

Table 9. Grade of influence on weighted overlay

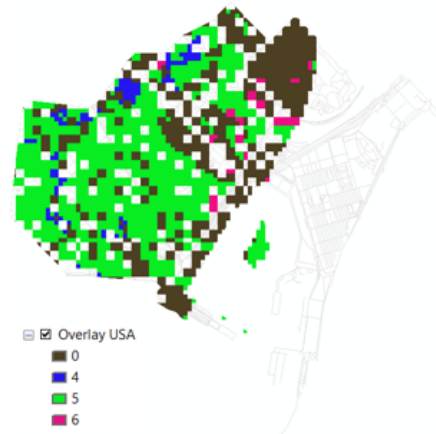


Figure 16. Weighted overlay map.

For this reason, the conditional tool in ArcGIS is necessary to pick up those pixels with value six (see figure 17). Now the picture is rather clear but still with multiple options are displayed. In order to solve that, a majority filter is used, where the areas obtained with value six are reduced to smaller areas (see figure 18)¹³. Narrowing down, ULA terminals ought to be close to the road network, selecting those areas that intersect them (see figure 19)¹⁴. Moreover, many polygons still remain, which regard to the potential competitors' influence area and the harbour zone. Then, it is certain that those have to be excluded from the spatial solution (see spatial analyst reference at '10.2. Geodatabase' section).

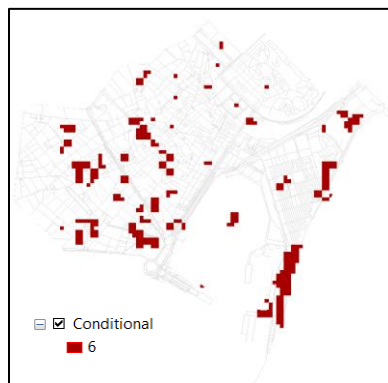


Figure 17. Candidate areas using conditional tool.

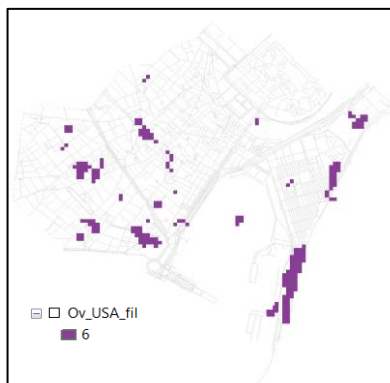


Figure 18. Candidate areas using majority filter.

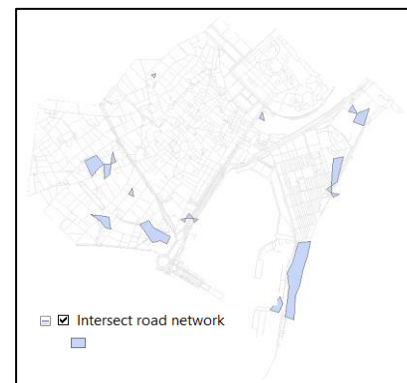


Figure 19. Candidate areas intersect selection.

¹³ The number of neighbours used is eight –number of nearest neighbours – and majority –the majority of the eight cells have the same value– within replacement threshold.

¹⁴ Converting this raster to a feature –concretely a polygon– beforehand.

What refers to the risk of competing with strengthened competitors might be considerable, since they likely cover a higher percentage of a certain market share of the territory. Besides, the competitors located in the neighbourhood of ‘el Raval’ outnumber the possibility of deploying any ULA terminal there, assuming that the model runs with a low influence over the demand at the very beginning. As mentioned previously in sub-chapter “5.1. *Theoretical approaches to urban logistics and sustainable spaces*” by quoting Nuzzolo, A. et al., the quality of the services relies on “*achieving short lead times in order to fulfil user expectations*” (pp.552. 2016). Because of that, those polygons that remain into a range of area within ‘el Raval’ –from 0 to 750 meters of perimeter– are excluded (see figure 20). On the other hand, those polygons located in the seaside (see figure 21) are out of the range influence, which correspond to ‘Hospital del Mar’ –3 and 6–, ‘Joan Salvat-Papasseit’ high school –21 and 23– and restaurants –36 and 36–.

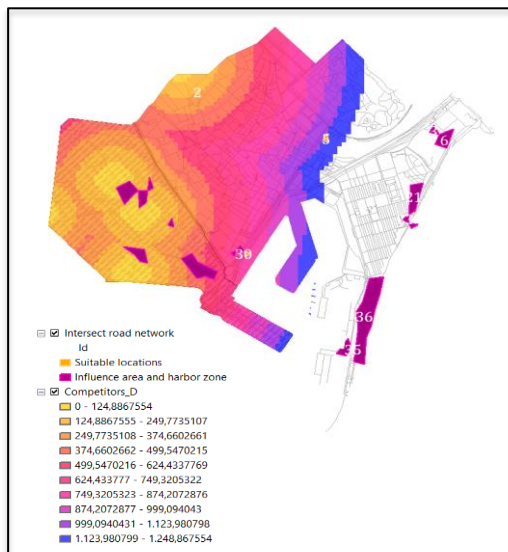


Figure 20. Filtering suitable locations from competitors range of action.

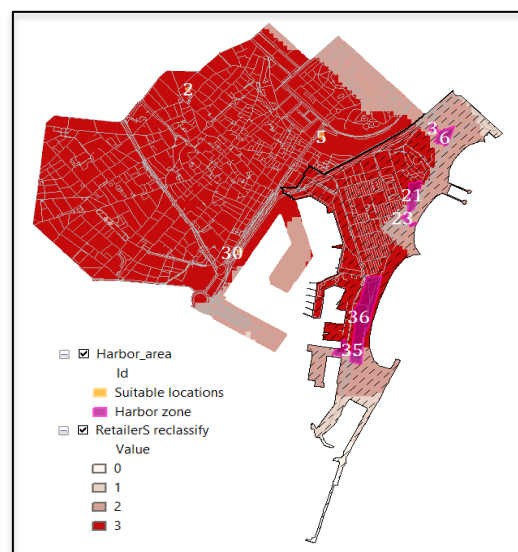


Figure 21. Filtering suitable locations from harbor zones.

Then, there are just four potential locations left, however there is a last point to consider regarding the type of facility at their surroundings. This typology corresponds to parking facilities, as required by policy, *a) free space locations for ULA terminals in parking facilities* (see table 4)¹⁵, which ensures the quality service by protecting hauled goods of any damage. Besides, the location of the terminals have to ease functional tasks to the third operator, since are carrying considerable loads in the e-bikes. In the case of SMILE project, the micro-distribution station was set above and out of the parking facility, thought for not disturbing ins and outs of cars, but also because of the steepness of the way outs. For this reason, two suitable spots are located at: 2) Ortigosa parking facility –private¹⁶– and 5) France train station hub –public¹⁷–. Both correspond to parking facilities with flat way outs, strategically located to tackle the market share corresponding to the retailers surveyed (see figure 22).

¹⁵ The table is at the section 5.5. Dynamic Analysis Policy-Making (DAP). pp. 32-34.

¹⁶ Cadastral reference: 1024715DF3812C. Main characteristics: Parking and storages. Source: www1.sedecatastro.gob.es/CYCBienInmueble/OVCBusqueda.aspx?from=

¹⁷ Cadastral reference: 2722102DF3822B0001RE. Main characteristics: Parking, storages, offices, education and services. Source: www1.sedecatastro.gob.es/CYCBienInmueble/OVCBusqueda.aspx?from=

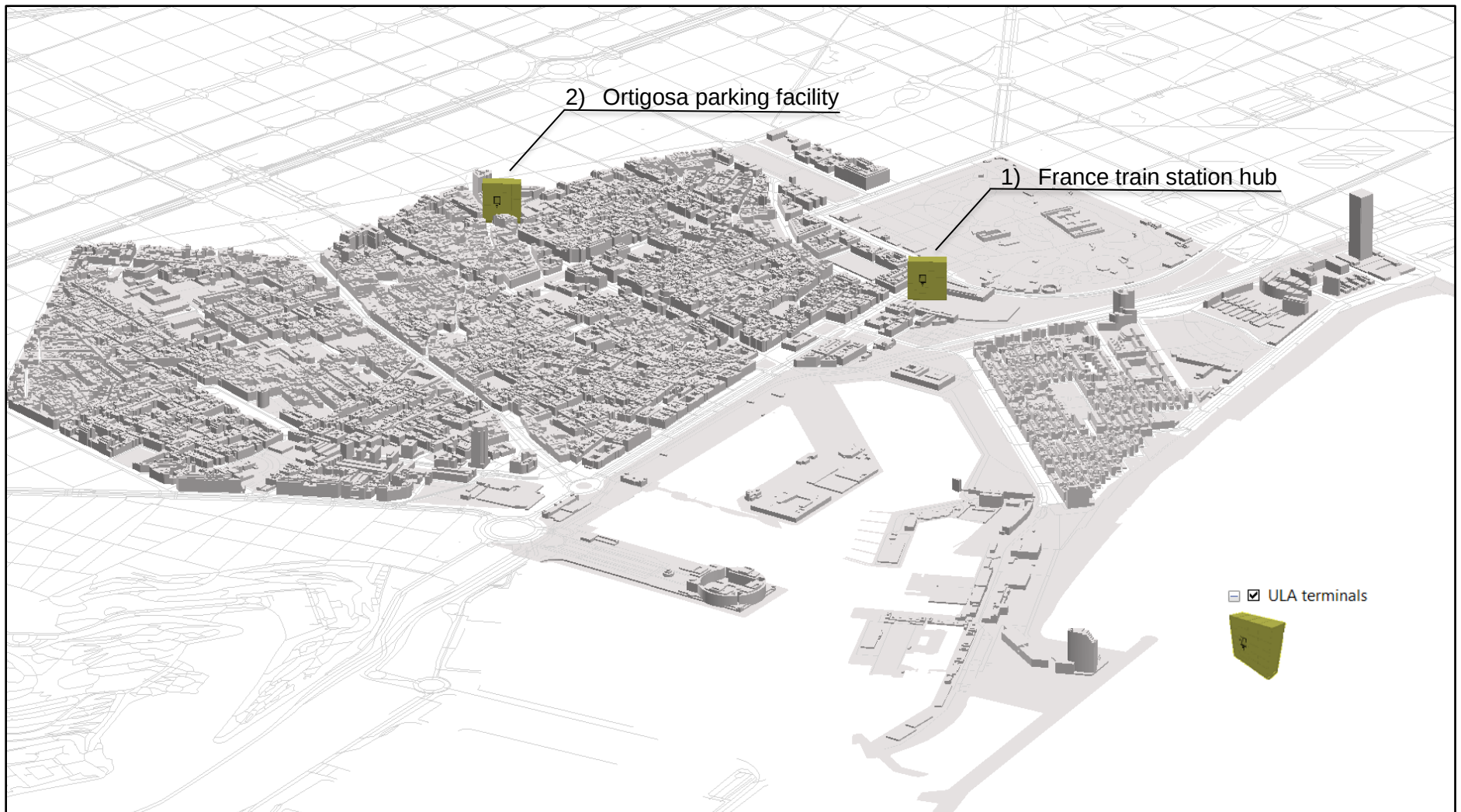


Figure 21. ULA terminals' suitable locations: 1) Ortigosa parking facility and 2) France train station hub.

7.2. Distribution of market share in Ciutat Vella

As a fact, the location of the facilities are set, but not what demand coverage each terminal has. For this reason, it is necessary to link the terminals to all retailers that were surveyed, and by that, some parameters are deterministic to this particular issue. These two indicators correspond to demand and service time, resulting both to allocation weight. In order to model that, network analyst have been used, precisely ‘new location-allocation’ tool, whose purpose is to locate facilities in the most efficient way to supply the demand (Ahmad, J., Majid Malik, M. & Shivamallu, D., 2017).

7.2.1. Potential demand

In fact, the survey made by CENIT did not compiled the demand. That is why; this research has made an assumption of the demand of each retailer based on socio-economic at census section scale. The variables used on the formula concerns the population and the household income at one side, additionally, the area and the number of retailers. Moreover, the Consumer Price Index (CPI) is included within the formula (see figure 23)¹⁸, since that variable makes fluctuate the demand of products according to consumers’ purchase power. All the data can be found in INE¹⁹ – also see IPC reference at ‘10.1. Database’ section–.

$${}_{dic(t-1)}I_i^{mt} = \frac{\overline{P}_i^{mt}}{\overline{P}_i^{dic(t-1)}} \times 100$$

Figure 23. Formula of the CPI’s elementary aggregate index. Extracted from ‘Instituto Nacional de Estadística (INE).

However, this formula shows an index of all the articles contemplated into a daily shopping cart, thus filtering just the articles sold in those retailers included into the model is necessary. The outcome is an aggregate price of group of articles of the current year (see table 10). Then, the formula varies at figure 24:

$$Pap\ 2018 = \frac{P_i^{2018} * P_i^{2017}}{\frac{100}{Na}}$$

Figure 24. Formula of the CPI’s elementary aggregate per article.

The P_i refers to an index compiling the total of all the indicators corresponding to each group in a year. Hence, the current year and the previous year are divided by hundred and Na , which is the number of articles that are contemplated within each group (see IPC reference at ‘10.1. Database’ section).

Now, an aggregate price of products is drawn for all typology of retailers for the scenario of Ciutat Vella district. All the variables needed for the respective neighbourhoods, Gòtic and Santa Pere, Santa Caterina i la Ribera are depicted, being the population and the area in a census section scale,

¹⁸ **Formula:** The Price index of recent year with a certain month, it is rested by the next year of the same month, in turn divided by that last and multiplied by hundred.

¹⁹ **Source:** ‘Subgroup provincial index’, INE: <https://www.ine.es/ipc01/coicop.htm>.

the household income per neighbourhoods and the products' aggregate prices based per retailer code (see figure 24).

Commerce	Retailers	Clothes/Complements	Hardware store	Kiosc/stationers	Book stores	Souvenirs	Hairdressing	Cosmetics	Others
Code	3	5	8	10	11	12	20	24	99
Products' aggregate prices	2,84	1,99	1,69	2,47	2,47	2,25	2,73	2,73	2,46
Census sections	22	23	25	26	27	28	29	30	
Area (m2)	81473,69	93480,77	82393,18	60834,04	47801,06	71704,20	48144,51	310179,61	
Population	1254	1964	1247	2622	1645	1853	1396	2475	
Household income	110,5	110,5	110,5	110,5	110,5	110,5	110,5	110,5	110,5

Table 10. Gòtic neighborhood. Variables for potential demand.

Commerce	Retailers	Clothes/Complements	Hardware store	Kiosc/stationers	Book stores	Souvenirs	Post office	Hairdressing	Cosmetics	Others
Code	3	5	8	10	11	12	14	20	24	99
Products' aggregate prices	2,84	1,99	1,69	2,47	2,47	2,25	21,74	2,73	2,73	2,46
Census section	43	44	45	46	47	48	49	50	51	52
Area (m2)	540000,02	53182,50	53817,36	48068,09	49077,53	31833,09	28848,35	28460,97	23023,96	91370,90
Population	1529	1499	1957	1742	1797	2139	1530	1598	1852	2563
Household income	97,8	97,8	97,8	97,8	97,8	97,8	97,8	97,8	97,8	97,8

Table 11. Sant Pere, Santa Caterina i la Ribera neighborhood. Variables for potential demand.

Finally, the potential demand can be assumed (see table 12), which represents the weight of each retailer based on current socio-economic characteristics $-Pd-$. Therefore, the potential demand is converted to an adequate scale by gathering all the retailers geospatially referenced²⁰. The weight of a single retailer $-PdW-$ is measured based on the number of retailers of a certain typology in a certain census section (Nr_S^i), the total of all typology of retailers in a certain section (Nr_T^i) and the weight of a certain typology of retailers ($\sum Nr_S^i$) per all census sections of all district ($Cs=57$) (see count weight reference at '10.1. Database' section). The formulas are represented as follows:

$$Pd = \frac{\sum P * RFD * AgPr}{A} \quad PdW = \frac{Nr_S^i * Nr_T^i}{\sum Nr_S^i \text{ Cs}}$$

Figure 25. Formulas to estimate weighting to each retailer in census section scale in Ciutat Vella

Retailers	Code retailer	Population	Area census section (m2)	Household income	Products' aggregate prices	Potential demand	Pd weighted
AGUA PATAGONA	5	1964	93480,76938	110,5	1,98	4,60	0,99
ANDREW'S TIES (CORBATES)	5	1964	93480,76938	110,5	1,98	4,60	0,99
ANGEL JOBAC S.A	3	1499	53182,49616	97,8	2,74	7,55	0,11
ANGELS	24	2113	85886,01561	74,6	2,73	5,00	0,03
ANTIC HERBOLARI CARULLA	3	1496	19072,58049	84,8	2,74	18,21	0,64
ARIZA	99	1964	93480,76938	110,5	2,81	6,52	1,70
ARLEQUIN MASCARAS	99	1797	49077,5264	97,8	2,81	10,06	5,93
ASTA LOGISTIK S.L	99	1247	82393,18235	110,5	2,81	4,70	1,24
ASTRUC	12	1964	93480,76938	110,5	2,12	4,93	0,08
BAS Y PUJOL S.A	99	1255	229602,3092	74,6	2,81	1,15	0,42
BIOMASS CONCEPTS (DAVID HERRERA GOMEZ)	99	2622	60834,03711	110,5	2,81	13,38	4,23
BLAUCELONA	12	1247	82393,18235	110,5	2,12	3,55	0,07
BOOGIE	5	2009	84621,63463	74,6	1,98	3,51	0,76
BROOKLYN	5	2113	85886,01561	74,6	1,98	3,64	1,76
BUFET VALLES	99	1530	28848,35251	97,8	2,81	14,57	3,58
CALÇATS CADIRA	5	2009	84621,63463	74,6	1,98	3,51	0,76
CALPA BOLSOS	5	1247	82393,18235	110,5	1,98	3,32	0,71
CAMBRE SEGUR	99	1797	49077,5264	97,8	2,81	10,06	5,93
CAP DRASSANES	99	3433	38992,40329	74,6	2,81	18,45	6,80
CARIAS	5	1964	93480,76938	110,5	1,98	4,60	0,99
CASC ANTIC BCN IMMOBILIARIA	99	1332	29714,87157	97,8	2,81	12,32	9,08
CASCA DOVO S.L	5	1530	28848,35251	97,8	1,98	10,28	2,59
CASI (INFORMATICA)	99	2563	91370,90074	97,8	2,81	7,71	5,68
CHANDAL	5	1650	57310,72078	74,6	1,98	4,26	3,21
CHINA SHIPING LINE	99,5	1255	229602,3092	74,6	1,98	0,81	0,30
CINDERELLA 21 ROBA	5	1964	93480,76938	110,5	1,98	4,60	0,99

Table 12. Sample: Variables, potential demand & potential demand weighted of retailers.

