

UNIVERSITY COLLEGE LONDON
FACULTY OF THE BUILT ENVIRONMENT
BARTLETT SCHOOL OF PLANNING

Urban design and the near future of city logistics
A sustainable placemaking approach

Juan José Víctor Raúl Arrué Rubín de Celis

Being a dissertation submitted to the faculty of The Built Environment as part of the requirements for the award of the MSc Urban Design and City Planning at University College London: I declare that this dissertation is entirely my own work and that ideas, data and images, as well as direct quotations, drawn from elsewhere are identified and referenced.

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Abstract

City logistics regards the transportation of goods and materials in urban settings. While important for the everyday life, traditional logistics systems have entailed negative externalities to cities and the planet. Some of them are traffic congestion, environmental pollution, and degradation of the built environment. In order to confront these problems, Western European cities are testing innovative schemes, transport modes, and types of infrastructure, with sustainability, efficiency, and reduction of operational costs as their paramount objectives. Although the topic has been researched within the fields of engineering and management, there is a void in the knowledge within the field of urban design. Thus, in aiming to open a door for more studies within this area, by adopting a *sustainable placemaking* approach, this research explores how city logistics innovations in Western Europe are related to the built environment and the implications of this on the urban design theory and practice. The analysis reveals some relations and implications. It seems to be a bidirectional relationship between city logistics and the urban morphology. Innovations on city logistics may impact positively or negatively on the perceptual experience, the pursuit of local character and place identity, as well as in the quality of public life and urban aesthetics. Moreover, city logistics innovations challenge some assumptions about what is a proper design. In order to gain more knowledge on the topic, this research identifies the need for some changes in the urban design theory. It also identifies some opportunities for urban designers and proposes a draft of design principles. Finally, this research concludes that cities will have to combine several logistics schemes, transport modes, and types of infrastructure in a way that they will not undermine social usages, damage urban aesthetics, and negatively affect sustainability.

1. Introduction

City logistics plays a role in the way our cities work and evolve. When lorries transport goods from warehouses located in the outskirts to shops located in city centres, when mail carriers deliver parcels, when people unload freight from vehicles on the street to supply offices, city logistics is present. City logistics can be defined as the transportation of goods and materials in urban areas. While essential for the day to day life, city logistics can cause several problems in cities, and thus affect the urban experience and the living conditions.

In a growing urbanised world, city logistics will impact more and more on people and their quality of life (Savelsbergh and Van Woensel, 2016: 2). Current city logistics systems negatively impact on cities, society, and environment. Its main adverse effects are related to the increasing presence of large goods motor vehicles in city centres, which derives on increasing traffic congestion, air pollution, and accidents, amongst other problems (Taniguchi and Thompson, 2008; UN-HABITAT, 2013).

As a reaction to those concerns, and mainly due to its negative impacts on the environment, the European Commission (2011) defined a set of goals to significantly reduced CO₂ emissions associated with city logistics. So European cities are not twiddling their thumbs, on the contrary, several regions and cities have started innovative projects to face the problems associated with the existing city logistics schemes. These new models will be pivotal in the attempts at freeing urban areas from motorised vehicles. In this regard, many European cities are announcing their intentions of banning cars within city centres and large urban areas—Oslo by 2020, Helsinki by 2025, and Hamburg by 2035. Monami, Kooijman and Duchâteau (2008), and Lenz and Riehle (2013) show that there is a vast list of innovative city logistics projects.

Given the above, it seems that several innovations will change the way city logistics works in cities. Will these innovations impact on the built environment? If that, will be these impacts positive or negative? Are city logistics schemes defined by urban shapes and patterns or the other way around? Should all these questions be a concern for the discipline of urban design and its practitioners? Is the current urban design theory suitable to understand this topic? In order to have a first approximation to these questions, this research tries to answer the following question: How are city logistics innovations related to urban design?

Chapter 2 presents a revision of the literature in city logistics innovations within the supranational sphere, and the fields of engineering and management; how the topic has been addressed within the urban design theory and practice; and proposes a theoretical framework to handle the topic within the field of urban design. Chapter 3 defines the research question and objectives. Chapter 4 proposes a methodology and research methods to address the subject of city logistics within the field of urban design, by adopting a *sustainable placemaking* approach. Chapter 5 sets forth the case studies: projects

and proposals concerning city logistics innovations. Chapter 6 investigates the relationship between city logistics innovations and the built environment. Chapter 7 analyses the consequences of city logistics innovations on the urban design theory and practice, and proposes a draft of urban design principles related to city logistics. Finally, Chapter 8 presents the conclusions.

2. City logistics

The theory and research on city logistics take place mostly within the disciplines of engineering and management, with several studies carried out during the last twenty years. Nevertheless, some authors (Lenz and Riehle, 2013; Savelsbergh and Van Woensel, 2016) agree on the need for more research. Supranational bodies and intergovernmental agencies define regulations and discuss paths on the field. A different situation takes place within the territory of urban design, where city logistics has played a minimal role in its theory and practice.

The first section of this chapter reviews the existing literature on city logistics within the supranational sphere and the fields of engineering and management. The second section explores the state of the topic in the urban design theory and practice. The third section presents the main elements of an urban design theoretical framework suitable for the analysis of city logistics.

2.1. City logistics, the supranational level, engineering, and management

As a general definition, city logistics concerns the transportation of goods and materials in urban settings¹. The process involves storage, collection and distribution of a variety of goods and materials. Several terms are used as synonyms of city logistics. Savelsbergh and Van Woensel (2016: 1) and Monami, Kooijman and Duchâteau (2008: 249) identify ‘urban (freight) distribution’, ‘last mile logistics’, ‘urban logistics’, ‘city distribution’, ‘city distribution’, ‘city freight’, and ‘urban goods transport’. Nevertheless, city logistics can evoke a more encompassing field than the other terms, since its emphasis is put on the setting (the city) and the process (logistics).

In the European supranational level, the European Commission defined a set of goals in its ‘White Paper’. Two of them are the following: ‘phase them [‘conventionally-fuelled’ cars] out in cities by 2050; achieve essentially CO2-free city logistics in major urban centres by 2030’ (2011: 9). Accordingly, its programme ‘Horizon 2020’ aims to develop ‘new concepts of freight transport and logistics’ (European Commission, 2016). When it comes to intergovernmental agencies, the United Nations (2013: 57-73) discuss the main issues of city logistics, its environmental, economic, social and institutional challenges, and the existing policies to mitigate its negative impacts.

A significant number of engineering and management studies have been carried out with the purpose of evaluating the costs and efficiency of new systems, explore their operative schemes and new technologies, and analyse their overall characteristics. Based on Monami, Kooijman and Duchâteau

¹ A more detailed explanation of concepts related to city logistics is found in Taniguchi (2014).

(2008), and UN-HABITAT (2013), the main elements of city logistics are the transport chain, the freight modes, the infrastructure, the actors, the operation, and the urban setting. All these elements are interrelated, and each city has a particular combination of them; as a result, each city has a unique logistics system. But logistics is an evolving field. In line with this, Savelsbergh and Van Woensel (2016: 3-6) identify the major contemporary drivers of changes in city logistics: the growth of Internet and e-commerce; the desire for speedy delivery; the sharing economy; and climate change and sustainability.

