Implementing the Supermanzana approach in Barcelona. Critical issues at local and urban level

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Abstract. To improve neighbourhood liveability and urban sustainability, Barcelona is seeking to re-organize its urban structure into superblocks, designed to discourage cut-through traffic and promote multiple uses of street space. Despite its potential, this approach is not without its limits, that should be properly taken into account. The implementation of the Supermanzana model in the Poblenou neighbourhood is explored in this paper to analyse its potentialities and constraints. Temporal synchronisation between the urban level and the neighbourhood level turns out to be particularly important to reduce conflicts and criticalities.

Introduction

Impacts of car traffic on the living quality of urban neighbourhoods have been widely acknowledged. They concern safety (Ewing and Dumbaugh 2009), air pollution (Cakmak et al. 2012; Houston et al. 2004), noise (Botteldooren, Dekoninck, and Gillis 2011), streetscape (Mukhija and Shoup 2006), waste of space (Shoup 1999), etc.

This friction between driveability and liveability of neighbourhoods emerged already in the early 1900s, when levels of car ownership began to rapidly increase. To face this challenge, new models of neighbourhood were proposed, such as that elaborated by Clarence Perry in the first *Regional plan for New York* (Perry 1929) and the project by Clarence Stein and Henry Wright for Radburn (Adams, Bassett and Whitten 1929). Although they had different street patterns, these models featured a common principle: to provide safe and liveable environments by limiting motorised mobility inside neighbourhoods. They were designed so to allow only 'access traffic' (i.e., car trips whose origins or destinations were located in the neighbourhood) in the streets inside them; on the contrary, '*cut-through traffic*' (i.e., car trips whose origins and destinations were both located outside the neighbourhood) was discouraged and diverted to main thoroughfares outside

them. Since then, this approach has been applied in a number of models for planning new-built neighbourhoods, up to recent neo-traditional neighbourhoods and eco-districts (Sharifi 2016).

In the last years, Barcelona's *Agencia de Ecologia Urbana* developed an innovative application of the neighbourhood unit, the so-called Supermanzana (i.e., superblock in Spanish; hereinafter, SM) model. The SM is meant not only to transform the public space of the neighbourhood, but also to reorganise the existing overall urban structure. A main network of thoroughfares is identified, which is intended to support cut-through traffic; all the meshes of this network are re-thought as superblocks, whose street space is re-designed in order to support non-motorised mobility and multiple street use.

The SM model is seen by its promoters as an effective strategy to improve neighbourhood liveability and urban sustainability, and it is also being considered as a model in other cities, not only in Spain but also internationally, especially in China, in the context of the debate over the retrofitting of the Chinese superblock model (Kan, Forsyth, and Rowe 2017). Still, the SM is not free of critical elements, both in the implementation process and in its final configuration.

In this paper, the implementation of the SM model in Barcelona is investigated. The aim is to explore potentialities and constraints of this model, when it is a) applied in existing, well-established urban neighbourhoods – rather than to design new ones – and b) extended to the entire urban area to systematically improve liveability of urban neighbourhoods and districts. In particular, the main research question concerns the coherence and consistency between the implementation of the SM model at the urban level and the neighbourhood level. To explore this question, the article also addresses three secondary research questions concerning: 1) the progression in SM implementation, 2) the influence of the structure of the existing street network on which SMs are realized and 3) the governance of such a wide process, with respect both to horizontal and vertical coordination and to participation of different stakeholders. As it will be shown, all these questions touch important nodes of debate at the core of urban planning and studies, such as land use /

transport integration, public space quality and use, spatial justice, temporal synchronisation of policies.

The article is organised as follows. The next section will give an overview of neighbourhood planning models grounded on the limitation of car traffic. A brief description of the SM model is then provided, and its implementation process in Barcelona is illustrated. A specific section is devoted to highlight some critical aspects related to this implementation, with respect to the main and secondary research questions outlined above, based both on the literature and on interviews with selected stakeholders. Finally, some conclusions and directions for further research are drawn.

Neighbourhood planning over the decades

The idea of improving neighbourhoods liveability by separating cut-through and access traffic dates back to almost a century ago, with the development of the 'neighbourhood unit'[1]. In the broadest sense of the term, neighbourhood planning is deeply rooted in the planning activity itself, since its origins (in particular because of the socioeconomic concerns generated by the industrial revolution: Johnson 2002). But it is since the end of the XIX century that the idea of neighbourhood – and the importance of planning it as a unit – has become a constant element in the planning discourse (Silver 1985). Albeit it has been interpreted in different ways across the decades and around the world, the neighbourhood unit has been undoubtedly one of the main landmarks in the twentieth-century urban planning (Mehaffy, Porta, and Romice 2015; Patricios 2002).

The neighbourhood unit is based on two main principles: a sociological principle, since the neighbourhood is seen as the necessary unit to ensure social cohesion (if not social control: Brody

1 The 'neighbourhood unit' expression is often referred specifically to the model developed by Clarence Perry in 1929. In this paper, this term will be used to express a pervasive and enduring 'planning idea', that has been implemented and inflected in a wide range of forms and versions for over a century (Brody 2016).

2016), mainly by providing basic services (elementary school, etc.); and a functional principle, as this model is meant to grant safe and secure accessibility to these services (Rohe 2009; Tetlow and Goss 1968).

Albeit the concept was first coined by William Drummond in 1916, the neighbourhood unit is usually traced back to the ideas of Clarence Perry, who was the first to develop and popularise it in his contribution to the first *Regional plan of New York and its environs* in 1929 (Brody 2016; Talen 2017). His neighbourhood unit was a sort of synthesis of a transatlantic dialogue, arising from the ideas of Ebezener Howard for the 'Garden Cities of Tomorrow' (1902); Howard's wards were designed as self-sufficient areas for basic services, bounded by a polygon of streets. After several centuries of urban development patterns that, stemming from the Hippodamian grid, were meant to favour movement, and especially wheeled traffic, Perry's unit reversed the perspective (Figure 1): cut-through traffic inside the neighbourhood was reduced by replicating the irregular geometry of 'organic' cities and by introducing a large proportion of T-intersections (Grammenos et al. 2008).

Figure 1. The organic pattern of the streets in Perry's neighbourhood unit. Source: authors

The other historic emblem of the neighbourhood unit, led by the principle of traffic separation, is Radburn, the 'town for the motor age' (Figure 2). In this case, Clarence Stein and Henry Wright designed the street pattern of the neighbourhood using cul-de-sacs (strictly for car access) and footpaths, to fully separate pedestrians from car traffic and discourage cut-through traffic (Grammenos et al. 2008).