²⁰ Throughout join count tool in ArcGIS, all the retailers have been counted per each census section.

7.2.2. Service time

Once retailers are weighted through a potential demand, distances play an important role when servicing through e-bikes. For instance, standalone retailers located within far distances from a higher densified demand area and ULA terminals, would be questioned whether they would be worth or not to join the supply chain. What is more, it will also depend on the demand captured from these standalone retailers that contemplate in a certain period.

For this reason, to assess whether an individual may join the supply chain taking into account these two variables, 'New location-allocation' tool from ArcGIS have been used for this analysis (see [location-allocation](#) reference at '10.2. Geodatabase' section). That tool enables to find the profits of chosen or candidates locations based on a certain cut-off. In this particular model, this approach is given by the timing to reach retailers from ULA locations. That parameter is important to appear within the model and not distances, since shorter distances within urban areas do not attribute shorter times –traffic jams, traffic lights, etc.–. Before that, the road system included that model have been set to behave with e-bikes mobility patterns, recreating the last-mileage at RHD (see figure 26). To make a more realistic analysis some restrictions have been included within the model (see table 13):

- **One way:** Whether is one way or two lanes in both directions.
- **Max speed:** being 25 km the maximum in passable roads and 7 km in pedestrian zones.
- **Hierarchy:** According to the criterion set, this restriction enables to construct a logical routing model by prioritize ways, based on e-bikes patterns. This pattern follows a specific order: 1) *Cycle ways and living streets*, 2) *primary, secondary and tertiary roads* -including links-, 3) *pedestrian*, 4) *residential*, 5) *footway*, 6) *service*, 7) *path* and 8) *steps, tracks, trunk and unclassified*.
- **Traffic lights:** One average, the scaled cost is on 1 minute every time routes pass through them.

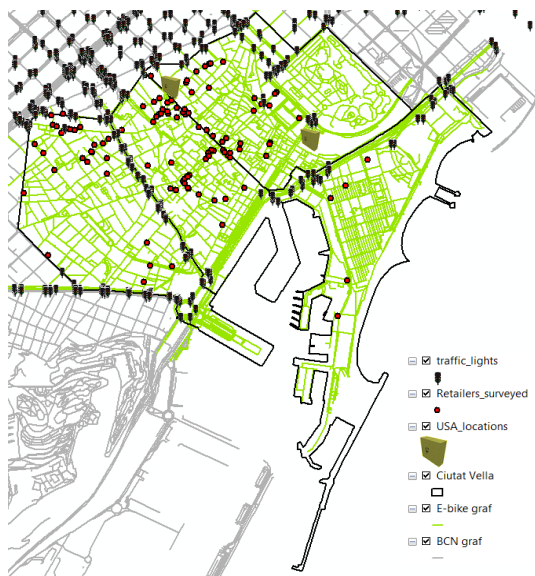


Figure 26. Overview of new location-allocation model.

code	fclass	Hierarchy	oneway	maxspeed	Shape Leng	Timin	Z Mean
5141 service	6 B	25	0.00085	0.00203	0		
5141 service	6 B	25	0.00038	0.000913	4		
5154 path	7 B	25	0.000407	0.000977	278.373985		
5114 secondary	2 F	25	0.00045	0.00108	0		
5133 primary link	2 F	25	0.000484	0.001161	0		
5141 service	6 B	25	0.000501	0.001202	0		
5124 pedestrian	3 B	7	0.000158	0.001356	0		
5154 path	7 B	25	0.000614	0.001473	0		
5113 primary	2 F	25	0.000675	0.001619	10		
5141 service	6 B	25	0.000769	0.001845	4		
5155 steps	8 B	25	0.000805	0.001933	73.25468		
5114 secondary	2 F	25	0.000845	0.002027	6.259007		
5155 steps	8 B	25	0.000909	0.002181	28.436164		
5155 steps	8 B	25	0.000917	0.00222	23.500218		
5143 track grade1	8 B	25	0.000946	0.002272	404.616543		
5155 steps	8 B	25	0.000979	0.002349	28.371183		
5154 path	7 B	25	0.001056	0.002534	363.378938		
5154 path	7 B	25	0.001095	0.002629	192.442989		
5141 service	6 B	25	0.001102	0.002646	186.908096		
5141 service	6 B	25	0.001121	0.002689	3		
5155 steps	8 B	25	0.001129	0.002709	12.429537		
5155 steps	8 B	25	0.001159	0.002782	111.848094		
5155 steps	8 B	25	0.001169	0.002806	24.363075		
5155 steps	8 B	25	0.001208	0.002899	192.717335		
5155 steps	8 B	25	0.001216	0.002919	9.244692		
5155 steps	8 B	25	0.001228	0.002947	190.853551		
5155 steps	8 B	25	0.00129	0.003095	24.113336		
5154 path	7 B	25	0.0013	0.003119	191.709598		
5142 track	8 B	25	0.001327	0.003184	0		
5155 steps	8 B	25	0.001333	0.003199	12.68692		
5155 steps	8 B	25	0.00135	0.003241	20.279579		
5155 steps	8 B	25	0.001396	0.00335	9.596137		
5155 steps	8 B	25	0.001442	0.00346	20		
5155 steps	8 B	25	0.001461	0.003506	23.921554		
5155 steps	8 B	25	0.001479	0.00355	23.97268		
5155 steps	8 B	25	0.001495	0.003587	189.078107		
5155 steps	8 B	25	0.001507	0.003616	24.458736		
5155 steps	8 B	25	0.001508	0.003619	24.565024		
5155 steps	8 B	25	0.001509	0.003621	192.093516		
5115 tertiary	2 B	25	0.00152	0.003649	97.485042		
5155 steps	8 B	25	0.001567	0.003653	189.077788		

Table 13. E-bike graf attribute table.

As the service time is key to improve the quality service, it is necessary to allocate the demand to their closest terminals. In the end, the total sum of potential demand and the impedance to this facility –time– shall be reduced to zero. This commitment regards to *'Minimize impedance problem'* within *'New location-allocation'* tool, travelling from facility –two ULA terminals– to each point of demand –119 retailers–, with a cut-off of 15 minutes around.

The outcome destines more demand to Ortigosa parking facility –terminal 1– due to its central location, being 80 retailers to attend with an accumulative service time of 6 hours and 57 minutes. On the other hand, France train station hub allocates 39 retailers with an accumulative service time of 2 hours and 42 minutes (see figure 26)²¹.

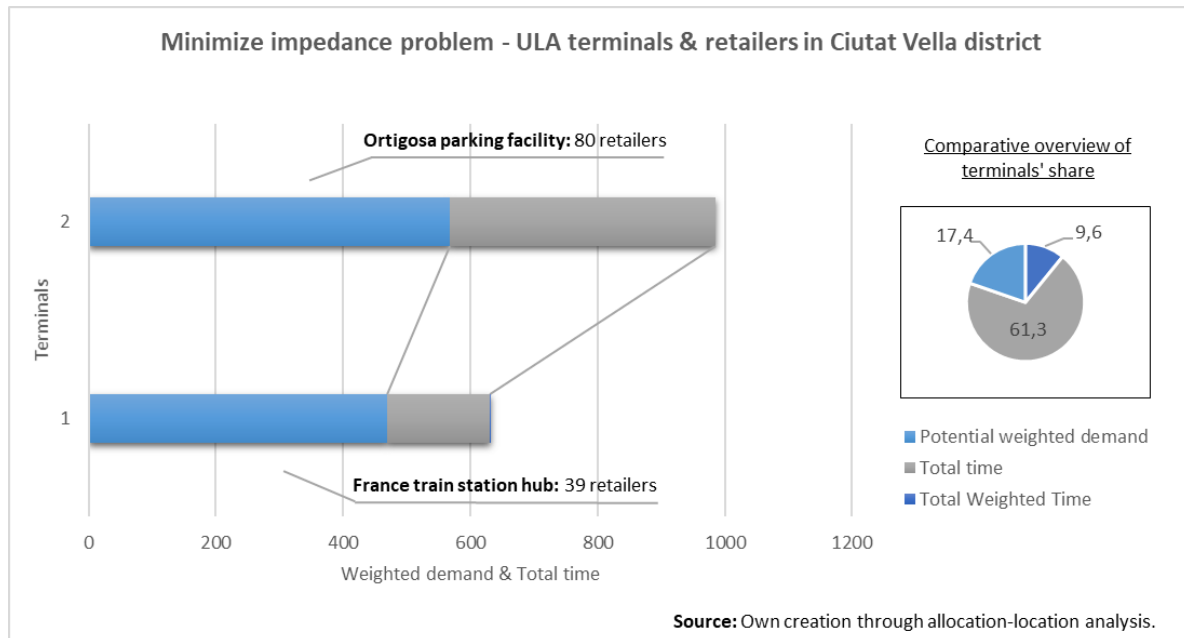


Figure 26. Overview of the results in minimize impedance problem.

As a fact, Ortigosa parking facility doubles in number of retailers to the second ULA terminal, existing a gap between them of at least 61% of servicing time with e-bikes. In comparison, this number is significant since the potential weighted demand of Ortigosa terminal is higher than the France terminal –17%–, and the total weighted time respectively, which contemplates almost a 10% of difference between them²² (see minimize impedance reference at *'10.1. Database'* section). As an overview, the model shows that a significant number of retailers concentrate at close distances –Ortigosa parking facility–, whilst few retailers concentrate at farther distances –France train station hub–. That implies greater efforts to reach a certain quality services in Ortigosa parking facility, by deploying more e-bikes in order to meet the expected demand.

Another fact to take into consideration is what market share ULA terminals would have in presence of competitors in Ciutat Vella surroundings. The motivation of that is to set a minimum consolidated demand being necessary to ensure revenues for the ULA supply chain, since that last

²¹ The time spent when unloading/loading goods is treated within the freight distribution analysis at chapter 8. Here, just the hauling line-distribution is connected between the terminal and the destination.

²² The model multiplies the potential weighted demand and the impedance to the facility, resulting the total weighted time. The lower the result is, the better outcome is acquired.

relies on carriers' contributions to the third operator. Through '*Maximize Market Share problem*' within '*New location-allocation*' tool, a certain market share is determined taking into account the potential demand, the service time and a cut-off impedance of 15 minutes (see location-allocation reference at '*10.2. Geodatabase*' section).

Figure 27 highlights the domain of ULA terminals over a half of the market share in Ciutat Vella district. Although potential competitors seem to cover more area being spatially distributed but also having one more locker, ULA terminal has a roughly 13 % more influence on the demand. Besides, the results have shown that competitors are less efficient than ULA terminals in a hypothetical scenario of line haul distribution. On average, the service time stresses by doubling its counterpart –18 hours 33 minutes–, ULA terminals–11 hours 18 minutes–. In fact, that would seem that competitors cover a significant market share, otherwise ULA terminals almost doubles the amount of potential demand in regards of competitors (see figure 27).

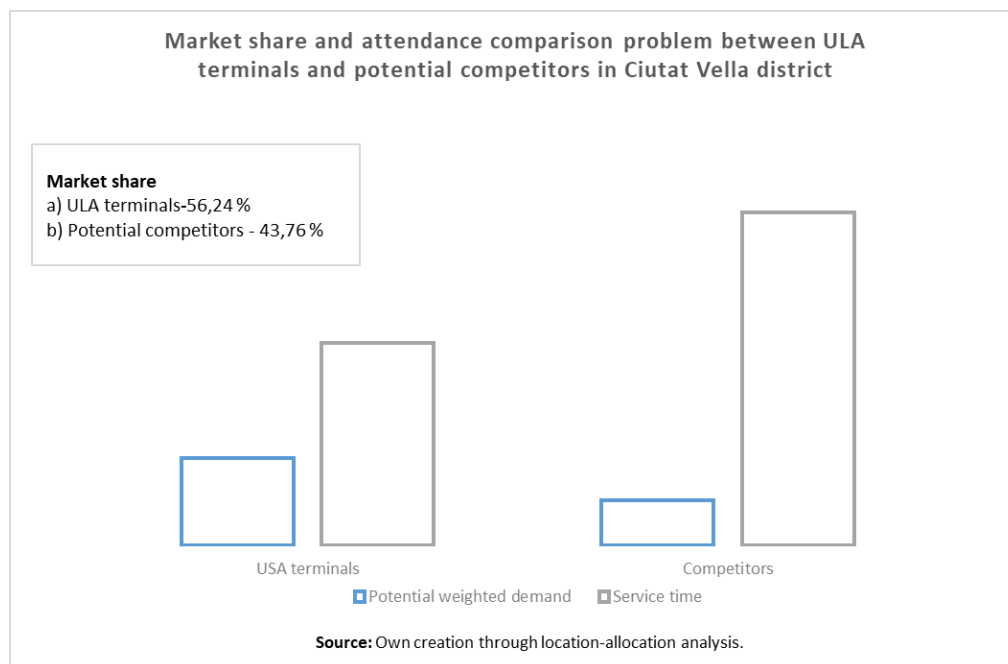


Figure 27. Market share and attendance comparison results. Own creation through location-allocation analysis.

It can be concluded that, the location of ULA terminals are optimally located in accordance to potential competitors. Moreover, minimize impedance problem have served to configure the connections of these urban terminals to the most correspondent retailer, always based on the relation between the potential demand and the service time parameters. An overview of the results obtained in that section are rendered at figure 28.

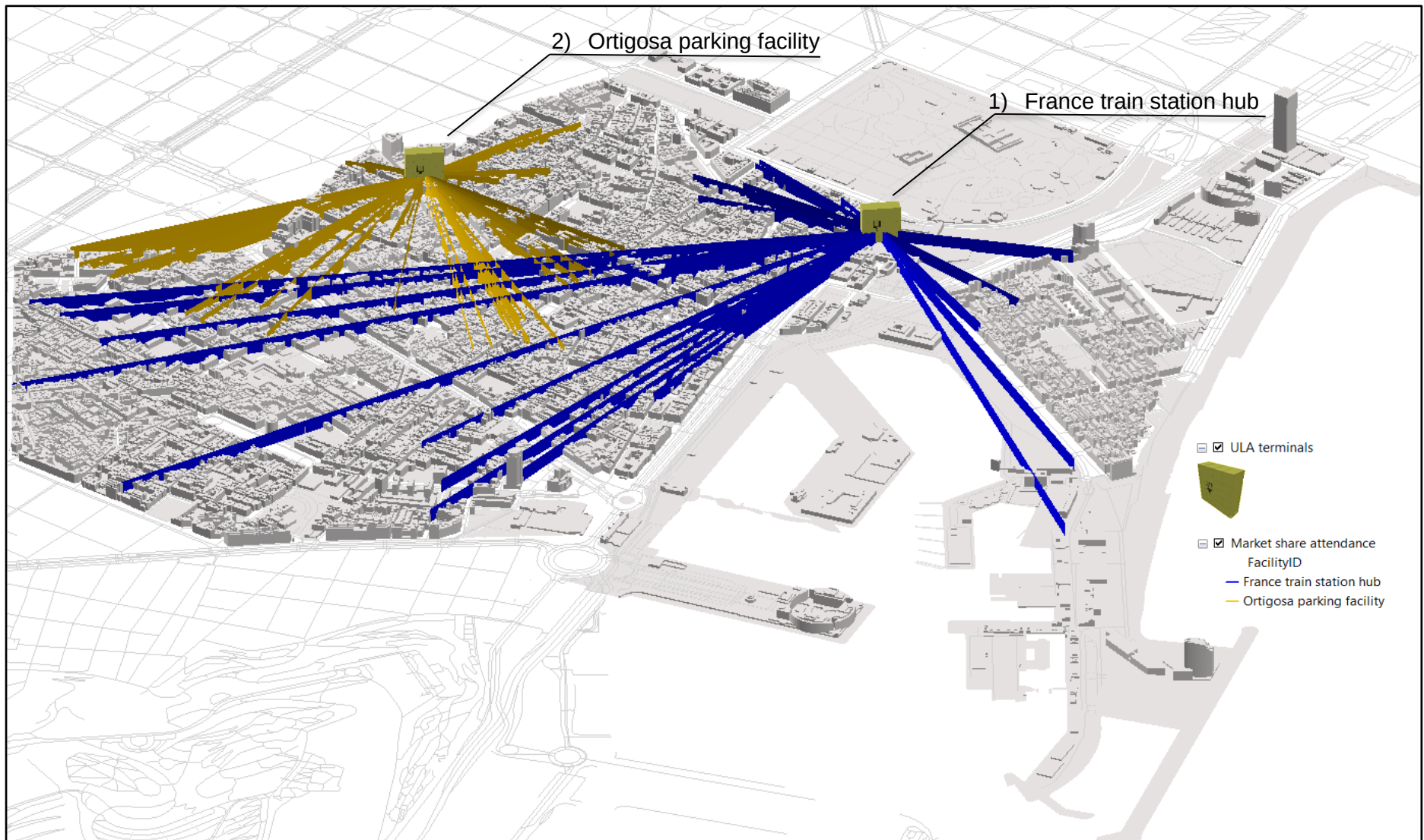


Figure 28. Overview market share and minimize impedance problems: 1) Ortigosa parking facility (80 retailers) and 2) France train station hub (39 retailers).