Depending on its characteristics, city logistics has positive or negative effects on the economy, environment and society, both locally (the city) and globally (the planet). Several problems are originated on the use of lorries for urban distribution (Figure 1 shows one example). According to diverse authors (Van Duin, 1997; Goldman and Gorham, 2006; Monami, Kooijman and Duchâteau, 2008; Taniguchi and Thompson, 2008; Browne, Allen and Leonardi, 2011; Lenz and Riehle, 2013; Ballhorn, 2015; Savelsbergh and Van Woensel, 2016), some of these negative effects are traffic congestion, road collapses and damage to buildings, greenhouse gas and particulate matter emissions, noise pollution, accidents, reduced pedestrian safety, conflicts between street users, logistics sprawl, reduced quality of life, and aesthetic impact on city centres.



Figure 1 Two lorries unloading freight in Rathausmarkt square around the midday, when a significant number of pedestrians use the public space, Hamburg, Germany

Image: author

Following the drivers of change, and due to the negative effects of traditional systems, there is a common concern about the efficiency, reduction of operational costs, and sustainability of city logistics. Thus, new models are being designed and tested, based on new technologies. These new models involve a variety of vehicles², the development of new infrastructure³, the use of transport networks, and technological innovations. Moreover, these innovations use the subsurface, the space adjacent to the surface and the sky. Table 1 groups and summarises several innovations on city logistics, involving schemes, transport modes, and types of infrastructure. It should be noted that most of them are frequently combined in the practice.

Table 1 Innovations on city logistics

Innovations	Description
Cycle logistics	<ul style="list-style-type: none"> • Delivery based on cargo cycles (i.e. bicycles, tricycles and quadricycles built or adapted for the transportation of goods)
Electric vehicles	<ul style="list-style-type: none"> • Electric vehicles (e.g. electric vans and electric cargo road trains) and electric-assisted vehicles (e.g. many cargo cycles)
Other modes	<ul style="list-style-type: none"> • Unmanned aerial delivery (e.g. drones) • Unmanned devices (e.g. robots) • On-demand delivery
Underground distribution systems	<ul style="list-style-type: none"> • Underground distribution rail networks • Underground road networks for freight transportation on conventional or automated guided vehicles • Underground distribution based on pipes and propulsion by magnetic fields or turbines
Infrastructure	<ul style="list-style-type: none"> • Logistics facilities located outside urban areas (e.g. suburban freight depots and some logistics centres) • Logistics facilities located on the edge of cities and within urban areas (e.g. urban consolidation and distribution centres, and some logistics platforms) • Logistics facilities located close or within city centres (e.g. containers, small logistics platforms, and parking spaces for freight unloading) • Physical points for dropping off and picking up items (e.g. packstations and community parcel boxes)

² An analysis of alternative modes is presented in Taniguchi, Thompson and Yamada (2014: 8).

³ Antún (2013) offers a classification of logistics centres and several examples.

2.2. City logistics and urban design

Based on a historical analysis of the field, Carmona et al. (2010: 6-8) identify four traditions in urban design: the *visual-artistic* with goals related to the physical setting and aesthetics; the *social usage* with goals related to people's activities; the *placemaking*, which integrates the goals of the first two traditions; and the *sustainable urbanism* with goals related to sustainability and the mitigation of global consequences. Unfortunately, city logistics has been overlooked or played a marginal role in most of the urban design theory. Nevertheless, it seems that logistics has to do something with how cities are shaped: a relationship between city logistics and the built environment. For instance, according to UN-HABITAT, the urban density, the street layout, and the land-use structure influence city logistics, while city scale may also influence it (2013: 63). In line with this, from an urban design and planning point of view, Clarke (2009: 12) says that 'the way in which people and goods move around urban areas determines their structure and how they function'.

While not an exhaustive revision of all the existing literature in the English language, the analysis of the following recognised publications gives an idea of the status of city logistics within the four urban design traditions. In the book 'The concise townscape', representative of the *visual-artistic* tradition, Cullen (1971: 121) highlights the negative impacts of cars on urban aesthetics. Similarly, in the books 'Life between buildings' (2006) and 'Cities for people' (2010), which are part of the *social usage* tradition, Gehl criticises the car-oriented design policies as opposed to the human scale design and at the expense of social activities. While Cullen poses a general critique to the 'motor-car', without distinguishing the types of motorised engines and their uses, Gehl's critiques are biased to passenger transportation at the expense of other functions (e.g. freight transportation). A not so different situation occurs within the core of The Congress for the New Urbanism, a movement which advocates for *placemaking* (2016). In its iconic publication 'Charter of the new urbanism', Principles 12 (Kulash, 2000) and 22 (Farr, 2000) argue for reducing car dependency, and analyse the traffic problems in American cities; but, once more, they do not address the subject of urban freight distribution on motorised vehicles. In the book 'Public Places Urban Spaces'—a key publication within the *placemaking* tradition—, when describing the capital web, Carmona et al. recognise that deliveries (amongst other urban functions) are required in contemporary developments, and that it has some implications on the design of the physical environment (2010: 239). Nonetheless, nothing additional related to logistics is developed in more depth on the next pages of this publication. Several publications within the *sustainable urbanism* tradition (Jenks and Dempsey, 2005; Low et al., 2005; Farr, 2008; Girardet, 2008; Ritchie and Thomas, 2009) address a variety of issues that are usually overlooked in the previous ones (e.g. waste management, energy production, food production, and stormwater systems). However, only in a few cases they barely address freight distribution, since their primary concern about transportation is the movement of people.

When it comes to the urban design practice, a similar void is found. As an example, the importance of accessibility to goods is recognised in some publications of the Commission for Architecture and the Built Environment (CABE) in the United Kingdom. Nevertheless, the complexity of city logistics is a missing topic amongst them. In its publication ‘Getting the big picture right’, CABE recognises environmental sustainability as a challenge of large scale urban design, and the adverse impacts of flows of goods on the environment (2010: 9). Under its second principle, ‘Facilities and services’, the guide ‘Building for Life 12’ poses the question ‘Does the development provide (or is it close to) community facilities, such as shops, schools, workplaces, parks, play areas, pubs or cafes?’ (CABE, 2015: 5), expounding its concern about how the community accesses to goods and services. Nevertheless, the guide does not address the topic of city logistics. In like manner, in the case of the United States, Project for Public Spaces (2016), an organisation that foster the *placemaking* approach, also emphasises on the need of creating streets for people rather than for cars, but, again, the understanding of transportation is biased to passengers, excluding freight from the analysis.

2.3. How to handle an innovative field within urban design?

The literature review shows that urban design theory and practice seem to be not particularly concerned about city logistics. However, the book ‘Public Places Urban Spaces’ (Carmona et al., 2010) is a theoretical cornerstone for the analysis of urban issues—and thus the relationship between city logistics and the built environment—since it systematises and classifies several topics, theories and studies. The authors identify six dimensions of urban design (see Table 2). In the theoretical framework offered by Carmona et al., these six dimensions pursuit the two main goals of the *placemaking* tradition (i.e. aesthetics and places for people). Although Carmona et al. recognise the limitations of the *placemaking* approach when it comes to addressing sustainability, the authors advocate for a more holistic approach that ‘not require reinventing the wheel’ (2010: 363-365). Consequently, in aiming to reach a more comprehensive understanding of city logistics within the field of urban design, a third cross-cutting goal from the *sustainable urbanism* tradition (i.e. sustainability) is integrated with the main goals of the *placemaking* tradition. The result is a *sustainable placemaking* approach.