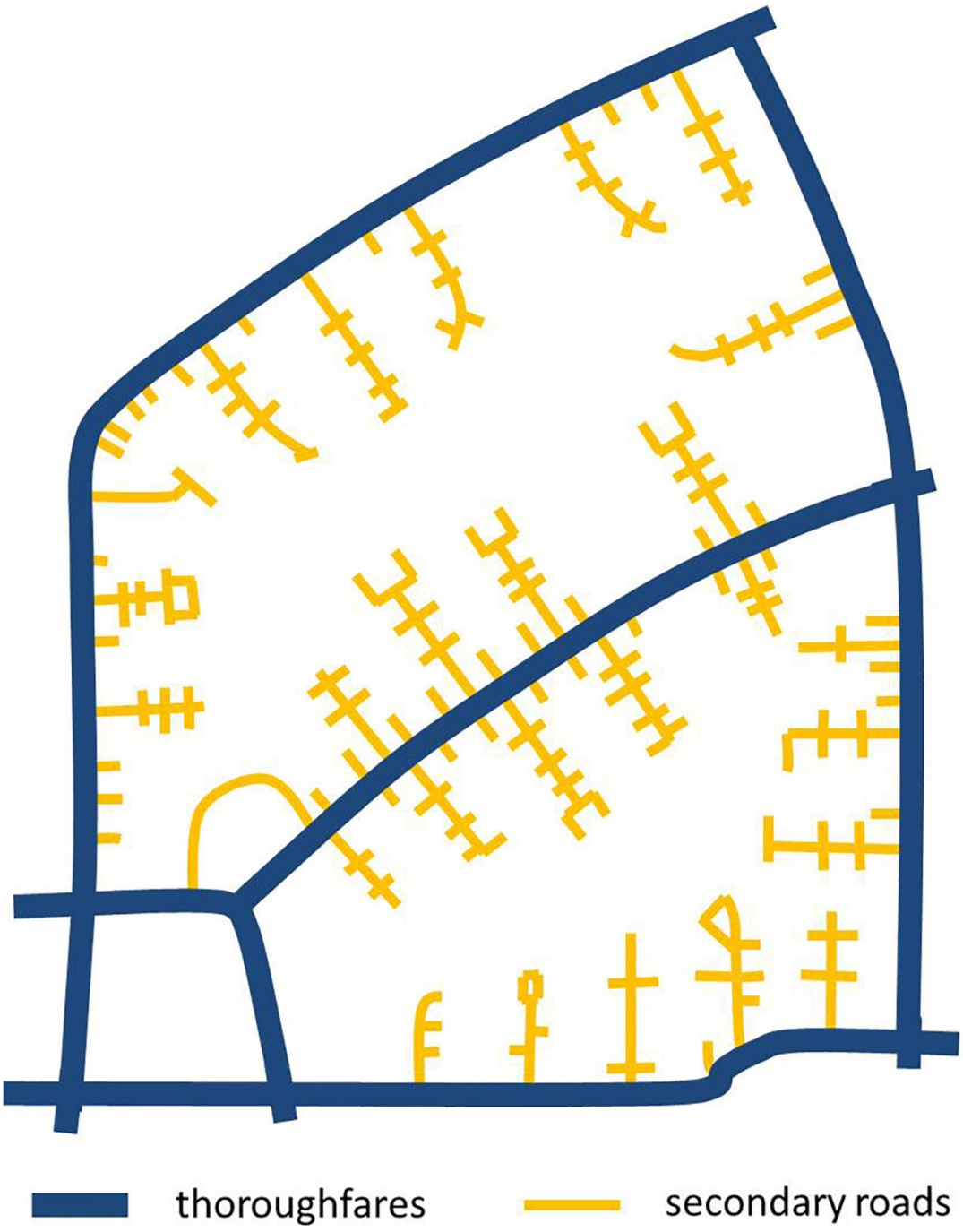

Figure 2. The cul-de-sac pattern of the streets in Radburn. Source: authors

Traffic separation at the neighbourhood level can be found in several other examples spread throughout the world, such as the plan of Le Corbusier for Chandigarh (Birch 1980) and the ‘environmental areas’ proposed by Colin Buchanan in the ’60s (Buchanan 1964). The neighbourhood unit principles were extensively applied particularly in urban developments in the Middle East in the ’60s. The expansion of cities such as Baghdad (Iraq), Islamabad (Pakistan),

Riyadh (Saudi Arabia) and Abu Dhabi (United Arab Emirates), featured a modernist layout, characterized by a regular grid network with superblocks (Alawadi and Benkraouda 2018; Middleton 2009; Scoppa, Bawazirb and Alawadi 2018).

More recently, after a period in which the neighbourhood unit seemed to go out of fashion (Brody 2016), the Congress for the New Urbanism rehabilitated it and its approach of traffic separation, not without criticism (Rohe 2009). And most current eco-districts reflect more or less the same principles (Sharifi 2016). Over the last decade, in the Middle East and China the superblock model has been encouraged both in newly developed areas and in retrofitting existing neighbourhoods, according to a nostalgic feeling for historical urbanism, accompanied by a search for sustainability and liveability (Alawadi and Benkraouda 2018; Kan, Forsyth and Rowe 2017; Scoppa, Bawazirb and Alawadi 2018).

Besides the differences in terms of density, street layout, localisation of services and functional organisation of space, all these experiences share the same basic principle: they try to reduce car traffic inside neighbourhoods to its only access component, and separate it from footpaths, with the aim to improve walkability, liveability and social interactions in public spaces (Ahn and And 2003; Lee and Stabin-Nesmith 2001; Zhang 2013).

The neighbourhood unit was not exempt from critics, not only from the sociological point of view (see, for example, Jacobs [1961]) but also from the functional one. In particular, Mehaffy et al. (2015) outlined that the neighbourhood unit breaks the ‘400 meter rule’, i.e. the maximum spacing of main thoroughfares that Mehaffy et al. (2010) identified through empirical observation of traditional, pedestrian-governed urban fabric. As these authors remarked, this spacing is surprisingly constant around the world and across planning history, and it is linked to the self-organising logic of pedestrian movement and people’s need to reach activities by foot (i.e. the typical 5-minute walk). But the neighbourhood unit proposed by Perry and then re-interpreted in several ways, is usually structured as an area with a *radius* – instead of a *diameter* – of 400 meters

(Lee and Stabin-Nesmith 2001; Mehaffy et al. 2015); therefore, even if conceived just to facilitate walking, it breaks a tacit rule that have been handed down for centuries.

Perry stated that the neighbourhood unit model is not 'limited to the unbuilt areas around the urban fringe', but can be applied also 'to central deteriorated sections, large enough and sufficiently blighted to warrant reconstruction' (Perry 1939, p. 96). But even though he extended this model also to already built-up areas – and there are many other examples, from Abercrombie's Greater London Plan to several US comprehensive plans among which those of Harland Bartholomew (Brody 2016; Erickson and Highsmith 2018) –, from its origins to current reinterpretations the neighbourhood unit has been primarily related to new developments, except for few cases.

The SM, conceived in Spain in the last twenty years, although conceptually consistent with the neighbourhood unit principles, is structured as a 400x400m 'urban cell' that straight tries to adapt the traffic separation principle to well-established urban areas.

The Supermanzana model

The SM concept has been developed by Salvador Rueda, director of the *Agencia de Ecologia Urbana de Barcelona* (Urban Ecology Agency of Barcelona - UEAB), in the framework of his 'Ecological urbanism' approach (Rueda 2014). The SM is conceived as the basic unit for reorganising the existing city and increasing its sustainability; indeed, it is designed to improve quality and liveability of public spaces at the neighbourhood level, and to reduce the modal share of private motorised vehicles in the whole city.

The SM is structured as a new 'urban cell' of approximately 400x400m, made up of a number of blocks and interstitial space between them (streets, sidewalks, squares, etc.). This superblock is based on a differentiation of streets into two levels. The streets inside the SM should support only car traffic whose origins or destinations are inside the SM. Cut-through traffic is discouraged in these streets in many ways: the space for cars is reduced to a single lane per street;

directions change frequently; maximum speed is set to 10 km/h; most on-road car parks are removed; loading/unloading activities for urban goods distribution are relocated on logistic platforms at the border of the SM. The result is that 60-70% of the street platform inside the SM is made free of motorised traffic (Figure 3).