7.3. Approximation budgeting cost for ULA terminals in Ciutat Vella district

The main question that prompts after locating and distributing the market share of each terminal, it is about the costs of ULA terminals. Certainly the answer is given by an approximation based on the characteristic of deliveries to distribute in this model. Principally, those carriers who carry small-mid packages were selected from the CENIT's survey –precisely represented in *chapter 8. ULA freight distribution analysis*-. Regardless that there is a lack of demand data, just knowing the typology of freight to transport, this research took in consideration some examples of services around Europe regarding lockers' dimensions (Faugere, L. & Montreuil, B., 2016).

	Dimensions per locker			In3
InPost	25 in	16 in	15 in	6000 in3
Deutsche Post DHL	24 in	14 in	14 in	4704 in3
Norway Post - Bring	24 in	14 in	14 in	4704 in3
Osterreichische Post AG	40 in	24 in	24 in	23040 in3
Bpost	27 in	16 in	12 in	5184 in3
Itella	24 in	24 in	14 in	8064 in3
Post Danmark	24 in	14 in	14 in	4704 in3
Groupe La Poste	24 in	17 in	14 in	5712 in3
DPD Groupe	24 in	17 in	14 in	5712 in3
UPS	32 in	10 in	10 in	3200 in3
Amazon	17 in	14 in	6 in	1366 in3
Zhilai	20 in	19 in	18 in	6840 in3
Average lockers' dimensions				In3/m3
Inches	25 in	17 in	14 in	5920 in3
Meters	0,64 m	0,42 m	0,36 m	0,10 m3

Table 14. Average lockers' dimensions. Based on 'Hyperconnected city logistics: smart lockers terminals & last mile delivery networks. Table 1.Capabilities of the set of services selected' (pp. 5. 2016).

Furthermore, there have been made two distinctions to have different models destining to:
a) one locker per retailer and b) one locker per two retailers. Some estimations based on the business model of 'Parcel/Pending 2016 annual report' (Capwell communications, 2016) have been made for these two approaches (see tables 15 and 16).

	USA terminal 1	USA terminal 2	Total
Retailers	31	88	119
Lockers	15,5	44	59,5
Capacity	1,50 m3	4,25 m3	5,75
Cost single locker	51,69 €	51,69 €	103,37 €
Total cost terminal	801,15 €	2.274,25 €	3.075,40 €

Table 15. One locker per two retailers.

	USA terminal 1	USA terminal 2	Total
Retailers	31	88	119
Lockers	31	88	119
Capacity	2,99 m3	8,50 m3	11,49
Cost single locker	51,69 €	51,69 €	103,37 €
Total cost terminal	1.602,31 €	4.548,49 €	6.150,80 €

Table 16. One locker per each retailer.

These two approximations are fixed costs that, at least in France ULA terminal which does not have to pay a renting –being a public space–, unlike the micro-distribution terminal of SMILE project it had to (see [smart lockers](#) reference at '10.2. Database' section). In short, the municipality it makes a small investment for facilitating the terminals, in exchange of having a source of freight transportation data. What it refers to CF manager, there are no assumptions made due to lack of data and because it has not been the focus of this research. In the following chapter 8. *ULA freight distribution analysis*, a comparative analysis between the conventional freight distribution model and the DAP framework takes place, in order to assess the capacity of those strategies to generate carriers' cost savings and potential contributions.

CHAPTER 8. ULA freight distribution analysis

8.1. Comparative analysis on independent deliveries and collaborative through consolidation facilities

In the previous chapter, ULA terminals' locations were determined and linked to each retailer surveyed. Now onwards, Ciutat Vella's scenario raises being CENIT's surveys –both, retailers and carriers– as the main component of the ULA freight distribution analysis. Even both surveys are not related, they have been crossed to make a comparison analysis between: a) The last-mileage is carried out by independent deliveries and b) ULA facilities working as a proxy between carriers, the third operator and retailers.

What regards carriers' survey, there are 102 transporters with different vehicles whereby different packages are hauled, wide sort of freight, vehicles' total capacity at the beginning of the route, addresses of stops, unloading/loading time spent and so on. However, not all carriers do not match with retailers' characteristics, for this reason, carriers were selected by some attributes (see table 17). In the end, 21 carriers were chosen to be the hypothetical retailers' suppliers according to their type of freight to distribute (see table 18 and schedule carriers' delivery reference at 'Database' section).

Type of vehicle	Car and van
Type of freight distributed	Clothes, shoes and personal accessories, cosmetics, perfumery products, home and household, documentation, shipping and return of freight and others.
Size of packages	Small packages
Unloading/loading time spent (minutes)	5, 10, 15, 20, 30 and 60.

Table 17. Carriers' survey. Selection of carriers based on suitable conditions for ULA terminals.

Before setting up the environment, unit costs are depicted. Those costs are based on a model discrete fleet (see table 18)²³ designed by Estrada, M. & Roca-Riu, M. in '*Stakeholder's profitability of carrier-led consolidation strategies in urban goods distribution*' (2017).

Strategy A (independent deliveries)			Strategy A (independent deliveries)	
Operative costs			Externalities (van 2.5 tonnes)	
Inputs	Value		CO2 (kg/km)	0,178
Receivers	119		Nox (kg/km)	0,0001025
Carriers	21		PM2.5 (kg/km)	0,000005
Unit temporal cost (€/veh-h)	23,49		Total (kg/km)	0,18
Unit distance cost (€/veh-km)	0,28		Monetization externalities (van 2.5 tonnes)	
Access time for regular carriers (hours)	3		CO2 (€/kg)	0,00136704
Time spent at consolidation facility (h/stops)	0,25 = 15 minutes		Nox (€/kg)	0,00064575
			PM2.5 (€/kg)	0,00024
			Total (€/kg)	0,0023
			Externalities (car < 2.5 tonnes)	
			CO2 (kg/km)	0,13
			Nox (kg/km)	0,00007
			PM2.5 (kg/km)	0,000005
			Total (kg/km)	0,13
			Monetization externalities (car < 2.5 tonnes)	
			CO2 (€/kg)	0,0009984
			Nox (€/kg)	0,000441
			PM2.5 (€/kg)	0,00024
			Total (€/kg)	0,0017

Table 18. Strategy A, Independent deliveries.
Operative costs & externalities costs based on
Estrada, M. & Roca-Riu, M. (2017).

²³ Total annual cost = Temporal-based cost (driver salary, depreciation, financial costs, insurances, company overhead and meals) + Distance-based cost (fuel/electricity, wheels, maintenance and tolls).

This article enlightens the profitability by comparing strategy A) independent deliveries, and strategy B) collaboration through a consolidation facility. Although, this model propose that carriers set a specific unit cost per package to give shares to the third operator –which would be more precisely by possessing demand data–, the aim of this research is to formulate new forms of contributions. Furthermore, CENIT’s surveys do not compiled a real demand as such, but carriers’ just show a certain loading percentage, representing then the amount of workload per day. This data have been included within the model in form of a weekly schedule to perform all routes and by that, gather all accumulative outcomes as a part of the solution.

These outcomes are generated according to some parameters. At strategy A and B (see table 18 and 19), the unit temporal costs and the unit distance cost are depicted, which both will be key to estimate an approximate contribution from carriers towards the third operator. Besides, access time for regular carriers –hours– can vary depending on the policies stipulated by the case of study. In that case, RHD in Barcelona goes from 9 am to 12 pm and from 16:00 to 20:00 (Ajuntament de Barcelona, 2015), thus, the service time stipulated for unloading/loading freight in strategy A is 7 hours. Regarding pollutants, two types of vehicles are recognized –car and van–, which are associated to European’s emission standards (DELPHI, 2017; EU, 2013).

Strategy B (collaboration through a consolidation facility)			
Ortigosa parking facility (USA terminal 1)		France train station hub (USA terminal 2)	
Inputs	Value	Inputs	Value
Receivers	80	Receivers	39
E-bikes	~	E-bikes	~
Unit temporal cost E-bikes (€/veh-h)	15,54	Unit temporal cost E-bikes (€/veh-h)	15,54
Unit distance cost E-bikes (€/veh-km)	0,015	Unit distance cost E-bikes (€/veh-km)	0,015
Access time for CF operators (hours)	~	Access time for CF operators (hours)	~
Time spent at consolidation facility (h/stops)	0,025 = 1,5 minutes	Time spent at consolidation facility (h/stops)	0,025 = 1,5 minutes
Carriers	20	Carriers	17
Unit temporal cost (€/veh-h)	23,49	Unit temporal cost (€/veh-h)	23,49
Unit distance cost (€/veh-km)	0,28	Unit distance cost (€/veh-km)	0,28
Access time for regular carriers (hours)	3	Access time for regular carriers (hours)	3
Time spent at consolidation facility (h/stops)	0,25 = 15 minutes	Time spent at consolidation facility (h/stops)	0,25 = 15 minutes
Externalities (E-bikes)		Externalities (E-bikes)	
CO2 (kg/km)	0	CO2 (kg/km)	0
Nox (kg/km)	0	Nox (kg/km)	0
PM2.5 (kg/km)	0	PM2.5 (kg/km)	0
Total (kg/km)	0,0	Total (kg/km)	0,0
Monetization externalities (E-bikes)		Monetization externalities (E-bikes)	
CO2 (€/kg)	0	CO2 (€/kg)	0
Nox (€/kg)	0	Nox (€/kg)	0
PM2.5 (€/kg)	0	PM2.5 (€/kg)	0
Total (€/kg)	0,0	Total (€/kg)	0,0

Table 19. Strategy B, collaboration through a consolidation facility. Operative costs & externalities costs based on Estrada, M. & Roca-Riu, M.’s model (2017)

Apart from that, strategy B shows different parameters (see table 19), since conventional carriers –OHD– and e-bikes –RHD– collaborate through ULA terminals at different shifts. In the case of e-bikes, unit temporal costs –15.54 €/veh-h– and unit distance costs –0.015 €/veh-km– are expected to be less than carriers’ operational costs. The same happens to the time spent at consolidation facilities and to the emission of pollutants, which are zero.

As a fact, strategy B already contemplates what receivers are connected to each terminal as estimated in the previous chapters, being 80 retailers for terminal 1 –Ortigosa parking facility– and 39 for terminal 2 –France train station hub–. Nonetheless, an optimal number of e-bikes are still

undetermined per each terminal, because carriers' contributions and the service time in the line haul distribution of e-bikes are still unknown.

In short, both scenarios –A and B– are represented to estimate cost savings and the externalities by a comparative analysis at the last-mileage in Ciutat Vella district. The analysis go through an entirely week, more specifically, during workdays: From Monday to Friday for carriers at RHD –Strategy A– and for e-bikes at RHD –Strategy B–, while carriers' at OHD –Strategy B– go from Sunday at midnight until Thursday at midnight. Besides, the model attends two shifts per day as is compiled at both surveys; morning and afternoon shifts.

8.1.1. Strategy A

In strategy A, each carrier manage a minimum of three retailers and a maximum of nine retailers (see schedule carriers' delivery reference at '10.1. *Database*' section and strategy A reference at '10.2. *Geodatabase*' section). Carriers contemplate two transport modalities –vans and cars– and because of that, differentiated parameters such as hauling cost, amount of contaminants and different speeds²⁴ are appreciated (see table 18). For this reason, two network datasets are created at table 20 –Carriers_ND for vans and Cars_ND for cars²⁵–, where the attributes are set to be accumulated as part of results at each transport modality (see strategy A, RHD ND reference at '10.2. *Geodatabase*' section). Therefore, these estimations are realized through 'New route', which can be found within the extension of Network Analyst in ArcGIS 10.5.

	Vans	Cars
<i>Source</i>	Carriers_network and Carriers_ND_Junctions	Car_network and car_ND_Junctions
<i>Connectivity policy</i>	Carriers_network (Any vertex)	Car_network (Any vertex)
<i>Elevation</i>	None	None
<i>Attributes</i>	CS_distances (monetization cost), CS_time (monetization cost), distance (km), e_emissions (monetization cost), Greenhouse_emissions (pollutants emitted), oneway (restriction), prohibited (avoid: medium) and time (minutes)	CS_distances (monetization cost), CS_time (monetization cost), distance (km), e_emissions (monetization cost), Greenhouse_emissions (pollutants emitted), oneway (restriction), prohibited (avoid: medium) and time (minutes)
<i>Travel mode</i>	Truck (type), time-minutes (impedance), distance-km (distance attributes), U-turns at junctions (allowed)	Automobile (type), time-minutes (impedance), distance-km (distance attributes), U-turns at junctions (allowed)

Table 20. Strategy A 'Independent deliveries'. Network Dataset properties of two transport models: vans and cars.

Both network datasets try to stick as much as possible to reality, which is why added costs – traffic lights– and restrictions –prohibited and one way– are included within the problem. For instance, 'prohibited' makes routes to avoid pedestrian and footway with a normal tolerance. In other words, vans and cars are able to drive by in order to attend the demand, however not considering the path as the first option but as a last alternative (see table 20). On the other hand, traffic jams –as an

²⁴ There is no specification of carriers' tare weight within the surveys, so maximum speed average were differentiated from cars'. These numerical specifications were extracted from open street maps' source, where each speed attribute is determined according to road network typology.

²⁵ This dataset can be found in 'Urban consolidation center/Results_contribution.gdb/Results_strategy_A/Cars_ND_1.

added cost extracted from Google Maps– were thought to be included within the model, though, data does not show numeric timing delays on events, but downshift averages classified by the intensity of traffic jams. Instead, static elements such as traffic lights were included, which represent an added cost of time -1 minute as default²⁶- to each delivery distribution.

Once both network datasets are constructed, layer properties need to be set before running the model. Within the analysis' settings (see figure 29), time is used as the impedance of both models –vans and cars–, which all routes' starting time initiate at 7:00 am every day of the week –corresponding to time windows from retailers' survey–. Taking into account these set of data, the model will draw all routes finding the best way where impedances are reduce, for instance, choosing the shorter route which has less restrictions on the way –traffic lights, speeds, avoid medium tolerance, one way and so on–. This logic is repeated for all shifts –morning and afternoon– and the entirely week, which at the end all the attributes' parameters (see table 21) are gathered. At figure 30, there is an example of routes generated for Monday at afternoon, where stops are set for that particular shift according to carriers' survey (see strategy A reference at '10.2. *Geodatabase*' section).

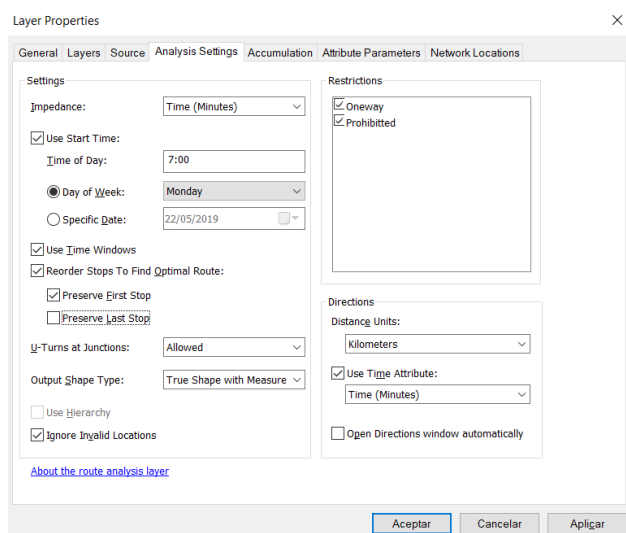


Figure 29. Analysis settings. Network dataset model using 'New routes'.

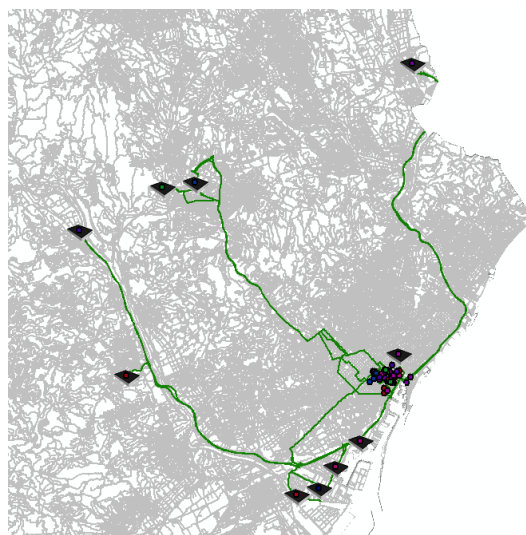


Figure 30. Line haul distribution model on Monday, two shifts with vans' fleet as transport mode.

Moreover, each carrier presented a total wait time between the morning shift and the afternoon shift. That is contemplated within the model, because it is assumed that each carrier ought to deliver to unknown retailers elsewhere during this gap of time, to afterwards returning to Ciutat Vella to cover the second shift. That way, at table 21 the time spent is deducted to the total time of each line haul distribution service.

The results shown in the table reflect the parameters compiled during workdays -from Monday to Friday- of conventional fleets at RHD. For a better understanding of the parameters, figure 31 shows an overview of the mobility patterns of all fleets. To highlight the inexistence correlation among operators at strategy A, they have been classified by their attendance at shops, which can be noticed that such strategy characterizes by its direct free competition –neither 'carriers ~<45 retailers' $R^2=0.3017$ nor 'carriers ~>45 retailers' $R^2=0.0277$ –.

²⁶ There is no open source, where red lights' timing is included as an attribute. This data remains classified out of public.