Table 2 Dimensions of urban design

Dimensions	Description
Morphological	The configuration and change of physical urban form and space, as well as the spatial patterns of infrastructure and processes of growth and change
Perceptual	The perception and experience of environment and place
Social	The relationship between space and society, or environment and people
Visual	The relationship between the spatial and visual qualities of the built environment, and its visual-aesthetic character
Functional	The way places work and how they can be improved
Temporal	The relationship between time and space, and how the passage of time is experienced in the built environment

Source: Adapted from Carmona et al. (2010)

This approach does not imply a whole new theory; it rather integrates the theoretical concepts of the two traditions mentioned before and complements them with some additional perspectives. Two of them are the following: the importance of analysing the wholeness of the physical urban space, composed of the subsurface, the ground and the elements above the ground; and the need for a more comprehensive view of sustainability. These and other issues will be discussed in more depth in Chapters 4 and 7.

3. Research question and objectives

This research aims to respond the following question: How are city logistics innovations related to urban design? An initial answer can contribute to filling the void in knowledge of city logistics within the field of urban design. In seeking to achieve this, the study is circumscribed to the analysis of innovative schemes, transport modes and types of infrastructure of city logistics. In doing so, a *sustainable placemaking* approach is applied. Other aspects related to city logistics such as operation and management, cost-efficiency, and technological details are taken into account in regards to their relationship with the built environment.

This research defines two objectives framed within the central question. The first of them is addressed in Chapter 6, and the second in Chapter 7. Below are presented:

1. Analyse the way innovative schemes, transport modes, and types of infrastructure of city logistics are related to the built environment of urban areas
2. Analyse the implications of city logistics innovations on the urban design theory and practice

In line with the first objective, schemes, transport modes and types of infrastructure are analysed through key theoretical concepts which correspond to the six dimensions of urban design. In doing so, the three cross-cutting goals of a *sustainable placemaking* approach (i.e. aesthetics, places for people, and sustainability) lead the analysis. The relationship explored is bidirectional: how the built environment influences city logistics, and vice versa.

Concerning the second objective, based on the results of the analysis accomplished for the first objective, the implications of city logistics innovations on the urban design theory and practice are addressed. In doing so, potential changes in the urban design theory and the production and management of urban data are analysed. Additionally, some opportunities for urban designers are identified, and a draft of urban design principles concerning city logistics is proposed.

4. Methodological framework

In order to answer the research question and reach its objectives, this chapter presents the methodology and research methods. In the first section is shown the theoretical approach, based on the theoretical framework of *sustainable placemaking* introduced in Chapter 2. The second section describes the research structure and process. The third section presents the research methods used to collect the data. Finally, in the fourth section, an ethical statement is presented.

4.1. Theoretical approach

In Chapter 2, the theoretical framework of *sustainable placemaking* was defined. As it was mentioned before, this approach pursues three cross-cutting goals (i.e. aesthetics, places for people, and sustainability) and its backbone are the six dimensions of urban design identified by Carmona et al. (see Table 2). It is important to precise three aspects related to the use of these six dimensions in this research. First, a variety of authors and their theories, studies and concepts are distributed and classified by Carmona et al. (2010) according to each dimension. Even though the theoretical concepts of each dimension are useful to analyse the built environment, not all of them are pertinent to the analysis of city logistics. In that sense, only some of them are addressed in this research. Second, despite the fact that Carmona et al. (2010) offers an easy-to-use framework, and covers a wide variety of topics and concepts, some key elements for the analysis of city logistics are missing. Thus, some additional theoretical concepts and themes addressed by the *sustainable urbanism* literature and other theoretical proposals (discussed in Chapter 7) are included in the analysis of each dimension. Third, the analysis of each dimension is framed within the three cross-cutting goals of the *sustainable placemaking* approach.

4.2. Research structure and process

The paper ‘Urban Design: Is there a Distinctive View from the Bicycle?’ written by Forsyth and Krizek (2011) is inspirational for this research. The authors use the dimensions of urban design proposed by Carmona et al. (2010) to investigate the built environment from the point of view of the bicycle usage. In a similar manner, this research analyses several cases of city logistics innovations, through the six dimensions of urban design and their key theoretical concepts, aiming to reach a critical understanding of the relationship between city logistics innovations and the built environment, and the implications of the former on the urban design theory and practice. In doing so, the analysis is based on cases of city logistics innovations carried out during the last twenty years (1996-2016) and within

Western Europe (although few examples are taken from other regions). Figure 2 shows the process of this research.

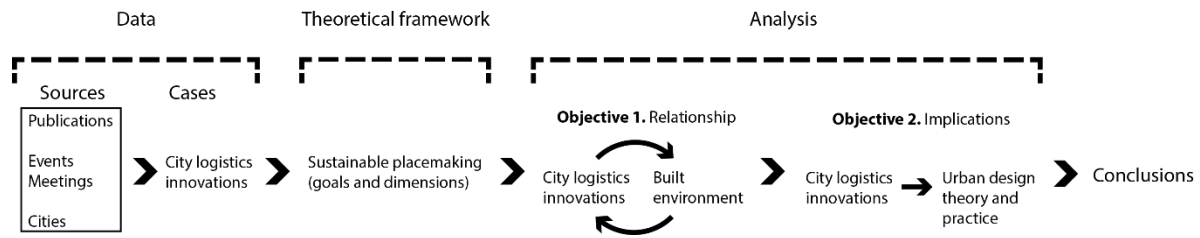


Figure 2 Research process

4.3. Research methods

For the collection of data, three research methods were applied in this research. The first of them is the use of case studies. This research collected data from Western European publications regarding past, ongoing and future projects, and creative proposals of city logistics innovations. These projects and proposals are used as case studies for the analysis in the following chapters and consist of innovative schemes, transport modes and types of infrastructure of city logistics. The publications consulted are both academic publishing (academic journals and books) and non-academic publishing (articles in newspapers and magazines, websites, and a variety of other non-academic sources). These publications are studies, summaries of experiences, theoretical proposals, feasibility assessments, reports, and plans. Chapter 5 introduces all the case studies used in this study (see also Appendix 1).

The analysis of case studies was complemented with site visits, which is the second research method. In some cases, site visits were necessary to broaden the understanding of the case studies and the physical settings where these innovations take place. Therefore, the following cities were visited (where non-participatory observations and visual records were carried out): Barcelona, Berlin, Brühl, Cambridge, Copenhagen, Gothenburg, Hamburg, London, and Stockholm.

Finally, the third research method consists of meetings with specialists and participation in events. The author participated in two meetings: one with Lotte Bech, a specialist in bicycle transportation, in Copenhagen; the other with Gary Armstrong, from Outspoken Delivery, a company of cycle logistics in Cambridge. The author also visited the exhibition ‘Urban Jigsaw’, organised by the Royal Academy of Arts. Finally, the author participated in the workshop ‘Cyclelogistics Empowerment’, organised by the European Cyclists’ Federation. A more detailed description is shown in Appendix 2.