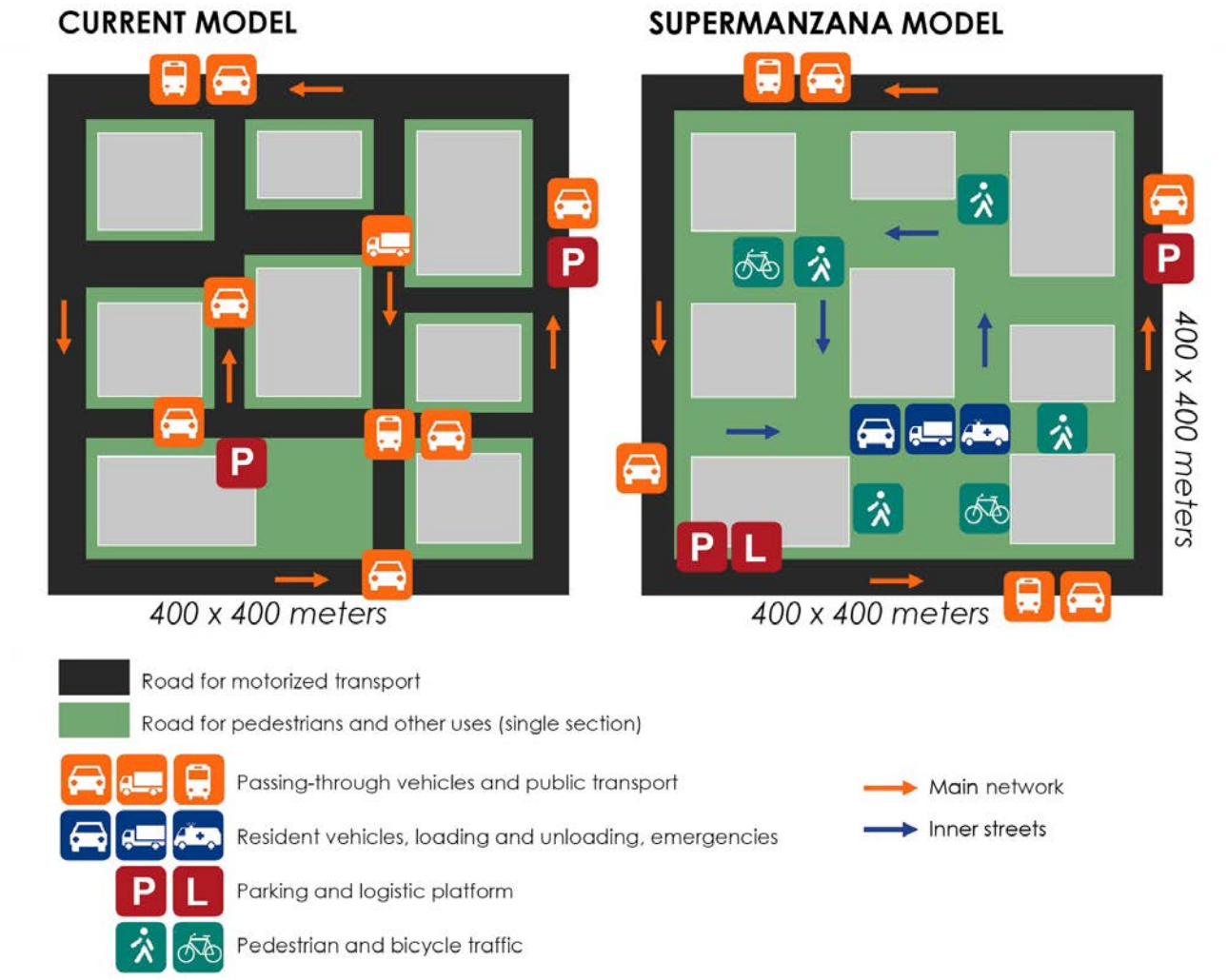

Figure 3. The SM model at the neighbourhood level. Source: Rueda (2014)

Instead, the streets that border the SM are designed as thoroughfares to host cut-through traffic, public transport (buses, taxis, tramways, etc.) and bike lanes. If the SM model is spread on the whole city, a new urban morphology is established, based on two components: a main network of thoroughfares and SMs. The main network is made up of thoroughfares that cross every 400

meters, to ease car traffic flow. SMs are the meshes of this network: they are sorts of islands whose inner streets are intended for multiple local uses and functions, and movement is mainly based on walking (Figure 4).

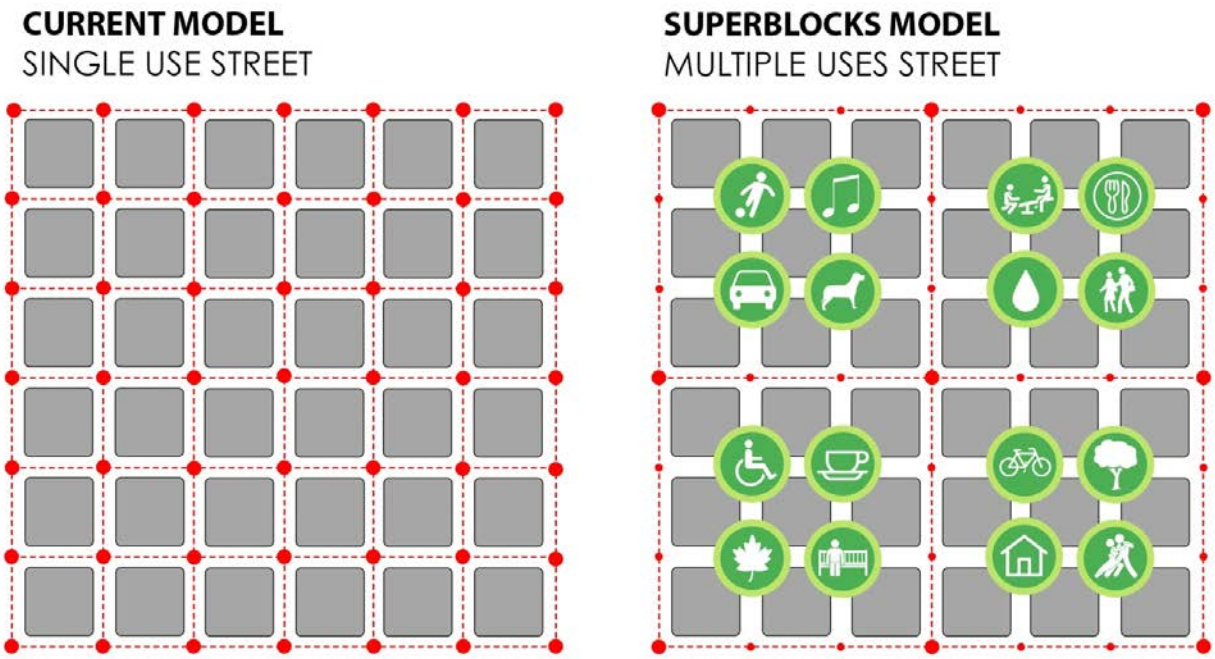

Figure 4. The SM model at the city level. Redrawn from : Ajuntament de Barcelona, Presentation Plan de Movilidad Urbana de Barcelona, PMU 2013-18, October 2014

This SM model conforms with the abovementioned '400 meter rule'. To set the SM dimension, Rueda (2009, 2017) compares the average urban speed of pedestrians and motor vehicles: the average speed of a car in cities is 15-20 km/h, that is four times the human walking speed (4-5 km/h). Rueda assumes that 100 meters is the right dimension for the sides of a block, as it allows pedestrians to turn around it and choose many different paths to reach a destination[2]. Hence the length of each side of the SM, that is four times 100m, is assumed to be the right measure

2 In a comparative study on forms and dimensions of urban blocks, Siksna (1998, 278) states that 'a circulation mesh ranging from 80 m to 110 m can be regarded as an optimal provision'.

for motorised vehicles to drive along the borders of the SM and increase the fluency of car traffic at the urban level.