Name	StopCount	Total distance	Total time (hours)	Wait time (hours)	Net time (hours)	Unit temporal cost (euros)	Unit distance cost (euros)	Unit operational cost (euros)	Green house emissions (kg)	Monetization GH (euros)
VAN 1	64	118,698681	28,83	12,94	41,77	373,36	51,78	425,15	20,40	0,17
VAN 2	51	106,420918	24,39	10,02	34,41	337,44	44,59	382,03	18,99	0,16
VAN 3	42	184,67973	29,73	14,02	43,75	368,88	62,75	431,63	31,58	0,29
VAN 4	57	95,307034	50,62	4,45	55,07	1084,65	36,73	1121,38	16,69	0,13
VAN 5	39	272,428526	32,26	15,70	47,97	388,98	85,33	474,32	46,81	0,40
VAN 6	45	195,379295	40,08	8,86	48,94	733,42	104,87	838,29	33,50	0,30
VAN 7	59	181,525541	52,17	16,01	68,18	849,48	142,10	991,58	30,93	0,30
VAN 8	44	199,288684	37,69	7,01	44,70	720,47	102,44	822,91	34,28	0,30
VAN 9	40	239,436369	24,75	14,28	39,03	245,97	69,05	315,02	41,50	0,35
CAR 10	40	546,043215	28,18	12,13	40,31	377,09	166,55	543,64	93,15	0,85
CAR 11	36	113,52318	29,09	11,54	40,62	412,22	57,10	469,32	20,05	0,16
CAR 12	49	172,558316	34,11	19,95	54,06	332,56	61,50	394,05	30,07	0,25
VAN 13	45	273,562292	31,21	15,36	46,57	372,48	76,43	448,92	47,11	0,41
VAN 14	69	185,988583	31,12	9,15	40,27	516,07	61,46	577,53	32,39	0,28
CAR 15	63	299,319721	38,62	14,37	53,00	569,69	103,95	673,65	51,27	0,45
VAN 16	44	196,383673	30,81	11,46	42,26	454,59	63,63	518,22	34,66	0,35
CAR 17	37	177,467981	21,34	11,82	33,16	223,65	46,28	269,93	30,55	0,25
CAR 18	52	313,597734	32,59	23,74	56,32	207,81	72,34	280,15	54,68	0,45
CAR 19	56	313,130783	29,12	16,83	45,95	288,67	60,15	348,82	55,55	0,42
CAR 20	34	277,901584	32,93	19,36	52,29	318,72	68,46	387,18	48,30	0,40
CAR 21	60	63,367749	34,12	17,29	51,41	395,30	24,92	420,22	10,84	0,10

Table 21. Strategy A) Independent deliveries at RHD.
Accumulative results from Monday to Friday. Ciutat Vella district.

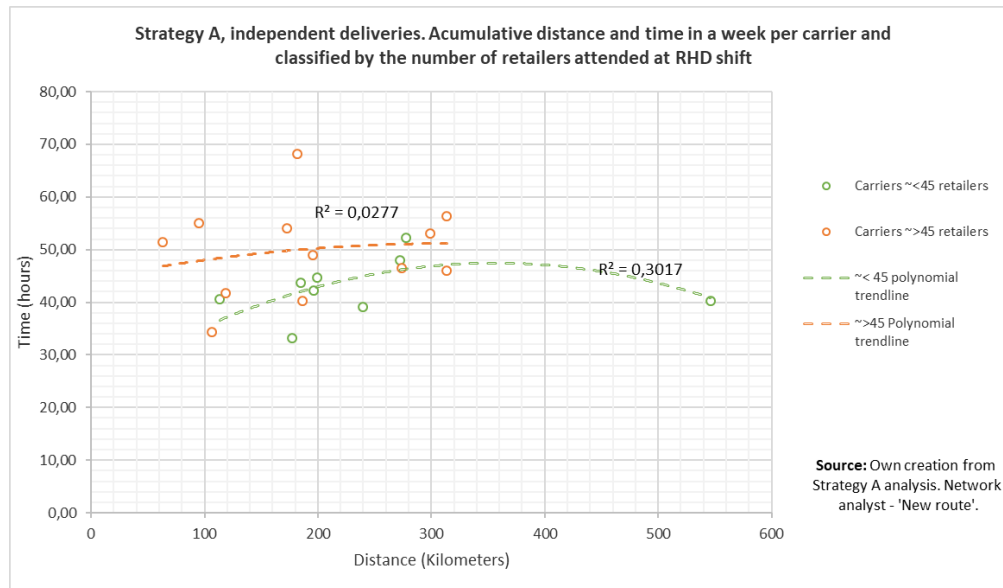


Figure 31. Strategy A) Independent delivery's results. Own creation from network analyst tool - 'New route'.

8.1.2. Strategy B

After seeing the results of conventional freight distribution, it can be denoted that direct competence lead to chaotic events, where mobility patterns can be hardly study for further policy-making to improve the efficiency of routes. In that regard, strategy B would enable to catch these data through the two ULA terminals –Ortigosa parking facility and France train station hub–, in exchange of guarantying carriers' cost savings. In this section, not only financial savings are appreciated, but also operational –quality service, travelled distances and attendance– and environmental (see [strategy B](#) reference at '10.2. Geodatabase' section).

In order to capture these values, the environment has to be set –as it has been done for strategy A– to run the 'new routes' through the network datasets. What regards to the operational parameters of strategy B, the third operator is included as part of the solution at RHD shift (see table 19). Nonetheless, carriers' section at OHD is treated first, thus all savings can be more understandable by comparing both strategies. That is why, the sequence is repeated by creating two network datasets for each carriers' transport modality –Carriers_ND and Cars_ND– (see [strategy B, OHD ND](#) reference at '10.2. Geodatabase' section), maintaining the restrictions and added costs set at strategy A (see table 22). Therefore, traffic jams are not included in this model as an added cost in form of delaying for the same motive that strategy A's. Even so, there would not be many differences, since at this time it is when there is traffic congestions.

Instead, the only thing that changes is the departure time slots from depots to ULA terminals, which is configured within the analysis settings (see figure 32). In fact, there were not time windows at OHD in CENIT's surveys, but it is assumed to be before midnight, thus this model formulate it to start at 23:00. As a fact, this particular network estimates the entirely routes, that means, when a carrier makes the routing towards one or two terminals and goes back to its corresponding depot (see figure 33).

	Vans	Cars
<i>Source</i>	Carriers_network and Carriers_ND_Junctions	Car_network and car_ND_Junctions
<i>Connectivity policy</i>	Carriers_network (Any vertex)	Car_network (Any vertex)
<i>Elevation</i>	None	None
<i>Attributes</i>	CS_distances (monetization cost), CS_time (monetization cost), distance (km), e_emissions (monetization cost), Greenhouse_emissions (pollutants emitted), oneway (restriction), prohibited (avoid: medium) and time (minutes)	CS_distances (monetization cost), CS_time (monetization cost), distance (km), e_emissions (monetization cost), Greenhouse_emissions (pollutants emitted), oneway (restriction), prohibited (avoid: medium) and time (minutes)
<i>Travel mode</i>	Truck (type), time-minutes (impedance), distance-km (distance attributes), U-turns at junctions (allowed)	Automobile (type), time-minutes (impedance), distance-km (distance attributes), U-turns at junctions (allowed)

Table 22. Strategy B ‘collaboration through consolidation facilities’. Network Dataset properties of two transport models: vans and cars.

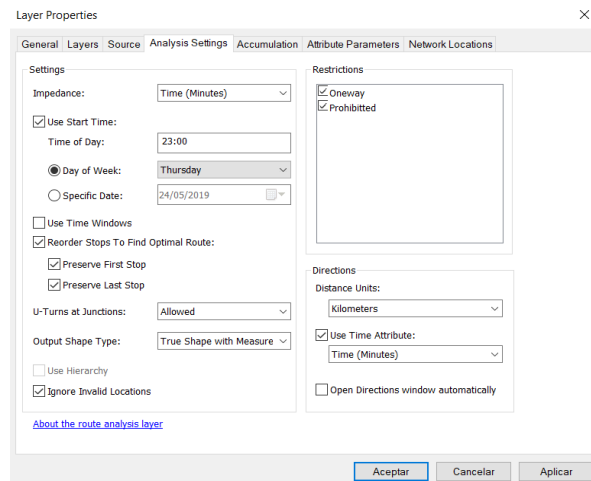


Figure 32. Analysis settings. Network dataset model using ‘New routes’.

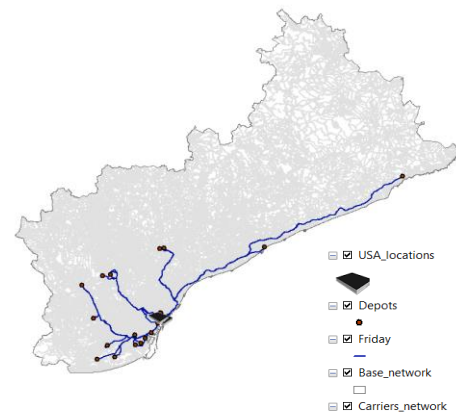


Figure 33. Carriers’ line haul distribution model on Friday at OHD shift.

Mostly, the results of strategy B for the entire week at OHD show significant improvements in respect of strategy A’s stats, where operational costs –unit temporal time and unit distance time– and greenhouse emissions –including its monetization– have dropped notably (see table 23). At least, 16 carriers plenty improve in their line haul distribution, which on average it is noticeable reductions at each indicator: a 40.04% in distances, a 58.06% on service time, a 52.80% of the total operational cost and a 39.52% of greenhouse emissions likewise.

Although, all carriers show positive numbers due to decreases on service time spent, thus operational costs, five of them –van 3, van 6, van 7, car 10 and car 15– experience an increase on travelled distances –52 km, 16.45% more on average–, and therefore, greenhouse emissions –9.44 kg, 17.28 % more on average–. For better visualization, figure 34 spotlights the changes that carriers have experienced on the relation between travelled distances and greenhouse emissions, under a

collaborative model. As a trend, those carriers located at inner and at short distances out of the city of Barcelona, got greater and positive changes, whilst those from 20 km to 68 km do not.

Carriers	Retailers	%	Distances (Km)	%	Time (hours)	%	Operational cost	%	Green house emissions (kg)	%
VAN 1	-44	-68,75	-21,61	-18,20	-10,77	-67,78	-247,05	-60,76	-3,69	-18,11
VAN 2	-33	-64,71	-41,82	-39,29	-9,27	-64,55	-211,31	-57,54	-5,10	-26,87
VAN 3	-22	-52,38	+24,86	+13,46	-6,67	-42,50	-132,73	-31,56	+4,47	+14,14
VAN 4	-38	-66,67	-70,66	-74,14	-37,47	-81,15	-864,33	-77,77	-12,46	-74,65
VAN 5	-19	-48,72	-6,18	-2,27	-6,65	-40,17	-143,11	-30,76	-0,96	-2,05
VAN 6	-26	-57,78	+11,35	+5,81	-21,02	-67,32	-467,94	-59,37	+2,10	+6,27
VAN 7	-39	-66,10	+47,64	+26,24	-28,47	-78,73	-646,39	-71,80	+8,46	+27,34
VAN 8	-27	-61,36	-6,89	-3,46	-21,87	-71,31	-497,66	-64,11	-1,12	-3,26
VAN 9	-24	-60,00	-42,76	-17,86	-4,40	-42,00	-109,70	-35,05	-7,57	-18,24
CAR 10	-21	-52,50	+154,34	+28,26	-1,88	-11,73	-14,08	-2,66	+27,53	+29,55
CAR 11	-16	-44,44	-93,12	-82,02	-13,20	-75,19	-319,09	-71,87	-16,56	-82,58
CAR 12	-33	-67,35	-73,49	-42,59	-8,21	-58,00	-197,99	-51,98	-13,04	-43,36
VAN 13	-26	-57,78	-52,25	-19,10	-7,49	-47,25	-177,67	-39,56	-8,99	-19,09
VAN 14	-52	-75,36	-78,30	-42,10	-15,90	-72,39	-380,44	-66,96	-13,83	-42,72
CAR 15	-48	-76,19	+25,30	+8,45	-12,85	-52,99	-279,61	-42,79	+4,65	+9,08
VAN 16	-24	-54,55	-143,72	-73,18	-11,20	-57,86	-273,07	-53,59	-25,58	-73,82
CAR 17	-20	-54,05	-8,22	-4,63	-3,64	-38,28	-80,33	-29,39	-1,43	-4,69
CAR 18	-32	-61,54	-141,26	-45,05	-2,61	-29,48	-91,92	-31,09	-24,99	-45,71
CAR 19	-36	-64,29	-285,81	-91,27	-8,05	-65,51	-253,44	-67,34	-50,84	-91,53
CAR 20	-14	-41,18	-79,31	-28,54	-6,20	-45,71	-156,88	-39,56	-14,08	-29,15
CAR 21	-40	-66,67	-36,05	-56,88	-12,17	-72,34	-278,52	-67,43	-6,13	-56,58

Table 23. Comparison of carriers' results between strategy A and strategy B. Ciutat Vella model.

This can be explained, perhaps, because of the spatial conditions of depots and the demand at certain days –number of retailers to attend in the whole week–, which both elements will determine the total sum of distances for the line haul distributions. At these certain events, horizontal collaboration would be necessary to reduce at minimum travelled distances and emission of pollutants. However, by putting in practice that policy, pay-offs such as operational costs and complexity of tasks for whom carriers collaborate have to be estimated, since excessive collaboration might drive farthest operators to be unfeasible into ULA's supply chain.

Besides, it is remarkable to mention that through urban terminals, the complexity of supply chains can be reduced significantly. At figure 31, the lack of correlation among carriers denoted that conventional freight operators are independent players. On the contrary, the correlation in strategy B (see figure 35) grew greatly $-R^2=0.6764-$, which roughly overpasses 0.4 points to each group of strategy A – carriers with $\sim <45$ retailers and $\sim >45$ retailers'-. Although carriers do not perfectly homogenize at strategy B $-R^2=1-$, the accumulative number of stops of fleets in a week with the same demand that in strategy A, it fluctuates from 15 to 20. By contrast, in strategy A the carrier who had less stops –car 17 with 37 receivers to attend–, almost doubled those carriers with 20 stops to make at OHD to ULA terminals. These numbers have effective consequences onto service time, where carriers just spent from four to fourteen hours, which is five to eight times less than in strategy A – most of carriers spent around 30 hours and the rest between 50 hours and 60 hours– (see figure 31). As a first approach, it is clear that distributing goods to ULA terminals at OHD, it is adequate for carriers regarding better quality service and cost savings. However, the conclusion of these correlations is that, whether the motive is to keep on board as many carriers as possible, the complexity of tasks has to be reduce to minimum; in other words, horizontal collaborations have to be exceptional. Hence, an optimal fleet would be those located at short-medium far distances from ULA terminals and by doing so, the correlation ought to move from $R^2=0.6764$ to $R^2=1$.

*Overview of results. Carriers' savings by swapping from strategy A (RHD) to strategy B (OHD)
Distances travelled and greenhouse emissions.*

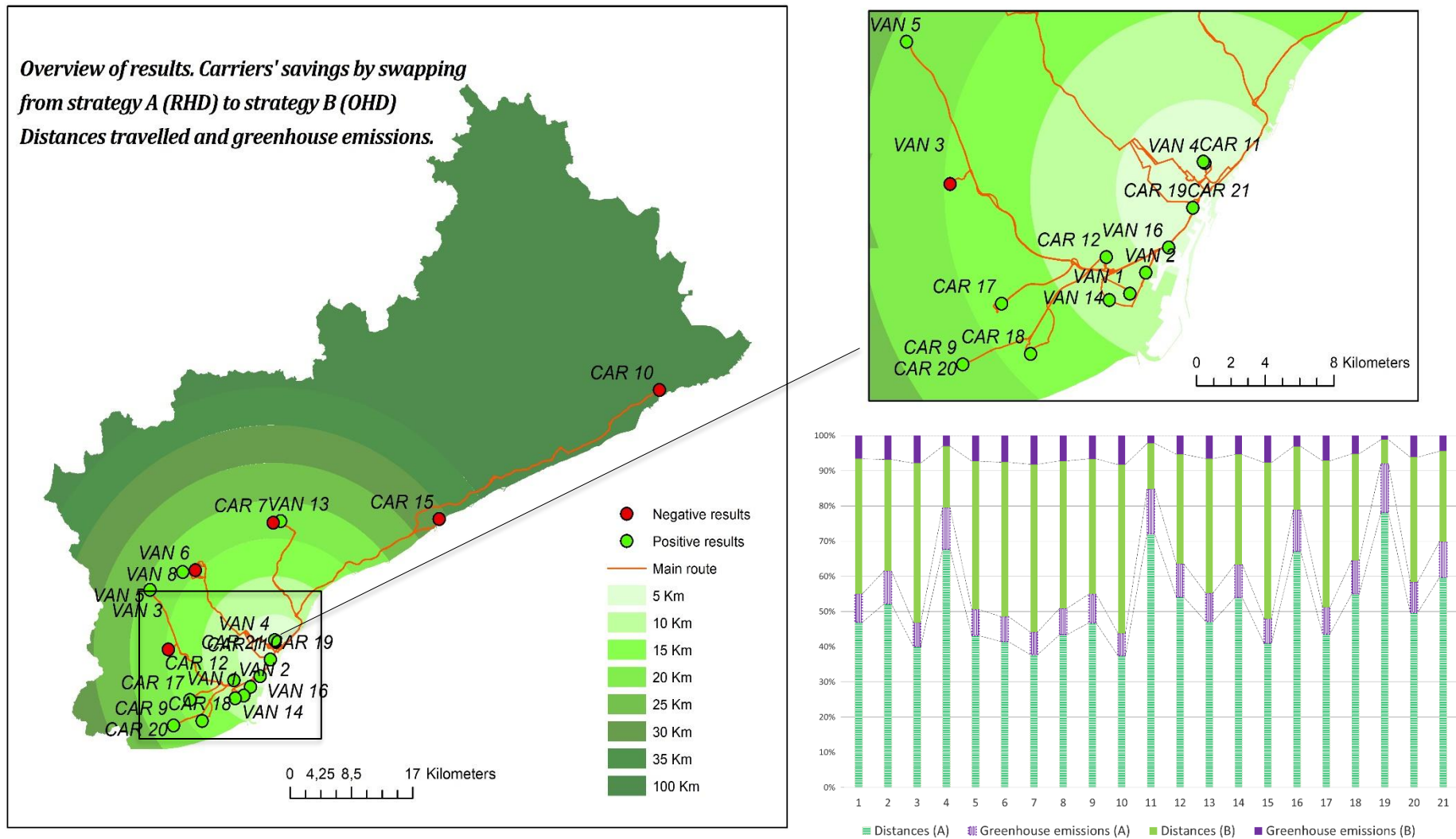


Figure 34. Overview of results. Carriers' saving results through network analyst (New routes).