4.4. Ethical statement

In order to illustrate this research, some photos were taken in both public and private spaces. Photos include both public and private infrastructure and vehicles, as well as people. Observations and records were carried out without infringing the private space and minimising any disturbance to people's activities. These photos do not involve any harm to the image of any person or organisation and have been used exclusively to make the analysis and findings of this research clearer. The photos taken in private spaces have been authorised to be used in this research. Some meetings and consultations were carried out with specialists and people involved in the topic of this research. When used, their ideas and statements have been referenced, with a previous consent of the authors. Finally, a Risk Assessment is included in Appendix 3.

5. Innovative city logistics projects and proposals

In the previous chapter were mentioned the temporal (data produced during the last twenty years) and geographical (Western Europe) boundaries of this research. In this chapter, those projects and proposals in the field of city logistics, which are used as case studies, are presented. A further description of them is found in Appendix 1. It is noteworthy that more comprehensive city logistics systems combine several schemes, transportation modes and types of infrastructure (summarised in Table 1). In other words, most of the time they are arranged in a variety of complex combinations in each urban area. As an example, cycle logistics companies may work in partnership with major freight companies that transship goods from larger vehicles (e.g. box lorries) to smaller vehicles (e.g. cargo tricycles), using transshipment spaces and unloading on micro hubs for the final delivery. With that being said, below are presented the cases.

Although underground distribution systems are not new⁴, from the 1990s onwards the discussions about their feasibility have increased. A theoretical proposal for Barcelona, Spain, is offered by Rueda (2007: 22), consisting of an underground servicing and goods distribution system supplying superblocks. Chetwood Architects proposes the Well-Line project in London, the United Kingdom, based on the former infrastructure of the Post Office Railway (Münzner, 2016). Though for servicing purpose (and other urban functions), a complex underground web is located in Helsinki, Finland, with a large network of facilities and tunnels (Helsinki City Planning Department, 2009). Even though this web is not a distribution system, many lessons can be obtained from this experience, relevant for the study of underground distribution systems. During the 1990s, some proposals were prepared for Dutch cities (Van Duin, 1997 and 1998), while recently, in Switzerland, a group of private organisations has announced a project of an underground logistics network connecting several cities nationwide (Ecommerce News, 2016). Finally, Mole Solutions is testing a system comprised of underground pipes for freight distribution in Northampton, United Kingdom (BBC, 2015).

In recent years, several cycle logistics companies have emerged⁵. Lenz and Riehle (2013) identified 38 companies in different European countries. This research uses several cases found in a variety of European cities: projects found in London, the United Kingdom (TfL, 2009); cycle courier messengers in Belgium (Maes and Vanelslander, 2012); the company Outspoken in Cambridge, the United Kingdom (Outspoken Delivery, 2016); and deliveries carried out in Barcelona city centre, Spain.

⁴ Two of them launched during the first half of the 20th century but currently closed are the Chicago Tunnel Company, in Chicago; and the Post Office Railway, in London.

⁵ Similarly to underground distribution systems, cargo cycles are not new. The use of these vehicles was common in Copenhagen several decades before they started to be used as a part of cycle logistics companies.

There is a variety of new vehicles and devices being tested. Many of them are small vehicles electrically assisted or with electricity as the main source. One of them is a small cargo road-train operated in the city centre of Gothenburg, Sweden. The most common vehicle is the electric van, very often part of freight companies. In recent years, some companies are planning, designing and testing a great number of vehicles and devices, as well as alternative schemes, for the last mile delivery. For instance, Amazon and DHL are testing drones while other companies are considering robots (Kobie, 2016).

Finally, logistics infrastructure elements differ greatly amongst them. They are included in any city logistics project, since they support the supply chain process. Some examples considered for this research are containers used in cycle logistics, such as one used by Outspoken. When it comes to drop-off and pick-up locations, two German cities (i.e. Brühl and Berlin) bring examples of packstations being operated by DHL. Seville is also used as an example, where Muñuzuri et al. (2012) propose small locations for unloading activities in its city centre.

6. City logistics and the dimensions of urban design

This chapter is divided into six sections, covering the six dimensions of urban design, following the same order established in the book 'Public Places Urban Spaces' (Carmona et al., 2010). As it was mentioned before, each dimension is comprised of a variety of theoretical concepts useful to analyse how city logistics innovations are related to the built environment. This chapter obeys to the first objective of this research: analyse the bidirectional relationship between city logistics and the built environment of urban areas.

6.1. The morphological dimension

One characteristic of cities is their scale. It seems to be a relationship between the scale of a city (in terms of population) and the feasibility of certain city logistics schemes. According to Lenz and Riehle, '[cycle logistics companies] operate in medium- and large-sized cities' (2013: 42), with at least 100,000 inhabitants. Two examples are Cambridge and Gothenburg. Underground distribution and servicing networks seem to follow a similar pattern. Some projects correspond to cities under 1 million inhabitants but over 100,000: proposals in Dutch cities during the 1990s, and recently a project in Northampton, the United Kingdom. Other cases correspond to larger urban areas over 1 million inhabitants (Barcelona in Spain; and London in The United Kingdom) or even to a regional and national scales (Switzerland). When it comes to schemes based on drones and robots (e.g. projects from DHL, Amazon and Starship Technologies), it is still difficult to predict their physical reach, since they are still being designed or in trial periods. Within the scope of this research, no innovative systems were found in cities under 100,000 inhabitants.

Utility tunnels were located in a hard bedrock below the city of Helsinki close to the ground surface (Helsinki City Planning Department, 2009; Vähäaho, 2014a). This complex web under the city was possible due to the existing physical natural characteristics (a hard bedrock). Even though this network is not an example of underground distribution, can help to imagine how future underground city logistics may transform the natural environment, such as the geomorphology. Whereas the natural ground may be reshaped, resulting in new physical compositions, the natural characteristics of cities can set limits. Hills and slopes can hinder the use of cargo cycles. Differently, it seems that drones do not find physical limitations, since they use the sky. Investigating how urban scales, geomorphology and the preceding setting are related to the feasibility of certain logistics schemes can help to define the most suitable logistics systems for future urban settlements. A question remains about the characteristics of those systems for Western European urban areas under 100,000 inhabitants.

But if the built environment influences the shape of city logistics, the latter may also impact on the former. City logistics can transform the urban morphology by producing changes in land uses and

buildings. For instance, the Well-Line project proposes the use of brownfield sites in London, as well as the creation of green spaces adjacent to the surface, along a six-mile underground goods distribution network (Münzner, 2016). The project also considers the development of residential units and manufacturing locations over the network, as well as warehouses located underground (see Figure 3).



Figure 3 Well-Line project

Source: Royal Institute of British Architects (2016)

Due to their narrow streets and restricted turning radii for vehicles, several Western European city centres create huge challenges to traditional freight distribution vehicles. Central London is an example, where ‘routes do have some very tight turns and height/width restrictions on individual drops’ (TfL, 2009: 34). What is a problem for large vehicles, is an opportunity for the small ones. In that sense, cadastral (street) patterns also play an important role when defining the most convenient logistics vehicles for a specific urban area. In Barcelona, cargo cycles operate within the historic city centre, composed of irregular blocks and a mix of narrow streets and wider avenues; in Gothenburg, a part of cargo cycles, small electric cargo road-trains operate within the historic city centre, part of it characterised by a gridiron street pattern. These cases show that city logistics transport modes can be adaptable to existing street patterns, without the need of physical alterations in street widths, intersections and the overall network. Nevertheless, the use of smaller vehicles can require some minimal changes on buildings and uses, such as warehouses, logistics platforms and parking spaces.