As inner streets represent a key ingredient of the SM model, the UEAB has developed a new urban planning tool for designing them, called 'Mobility and public space plan'[3]. The Plan is aimed to develop an integrated approach in the application of the traffic separation principle, adopting in the first phase cheap, tactical and reversible solutions, that are supposed to become structural in a later stage. Inner streets are redesigned not only to discourage cut-through traffic, but also to revitalize and regenerate them as public spaces at the same time.

Because of its recent implementation, few scientific studies have analysed the benefits of the SM model till now. Delsoa, Martín and Ortega (2018) showed that the implementation of SMs in Vitoria-Gasteiz city reduced pedestrian travel times by approximately 4–5%, Speranza (2016) combined mobile data collection technology and parametric urban design software to measure ecological and atmospheric quality at the scale of SMs in Barcelona, and (2017) to test how this quality supported social interactions in SMs. Ortolani and Vitale (2016) identified SMs as an example of 'environmental areas', where street trees can be placed for removing PM10 emissions by cars. Oliver and Pearl (2017) described how a neighbourhood-scale sustainability assessment system developed by the UEAB was used in the design process of a SM in Barcelona, and in particular how it was framed in the community participation process.

Most of these articles were centred on the application of the SM model to a single neighbourhood. On the contrary, in the next sections attention will be also focused on the

3 This plan has not yet been formally adopted by Spanish legislation, but it has already been tested to apply the SM strategy in some Spanish cities. It was adopted for the first time in Barcelona, in 2006 in the District of Gracia and more recently in the District of Sant Martí (as reported in next section). Moreover, UEAB collaborated with other municipalities, such as A Coruña, Bilbao, Ferrol, Figueres, Lugo and Vitoria-Gasteiz, to export the SM model and its Mobility and public space plan also outside Barcelona.

application of the model to the whole city, and on the consistency between the urban level and the neighbourhood level.

Case study

Although SMs have been tested in a number of Spanish cities, Barcelona is the city that has most experienced the application of the SM model[4]. It was first tested in the older part of the city, *District Ciutat Vella* (1993) and *Gracià District* (2003); subsequently, the Administration has drafted three SM programmes in order to spread the SM strategy to the rest of the city. The last one (*Omplim de vida els carrer*, launched in 2016) proposed each of the ten city's Districts to adopt a specific Mobility and public space plan, and to implement a SM pilot project. Nowadays, therefore, Barcelona has several SMs executed in different locations and at different implementation levels.

Barcelona is a relevant case also because the SM model has been assumed during the last decade by the Administration as a key issue in its main policies and plans, such as the local Agenda XXI (*Compromís Ciutadà per la Sostenibilitat 2012-2022*), the Plan for green areas and biodiversity (*Pla del Verd i de la Biodiversitat de Barcelona 2020*), the Urban mobility plan (*Pla de Mobilitat Urbana 2013-2018*), the Plan for air quality (*Pla de millora de la qualitat de l'aire de Barcelona 2015-2018*) and the Strategic plan (*Pla d'actuació municipal 2016-2019*). Hence, the

4 Also in Vitoria-Gasteiz (the capital city of the Basque Country in Northern Spain) UEAB has widely tested the SM model. In 2008 a *Sustainable mobility and public space plan* was adopted; it identified 68 SMs all over the city; 17 of them have been implemented till now. In this article, Barcelona was preferred as a case study instead of Vitoria-Gasteiz for two reasons. First, it is a metropolis; this stresses the implementation of the SM model on the whole urban area to a more challenging level than in the case of Vitoria-Gasteiz (whose population is one fourth than in Barcelona). Second, Barcelona is characterized by a particular regular grid network (differently from the radial network in Vitoria-Gasteiz) that can be a critical issue for the SM model, as it will be shown in the next pages.

urban government can rely on a strong policy framework to promote the implementation of SM on the whole city.

Finally, Barcelona is an interesting case study for its physical and social features. It is the first large city (over 1 million inhabitants) that has adopted a SM strategy on its overall urban area. It is one of the densest cities in Europe, and availability of public spaces at neighbourhood level is particularly relevant in such a case (Howley, Scott, and Redmond 2009). Last but not least, it features, in its core part (about 13 km2), a homogeneous and isotropic road network, as a result of the Cerdà plan (Salat, Bourdic, and Labbe 2014) (Figure 5): 550 identical square blocks (113.3 meters side) in an orthogonal grid of identical 20 meters wide streets (excepted two diagonals and some minor streets).

Aims and method

As it was anticipated, the case study aims to explore potentialities and constraints of the implementation of the SM model on an entire existing, well-established urban area in order to improve the liveability of its urban neighbourhoods and districts. The focus of this paper is on a main research question, concerning the coherence between the urban and the SM levels: when implementing the SMs on the entire urban area, how should the urban and the neighbourhood levels be correlated?

To answer this question, three secondary research questions are addressed:

1) the progression in SM implementation. Should the implementation of SMs follow a precise schedule or each SM can be implemented with its own timing?
2) the influence of the structure of the existing street network on which SMs are realized. Are all kinds of existing street networks and contexts suitable for the implementation of the SM model?
3) the implications for the governance of the process. Which requirements must this process meet, in terms of spatial and temporal synchronization, as well as horizontal and vertical coordination

of the involved stakeholders?

The analysis was carried out both at the urban and at the local level. First, it was examined how the SM strategy was implemented in Barcelona at the city level, and its possible synergies with other urban policies. Then, the implementation of *Barrio de El Parc i la Llacuna de Poblenou* SM (hereinafter Poblenou SM), which is Barcelona's most advanced SM in the Cerdà Grid, was examined.

The case study was explored through a twofold methodology. On the one hand, a systematic review of the grey literature (such as proceedings and reports) and the official documents (plans, regulations, contracts, etc.) about the SM programme in Barcelona was carried out. On the other hand, in order to gain insights and have the possibility to discuss about specific issues related to the implementation phase, in-depth semi-structured interviews were run with local stakeholders, and short semi-structured field interviews were run with people encountered in the Poblenou SM.

As regards the in-depth interviews, eight stakeholders were selected; they are members of various institutions and associations in some way involved in this project or affected by its effects, such as designers of the SM model (Urban Ecology Agency of Barcelona), promoters of the SM inside the Municipality (Urban model Division and Communication and participation Division of the Ecology, urban planning and mobility Department), neighbourhood authorities (Services to people and territory Department of San Martí District), citizens representatives pro (Collectiu Superilla Poblenou) or against (Plataforma d'Afectats per la Superilla) the Poblenou SM, universities (Universitat Autònoma de Barcelona) and external experts (Center for Environmental Studies - Vitoria-Gasteiz Municipality). The in-depth interviews lasted one hour, and were semi-structured on questions about the implementation process of the SM strategy both at the urban and at the local level.