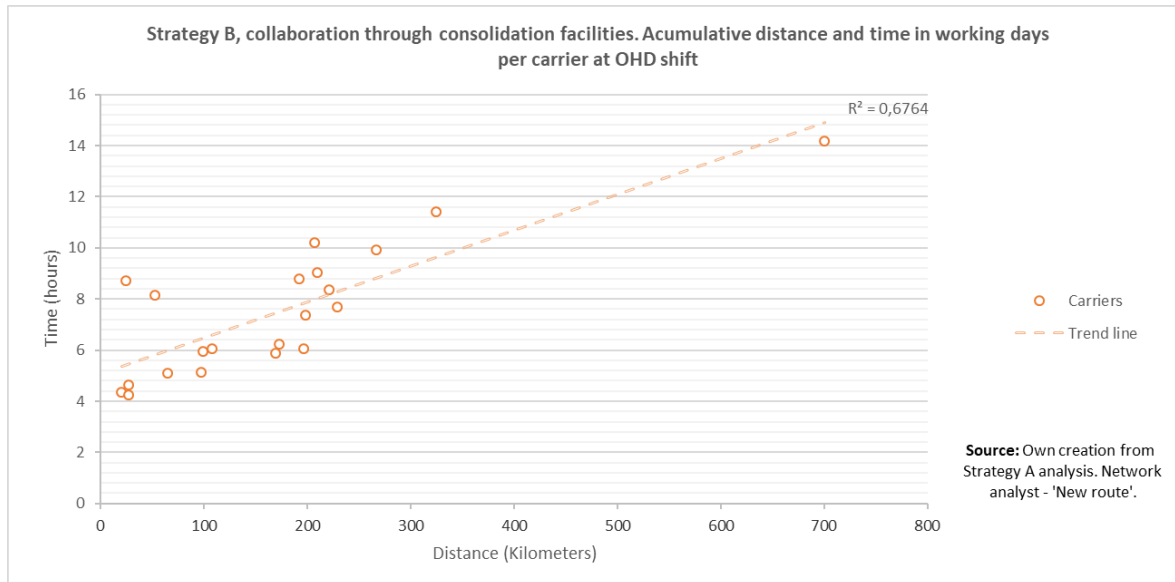


Figure 35. Strategy B, collaboration through consolidation facilities.
Own creation from network analyst model - 'New route'.

Besides, by centralizing freight distribution at last mileage through collaboration, with an optimal number and characteristics of operators –understanding that $R^2=1$ would be ideal–, would enable to extract quality data from carriers' patterns. In fact, these hypotheses seeks to highlights the factors that may unify both players into a common action, that is on finding a way to achieving their outcomes on interests, which in the end will finance all parts. Under the premise of capturing revenues from carriers' cost savings and the municipality making policies to optimize the last-mile distribution, that will result to the robustness within ULA supply chain. However, not only contributions are the only benefactors of the third operator's operability. In addition, there must be an approximate estimation of operational unit costs and service time spent from the eco-friendly operator.

Then, the last modelling regards e-bike performance in the last-mileage at RHD (see [strategy B, RHD ND](#) reference at '10.2. Geodatabase' section) to have all results of strategy B –carriers and e-bikes–. Again, the parameters are estimated through network analyst, using 'new routes' through e-bikes' network datasets. The architecture of this network dataset remains as carriers' at RHD and OHD (see tables 20 and 22) and it is named Ebike_ND. E-bikes' patterns in terms of speed, are set to be; a) a maximum of 7 kilometres driving through *residential, living streets and footway roads*, and b) a maximum of 25 kilometres at the rest of the roads. On the other hand, there is a hierarchy and its prioritisation goes as it follows: 1) *living streets and cycleway*, 2) *primary, secondary and tertiary roads*, 3) *pedestrian*, 4) *residential*, 5) *footway*, 6) *service*, 7) *paths* and 8) *others –steps, trunk_link, trunk, track, motorway_link, motorway and unclassified–*. At first sight –as it has been already mentioned–, the total cost of a fleet of e-bikes during a day will be rather low than carriers' at any shift. Not just on its unit operational costs, but also in its time spent at consolidation facilities and its contribution on the environment by its zero emissions of pollutants. What referrers to delivering shifts and time windows of receivers, e-bikes model has kept the patterns compiled in CENIT's survey to retailers –the same used in strategy A with carriers at RHD–. Despite the fact that probably urban terminals would optimize the line haul distribution from two shifts –morning and afternoon– to one

–morning or afternoon–, Ciutat Vella scenario has kept into two shifts, thus it is assessed whether carriers’ contributions cover –in the worst scenario as more costs are perceived– the last operators’ line haul distribution expenses.

Even so, e-bikes’ model shows substantial differences from carriers’ scenario at each strategy –A and B–. Indeed, it has to take into account that this third party just operates at the last-mile distribution area. At figures 36, results from e-bike model are depicted, where can be noticed by numbers, that both terminals are differentiated by their own market share. For instance, Ortigosa parking facility travelled slightly less distances –120.17 km– than France train facility hub –156.87 km–, doubling the number of retailers to attend in a week. On the contrary, France’s ULA terminal spent roughly 22% less time –almost 10 hours– than Ortigosa’s ULA terminal, which indeed it is denoted due to the number of retailers to be attended. Nonetheless, the difference is not that high considering the number of retailers, since Ortigosa’s terminal dedicates at least 5 minutes per retailer, whilst France’s terminal does approximately 7 minutes per retailer. In other words, Ortigosa’s ULA terminal by doubling the number of retailers to attend just does a 29% less time per retailer than France’s terminal. That can be explained because of the characteristics of location of both terminals and their market share. France’s ULA terminal spent less time in total distributing goods, which it could be because the accessibility to retailers and the fact that this terminal is close to main roads. On the contrary, Ortigosa’s terminal have retailers at short distances but those are located at narrow streets (see figure 28)²⁷.



Figure 36. E-bikes' network analysis.

Last-mile distribution (Strategy B, E-bikes)		France train station hub
Retailers attended		290
Time (hours)		34,99 h
Unit temporal cost (euros)		543,71 €
Total distances (Km)		156,87 Km
Unit distance cost (euros)		2,35 €
Operational cost (euros)		546,06 €
Last-mile distribution (Strategy B, E-bikes)		Ortigosa parking facility
Retailers attended		527
Time (hours)		44,8 h
Unit temporal cost (euros)		696,17 €
Total distances (Km)		120,17 Km
Unit distance cost (euros)		1,80 €
Operational cost (euros)		697,97 €
Last-mile distribution (Strategy B, E-bikes)		Total
Retailers attended		817
Time (hours)		79,79 h
Unit temporal cost (euros)		1.239,88 €
Total distances (Km)		277,04 Km
Unit distance cost (euros)		4,15 €
Operational cost (euros)		1.244,03 €

Table 24. E-bikes' operational costs in an entirely week.

The total costs counting both terminals showed the resources needed to perform better practices for the environment of neighbourhoods of Ciutat Vella district. These parameters are merged with carriers’ at OHD, thus results of strategy B can be evaluated to answer one of the research sub-questions ‘*To what extent ULA model improves the conventional freight distribution in Ciutat Vella, in terms of operational efficiency, environmental standards and cost optimization*’. Besides, this comparison may show what the opportunities are of the policies proposed to capture

²⁷ The situation, perhaps, would change by engaging potential retailers closer to France’s ULA terminal.

more cost savings for carriers, being their contributions as an alternative way to reach a finance equilibrium among all players.

Such comparison is made at figure 37 (see [Results A-B](#), reference at '10.1. Database' section), which strategy A –carrier performing at RHD– and strategy B –carrier performing at OHD and e-bikes performing at RHD–. The graph indicates the total amount of distances travelled (kilometres), service time (hours) and greenhouse emissions (kilograms) in a week, from Monday to Friday in the case of RHD and from Sunday midnight to Thursday midnight for those operators at OHD. Despite that strategy B counts with two transport modes, so the supply chain augments at the number of tasks to realize –a total of 1209 stops at retailers' placement²⁸–, strategy A –1026 stops– gets over on distances travelled in a whole week, exactly a 14.16% more –640.91 km–. Consequently, by reducing distances travelled, directly reduce emission of pollutants in a week, at least a 20.32% –183 kg in a week–. Again, although the number of stops in strategy B are a 15.14% higher than in strategy A, the total amount of service time is reduced sharply in strategy B by a 41.80% –170 hours–.

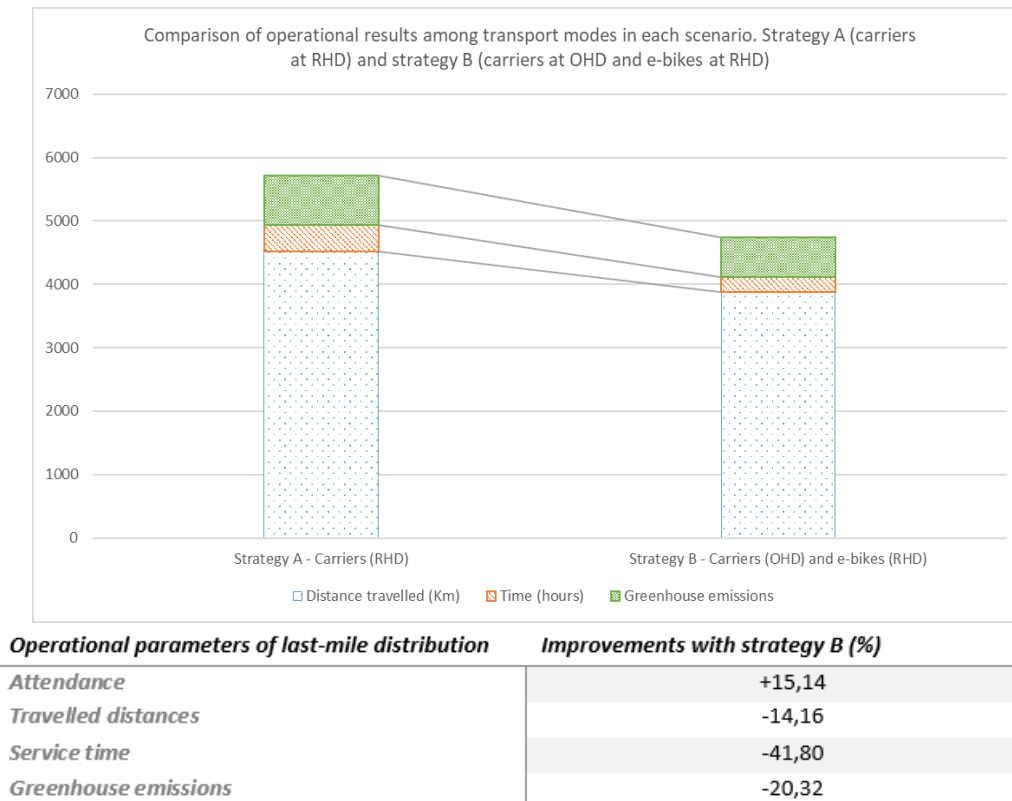


Figure 37. Comparison of operational results among transport modes at strategy A and strategy B. Own creation through network analysis of Ciutat Vella model.

In short, strategy B or 'collaboration through consolidation facilities', results to be beneficial in an operational level, reducing logistic parameters that finally generate costs savings towards carriers, thus reassuring future revenues from carriers' contributions. However, a general budget has to be estimated from the model that have been created. In the following section, costs savings and cost of terminals are determined.

²⁸ Strategy B: The total of stops from carriers at OHD is 392 and e-bikes at RHD 817 stops.

8.2. Operational cost savings generated, carriers' contribution and infrastructural expenses estimation

In the previous section, main operative parameters –such as distances, time, retailers attended and greenhouse emissions– were compared between strategies, obtaining fruitful outcomes balancing in favour of strategy B. However, the strategy must be financially feasible, thus improvements within the model can last in the long term. As raised within the DAP model 'c) *Cost sharing contribution*' policy, contribution flows are guaranteed as a duty by joining the ULA supply chain. Moreover, 'b) *OHD distribution to ULA & horizontal collaboration*' policy has helped on achieving an economic compensation model between freight operators –LDV and e-bikes–. Such policies have raised optimal costs savings, whose collection comes from the comparison of a sustainable strategy B, against an independent strategy A. To sum up, these strategies in form of policies seek to guaranteed the participation of carriers by generating cost savings, to lastly generate contributions that cover the third operators' operational costs.

8.2.1. Operational cost savings

Figure 38 shows a comparative overview of operational expenses on carriers in strategy A – RHD– and in strategy B –OHD– in a non-horizontal collaborative scenario (see [comparison of LDV operational costs](#) reference at '10.1. Database' section). By just looking from an overviewed perspective, it can be noticed that most of the unit operational costs are generated by strategy A. On average, the influence of that last strategy doubles its counterpart –being 69.45%–, whilst strategy B just generates a 30.55% of operational costs. As it was expected, vehicles corresponding to van 3 and car 10, contemplate less changes on operational costs because of travelled distances, which finally contributes to dedicate more time on delivering, and adding the fact that both carriers attend accumulatively more retailers than any other carrier does in strategy B (see table 23). Furthermore, surprisingly van 5, car 17 and car 18 surround a 40% of the total cost savings (see figure 38). In the case of van 5 and car 17, it can be understandable since both attend more or less the same number of retailers in a week, a relation of 4 retailers visited per day –when the carrier with the biggest gap

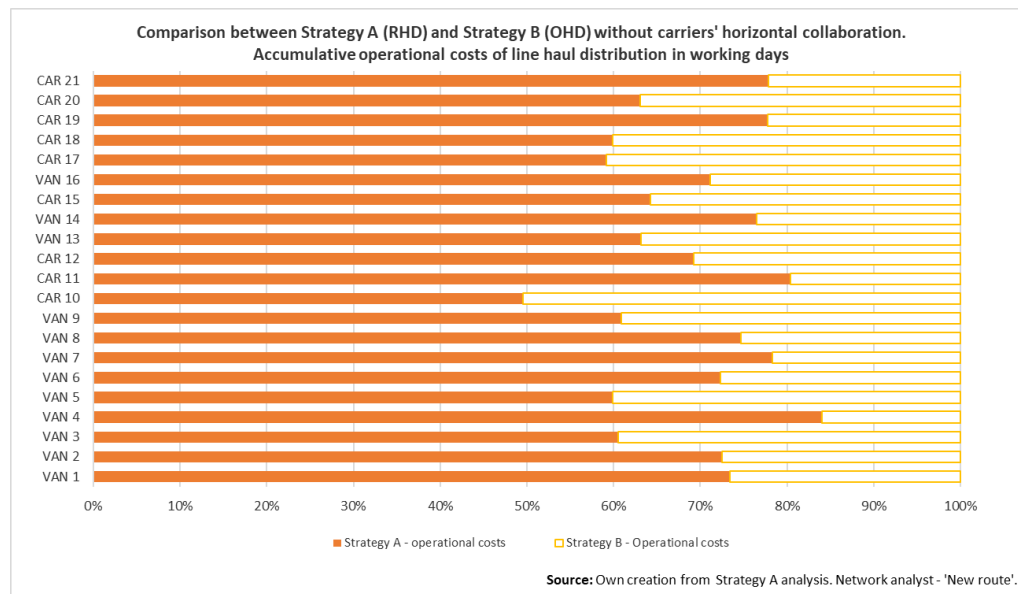


Figure 38. Comparison of strategy A and strategy B in a non-horizontal collaborative scenario among carriers.

has a relation of 10 retailers to attend more per day-. Besides, distances travelled almost remain the same that in strategy A (see table 20). In the case of car 18, equally grows in the three parameters – distances, retailers and time–, however, in comparison with other carriers included in the model, it is the second on the queue in means of service time improvements (see table 20).

Even seeing that cost savings might be substantially appealing for a great number of these carriers, it is expected to generate more cost savings through ‘b) ...horizontal collaboration approach’ policy (see table 4 and comparison of LDV operational costs reference at ‘10.1. Database’ section). As seen at figure 39, some carriers have experienced to generate more cost savings. Principally those that made more distances –van 5, van 9, car 10, van 13, car 17 and car 20– and therefore, more greenhouse emissions, they are compromised to deliver their freight to the closest carrier that have enough capacity to carry that extra load in a certain day. Besides, the criterion for such collaboration is that, these potential proxies should be those that, in a non-horizontal collaborative scenario, would have visited the same terminals as the one who is in need to perform this policy²⁹. That policy makes distances remain the same for the collaborative carrier and less distances to make for those carriers that are in need to put in practice that policy. Moreover, this policy not only would maintain carriers from far distances by increasing their cost savings, but also, existing the CF manager’s role whose commitment is to control and plan all line haul distributions for those who belong to ULA’s supply chain. Ultimately, this policy brings positive insights what it refers to cost savings for the whole ULA’s fleet, since in that model horizontal collaboration has generated at least 10% more savings –4.208,60 €– than in the non-horizontal collaboration –4.768,01 €– (see figure 39).