6.2. The perceptual dimension

City logistics can impact negatively on human and other species perception. The recurring presence of lorries on the street can be visually intrusive (see the visual dimension). Several authors (European Commission, 2011; Muñuzuri et al., 2011; Maes and Vanelslander, 2012; Lenz and Riehle, 2013) identify noise as one problem related to cities and freight distribution. While electric vehicles, cargo cycles and underground distribution systems can help in reducing the level of noise pollution in the urban surface, the impact of drones is not yet known. The chosen scheme will have a positive or negative impact on the way humans and other species perceive the sonic environment. Moreover, the location and design characteristics of logistics infrastructure may be crucial in the pursuit of a friendlier sonic environment. Further studies may investigate on to what extent encapsulating the noise associated with transshipment and unloading activities in buildings (e.g. logistics platforms and distribution centres) and inserting them within perimeter blocks could be feasible decisions in high-density urban areas.

Physical elements serving logistics functions can have implications on the pursuit of a place identity. It is not difficult to find some standardised elements in streets which can contribute to exacerbating the loss of local character and identity, as a part of a decaying process towards placelessness. Packstations in Figures 4 and 5 show similarities in forms and colours, no matter they are located in two different German cities. The presence of graffiti in both packstations may manifest a lack of attachment to the elements. Likewise, other physical elements, especially those of larger dimensions (e.g. warehouses, and collection and distribution centres), may have similar effects on the environmental perception. Creating identity, memorable places, and local and visual distinctiveness can be latent functions of these types of logistics infrastructure. For instance, large and medium-sized elements located in compact urban areas can serve as landmarks, while smaller elements (e.g. community parcel boxes and containers) can be designed incorporating the local culture and aesthetics. When strategically designed and located, these latent functions can even reach other benefits for society, such as fostering interactions between neighbours (see next section) and symbolism.



Figure 4 A DHL packstation located in a train station in Brühl, Germany

Image: author



Figure 5 A DHL packstation located next to a market entrance in Berlin, Germany

Image: author

6.3. The social dimension

The relationship between streets and freight vehicles can be beneficial or, on the contrary, detrimental for the public realm. Vehicles such as cargo cycles and electric cargo road-trains seem to be less disruptive to pedestrian flows in comparison with electric vans and box lorries, allowing the recovery of the public space for people in streets. Especially in city centres, loading and unloading activities can impact negatively on the functionality of the city (Rueda, 2007: 22). Figures 6 and 7 show vehicles and devices being operated in narrow streets of Barcelona, Spain, and Gothenburg, Sweden, while pedestrians continue walking, in contrast with Figure 8, where the vehicle—along with parked motorbikes—obstructs the pass of pedestrians in the neighbourhood of Gràcia, Barcelona. In a hypothetical narrow street of 4 m wide, a cargo cycle of 1 m wide would occupy only 25 percent of its width. Similarly, an electric cargo road train of 1.25 m wide would occupy 31 percent of the road. The situation changes when it comes to a box van of 2 m wide and a box lorry of 2.3 m wide; the former would occupy 50 percent of the space, while the latter 58 percent. When considered the unloading activities, the box van and the lorry could make impossible any pedestrian circulation.



Figure 6 On the left, a man pushing a hand trolley; in the centre, a cargo tricycle on Sant Pau street, Barcelona, Spain
Image: author



Figure 7 An electric road-train operating in Kungsgatan Street, Gothenburg, Sweden
Image: author



Figure 8 A box van and parked motorbikes obstructing the pass of pedestrians on a narrow street in Vila de Gràcia Square, Barcelona, Spain
Image: author

Underground distribution services can also play an important role in gaining public spaces for pedestrians and raising the quality of public life. Many authors (Rönkä, Ritola and Rauhala, 1998; Rueda, 2007) emphasise the advantages of freeing the surface from logistic vehicles to gain room for public life. Nevertheless, Van Binsbergen and Bovy (2000: 124) observe that freeing the surface from vans and small lorries may attract traffic if any regulations are applied. Despite all these benefits and

risks, the underground does not only offer opportunities for the location of a distribution network, but it seems to be an important complement to the surface for the creation of public and people-oriented spaces (Rönkä, Ritola and Rauhala, 1998; Durmisevic, 1999). These are the cases of Helsinki and Montreal (Chow, 2002).

The use of certain schemes and types of infrastructure may increase social interactions in the public space. Community parcel boxes located in places where social interactions between neighbours take place may increase the probability that these interactions occur. People going to collect their parcels could come across with neighbours. It does not mean that direct delivery to the final consumers does not have social advantages. For instance, home delivery can be useful for elderly people and, in that sense, successful in achieving equity and social justice in the urban space.

6.4. The visual dimension

Many authors (Chow et al., 2002; Sterling et al. 2012; Vähäaho, 2014b) agree on that using underground spaces for the location of urban infrastructure have positive impacts on the urban aesthetics. Sterling et al. assert that '[f]acilities placed fully underground (once constructed) do not impact the surface aesthetic' (2012: 242). Talking about the Well-Line project in London, Münzner (2016) quotes Laurie Chetwood, who says that with 'green oases across the densest parts of the city the Well-line would bring back a joy which has been lost in the grey of urban design'. Similarly, explaining the case of Helsinki, Vähäaho says that '[t]he city's appearance and image are improved as the number of overhead lines can be reduced.' (2014b: 396). In other words, underground distribution and servicing systems can offer a solution to those not desired logistics elements located over the surface, by relocating them below the ground and recovering the urban surface with greenery and social usages.

The characteristics of the built environment are related to the way people experience beauty (Ipsos MORI, 2010). Thus, some logistics activities can impact in the appreciation of the visual surroundings. While one drone is barely noticed, a significant number of them flying over the city might create visual pollution and disturb other species such as birds. Lorries parked on the street can darken the pavements, create a similar effect to a blank wall, and be perceived as visual barriers, obstructing the appreciation of activities and attributes on frontages (i.e. shapes, details, and patterns). A case in Cambridge can be illustrative. Even though a container was located in an urban space with few pedestrians across the day, according to Armstrong (Appendix 2), some people complained about its characteristics and location (see Figure 9).



Figure 9 Outsspoken container in its new location within the company's depot, Cambridge, the United Kingdom
Image: author

6.5. The functional dimension

City logistics innovations can help to achieve a friendlier environment for people. Cargo cycles can lower the severity of traffic accidents, due to their lower speed and weight when compared with vans and lorries. Underground distribution systems—and probably also drones—could help to reduce the motorised traffic volume on streets. Nevertheless, according to Van Binsbergen and Bovy (2000: 123-124), its impact may be limited to the smallest urban freight transport vehicles, such as vans and small lorries. Although limited, the potential to reduce motorised vehicles on streets (see Figures 10 and 11) goes in the direction towards a people-oriented urban design.