Thirty people were interviewed on field, representing different points of view: residents of the Poblenou SM (living inside the SM and on its border); residents of the blocks surrounding the

SM; workers in the SM (commuters and small business owners); university students; retired people. The interviewees were asked three common questions, regarding their living or working relations with the Poblenou SM, their personal awareness about the *Omplim de vida els carrer* programme and the Poblenou SM pilot project, and their personal opinion about the implementation of the Poblenou SM; finally, an unstructured chat followed. These fields interviews were mainly meant to verify the viability and representativeness of the in-depth interviews; in essence, they did.

In the next two sections, the process of implementation of the SM model in Barcelona will be first described, and then critically analysed with respect to the research questions outlined above.

The implementation of the SM model in Barcelona

The urban level

As already mentioned, the SM model has been assumed during the last decade by Barcelona's administration as a key issue in its main plans and policies at the urban level. In particular, the *Pla de Mobilitat Urbana 2013-2018* has a central role in the implementation of the SM approach at this scale. This plan identified the main network of thoroughfares (Figure 5) and the SMs in its meshes (generally a superblock of 3x3 blocks, i.e., 400x400m). Speed limit was set to 50 km/h for thoroughfares and to 10 km/h for inner streets of SMs. Moreover, the plan suggested to ensure sufficient car parks to the residents inside their own SM, but to reduce the number of public on-road car parks for visitors and to raise their charges. A 13% reduction of the modal share of car was estimated as necessary for thoroughfares to support the traffic diverted from the inner streets of SMs. An even more ambitious objective (i.e., a reduction of car modal share by 21%, from 26.7% to 21.1%) was set in the plan. To this aim, 'push' measures (reducing maximum speed and number of car parks inside the SMs) were combined with 'pull' ones (improving public transport and cycling).

Figure 5. The main network of thoroughfares. Source: INFORME. Pla d'Espai Públic i Mobilitat del Districte de Sant Martí, Barcelona

The identification of the main network was also seized as an opportunity to reorganise and improve the mobility system of the city as a whole. As regards public transport, the *Pla* proposed the enhancement of the bus system, establishing the 'Nova Xarxa de Bus'; 28 bus lines riding along the thoroughfares, without crossing the SMs. These lines were devised according to a grid pattern (8 horizontal lines, 17 vertical and 3 diagonals), which was supposed to have several benefits: it is easier to read, it ensures major speed and frequency, it makes it possible to go from any origin to any destination in the city using two buses at most. In addition, over 200 km of new bicycle lanes were planned on the main network in order to guarantee a high-speed cycling mobility, while the streets inside the SM (the 67% of the urban streets) were supposed to became shared spaces where pedestrian and cyclists have the priority on vehicular traffic[5]. As regards goods distribution, the

5 The *Pla de Mobilitat Urbana 2013-2018* is coming to an end: currently, just over the half of its 64 measures has been executed. The renovation of the new bus network was completed in November

urban mobility plan defined a decentralized system, based on ‘neighbourhood logistics platforms’ and ‘urban distribution centres’, which should be located on the fringes of the SMs. Last mile distribution inside the SMs must be carriedby non-polluting electrical vehicles and cargo-bikes.

In addition, the *Pla del Verd i de la Biodiversitat de Barcelona 2020* differentiated the minimum tree density that should be ensured along the thoroughfares and inside the SMs. The inner streets that were supposed to become free of traffic offered the opportunity to increase the green areas.

Whereas these plans were mainly focused on the urban levels, three programmes were adopted one after another to schedule the implementation of the SM model at the local level: *Programa Superilles 2011- 2015* (2011), *Barris a Velocitat Humana* (2014) and *Omplim de vida els carrer* (2016). They launched a few pilot projects of SMs in several parts of the city, which are now at different stages of completion, as shown in Figure 6. Among them, the Poblenou project in the Sant Martí District (Figure 7) is nowadays at the most advanced level of implementation[6].

2018, but at the moment it hasn't reached the expected results in terms of average speed and frequencies. In 2016 pedestrian and bicycle mobility have increased their modal share compared to 2011 (respectively from 31.9% to 32.2%, and from 1.5% to 2.1%), but that of the car has decreased very slightly (from 26.7% to 26.1%, and the target of 21.1% in 2018 seems very far to be reached). In the last months of 2018 the participation process to support the elaboration of the new *Pla de Mobilitat Urbana 2019-2024* was launched.

6 In the *Barris de Sants i Hofstrafrancs*, which is located outside the Cerdà grid, some structural changes were already realized between 2015 and 2017, but they were limited to some urban squares.

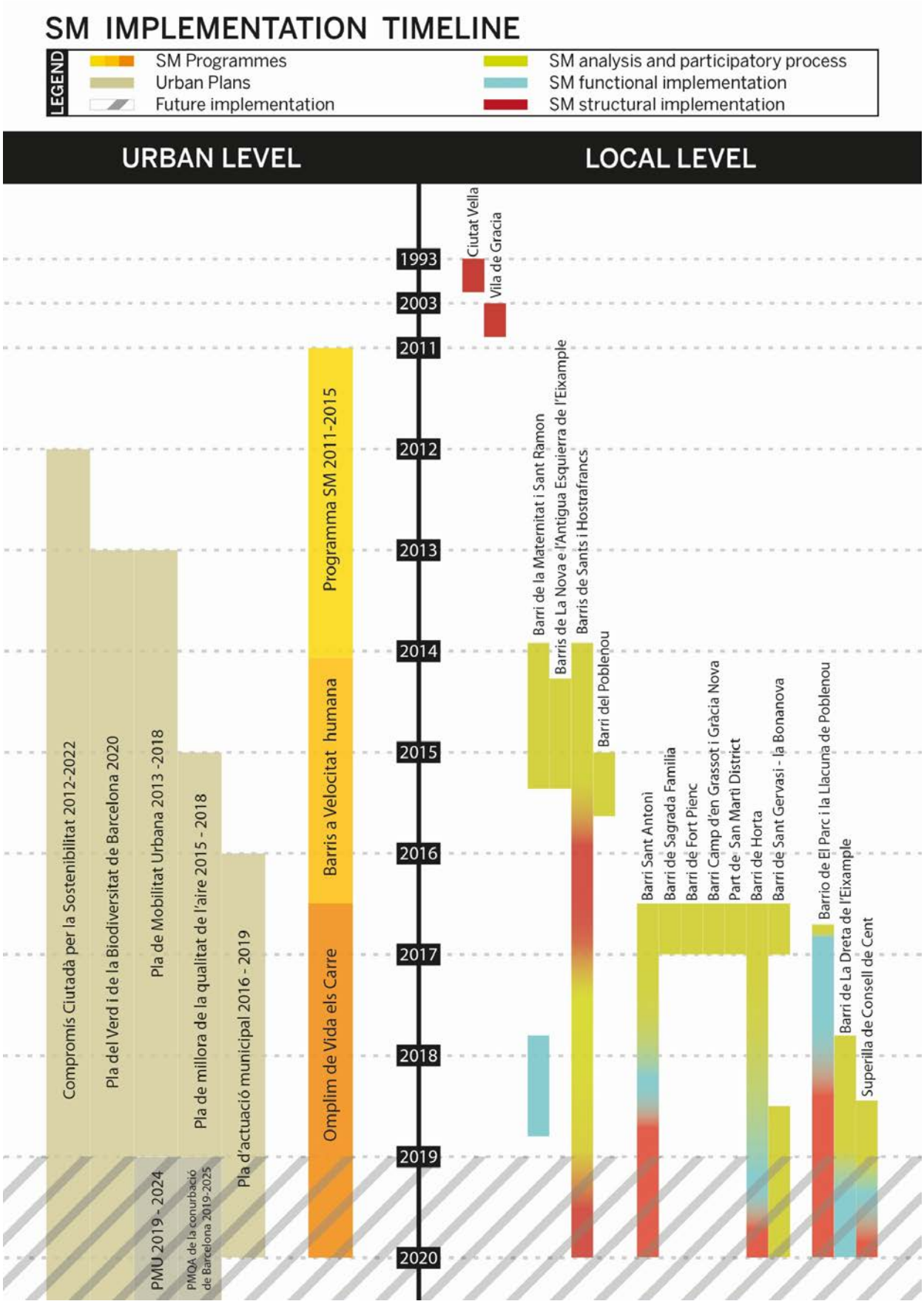

Figure 6. Time line of urban plans and programmes to implement the SM strategy in Barcelona, and stage of completion of SM pilot projects: Source: authors