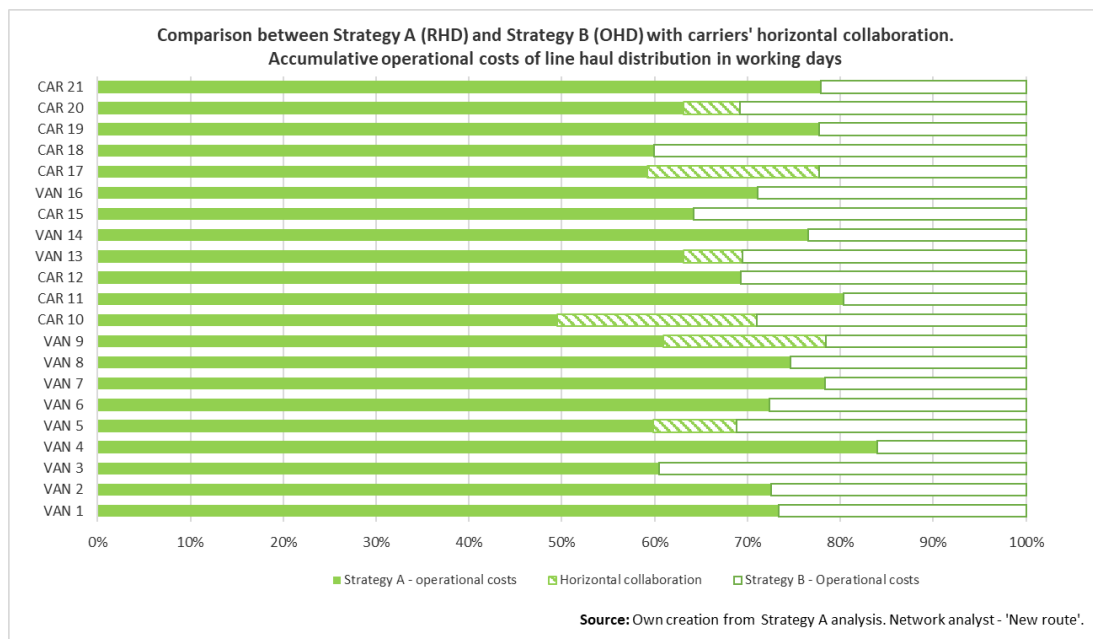


Figure 39. Comparison of strategy A and strategy B in a horizontal collaborative scenario among carriers.

²⁹ For instance, a carrier has to deliver to ULA terminal 1 and ULA terminal 2, so the horizontal collaboration would be with the closest collaborator that have to deliver their own goods to these two terminals. Otherwise, making a collaboration to those carriers that just go to one terminal, would generate more distances, greenhouse emissions and less cost savings, thus less contributions.

8.2.2. Carriers' share contribution

Cost savings, as mentioned multiple times, have to be guaranteed as stated by DAP framework (see table 4), which may likely be appealing to engage carriers in the short term. After seeing the proceeding of modelling both strategies with some straight conditions and contexts – different shifts with different operators– cost savings are captured for an entirely week. Table 25 represents an overview of all carriers' operational costs at each strategy, including e-bikes costs. And the horizontal and the non-horizontal collaborations among carriers at OHD. The total sum of strategy A doubles in costs –11133.92 euros– to just the section of carriers at OHD in strategy B with non-horizontal collaboration –4768.01 euros–, and it roughly triples at OHD in strategy B with horizontal collaboration –4208.60 euros–. Operational costs in strategy B with e-bikes at RHD are much low counting both terminals –1244.03 euros–, assuming that the eco-friendly operator willingly acts as an outsourcing within ULA supply chain, thus e-bikes are not counted as a fixed cost within strategy B. At least, swapping from strategy A –carriers at RHD– to strategy B with non-horizontal collaboration –carriers at OHD + e-bikes at RHD–, fruitful savings can be ensured within the model up to a 57.17% of the total amount of the conventional line haul distribution at RHD –5121.89 euros–. However, in perfect horizontal collaborative scenarios among carriers, cost savings reach a 62.20% of the total amount of the conventional line haul distribution at RHD –5681.29 euros.

Continuing that tendency in a longer timeline, savings grow as the time passes and operational costs expectancy from both strategy do as well. For instance, in a month, performing horizontal collaborative scenarios, savings will expand to a 4.5% more –25565.82 euros–, after 6 months a 27% more –153394.94 euros– and finally, in a year a 54% more –306789.88 euros–. The total savings can be impressive, nevertheless, that tendency represents a stationary scenario, where neither potential stakeholders are joining the ULA model nor other that joined stop doing it. In order to estimate precisely, a tendency on expectancy of growth and decrease would be necessary to assess a real progress as a whole in the long term³⁰.

Now that cost savings are estimated at strategy B with non-horizontal and horizontal collaboration, carriers' contribution can be modelled within the ULA supply chain for Ciutat Vella logistics. Their contribution will be accordingly to their influence in the line haul distribution of ULA supply chain, which means that each carrier will contribute based on their activity's stats influence – operational such as distances, time and retailers, cost savings and greenhouse emissions' share– during a week. That is why all parameters are expressed in percentage at table 25. The formula expresses as it follows³¹:

$$Crc = OpSh + CsS + GheS$$

³⁰ For that, more data about all operative carriers would be necessary in order to exploit their prospective within the ULA model. Furthermore, game theory would play as a key element on decision-making when developing stakeholder engagement strategies. These ideas are integrated within '9. Conclusion and next steps'.

³¹ The meaning of the variables are depicted as follows: Crc (carriers contribution), OpSh (operational share), CsS (cost saving share), GheS (greenhouse emission share), D (distance), DsA (distance strategy A), DsB (distance strategy B), T (time), TsA (time strategy A), TsB (time strategy B), R (retailer), RsA (retailer strategy A), RsB (retailer strategy B), OpCsA (operational cost strategy A), OpCsB (operational cost strategy B), GheA (greenhouse emission strategy A), GheB (greenhouse emission strategy B).

Operators	Strategy A (carriers at RHD)	Strategy B (carriers at OHD). Non-horizontal collaboration	Strategy B (carriers at OHD). Horizontal collaboration	Strategy B (e-bikes at RHD)
VAN 1	425,15 €	147,49 €	147,49 €	-
VAN 2	382,03 €	139,07 €	139,07 €	-
VAN 3	431,63 €	274,38 €	274,38 €	-
VAN 4	1.121,38 €	211,83 €	211,83 €	-
VAN 5	474,32 €	311,73 €	242,05 €	-
VAN 6	838,29 €	301,07 €	301,07 €	-
VAN 7	991,58 €	248,91 €	248,91 €	-
VAN 8	822,91 €	263,75 €	263,75 €	-
VAN 9	315,02 €	200,85 €	110,59 €	-
CAR 10	543,64 €	540,56 €	310,00 €	-
CAR 11	469,32 €	108,38 €	108,38 €	-
CAR 12	394,05 €	169,17 €	169,17 €	-
VAN 13	448,92 €	262,15 €	217,05 €	-
VAN 14	577,53 €	174,41 €	174,41 €	-
CAR 15	673,65 €	364,08 €	364,08 €	-
VAN 16	518,22 €	207,18 €	207,18 €	-
CAR 17	269,93 €	188,33 €	102,86 €	-
CAR 18	280,15 €	197,67 €	197,67 €	-
CAR 19	348,82 €	107,66 €	107,66 €	-
CAR 20	387,18 €	231,91 €	193,56 €	-
CAR 21	420,22 €	117,44 €	117,44 €	-
Ortigosa's USA terminal	-		-	697,97 €
France's USA terminal	-		-	546,06 €
Total (each strategy)	11.133,92 €	4.768,01 €	4.208,60 €	1.244,03 €
Total costs strategy B	-	6.012,04 €	5.452,63 €	-
Savings (per week)	-	5.121,89 €	5.681,29 €	-

Table 25. Total line haul distribution savings by shifting to a collaboration through ULA terminals.

$$OpSh = \sum_{21}^i \left(\frac{D_1(DsA - DsB)}{\sum_{21}(D_1, D_2 \dots D_{21})} * 100 + \frac{T_1(TsA - TsB)}{\sum_{21}(T_1, T_2 \dots T_{21})} * 100 + \frac{R_1(RsA - RsB)}{\sum_{21}(R_1, R_2 \dots R_{21})} * 100 \right)$$

$$CsS = \frac{(CsS_1(OpcsA - OpcsB))}{\sum_{21}(CsS_1, CsS_2 \dots CsS_{21})} * 100$$

$$GheS = \frac{(GheS_1(GheA - GheB))}{\sum_{21}(GheS_1, GheS_2 \dots GheS_{21})} * 100$$

Figure 40. Formulas to estimate carriers' share contribution towards e-bikes service.

Although, a more realistic option would be to estimate the share contribution by integrating the number of packages delivered in a whole week, as mentioned previously, the demand was not included in both surveys. Because of that, the formulas shown above are the ones to constitute the share contribution of each carrier from cost savings (see share contribution with horizontal and non-horizontal collaboration reference at '10.1. Database' section), either with non-horizontal collaboration (see table 26) and with horizontal collaboration (see table 27). At both scenarios, their attributes interact –travelled distances, service time and number of retailers– according to their activity within the model, which will influence against carriers' cost savings and contributions. That means, for instance, that if a carrier sees positive outcomes for itself, it may be interested to get involve more customers within the model, which it individually served until now. By doing that, operational share as a whole would increase –distances and service time–, plus cost savings' share and greenhouse emissions savings, which at the end; more contributions would be steered towards the eco-friendly operator. Yet, it can happen the other way around, where carriers unjoin or reduce the number of retailers to serve, so operational shares, cost savings and greenhouse emissions would be affected.

What concerns to greenhouse emissions as an indicator within the model, it works as incentives by deducting their contributions –that may be appealing for carriers–, thus this measure encourages carriers to be more sustainable and indirectly, cleaner and liveable spaces may arise. For instance, van 1 that have swapped to strategy B, made less travelled distances, which is around 21.61 km –representing a 2.35% of the whole ULA's fleet–, thus it contributed by emitting 3.69 kg less of greenhouse emissions –minus 2.32%–. The total sum to contribute towards e-bikes maintenance as a first approach was 17.89%. However, counting the deduction at the end its share contribution will be 15.57%, thus carrier keeps more cost savings. In contrast, van 7 obtained a total sum of share contributions, without counting greenhouse emissions, around a 23.91%. At the end, by doing more kilometres, 5.58% are added, so it ends by contributing a 29.22%.

As a result, in a situation with horizontal collaboration and with non-horizontal collaboration among carriers, at least on average, 85.71% of cost savings are kept for each carrier, whilst a 14.29% of the cost savings are contributions towards the third operator. However, the operational costs that involve the third operator in a week is slightly more that collected by swapping from strategy A to strategy B with non-horizontal collaboration –1143.52 euros < 1244.03 euros–. However, performing in a perfect horizontal collaboration among carriers (see table 27), always schedule by the ULA manager, third operator's expenses are covered by carriers' contribution –125.37 euros > 1244.03 euros–.

Operators	Cost savings	Distance	Time	Retailers	Greenhouse emissions	Distance %	Time %	Retailers %	Operational share (%)	Cost savings %	Ghe %	Total %	Contribution (euros)
VAN 1	277,65	21,61	10,77	47,00	-3,69	2,35	4,10	7,08	13,53	4,36	-2,32	15,57	43,24
VAN 2	242,96	41,82	9,27	34,00	-5,10	4,56	3,67	5,21	13,43	3,82	-3,21	14,04	34,12
VAN 3	157,25	-24,86	6,67	22,00	4,47	-2,71	2,64	3,47	3,41	2,47	2,81	8,68	13,65
VAN 4	909,55	70,66	37,47	37,00	-12,46	7,70	14,84	5,99	28,53	14,29	-7,83	34,99	318,24
VAN 5	162,59	6,18	9,46	24,00	-0,96	0,67	2,63	3,00	6,30	2,55	-0,60	8,26	13,42
VAN 6	537,22	-11,35	21,02	25,00	2,10	-1,24	8,32	4,10	11,19	8,44	1,32	20,95	112,52
VAN 7	742,67	-47,64	28,47	39,00	8,46	-5,19	11,27	6,15	12,24	11,67	5,31	29,22	216,98
VAN 8	559,16	6,89	21,87	28,00	-1,12	0,75	8,66	4,26	13,67	8,78	-0,70	21,75	121,63
VAN 9	114,17	42,76	5,74	27,00	-7,57	4,66	1,74	3,79	10,18	1,79	-4,75	7,22	8,25
CAR 10	3,09	-154,34	5,81	30,00	27,53	-16,81	1,74	3,31	-11,76	0,05	17,29	5,58	0,17
CAR 11	360,94	93,12	13,20	19,00	-16,56	10,14	5,23	2,52	17,89	5,67	-10,40	13,16	47,51
CAR 12	224,88	73,49	8,21	29,00	-13,04	8,01	3,25	5,21	16,46	3,53	-8,19	11,80	26,54
VAN 13	186,77	52,25	9,30	29,00	-8,99	5,69	2,97	4,10	12,76	2,93	-5,65	10,05	18,76
VAN 14	403,11	78,30	15,90	50,00	-13,83	8,53	6,30	8,20	23,03	6,33	-8,69	20,67	83,33
CAR 15	309,57	-25,30	12,85	43,00	4,65	-2,76	5,09	7,57	9,90	4,86	2,92	17,69	54,76
VAN 16	311,04	143,72	11,20	28,00	-25,58	15,66	4,43	3,79	23,88	4,89	-16,07	12,69	39,47
CAR 17	81,60	8,22	4,87	28,00	-1,43	0,90	1,44	3,15	5,49	1,28	-0,90	5,88	4,79
CAR 18	82,48	141,26	2,61	32,00	-24,99	15,39	1,03	5,05	21,47	1,30	-15,70	7,06	5,83
CAR 19	241,16	285,81	8,05	36,00	-50,84	31,14	3,19	5,68	40,00	3,79	-31,94	11,85	28,58
CAR 20	155,27	79,31	7,79	17,00	-14,08	8,64	2,46	2,21	13,30	2,44	-8,85	6,90	10,71
CAR 21	302,78	36,05	12,17	40,00	-6,13	3,93	4,82	6,31	15,06	4,76	-3,85	15,96	48,32
Cumulative total	6365,92	917,95	262,71	664,00	-159,18	100,00	100,00	100,00	300,00	100,00	-100,00	300,00	1143,52

Table 26. Carriers' share contribution with no horizontal collaboration among carriers.

Operators	Cost savings (euros)	Distance	Time	Retailers	Greenhouse emissions	Distance %	Time %	Retailers %	Operational share (%)	Cost savings %	Ghe %	Total %	Contribution (euros)
VAN 1	277,65	21,61	10,77	47,00	-3,69	1,68	3,98	7,20	12,86	4,01	-1,38	15,49	43,01
VAN 2	242,96	41,82	9,27	34,00	-5,10	3,26	3,43	5,21	11,89	3,51	-1,91	13,49	32,78
VAN 3	157,25	-24,86	6,67	22,00	4,47	-1,94	2,47	3,37	3,90	2,27	1,67	7,84	12,33
VAN 4	909,55	70,66	37,47	37,00	-12,46	5,51	13,85	5,67	25,03	13,13	-4,67	33,49	304,65
VAN 5	232,26	32,81	9,30	23,00	-1,82	2,56	3,44	3,52	9,52	3,35	-0,68	12,19	28,32
VAN 6	537,22	-11,35	21,02	25,00	2,10	-0,88	7,77	3,83	10,71	7,76	0,79	19,26	103,46
VAN 7	742,67	-47,64	28,47	39,00	8,46	-3,71	10,53	5,97	12,79	10,72	3,17	26,68	198,12
VAN 8	559,16	6,89	21,87	28,00	-1,12	0,54	8,09	4,29	12,91	8,07	-0,42	20,57	115,00
VAN 9	204,43	118,42	7,34	25,00	-21,04	9,23	2,71	3,83	15,77	2,95	-7,88	10,84	22,17
CAR 10	233,64	-36,66	8,93	27,00	-13,10	-2,86	3,30	4,13	4,58	3,37	-4,90	3,05	7,12
CAR 11	360,94	93,12	13,20	19,00	-16,56	7,26	4,88	2,91	15,05	5,21	-6,20	14,06	50,74
CAR 12	224,88	73,49	8,21	29,00	-13,04	5,73	3,04	4,44	13,20	3,25	-4,88	11,57	26,02
VAN 13	231,87	96,03	8,89	28,00	-15,97	7,48	3,29	4,29	15,06	3,35	-5,98	12,43	28,82
VAN 14	403,11	78,30	15,90	50,00	-13,83	6,10	5,88	7,66	19,64	5,82	-5,18	20,28	81,76
CAR 15	309,57	-25,30	12,85	43,00	4,65	-1,97	4,75	6,58	9,36	4,47	1,74	15,58	48,22
VAN 16	311,04	143,72	11,20	28,00	-25,58	11,20	4,14	4,29	19,63	4,49	-9,58	14,54	45,23
CAR 17	167,07	78,28	8,81	25,00	-41,34	6,10	3,26	3,83	13,19	2,41	-15,48	0,12	0,20
CAR 18	82,48	141,26	2,61	32,00	-24,99	11,01	0,96	4,90	16,87	1,19	-9,36	8,71	7,18
CAR 19	241,16	285,81	8,05	36,00	-50,84	22,28	2,98	5,51	30,76	3,48	-19,04	15,21	36,68
CAR 20	193,62	110,62	7,46	16,00	-20,12	8,62	2,76	2,45	13,83	2,80	-7,53	9,09	17,60
CAR 21	302,78	36,05	12,17	40,00	-6,13	2,81	4,50	6,13	13,44	4,37	-2,30	15,51	46,97
Cumulative total	6925,32	1283,07	270,48	653,00	-267,07	100,00	100,00	100,00	300,00	100,00	-100,00	300,00	1256,37

Table 27. Carriers' share contribution with horizontal collaboration among carriers.

8.3. Findings on Ciutat Vella model

In the second phase of this research, a transition from independent deliveries to a collaboration through urban locker areas (ULA) has been successful. In terms of operability and affordability, the model proposed covers plainly all outcomes of interests of the municipality and the operators – carriers and the eco-friendly operator– and indirectly towards retailers and residents.

From an operational perspective, ULA terminals or smart lockers have been spatially located close to the demand –retailers– and into reasonable distances, where their market share outweighs to potential competitors'. Furthermore, comparing both strategies, it is concluded that strategy B implies to have a centralized system in a local scale –Ciutat Vella district–. In other words, all carriers joining the ULA supply chain majorly keep a homogeneous line haul distribution patterns at OHD, which can be studied in order to rise more tailored strategies to expedite and to make carriers' performance more efficient and optimal. What regards the effectiveness of the policies gathered in the DAP framework, results have shown great gains obtained for carriers by swapping to strategy B, on parameters such as travelled distances, service time and optimization of the costs. In addition, positive pay-offs can be assumed for residents, fulfilling local administration's ambitions likewise. That points to a significant reduction on greenhouse emissions in an entirely week, taking into account that this model just contemplates 3.88% of all retailers in Ciutat Vella district. On the other hand, the affordability of the model is the most relevant aspect, since that concept made fail most of the UCCs pilots. Whilst infrastructural costs are considered to be minimum by deploying two ULA terminals –instead of UCCs–, just receiving small packages and widely assumed by the local administrator, the third operator is completely covered by the contributions from carriers' cost savings through horizontal collaborations.