Figure 10 A fence limiting the entrance of logistics vehicles to the city centre, Cambridge, United Kingdom

Image: author



Figure 11 Bollards limiting the entrance of logistics vehicles to the city centre, Cambridge, United Kingdom

Image: author

Designing for cyclists can create challenges for urban designers if considered the variety of cycling vehicles, users and uses. According to Forsyth and Krizek, ‘the cyclist’s view is typically *not* central in even the most comprehensive work on urban design’ (2011: 533). What is even more interesting is that in the few cases in which cyclists are addressed in several disciplines, only those who use their vehicles for transportation or recreation are considered. Therefore, most of the time those users who ride cycles for goods distribution are not taken into account. Do cargo cyclists need the same kind of infrastructures (e.g. cycle tracks and racks) than other cyclists? For instance, cargo cyclists need to achieve higher speeds than those who use bicycles for a promenade. In line with this, Maes and Vanelslander (2012) highlight the importance of being ‘fast’ in bicycle courier services in Belgian cities. While a one-way 1.5 m wide cycle lane can be comfortable for a commuter cyclist, this width could originate problems to cargo cycles. According to Armstrong (Appendix 2), biggest cargo cycles, when using conventional cycle paths, can cause problems to other cyclists in their attempts to overrun, due to their width. The creation of urban infrastructure can be an opportunity to include cargo cycles in their design. For instance, according to Armstrong (Appendix 2), the extension of the guided busway route (which includes a two-way cycle path in one of its sides) to the South-East area of Cambridge, as well as the creation of new connections (such as tunnels or bridges) can favour the use of cargo cycles for goods distribution. From 38 companies identified in Europe, Lenz and Riehle found that ‘[s]ome companies made the particular point that the infrastructure was not suitable for cargo bikes or that there needed to be improvement’ (2013: 43). Given the above, it seems to be that cycle logistics challenges the current practices in the design of cycle-friendly infrastructures and facilities.

When carried out on roads and pavements, loading and unloading activities can impact negatively both on pedestrians and vehicles movements. In order to reduce these undesired and disturbing activities, some possible solutions take into consideration the use of spaces inside buildings, as well as the reduction of the dependency on large vehicles. Underground distribution systems may play an

important role in organising the loading and unloading activities by defining specific locations for them. For instance, Rueda (2007: 22) proposes underground locations for these activities, while the Well-line project proposes new logistics warehouses connected directly to the tunnels network from where drones would distribute goods in London (Royal Academy of Arts, 2016).

Many authors (Rönkä, Ritola and Rauhala, 1998; Durmisevic, 1999; Van Binsbergen and Bovy, 2000; Rueda, 2007) find a relationship between the use of the underground for different urban functions and the creation of more compact cities and higher densities. Durmisevic highlights the advantages of using the subsurface in seeking more compact cities: ‘more efficient use of space; better traffic mobility; more green areas; reduced traffic congestion; better air quality and reduced noise level’ (1999: 235). According to Rönkä, Ritola and Rauhala, when the underground is used effectively, it is possible to achieve ‘a more compact community structure without adversely affecting the quality of the environment’ (1998: 41). Talking about Barcelona, Rueda also conceives the use of underground spaces as a means to achieve compactness (2007: 12). This relationship can be found in the Helsinki Underground Master Plan, which seems to respond to and on-going urban densification process which drives decisions to locate functions in underground places (Helsinki City Planning Department, 2009). In the light of the above, the use of the underground for a variety of urban functions can help to achieve higher densities, accessibility and compactness. In turn, compactness can foster the use of cycle logistics. According to one company of cycle logistics, places geographically compact (such as Soho in London) can favour this scheme (TfL, 2009: 17).

Reducing vehicles and emissions in urban areas can result in more livable cities (Maes and Vanelander, 2012: 417), especially when ‘[in] Europe’s cities, 16% to 50% of traffic emissions are attributable to commercial transport, which is almost exclusively carried out with motor vehicles’ (Lenz and Riehle, 2013: 39). Rönkä, Ritola and Rauhala identify that one advantage of using the underground for different purposes is that ‘reduces local noise pollution and emissions’ (1998: 41). In that sense, the way city logistics and the built environment are planned, designed and managed can positively impact both on the local and the global environments. The former can be improved by reducing particulate matter and noise, the latter by reducing CO₂ emissions and other atmospheric pollutants. Electric vehicles, cargo cycles, and underground distribution systems, as well as the infrastructure associated with them, can play a determining role on this.

6.6. The temporal dimension

Some schemes—as an alternative to the use of large areas and lorries—suggest the use of small (on- and off-street) urban spaces for unloading activities and transshipment to pedestrian-friendly small vehicles and devices (such as cargo cycles and hand trolleys), which are responsible for delivering items

to the final customers. Using Seville as an example, Muñuzuri et al. recommend small locations, called 'mini-hubs', in 'specified sections of curb where delivery vehicles have to stop in order to make final deliveries' (2012: 229). Some questions arise from this logistics strategy: Are these spaces for unloading and transshipment fixed locations in the urban mesh (on- and off-street parking areas)? If does, how many hours a day do they serve for these activities? Is their specific use compatible with other uses? In a 24-hour society, this kind of places could host multiple uses, including those that foster more people interaction and public life. In this sense, urban design can play a central role in the creation of micro spaces for logistics activities compatible with the public life, avoiding dead periods and disruptive activities.

The implementation of city logistics schemes and physical innovations can follow an incremental change. In the morphological dimension was presented the idea of changes in land uses and buildings related to some schemes, such as underground distribution systems. Nevertheless, incremental changes over time are not limited to that scheme. Muñuzuri et al. also introduce the idea of a gradual change in city centres to adapt streets for 'mini-hubs', in this way urban planners would have time to test these places, solve problems or discard the idea (2011: 229). Urban designers can play a role in the way these spaces are produced and, along with planners, test prototypes. Similarly, major changes that involve significant transformations of urban dynamics and patterns (such as the creation of superblocks in Barcelona) could be gradual.

7. City logistics and the urban design theory and practice

Some implications for the urban design theory and practice emerge from the analysis of city logistics innovations, presented in the previous chapter. The first section of this chapter addresses some implications of city logistics on the urban design theory. The second section presents some implications for the urban design practice and a draft proposal of urban design principles concerning city logistics.

7.1. Towards a more comprehensive theoretical framework

7.1.1. *A sustainable placemaking approach*

The *sustainable placemaking* approach proposed in Chapter 2 aims to reach a more holistic perspective than the existing traditions in urban design. Nevertheless, it does not involve a new theory; rather it integrates concepts and discussions produced by several authors and theories, arising several challenges. One of them regards to handle goals and concepts that can be difficult to integrate them into a more comprehensive theory since they can promote conflictive solutions or paradoxes. For instance, a pedestrian-friendly environment, accessible to all (people), can be adverse for other species. The literature on *sustainable urbanism* offers a variety of concepts that can help to refine the *placemaking* approach into a more holistic framework, such as the concepts of biophilia (Farr, 2008: 48-49) and circular metabolism (Girardet, 2008: 123-130)

7.1.2. *A three-dimensional understanding of the urban space*

As it was showed in Chapter 6, innovations on city logistics make use of spaces below the ground. In aiming to understand its implications from an urban design perspective, it is necessary at least two key changes in how cities are conceived and managed. The first of them is a paradigm shift and applies to the way urban planners and designers understand the urban space. According to Zhang, Chen and Yang (2011), the underground space is an important resource, only used when an element is not suitable to locate on the surface. The authors find its explanation in a two-dimensional understanding of the urban space as a ‘flat model’. This conception is consistent with Rueda’s idea of an ‘urbanism on three levels’ (Rueda, 2007). In that sense, changing the paradigm means starting to see the city as a whole three-dimensional space, in which all its parts are important and complementary.