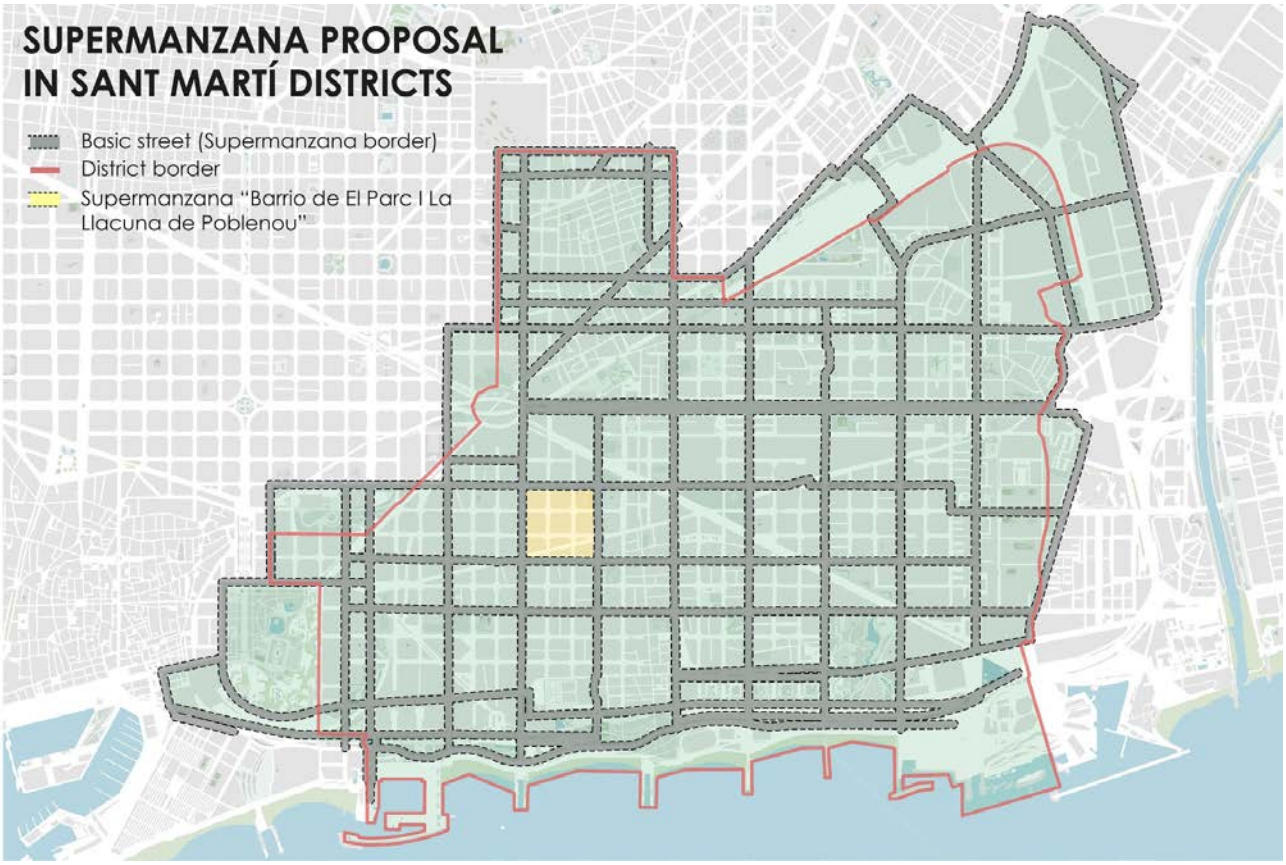

Figure 7. The proposed SMs and the Poblenou pilot project in the San Martí District. Source: INFORME. Pla d'Espai Públic i Mobilitat del Districte de Sant Martí, Barcelona

The neighbourhood level

The Poblenou neighbourhood was chosen as a pilot project for several reasons: it was located in an old industrial area which is already undergoing a renewal process; levels of car traffic on its inner streets were not so high; it allowed to test the SM model on the Cerdà grid. Its implementation started in September 2016 with a two-week workshop, organised by UEAB with the International University of Catalonia: 200 architecture students were asked to design temporary street furniture using waste material, in order to suggest how to reuse the street space that was bound to be freed from car traffic inside the new SM. At the end of the workshop, the Poblenou SM was implemented on a temporary basis till the end of the 2016; in the inner streets, vertical and horizontal road signs

were placed to change traffic directions, car lanes were narrowed by painting the street surface, space for car parking was reduced, the bus and the bike lanes were removed (Figure 8). The four inner streets became a shared space for pedestrian and cyclists, while four ‘rings’ were created forcing cars to turn left at each intersection and so preventing traffic from crossing the SM (Figure 9).

Figure 8. Functional implementation of the Poblenou SM: inner streets (2016). Source: authors

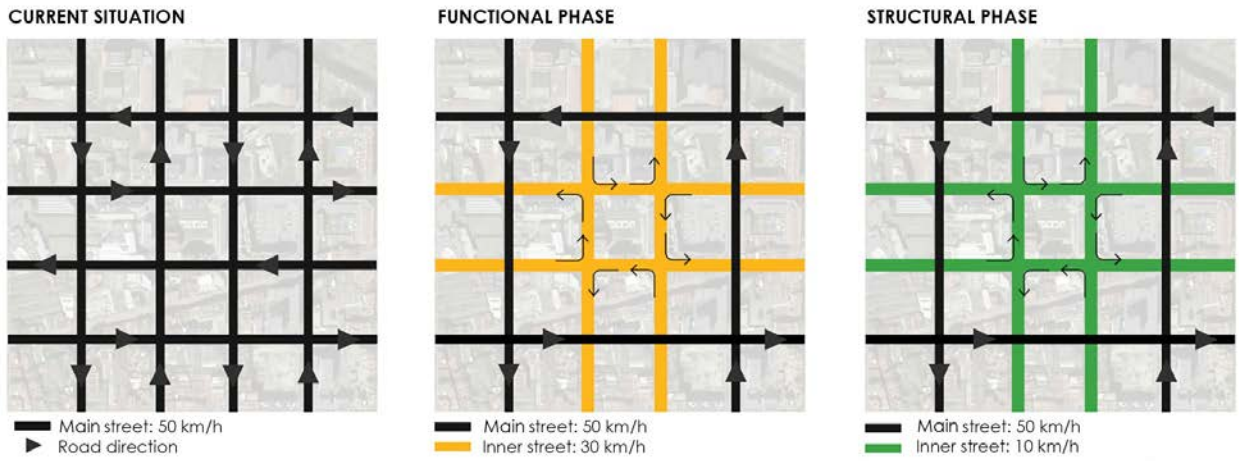

Figure 9. Phases of implementation of the SM. Source: INFORME. Pla d'Espai Públic i Mobilitat del Districte de Sant Martí, Barcelona

Despite some local protests, also due to some deficit in the participation process (Oliver and Pearl 2017), in the early 2017 the Poblenou SM project was confirmed by the administration, which began to modify its design to solve some problems arisen during the first phase. New street furniture (such as benches, temporary trees, street games, athletic tracks, etc.) was placed to improve the quality of the public space in the inner streets (Figure 10). At the time of writing (early 2018), the Poblenou SM is going to be completed in its structural and definitive version, through the adoption of a permanent layout[7] (Figure 11).