In short, findings have permitted to identify a key actor for maintaining the model in the long term. Carriers raise as that relevant stakeholder, being the benefactor on preserving financially a more sustainable last-mileage. Nevertheless, results showed that some carriers needed of horizontal collaboration, which can make the line distribution more complex, although thanks to that policy, contributions can finance entirely third operators' total costs. That aspect pointed that, just those carriers at short-mid distances from the case of study would be optimal for the supply chain, seeing positive results in all carriers' parameters. In that sense, the regulatory sphere –local administration– must tailor the DAP framework to endorse carriers' performance, assuring their role within the model and guaranteeing their cost savings, in exchange of contributions and data sharing of their mobility patterns while delivering towards ULA terminals.

CHAPTER 9. CONCLUSION AND FURTHER STEPS

9.1. Conclusions

During this research, issues concerning conventional freight transportation system at last-mileage have been studied to spotlight what the bottlenecks are, and what solutions can be presented. Thanks to a literature introspection, a premise have been assembled from different events, which have had a common denominator. That is, the carelessness of relevant players to seek a solid collaboration among them through consolidation strategies, which potentially would drive to a more efficient and sustainable urban logistics' practices. That is noticed after seeing different examples during this research, which all of them meet into the same conclusion; players seek to have the best individual outcome for themselves in the short term, without having much responsibility within the model. In fact, different scenarios of private domain –carriers– and public domain –local public authorities– have ended up stopping the models. On one hand, carriers resulted to have a low quality service due to a fierce competition, which pushed operators to obtain more market share, thus complexity of supply chains grew. On the other hand, public domain is restricted because of lacking financial resources and the political context. From this point, this research have tried to find an adequate formula to conform a consolidated model, where both stakeholders could fit together through collaboration to keep running the model in the long term. Indeed, such collaborative equilibrium is conspicuous by its complexity, given by a set of identified barriers. For this reason, certain stakeholders and their outcomes of interests are potential to solve these bottlenecks at different stages.

This research concludes that carriers are the stakeholder to start working with, since are the ones who gather a consolidated market share in Ciutat Vella. It is clear that consolidating that demand, it ensures a longer durability of the model. Most of the concerns appear when there is not enough demand to cover financial costs of a more sustainable last-mileage, most likely, because carriers unjoin the supply chain – when outcomes of interest are not achieved–, so dependencies on subsidies may emerge. In that respect, this research have configured a formula where there is an understanding and a compromise between the municipality and carriers. Whilst the municipality's objective is to generate strategies in form of policies –DAP framework–, with the final purpose of generating as much cost savings as possible, carriers' commitment just focuses on contributing through cost savings, whereby are used to cover the eco-friendly's operative costs. This logic have ranked carriers in a relevant position within the supply chain, since those participate in a physical and economical layer. Following that line of thought, seeing that consolidation strategies are not adequately at scenarios of perfect competition, the ambition ought to remain on reaching a perfect collaboration in ULA's supply chain, which is made by optimizing the line haul distribution to keep carriers on board.

In order to go on details, the following research sub-questions and the research question are answered, which shall help to have a better approach and a better understanding of Ciutat Vella model.

Research sub-questions

- 1) *What are those potential engagement strategies to be raised and for whom those might be steered?*

Before going to the comparative analysis, operational strategies were extracted from literature, and thereupon, they were transformed to basic adaptive policies. Those policies implemented within DAP framework, were sharpened and tailored in favour of carriers, thus optimal conditions were thought to reach the best results that matched with carriers' outcomes of interests. Although carriers are the cornerstone of Ciutat Vella model's finance, the policies raised have attended all those key factors and identified barriers, which concern relevant players involved in the last-mile distribution. For this reason, Ciutat Vella model is designed in a way where all the strategies overlay and fit with individual goals of each stakeholder, but at the same time fulfil on making more liveable spaces within neighbourhoods and their surroundings.

The first policy proposed a) *free space location for ULA terminals at parking facilities*, not only made easier line-haul performance to carriers, but it also protects goods from damages and robberies by locating them at secure spaces. Thus, quality service is partly ensured for retailers at OHD –less service time spent–. Moreover, being the municipality as the space facilitator, infrastructural costs have been optimized adequately for the launching phase. That is why ULA or smart lockers are suitable, because of its adequate dimensions for small packages and the budgeting costs that remain low, where Ortigosa parking facility and France train station hub go from 3000 € to 6000 €, as an approximate total cost.

Thereupon, b) *OHD shift to ULA terminals & horizontal collaboration approach*, greatly improve the situation for carriers when performing –operational parameters and emission of pollutants–, but it also generated huge cost savings for all carriers in a week –roughly 7000 €–, above all, those carriers at short –0-10 km– and at mid distances –10-20 km–. During the analysis, some carriers showed that by joining the ULA supply chain travelled more distances punctually, thus greenhouse emissions grew in comparison to independent deliveries. For this reason, horizontal collaboration approach was key to reduce these worrying parameters; enabling to generate a 10% more cost savings to carriers in a week. Nonetheless, this policy is recommended to test it in a situation where the demand is available, thus the relation between the quality services –whether goods can be transported by the collaborator the same day– and generating more cost savings, can be assessed. Moreover, a dynamic scenario with demand data, would be determined if certain carriers at far distance may be optimal to join the supply chain or not.

Finally yet importantly, c) *cost sharing contributions* is the policy where revenues are collected in form of contributions from carriers' cost savings. Being the municipality as the space facilitator and the policy-maker –whose commitment is to endorse carriers by generating cost savings–, carrier has the duty of contributing economically as a condition to join the supply chain. The important thing is that, each share contribution is based on the operational parameter savings and the operational cost savings. Findings showed that, the more market share of each carrier at short-mid distances is integrated within the model, the more cost savings are generated and the more contributions are collected.

As a fact, these three policies have settled the environment of the spatial –ULA facilities location– and the network modelling –the market share attendance, the maximization of market

share and the comparative analysis of line-haul distribution strategies– in the hypothetical case of Ciutat Vella district. Hereafter, the following sub-question to answer gathers all the findings of the model, through three benchmarks:

- 2) *To what extent ULA model improves the conventional freight distribution in Ciutat Vella, in terms of operational efficiency, environmental standards and cost optimization?*

As assessed within the ULA model, results showed that swapping from independent deliveries –strategy A– to collaborations through ULA terminals –strategy B–, have successfully overcome the expectations of the conventional freight transportation system in the scenario of Ciutat Vella district. Locating two ULA terminals at the surroundings of Ciutat Vella district, has been the basis to optimize operational parameters and unit operational costs to carriers at OHD and e-bikes at RHD, since they remained close to retailers but also nearby the main roads that facilitate the entrance for carriers.

After running the model with these two terminals, substantial savings have showed up. Firstly, as expected, during the analysis of the model the attendance rate have grown by a 15.14% in the whole week by adding the OHD shift –carriers– and the RHD shift –e-bikes–, which means that the number of stops slightly grew. Even though the accumulative tasks could be less attractive for carriers when deciding to join the ULA model or not, is stated as a condition of the business model that the process of organizing all the exchanges of goods is under ULA managers’ responsibility. Besides, carriers undergo a significant reduction of their own tasks by swapping from strategy A – 1026 retailers to attend– to strategy B –362 retailers to attend–, more specifically of a 64.71%.

Although, the number of tasks to make by visiting retailers have been extended, distances travelled –14.16 %– and therefore greenhouse emissions –20.32 %–, have been abruptly reduced throughout horizontal collaborations among carriers in strategy B. What refers to service time, which is closely attached to travelled distances, have been reduced a 20.62%. In short, the optimization of the line haul distribution in the last-mile as a whole, not only enables to carry out a sustainable and efficient system, but also in terms of finance, strategy B enables to generate fruitful cost savings for carriers by reducing unitary operational costs either with horizontal collaboration or without horizontal collaboration. In short, it can be said empirically that the collaboration through urban terminals widely fulfil the objectives of the consolidation concept in the last-mileage, thus the ambitions of this research sub-question likewise. Nonetheless, through the analysis of the model, there has been identified certain aspects to consider.

Firstly, according to ‘c) cost sharing contributions policy’, the outcomes of the model – operational efficiency, environmental standards and cost optimization– are linked to the current demand, which will be balance at any change. For instance, in Ciutat Vella model there are twenty-one carriers carrying a hundred nineteen receivers as a whole. However, if three of the carriers that attend twenty retailers would unjoin the supply chain, the model would contemplate less cost savings but also, less travelled distances and therefore, less emission of pollutants. Thereupon, the ULA manager and the municipality would identify that change and consequently the third operators’ activity would be shorten. Then, Ciutat Vella model would remain at equilibrium, instead of being dismantled, which means that it will be mouldable to any change coming in the short term.

Another aspect is what the number of carriers are to be optimally adapted to the model, holding a balance between environmental standards and operational efficiency. Although, in that

model there has not been a special criterion whether a carrier could join the supply chain or not by their locations, a suggestion for future research is highlighted. That is, the importance of including just those carriers at short-mid distances (0-15 km) at the last-mile area, where terminals are located. By doing that, the balance might lean towards a greener model that totally corresponds to the nature of consolidation strategies, but also it would reduce the complexity of the supply chains by doing horizontal collaborations. To sum up, considering these two aspects and, guaranteeing cost savings for carriers thanks to the support from municipality, fruitful and remaining outcomes might keep the supply chain in motion, based on Ciutat Vella's financing model. Hereby, the research question shall clarify the possibilities of engaging carriers as the facilitators of such consolidation demand in the short and the long term.

1) To what extent Ciutat Vella's business model, could be appealing to engage and to keep on board those operators in the last-mile distribution?

According to Ciutat Vella's business model, the objective is to maintain the supply chain in the long term, and to reach that ambition, retailers need to be consolidated within the model. Thus, in order to get that potential demand, local authorities must put efforts on gaining the reliability of carriers, who are the ones that maintain influences widely in their own market share.

Hence, the particularity of those carriers included in the analysis, is that they hypothetically do not form part of a solid supply chain, being less likely to have resources, knowledge and time to conform solid collaborations to other operators at the last-mile distribution. Besides, as it has been identified through literature, majorly carriers still perform independent deliveries in urban areas. However, there are some cases where carriers put in practice horizontal collaborations and OHD shifts, which is likely that they belong to solid supply chains. In that sense, the municipality has the duty to improve the efficiency of urban logistics, as its externalities affects over its citizens and visitors. Furthermore, the municipality has more financial resources –although limited– and knowledge on the traffic behaviour in a city than small carriers. For this reason, the municipality has to act as the facilitator of those strategies that small carriers are not capable of doing by themselves –locating ULA terminals at parking facilities and being the policy-maker endorsing small carriers–. Nonetheless, that does not mean that the model might fall into a monopolistic scenario, but there would be a collaboration between private parties and the public administration to achieve their own outcomes of interests. In all, Ciutat Vella model acts as a starting point where its positive effects were shown in order to, firstly, engage potential early adopters –carriers– in the short term, and secondly, maintaining them in the long term thanks to adaptive policies –DAP framework–.

In fact, other relevant stakeholders might influence for different concerns within the model however, this research has tackled financial issues, that according to literature and cases of study, are the most likely to stop running consolidation strategies –such as UCCs–. In that sense, the third operator entirely depends on carriers' participation, since cost savings will enable to cover last-mile distribution's costs. For this reason, e-bikes' workload is completely tied to the current demand, than means, that unitary operational costs are subjected to carriers' participation on the model. According to this model, the local authority needs to encourage eco-friendly operators to join the supply chain, thus fixed costs are avoided –purchasing e-bikes– in exchange of giving presence to them in the last-

mileage, as the responsible of distributing goods –small packages– in a densified area as Ciutat Vella district.

Because carriers and e-bikes operators keep running other activities at different locations, the presence of the relationship between the ULA manager and the municipality is key. Firstly, because having a continuous feedback of ULA terminals' activities, whose purpose is to have an exhaustive control of the last-mile distribution area, and therefore, reformulate adaptive policies if needed, always supporting carriers. Secondly, by delegating the inbound and the outbound planning tasks to the ULA manager, it easier operational task towards carriers and eco-friendly operators. Thus, whilst carriers generates cost savings and e-bikes gain influence on the last-mile, they only concern is just about meeting quality service standards, regarding service time and the conditions of goods.

Then, it is denoted that there are many ways to configure consolidation models, whose successfulness relies on the territory conditions and the approaches made by academia in urban logistics. Nonetheless, due to the presence of financial barriers and the unwillingness of conventional stakeholders, the municipality as the administrative body of a city, must configure consolidation models according to their territorial characteristics. Not only in terms of operability and financially, but also including a regulatory phase, where policies are based on a deep analysis to engage potential stakeholders within the supply chain. In the case of this research, Ciutat Vella model was constructed under the premise that carriers are the key to financially run the ULA supply chain through contributions, since there have been unsuccessful approaches towards retailers that culturally were not acceptable, as it is the example of the SMILE pilot. Even so, the contribution of this research is to usher inclusive strategies to conform bidirectional collaborations –top-down and bottom-up approach–. Without the approach of conventional operators within consolidation models, sustainability in urban logistics is far to be reached.

As a personal thought, this research have been challenging but motivating at the same time, being able to analyse and to understand the chaotic nature of urban logistics, constructing a tailored framework for stakeholders and modelling through GIS, which at the end resulted to achieve the stated hypothesis. Mixing theoretical approaches –policy-making– and analytical approaches –GIS–, a basic model raised and by that, showed that deeper thoughts that may spotlight innovative formulas, where urban terminals might operate successfully through collaboration among parties of any kind. Finally yet importantly, because of different difficulties during this research –mainly concerning data–, there has not been possible to have a more precise model including a real demand, but enough to establish a starting point for further research. That is the reason why, further steps and recommendations are compiled in the next and final sub-chapter.

9.2. Further steps

During the analysis and after fulfilling the main purposes of this research, some aspects prompted as further steps to take as a follow-up of the line of thought of the research, which might make a more robust consolidation model. Firstly, it concerns to all operators and that is, to calibrate and to make more precise the Ciutat Vella model through real time traffic data and real demand of retailers. In the case of traffic data, more cost savings would be collected because of traffic jams, which would make wider the gap between strategy A –carriers at RHD– and strategy B –carriers at OHD–. Furthermore, thanks to this traffic data e-bikes' operational parameters –travelled distances and service time– and

operational costs would be affected positively, since the line haul distribution would be designed to reach destinations in the shortest timeframe. Secondly, having a real demand data in a week would enable to optimize the availability of vehicles on the last-mile distribution, always maintaining a balance between that aspect and quality service standards.

Another aspect that need to be integrated within the model, it is the further development of policies regarding retailers and restrictions on a specific cluster of carriers. In the case of retailers, it regards to seek specific conditions to join the supply chain as potential demand, being at reasonable near distances to the already consolidated demand within the ULA supply chain. Besides, there must be room to a compromise between the municipality and the retailers already integrated in the model, whose motivation must be steered towards the robustness of the network of collaborators in the supply chain, and that means, capture new potential retailers that may join. What refers to restrictions, it focuses on those carriers that deliver small packages at RHD in Ciutat Vella district, which do not collaborate to make more liveable spaces, unless they deliver at full capacity. These restrictions are linked to inappropriate behaviours from carriers, where local authorities spend more resources to punish these actions, which at the end result ineffective. For this reason, developing restrictions towards this public, whilst the municipality supports those carriers joining the Ciutat Vella model, that indirectly may push carriers to join the new supply chain, seeing that their outcomes of interests are likely to be completed.

These additional measures, together with carriers' responds of the proposed DAP framework in this research –including trigger responses–, will render a complete scenario in Ciutat Vella. Under the main assumption developed during the research, the contributions from carriers as a motor on making the last-mile greener, simulations of '*what if*' scenarios or game theory would be helpful on completing the robustness of the study. What is more, once the simulation with these characteristics is settled, serious game simulation sessions have to be conducted, inviting representative experts of each role performing their activities in Ciutat Vella district. Thanks to these approaches, stakeholders could grasp instantly the positive impacts of the strategies developed within the model, without risking anything and undergoing to the worst situations to oversee what, how and why of the trigger responses proposed from local authorities. That fact would help to have open conversations to discuss and to enhance the policy framework, fulfilling the challenging task of the chaotic freight transportation system, which is seeking a real consensus among the counterparts.