The second change is a consequence of the previous one and concerns how we produce and manage urban data. Using the space below the ground implies producing information according to a three-dimensional urban space. Helsinki is a city going on this track. Vähäaho (2014a) highlights a change in

the Finnish cadastral system, which is moving from a two-dimensional system to a one that manages information about the extent of landownership, both downwards and upwards. Therefore, by adopting a three-dimensional outlook, the territory of urban designers increases in size and complexity, covering not only the space of the surface but also the underground dominion.

7.1.3. Overcoming the bias to movement of people

In Chapter 2 was underscored the trend of many urban design theories to focus on the move of people, disregarding the move of goods—also common in urban planning (UN-HABITAT, 2013: 58). The consequences of this bias have been to conceal the real size of the problems which derive from traditional freight distribution. Therefore, it is essential to recognise the importance of the movement of goods as a shaping agent of cities and integrate the topic into the academic discussions of urban design.

7.1.4. Production of and accessibility to goods and supplies

The emphasis of city logistics lies on the last part of the supply chain, when final customers receive their goods, being transportation a central issue. Thus, innovations in this field are related to making it faster and efficient. Although this research has focused on city logistics, it may be advantageous to address city logistics as a part of a broader topic in order to produce further knowledge in future investigations: the production of and the accessibility to goods and supplies. Under this overarching umbrella, transportation would be an important—but not an overshadowing—element of a more sophisticated process that involves several users and its characteristics (e.g. their needs, and production and consumption patterns), spaces, and societal concerns. Within this topic, the role of cities in securing local food and supplies would emerge. Similarly, the contribution of the physical design to secure the accessibility to goods and supplies, with careful regard to the more vulnerable groups and spaces, gains importance.

7.2. The near future of city logistics and its implications on urban design practice

7.2.1. Opportunities for practitioners

Urban designers should not elude the current discussions on city logistics, due to its effects on the built environment and the aims of urban design. Rather than a passive voice, urban design may have an active role in the way city logistics innovations are designed. In that regard, urban designers should be involved during the design process of city logistics systems, securing that any project in urban areas does not hinder the seeking of the urban design goals. This field opens the door to work in partnership

with other pundits and practitioners from the fields of computational, logistics, civil and transport engineering, as well as management and planning. Similarly, due to its normative dimension, urban designers may contribute to the production of policies and principles related to city logistics in the different levels of government.

7.2.2. *Towards urban design principles regarding city logistics*

Although regulations on city logistics vary amongst the different Western European countries, regions and cities, the following principles can contribute to initiating the debate around the suitability of urban design guidelines and criteria that help practitioners to implement city logistics systems without undermining the aesthetics, social uses and sustainability related to the built environment.

Draft principles:

- The design of spaces for transshipment, loading and unloading located in streets and other public places must secure that they will not (significantly) disturb the movement of pedestrians and vehicles, and social activities.
- When transshipment, loading and unloading take place in streets and other public spaces, it is recommended to design temporary and flexible spaces appropriate for these functions as well as for other social activities, avoiding single uses and dead periods.
- When located in streets and other public spaces, it is recommended to design temporary and flexible spaces for transshipment, loading and unloading, avoiding single uses and dead periods; fostering other activities suitable for s
- Any physical element related to city logistics (such as warehouses, depots and hubs) should respect the local character and sense of place, as well as be integrated with its surroundings in terms of design, location, and connexion with streets and the public realm.
- The production of and accessibility to goods and supplies must be secured when planning and designing new urban settings, prioritising walkable distances for the collection of goods.
- Logistics infrastructure must be compatible with the character of streets, considering their uses, users, and dimensions.

8. Conclusions

This research shows that most of the discussions on city logistics innovations correspond to the fields of engineering and management, while there is a void in the knowledge within the field of urban design. A *sustainable placemaking* approach can help to understand the relationship between the built environment and city logistics. In this line, a critical study of city logistics innovations from an urban design perspective reveals how they are influenced by and impact on the built environment of urban areas. More clarity may be achieved with further research.

While city scales and street patterns seem to influence the planning and design of city logistics systems; the relationship between the urban geomorphology and the city logistics systems seems to be bidirectional: the former sets limits, but the latter modifies the former. Differently, some changes on land uses and buildings seem to be caused by the evolution of city logistics systems. Understanding the relationship between the urban morphology and the feasibility of certain city logistics innovations may improve the discussions about which logistics elements are better for certain urban areas and which not, as well as the best combinations of them.

Innovations on city logistics may impact positively or negatively on the perceptual experience of humans and other species. Logistics infrastructure could play a role in creating place identity, memorable places, and distinctiveness. Similarly, many physical elements of city logistics could contribute to the strengthening of the local character. Contrary, carelessness in the design of city logistics physical elements may trigger decaying processes towards the loss of attachment, distinctiveness and identity.

Some city logistics schemes can be less disruptive to social interaction and the public life. While underground distribution systems can reduce the presence of disruptive freight vehicles in streets, the use of cargo cycles and electric cargo road-trains may reduce conflicts with pedestrian flows and people on public spaces, therefore improving the quality of the public realm. Moreover, some types of infrastructure such as community parcel boxes may increase the probability of social interactions by an appropriate location and design.

It seems that locating logistics functions in the subsurface could have a positive impact on the aesthetics of the city surface and the appreciation of beauty related to the visual characteristics of the built environment. Reducing the presence of logistics elements that obstruct facades may favour the perception of their attributions and activities.

Using spaces below the ground and smaller freight vehicles for logistics could also help to create friendlier spaces for people. But it also challenges the assumptions of what is a proper design. For instance, cargo cycles seem to require some adjustments in the way cycle infrastructure is designed.

Some other adjustments in the way cities design roads and public spaces may be necessary if the inclusion of logistics is sought. Due to their disruptive effect on traffic and social activities, loading and unloading activities can be located in spaces below the ground and specific micro spaces of the city. Some innovative city logistics schemes can also reduce local and atmospheric pollutants. Since they seem to be linked, city logistics innovations may play a role in some processes of urban densification and compactness.

In a 24-hour society, especially in places with high density of uses and activities, spaces for logistics activities can be flexible enough to provide multiple uses, avoiding dead periods. Thinking in the long-term, incremental changes over time may permit urban designers to test innovations gradually, in the quest for better city logistics systems and high-quality urban spaces.

The relationship between city logistics innovations and the built environment unveil certain implications on the urban design theory and practice. First, in aiming to develop a more comprehensive urban design theory, a sustainable placemaking approach can help to combine different goals and concepts. Nevertheless, this choice originates theoretical challenges. Second, there is a need for changing the way urban settings are understood, by integrating both physically and functionally the underground region to the surface. As a consequence, the production and management of urban data must be adapted to this paradigm shift. Third, it is necessary to recognise the importance of the freight transportation as a shaping agent of cities. Fourth, the analysis of the production of and the accessibility to goods and supplies may broaden the analysis of city logistics within a more comprehensive topic. Fifth, city logistics innovations open a new window for urban designers who could participate in the overall design process of city logistics, securing a proper urban design. Lastly, it is necessary more normative frameworks that incorporate city logistics within its spectrum of urban issues and the pursuit of a good urban design. In that sense, urban design principles—through policies, guidelines, and codes—may help to achieve this objective.