[7] In Autumn 2018 inside the Poblenou SM space for cars had been reduced by 48%, parking spaces from 575 to 316, car traffic from 2.218 cars/day to 932 cars/day; on the other hand, pedestrian surface had almost been doubled (from 31.536 to 56.665 sq.m.), with 176 new trees.

Figure 10. Functional implementation of the Poblenou SM: inner streets (2017). Source: authors

Figure 11. Structural implementation of the Poblenou SM: inner streets (2018). *Source*: authors

Analysis of critical issues

With respect to the three research questions outlined in the methodological section, the analysis of the implementation of the Poblenou SM revealed some critical issues. They were identified both through the literature and policy review and through in-depth and field interviews, and show that despite a prevalent acceptance and support for the SM model, its implementation is far from easy.

> All parties in the City government stated they agreed with the project, and have approved it within the Urban Mobility plan, but its implementation has put them in crisis (member of the UEAB).

Coherence between the urban and the SM levels

A first order of critical issues concerns the weak consistency between the urban level and the SM level. A striking example of this regards the network of thoroughfares. According to the SM model, thoroughfares at parallel sides of each SM should have opposite directions of movement, so to ease circulation outside them. But despite the model is meant to be implemented on the whole urban area, the Poblenou SM was realised (even if in its first functional phase) before the main network of thoroughfares was systematically re-organised according to the SM model. Most of the Barcelona main network is made of one-way roads, and the Poblenou SM happened to be bordered on its Eastern and Western sides by two one-way roads having the same direction. This caused complaints, as highlighted both in the in-depth and field interviews, especially by non-residents, who found it difficult to go beyond the SM without crossing it. Reversing one single direction in the main network turned out to be not possible, as it would have altered traffic flows on a wider part of the network. Therefore, through traffic was allowed on two streets inside the SM (Figure 12). Also a bus line was permitted to cross the SM along an inner street, otherwise its two directions would have been too far from each other.

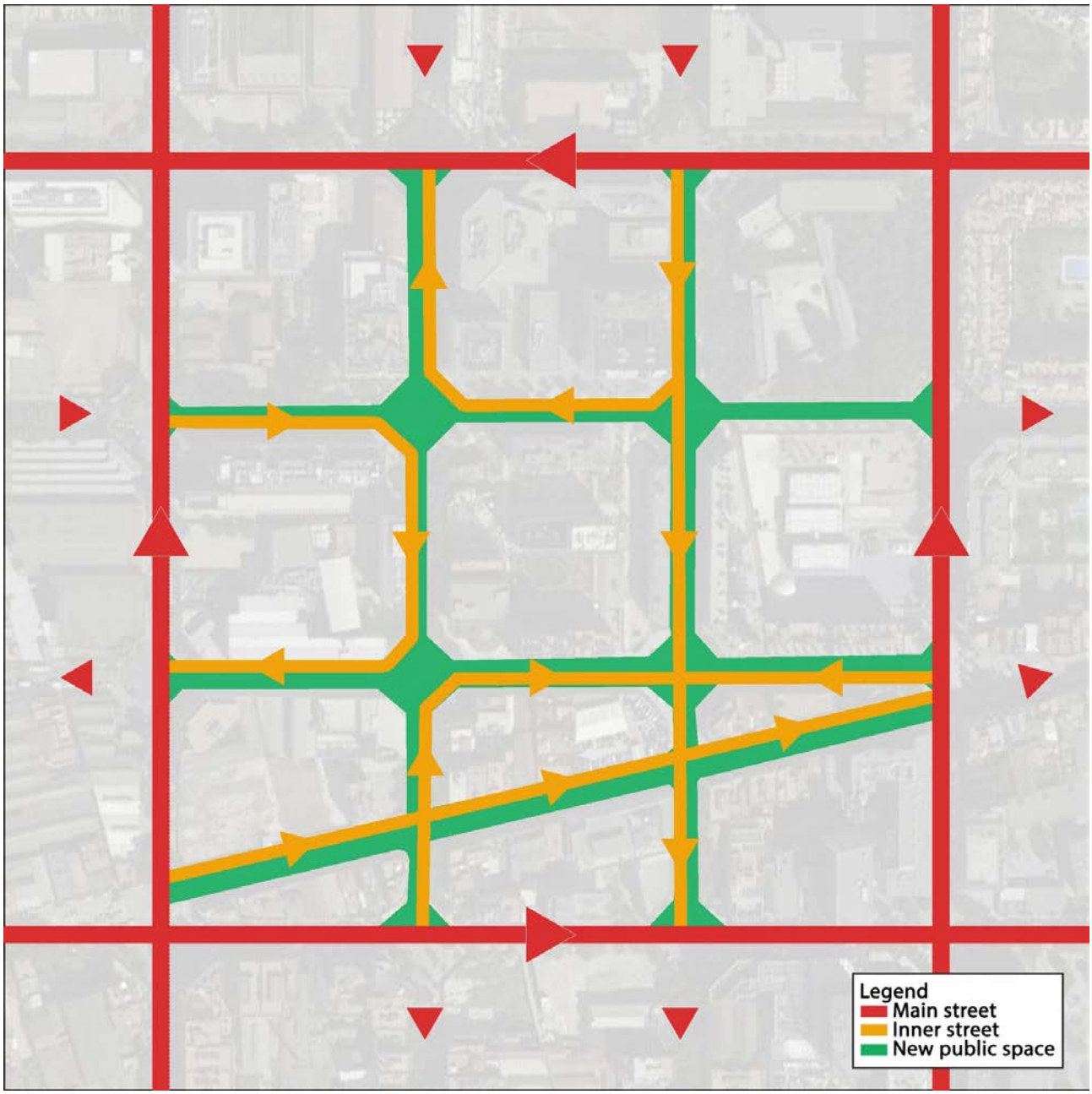

Figure 12. Revised traffic directions in Poblenou SM. Redrawn from: Ajuntament de Barcelona, Presentation Omplim de vida els carrers. Implantaciò de les Superilles a Barcelona, March 2017

Similar challenges emerged for cycling. According to the SM model, cycle lanes should be present in all the thoroughfares of the main network, and not in the inner streets inside each SM, where speed limits safeguard cyclists; reserved lanes could hinder public space sharing and cycling cut-through traffic could interfere with the use of this space. But the SM model is not consistent with the existing cycle network; some cycle lanes are on the main network, some on inner streets,

and their re-allocation according to the SM model has not been implemented yet. In Poblenou, the four thoroughfares bordering the SM have not a cycle lane, while there are two inside the SM. These two lanes were erased when the inner streets' space was redesigned in favour of walking. As a result, cyclists who wish to go beyond the Poblenou SM cannot circumnavigate it safely (as there are no protected lanes on its borders) and have to cross inner shared spaces. This situation aroused complaints both from residents (as bikes were perceived as intrusive in the renovated, pedestrian public space) and from cyclists (since the presence of pedestrians and urban furniture in the middle of the street poses several problems for those which want to cycle fast to cross the SM).