CHAPTER 10. BIBLIOGRAPHY

- Ahmad, J., Majid Malik, M. & Shivamallu, D. (2017). Location-Allocation model applied to urban public services: Spatial analyst of fire stations in Mysore urban area Karnataka, Indi. University of Mysore.
- Ajuntament de Barcelona (2013). Estudi de mercat del node de distribució del Passeig de Lluís Companys de la Xarxa d'Espais de Microdistribució (XEM) de Mercaderies de Barcelona. Pp. 4.
- Ajuntament de Barcelona (2018). Evolució del trànsit de passatgers, operacions i càrrega. (<http://ajuntament.barcelona.cat/barcelonaeconomia/ca/transports-i-comunicacions/aeroport-passatgers-i-mercaderies/transit-aeroportuari>).
- Ajuntament de Barcelona. (2014). Plan de mobilitat urbana de Barcelona PMU 2013-2018. Síntesi.
- Ajuntament de Barcelona. (2016). Let's fill streets with life, establishing superblocks in Barcelona. Comission for Ecology, Urban Planning and Mobility.
- Ajuntament de Barcelona. (2019). Document resum, PMU de Barcelona 2013-2018.
- Ajuntament de Barcelona. (2019). Informe de resultats del procés participatiu del Pla de Mobilitat Urbana (PMU) 2019-2024. El globus vermell.
- Allen, J., Browne, M., Woodburn, A. & Leonardi, J. (2012). The role of urban consolidation centres in sustainable freight transportation. Department of Transport and Planning, School of Architecture and the Built Environment, University of Westminster. London, UK.
- Allen, J., Browne, M., Woodburn, A. & Leonardi, J. (2012). The role of urban consolidation centres in sustainable freight transport. Department of Transport and Planning, School of Architecture and the Built Environment
- Barcelona Activa, Ajuntament de Barcelona (2017). Perfil socio-econòmic de Ciutat Vella.
- Barcelona turismo (2011). Estadístiques de turisme a Barcelona.
- Bestufs. (2007). Good Practice Guide on Urban Freight Transport. Best Urban Freight Solutions. NEA Transport research and training (the Netherlands) & PTV (Germany).
- Bishop, Z. (2015). Transit-Oriented Development. Benefits and Studies. Ball State University. Virginia Ball Center for Creative Inquiry. May 2015.
- Browne, M., Allen, J., Nemoto, T., Visser, J. (2010a). Light goods vehicles in urban areas. *Procedia - Soc. Behav. Sci.* 2, 5911–5919.
- Browne, M., Sweet, M., Woodburn, A. & Allen, J. (2005). Urban Freight Consolidation Centres final report. Transport Studies Group. University of Westminster.
- Browne, M., Woodburn, A. & Allen, J. (2007). Evaluating the potential for urban consolidation centres. Transport Studies Group, University of Westminster, London. *European Transport\Transporti Europei* n. 35 (2007): 46-63.
- Capwel communications. (2016). Parcel/Pending. The package management solution. 2016 annual report.
- Coldrey, M. (2016). Stadsleveransen: A success story on urban freight logistics. City of Gothenburg. Urban Transport Administration. CIVITAS forum 2016.
- Cruijssen, F., Dullaert, W. & Fleuren, H. 2007c. Horizontal collaboration in transportation: estimating savings of joint route planning under varying market conditions. *International Journal of Physical Distribution and Logistics Management*, 37 (4), 287–304.
- Cruijssen, F., Dullaert, W. & Joro, T. (2010). Freight transportation efficiency through horizontal cooperation in Flanders. *International Journal of Logistics: Research and Applications*.

- Curtis, C. & Olaru, D. (2010). The relevance of traditional town planning concepts for travel minimization. *Planning, Practice & Research*, Vol. 25, No. 1. Pp, 49-75.
- D.Simoni, M., Zuidwijk, R., Wiegman, B. & (Ron) van Duin, J.h.r. (2016). Introducing Competition in Urban Consolidation Centre freight allocation modelling.
- Danielis, R., Rotaris, L. & Marcucci, E. (2010). Urban freight policies and distribution channels. Department of Economics and Statistics, University of Trieste (Italy) & Department of Public Institutions, Economics and Society, University of Roma Tre (Italy). *European Transport* n. 46 (2010): 114-146.
- Deboosere, R., A. El-Geneidy, A. & Levinson, D. (2018). Accessibility-Oriented Development. School of Urban Planning, McGill University, Canada & School of Civil Engineering, University of Sydney, Canada. *Journal of Transport Geography* 70 (2018) 11-20.
- DELPHI (2017). Worldwide Emissions Standards. Passenger Cars and Light Duty.
- Duin, J.h.r., Quak, H. & Muñuru, J. (2010). New challenges for urban consolidation centres: A case study in the Hague. Delft University of Technology, Delft (the Netherlands), TNO Mobility and Logistics, Delft (the Netherlands) & University of Seville, Seville (Spain). The Sixth International Conference on City Logistics.
- E. Nordtømme, M., Y. Bjerkan, K. & B. Sund, A. (2015). Barriers to urban freight policy implementation: The case of urban consolidation center in Oslo. SINTEF Technology and Society, PB 4760 Sluppen, NO-7465 Trondheim, Norway.
- E. Walker, W. & A.W.J. Marchau, V. (2009). Dynamic adaptive transport policies for handling deep uncertainty. Delft University of Technology, Faculty of Technology, Policy and Management, Delft.
- E. Walker, W. & A.W.J. Marchau, V. (2017). Dynamic adaptive policymaking for the sustainable city: The case of automated taxis. Delft University of Technology, Faculty of Technology, Policy and Management, Delft & Radboud University, Nijmegen School of Management, Nijmegen (the Netherlands).
- E. Walker, W., Adnan Rahman, S. & Cave, J. (2001). Adaptive policies, policy analysis, and policy-making. RAND Europe, Newtonweg 1, 2333 CP Leiden, Netherlands.
- ERTRAC. (2011). Sustainable freight system for Europe: Green, safe and efficient corridors. ERTRAC Working group on long distance freight transport.
- Estrada, M. & Magín Campos, J. (2015). Estratègies de distribució de mercaderies per fomentar una mobilitat més sostenible. Escola tècnica superior d'Enginyers de Camins, Canals i Ports de Barcelona. Universitat Politècnica de Catalunya.
- Estrada, M. & Roca-Riu, M. (2017). Stakeholder's profitability of carrier-led consolidation strategies in urban goods distribution. Universitat Politècnica de Catalunya, BarcelonaTECH, Barcelona & ETH Zürich, Zürich, Switzerland. *Transportation Research Part E* 104 (2017) 165-188.
- Estrada, M., Campos-Cacheda, J.M. & Robusté, F. (2017). Night deliveries and carrier-led consolidation strategies to improve urban goods distribution. Department of Civil and Environmental Engineering, Polytechnic University of Catalonia, Barcelona, Catalonia, Spain.
- Euro-CASE. (2001). Freight Logistics and Transport Systems in Europe. Executive Summary.
- European Commission (2017). An overview of the EU Road Transport Market in 2015. DG for Mobility and Transport. Unit C.1 - Road transport. May 2017.
- European Commission, Mobility and Transport. (2018). Transport in the European Union. Current Trends and Issues.
- Eurostat. (2016). Urban Europe. Statistics on cities, towns and suburbs. Statistical books.

- Eurostat. (2019). Summary of anual road freight transport by type of operation and type of transport. Total – Total transport, thoULAnd tonnes. (1000 t, Mio Tkm, Mio Veh-km). http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=road_go_ta_tott&lang=en
- Eurostat. (2019). Summary of anual road freight transport by type of operation and type of transport. Total – Total transport, million vehicle-kilometres (VKM). (1000 t, Mio Tkm, Mio Veh-km). <http://appsso.eurostat.ec.europa.eu/nui/submitViewTableAction.do>
- Faccio, M. & Gamberi, M. (2015). New City Logistics Paradigm: From the “Last Mile” to the “Last 50 Miles” Sustainable Distribution. Department of Management and Engineering, University of Padova, Stradella San Nicola.
- Faugere, L & Montreuil, B. (2016). Hyperconnected city logistics: smart lockers terminals & last mile delivery networks. School of industrial and systems engineering, Georgia Institute of Technology. Physical Internet Center, Georgia Institute of Technology. Supply Chain and Logistics Institute.
- Gibson, B., Rutner, S., and Keller, S., 2002. Shipper-carrier partnership issues, ranking and satisfaction. *International Journal of Physical Distribution and Logistics Management*, 32 (8), 669–681.
- Gobierno de España, Ministerio de Hacienda. (2019). Consulta descriptiva y gráfica de datos catastrales de bien inmueble. Referencia catastral del inmueble (1024715DF3812C0001PI).
- Gobierno de España, Ministerio de Hacienda. (2019). Consulta descriptiva y gráfica de datos catastrales de bien inmueble. Referencia catastral del inmueble (2722102DF3822B0001RE).
- Gogas, M. & Nathanail, E. (2016). Evaluation of Urban Consolidation Centers: A Methodological Framework. University of Thessaly, Traffic Transportation and Logistics Laboratory (TTLog) Pedion Aeros, 38334, Volos, Greece.
- Hezarkhani, B. (2018). Gain-sharing in Urban Consolidation Centers. Nottingham University Business School, University of Nottingham.
- Holguín-Veras, J., Amaya-Leal, J., Wojtowicz, J., Jaller, M., González-Calderón, C., Sánchez-Díaz, I. & Wang, X (Rensselaer Polytechnic Institute, Troy, NY). G. Haake, D. & S. Rhodes, S. (Smith, CDM, Columbus, OH). Darville Hodge, S. (New York Department of Transportation, New York, NY). J. Frazier, R., K. Nick, M., Dack, J. & Casinelli, L. (HDR, New York, NY). Browne, M. (London, United Kingdom). (2015). Improving Freight System Performance in Metropolitan Areas: a Planning Guide.
- Holguín-Veras, J., Encarnación, T. González-Calderón C. A., Winebrake, J., Wang, C., Kyle, S., Herazo-Padilla, N., Kalahasthi, L., Adarme, W., Cantillo, V., Yoshizaki, H. & Garrido, R. (2016). Direct impacts of off-hour deliveries on urban freight emissions.
- Idescat (2018). Establiments hotelers. Grau d’ocupació. Per marques turístiques i categories. (<https://www.idescat.cat/indicadors/?id=anuals&n=10521>).
- Islam, S. (2017). Empty truck trips problema at container terminals: A review of causes, benefits, constraints and solution approaches. University of Auckland.
- Jittrapirom, P., Meurs, H., van der Heijden, R. & Marchau, V. (2018). Dynamic Adaptive Policymaking for implementing Mobility As a Service (MaaS). Nijmegen School of Management. Radboud University. Nijmegen, the Netherlands.
- Kaynak, E., Tatoglu, E. & Kula, V. (2005). An analysis of the factors affecting the adoption of electronic commerce by SMEs. Evidence from an emerging market. School of Business Administration, Pennsylvania State University at Harrisburg, Middletown, Pennsylvania, ULA. Faculty of Business Administration, Bahcesehir University, Besiktas, Istanbul, Turkey & Faculty of Economics and Administrative Science, Afyon Kocatepe University, Afyon, Turkey.

- Koning, M., Conwar, A. & Conway, A. & Koning, M. (2014). Biking for goods is good: an assessment of CO2 savings in Paris. MetroFreight Center of Excellence. Project number: 14-3.2b. Marne-la-Vallée, France.
- Kopp, S., et al. (2001). Using ArcGIS Spatial Analyst. ArcGIS 9. Environmental System Research Institute (ESRI).
- Lebeau, P. (2016). Towards the electrification of a city logistics?. Vrije Universiteit, Brussels.
- Leise Kelli de, O., Nadja Glheuca da S. D., Vagner de, A.C., Waldemiro de A.P.N. & Leite Guerra, A. (2012). Adoption assessment by carrier and retailers to use an urban consolidation center - A case study in Brazil. Federal University of Minas Gerais. Federal University of Ceará. The Seventh International Conference on City Logistics.
- Marchau, V., E. Walker, W., & van Wee, G. (2009). Dynamic adaptive transport policies for handling deep uncertainty. Faculty of Technology, Policy and Management, Delft University of Technology.
- Matyas, M. & Kamargianni, M. (2018). Exploring Individual Preferences for Mobility as a Service Plans: A Mixed Methods Approach. University College London.
- May, A.D., Kelly, C. and Shepherd, S. (2010). The principles of integration in urban transport strategies. Institute for Transport Studies, University of Leeds, Sheffield & York (England). White Rose University Consortium (pp. 5).
- McKinnon, A. (2010). European Freight Transport Statistics: Limitations, Misinterpretations and Aspirations. Logistic Research Centre & Heriot-Watt University. Report prepared for the 15th ACEA scientific advisory group meeting. Brussels, 8th September, 2010.
- Mohajeri, N. Gudmundsson, A. & Louis Scartezzini, J. (2015). Expansion and densification of cities: linking urban form to urban ecology. Department of Earth Sciences, Queen's Building, Roya Holloway University of London.
- Moschovou, T. & Tyrinopoulos, Y. (2018). Exploring the effects of economic crisis in road transport: The case of Greece. National Technical University of Athens, Department of Transport, Greece. University of West Attica, Department of Civil Engineering, Greece.
- Navarro, C., Roca-Riu, M., Furió, S. & Estrada, M. (2015). Designing new models for energy efficiency in urban freight transport for smart cities and its application to the Spanish case. Fundación Valenciaport, Valencia, Spain. Centro de Innovación del Transporte, Barcelona, Spain.
- NRCD. (2017). The Paris Agreement on climate change. Issue Brief.
- Nuzzolo, A., Comi, A., Ibeas, A. & L. Moura, J. (2016). Urban freight transport and city logistics policies: Indications from Rome, Barcelona and Santander. International Journal of Sustainable Transportation.
- OECD (2011). Moving Freight with Better Trucks. Greenhouse gas emissions. International transport forum. Pp.152-155.
- Olson, J. & Woxenius, J. (2012). Location of freight consolidation centres serving the city and its surroundings. Department of Human and Economic Geography, University of Gothenburg (Sweden) & Department of Business Administration, University of Gothenburg (Sweden). The Seventh International Conference on City Logistics.
- P. Deflorio, F., Gonzalez-Feliu, J., Perboli, G. & Tadei, R. (2013). Transportation cost estimation in freight distribution services with time windows: application to an Italian urban area. The Sixth International Conference on City Logistics. Puerto Vallarta, Mexico.

- Papa, E. & Bertolini, L. (2015). Accessibility and Transit-Oriented Development in European metropolitan areas. Department of Human Geography, Planning and International Development AISSR, University of Amsterdam.
- Regional Plan Association & Volvo Research & Educational Foundations (2016). Why goods movement matters. Strategies for moving goods in metropolitan areas.
- Renne, J. (2016). Transit Oriented-Development and ports: A national analysis in the United States. The Journal of Transport and Land Use. Vol. 11, No. 1 [2018] pp. 297-304.
- Roca-Riu, M. & Estrada, M. (2012). An evaluation of urban consolidation centers through logistic systems analysis in circumstances where companies have equal market shares. Center for Innovation in Transport (CENIT). Barcelona, Spain.
- Roca-Riu, M., Estrada, M. & Fernández, E. (2016). An evaluation of urban consolidation centers through continuous analysis with non-equal market share companies. The 9th International Conference on City Logistics, Tenerife, Canary Islands (Spain), 17-19 June, 2015. Center for Innovation in Transport, Barcelona-Tech (UPC), Spain & Department of Statistics and Operations Research, Barcelona-Tech (UPC), Spain.
- RPA & VREF. (2016). Why Goods Movement Matters. Strategies for moving goods in metropolitan areas.
- Russo, F. and Comi, A. (2018). From city logistics theories to city logistics planning. City Logistics 3 – towards sustainability and liveable cities, Taniguchi E. and Thompson, R.G. (eds), ISTE Ltd, John Wiley and sons, London, UK, pp. 329-348. ISBN: 978-1-78630-207-6
- Russo, F., Comi, A., 2012. City Characteristics and Urban Goods Movements: A Way to Environmental Transportation System in a Sustainable City. Procedia - Soc. Behav. Sci. 39, 61–73.
- Savelsbergh, M. & Van Woensel, T. (2016). City Logistics: Challenges and Opportunities. H. Milton Stewart School of Industrial & Systems Engineering, Georgia Institute of Technology, U.S.A. & School of Industrial Engineering, Eindhoven University of Technology, The Netherlands.
- Suárez Falcón, H., Verano Tacoronte, D. & Sosa Cabrera, S. (2015). El transporte público urbano y las políticas municipales de gestión: Una reflexión a la luz de la situación en España. Criterio Libre, 13 (22), 201-224. ISSN 1900-0642.
- Transport intelligence (2017). European Road Freight Transport 2017.
- UNDP/UNFPA, UNICEF & WFP. (2009). Agenda Item 1: Population Growth and Rapid Urbanization: Food Insecurity on the Rise in Urban Settings. 23 and 26 January 2009. New York.
- Van Audenhove, F-J., de Jongh, S. & Durance, M. (2015). Urban logistics. How to unlock value from last mile delivery for cities, transport and retailers. Arthur D Little FUM.
- Van Heeswijk, W.J.A., Larsen, R. & Larsen, A. 2017. An urban consolidation center in the city of Copenhagen: a simulation study. Beta, Research School for Operations Management and Logistics. Eindhoven, the Netherlands.
- Van Winden, W. & van den Buuse, D. (2017). Smart city pilot projects: Exploring the dimensions and conditions of scaling up. Journal of Urban Technology.
- Walker, W. E. (2000). Policy analysis: a systematic approach to supporting policymaking in the public sector. Journal of Multi-Criteria Decision Analysis, 9(1-3), 11–27.

11. DATABASES & GEODATABASES DICTIONARY

In this chapter all the databases -excel files- and geodatabases -shapefiles and mpks- are compiled to whom it may be interested to go deeper in Ciutat Vella model, from locating ULA terminals –spatial analyst- to ULA freight network –network analyst-. Besides, all data to render all the environment, results from strategy A and strategy B, and the comparison analysis are stored within the data attached to this final report. This data shall help through its visualization to grasp this research.

11.1. Databases

- Typology of retailers: ULA_locations.xls/Typology_retailers.
- Drivers surveyed: E4085_TRANSPORTISTES-CONDUCTORS.
- Retailers table: E4085_DEMANDA.
- IPC: ULA_locations.xls/IPC & Neigh_potential_demand/IPC_index.
- Smart lockers: ULA_network.xls/Smart lockers.
- Schedule carriers' delivery: ULA_networks.xls/Schedule_carriers_delivery.
- Results A-B: ULA_network.xls/Results A-B/Savings swappin from A to B.
- Comparison of LDV operational costs: ULA_network.xls/Results A-B/Strategy B – Night deliveries (OHD) to ULA terminals.
- Share contribution with horizontal and non-horizontal collaboration: ULA_network.xls/Results A-B/Savings swapping from A to B

11.2. Geodatabases

- Spatial Analyst: ULA_locations.mpk.
- Location-allocation: Location_allocation.mpk.
- Strategy A, RHD ND: StrategyA_problem.mpk.
- Strategy B, OHD ND: StrategyB_problem.mpk.