Finally, since city logistics innovations can contribute either to the betterment or the damage of urban areas and their built environment, cities will have to confront several challenges. Cities will have to secure that hosting logistics innovations will not undermine social usages, damage urban aesthetics, and negatively affect sustainability; therefore, reducing the quality of urban life. What is more, they will have to carefully combine several logistics schemes, transport modes, and types of infrastructure in a variety of forms according to their urban needs and constraints.

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Appendix 1 - Case studies

Well-line

Münzer (2016) explains that the Well-line proposal, created by Chetwood Architects, aims to use brownfield sites and the former Post Office Railway underground from Paddington to Whitechapel for carrying parcels across central London. This proposal was one of the four winners of an ideas competition organised by the Royal Academy of Arts. Münzer adds that the ‘Well-line will remove the need for 90 percent of goods vehicle movements around Oxford Street’, and that the ‘street traffic will be replaced by a linear park’. The proposal also considers a new logistics warehouse, distribution supplied by wind turbines and drones, amongst other features (Royal Academy of Arts, 2016).

Helsinki underground

Below the city of Helsinki is located a complex network of tunnels and facilities. According to the Helsinki City Planning Department (2009), these underground locations include facilities such as depots and water management, as well as servicing activities such as heating, cooling, electricity and telecommunications. Based on Vähäaho (2014b), some characteristics of this complex networks are the following:

- The bedrock quality makes tunnelling possible and easier.
- The Underground Master Plan of Helsinki is key for the underground network development.
- The underground locations are connected between them as an underground city
- The space below the ground helps to use the surface for other functions more valued by Finns (such as green areas).
- The utility network is comprised of 60 km.

Barcelona

Barcelona, Spain, was visited for the purpose of this research. Some cargo cycles operate on its city centre, while box lorries distribute goods in the neighbourhood of Gràcia. These urban settings permit to understand the impact of freight transportation in narrow streets. From the other hand, Barcelona is also a laboratory for innovations. Rueda (2007: 22) proposes the creation of interconnected galleries located below the ground in Barcelona. The purpose of these galleries would be to reduce the frictions in the surface related to loading and unloading activities, by combining motor vehicles with railways. Rueda continues explaining the process: ‘The L/U [loading and unloading] galleries connect to the surface by goods lifts for business, lifts for persons, and underground containers for waste’. Rueda’s idea is based on an ‘urbanism on three levels’ approach.

Mole Solutions

With the support of the British government, Mole Solutions started to test an environmentally friendly system for freight delivery based on pipes propelling goods by magnetic waves (BBC, 2015). The trial period started in 2015 in Northampton.

Cargo Sous Terrain

Ecommerce News (2016) points that Cargo Sous Terrain, a group of several organisations, plans to create an underground system for the transportation of freights, by using autonomous vehicles. This system would transport goods between Swiss cities and towns. The system is expected to be launched in 2030, consisting of a network of 70 km of length.

Underground distribution systems in the Netherlands

According to Van Duin (1998), during the 1990s several plans for underground distribution systems appeared in the Netherlands. Plans were promoted by the national government and covered the city (e.g. Utrecht), the regional (e.g. the Province of Limburg) and the international levels.

DHL packstations

The company DHL uses packstations, which operate 24 hours a day. Packstations consist in yellow modules for dropping-off and picking-up shipments. They are located in different parts of a city. Several German cities have these logistics elements.

Mini-hubs in Seville

Muñuzuri et al. (2012: 229) define mini-hubs as ‘specific streets or areas where delivery vehicles are allowed to park, regardless of the access time window, in order to complete the final deliveries on foot or using a handcart’. Using Seville as a case study, the authors show that a balanced number of mini-hubs optimally located in the city centre can be an alternative to other logistics schemes, such as urban distribution centres. A system based on mini-hubs ‘would replace the existing access time windows without allowing delivery vehicles to freely drive around downtown areas, with all the emissions and nuisance involved’ (2012: 236).

Outspoken Delivery

Outspoken Delivery is a cycle logistics company operating in three cities: Cambridge, Glasgow, and Norwich. Its 'mission is to help create less congested, less polluted and more liveable cities' (Outspoken Delivery, 2016). Its depot and offices in Cambridge, where the company operates since 2005, were visited for the purpose of this research. A variety of cargo bicycles and tricycles operate daily.

38 cycle logistics companies in Europe

Lenz and Riehle (2013) carried out a study in which they found 38 cycle logistics companies operating in Europe. Their study analyses the characteristics of the sector, its potentialities as well as limitations. Some of their findings show how the companies interact with other companies operating in the supply chain process, and the need for improvements in the urban infrastructure making the operation of cargo cycles easier.

Belgian cycle couriers

In the research 'The use of bicycle messengers in the logistics chain, concepts further revised' (2012), Maes and Vanellander analyse bicycle messengers in Belgian cities. Based on empirics, some of their findings are that bicycle couriers can help to reduce CO₂ emissions; they can be fast and reliable; and that the companies 'can play a role in urban transport, although being limited to a certain region or city' (2012: 421).

Gothenburg

Alike Barcelona, Gothenburg, Sweden, was visited during the research process. Some observations and visual records were carried out in its city centre, where electric cargo road trains and cargo cycles operate.

Drones and robots

Drones and robots are recently being tested for freight distribution. Two companies already testing drones are DHL and Google, while Amazon is already operating in Germany, according to Kobie (2016). Similarly, on-demand delivery companies are growing (e.g. UberRUSH). Kobie also explains how a company called 'Starship' is designing wheeled robots for delivery.

Appendix 2 - Meetings and events

Meeting with Lotte Bech

On 15th April 2016, a meeting and a tour on bicycle were organised with Lotte Bech in Copenhagen. Lotte Bech is an architect and urban planner specialist in bicycle transportation and road safety. The purpose of the meeting was to learn about the cycling experience in Copenhagen and some characteristics of the cycling infrastructure, including aspects related to cycle logistics. The tour was useful to get a better understanding of the cycling network.

Meeting with Gary Armstrong

On 15th August 2016, a meeting with Gary Armstrong, from Outspoken Delivery, was organised in the company's office and depot located in Cambridge. The purpose of the meeting was to gain more knowledge about the field of cycle logistics and the experience of Outspoken Delivery. The author visited the location, and an unstructured interview was applied. The discussed topics were the following:

- Characteristics of the freight vehicles fleet
- Characteristics of the freight operations
- Characteristics of cycle logistics in Cambridge
- Other relevant information related to the company's experience, the city logistics sector and the city of Cambridge

Exhibition Urban Jigsaw

On 29th April 2016, the author visited the exhibition Urban Jigsaw, organised by the Royal Academy of Arts. Chetwoods Architects presented their proposal to develop an underground distribution system in London. Some valuable information was gathered in this event.

Workshop Cyclelogistics Empowerment

On 14th June 2016, the author participated in the workshop Cyclelogistics Empowerment, organised by the European Cyclists' Federation in Gothenburg. The event was aimed at local authorities. The objective was to present strategies concerning how European governments can get involved in the field of cycle logistics.

Appendix 3 - Risk Assessment