> Cyclists are a problem, because they must have the same respect for the Highway Code even in the streets inside the SM (officer of San Martí District).
>
> I like the project, I think it is very useful to leave the street space to pedestrians, but that creates lots of problems to cyclists, as the cycle lane inside the SM has been removed (citizen).

Finally, car parks that were removed or made more expensive inside the SM (except for residents) in order to free up space for pedestrians were not replaced by new underground parking along the thoroughfares. Interviews to citizens and representatives of local associations showed strong dissatisfaction, especially among non-residents.

Progression in SM implementation

As regards the implementation of the SMs across the whole city, the UEAB and the city administration had discordant visions. The UEAB was pushing for rapidly spreading the SMs throughout the city, firstly implementing all of them in a low cost, functional version, and only in a second stage in a structural version:

> The time needed for realizing all the around 500 SMs foreseen in Barcelona, if it depended only on me, would be 4 years. Because it is a very easy process as regards the first stages of implementation; these are functional transformations, made through signs and road paints (member of the UEAB).

On the contrary, the *Omplim de vidas els carres* programme adopted by the city administration in 2016 proposed a stepwise, 'here and there' spatial implementation for the SMs strategy. It was not applied all at once throughout the city, nor incrementally from an area and extending like wildfire; conversely, one pilot SM was identified in each of the ten city Districts to be realized:

> so as to demonstrate to citizens throughout Barcelona that the SM programme is really possible. In doing so, we hope to increase participation, prevent criticism and dampen possible protests. Only in this way will it be possible to speed up the implementation of the programme all over the city (officer of Barcelona's Department of Ecology, urban planning and mobility – Urban model Division).

These pilot SMs were planned to be implemented within three years, initially in a functional version, and shortly after in the structural form.

This approach was received differently by residents and non-residents. The former stated to be quite satisfied with the renovated public space inside the SM, and did not notice new problems for their movement. On the contrary, non-residents perceived the SM mainly as on obstacle to their trips, as crossing it became more difficult. This divergence of opinion emerged both from the in-depth interviews with stakeholders and from field interviews run with people encountered in the SM. Likely, a more extensive and quicker implementation of a number of neighbouring SMs could have mitigated this disagreement, as more people would have undergone the advantages of living *in* a SM, and not only the disadvantages of living *near* a SM.

Moreover, a too dilatory scheduling in SM implementation could have impacts on traffic levels. According to Barcelona's Urban mobility plan, the main network of thoroughfares would be able to absorb car traffic diverted from inner streets only thanks to a modal shift, that should be ensured by a push and pull strategy. To this aim, the role of SMs is crucial, as they discourage car

use and promote walking. But if the improvement of the alternatives to driving (such as public transport and cycling) in the main network is not timely, and the SM implementation is too slow and scattered, modal shift might be modest and traffic congestion could arise, as some of the interviewees complained for the Poblenou SM. Anyway, this risk will have to be verified when more SMs will have been realised.

Structure of the street network

A third order of critical issues is related to the specific pattern of the Cerdà grid in Barcelona. In the oldest core of the city there is a clear difference in width between main and secondary streets; the latter are quite narrow (6-10 meters), and the strategy of discouraging car traffic along them is quite effortless to be justified. The Cerdà grid is completely different. It does not show a hierarchy between main and secondary streets; on the contrary, it is extremely homogeneous: all its streets have the same width, which is quite significant (20 meters). In such an undifferentiated grid, classifying a street as main or inner depends only on an 'urban logic' (i.e., creating an effective overall main network on the whole city) and not on the peculiar geometric features of the street. So, defining a 20 meter-wide street as 'inner' and preventing cut-through traffic along it can turn out difficult to be accepted by people. And as the interviews outlined, this criticality is perceived both by the public administration and by citizens.

> The wide, three-lane streets [of the Cerdà grid] seem designed especially for the car, and after decades of undisputed domination it is not easy to promote car-free street (officer of Barcelona's Department of Ecology, urban planning and mobility – Communication and participation Division).

Another perceived discrimination emerged between residents in the Poblenou SM living on the traffic calmed streets inside it or on its four bordering thoroughfares, where cut-through traffic

should be concentrated. As outlined in the interviews, this difference in traffic volumes can also affects house prices (Kawamura and Mahajan 2005):

> It is hard for citizens to understand why your street can be full of trees and birds while mine must host all car traffic. This problem is very evident in Cerdà grid: a street has no cars, pollution or noise, while the next one is identical but must support car traffic. (officer of Barcelona's Department of Ecology, urban planning and mobility – Communication and participation Division).

The same discrimination concerns local tertiary activities, such as retail and services that benefit mainly from passers-by, therefore from their location, as they are not attractive enough by their own function to draw people as final destinations (Porta et al. 2012). If these activities happen to be localised in streets that are incorporated inside a SM, they risk to be penalised compared to those along the thoroughfares of the main network.

Finally, the implementation of Poblenou SM demonstrated that it is not immediate to convert a wide, former car traffic road, in a shared public space that is steady and safely lived and experienced (Podjapolskis 2017). To this respect, the speed of the transition from the functional to a more structural implementation is an essential factor. The functional phase can be useful to verify if the design of the SM (traffic directions, redistribution of the street space between cars, cyclists and pedestrians, location of car parks etc.) may work; but the interviews showed that the street space freed up by the cars in the functional phase turned out not to be so attractive for residents, that complained their desertification. Interviews also let emerge safety issues due to the fading of natural surveillance that was provided by car traffic.

> The new street spaces that are now free of cars become completely deserted from 18:00/19:00, there is nobody around. So nobody uses them because it is not safe (member of the Plataforma d'Afectats per la Superilla).

The Poblenou SM began to be really lived only when green equipment and street furniture were put in place in a more definitive, structurally finalized version[8]:

> It is necessary to make citizens understand that a car-free space is a space for them, but in order to do this we need to have a project for the transformation of public space to be applied simultaneously with that for mobility (officer of Barcelona's Department of Ecology, urban planning and mobility – Communication and participation Division).

Implications for the governance of the implementation process

The critical issues that have been analysed in the previous section have important implications for the governance of the implementation process of the SM strategy.

First, the speed of the transition from the functional to the structural implementation is an essential factor, if SMs have to be accepted by residents. But the structural implementation of a SM is quite expensive (in the case of Poblenou, 3.8 million euros were invested, compared to 50,000 for the initial functional phase). If each SM has to be realized almost immediately in his definitive permanent form, it becomes very difficult for a city to rapidly spread SMs across its entire urban surface, unless a very substantial budget is available. In other words, the time horizon for completing the SM strategy implementation on the whole city becomes very long; and this incremental implementation could heighten the risks of disparities and conflicts between citizens living inside and outside existing SMs, especially in a very homogeneous urban context such as the Cerdà grid.

In such a long horizon, the inclusion of the SM strategy in official documents and plan at the

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[8] In a recent interview by a Spanish newspaper, a member of the Collectiu Superilla Poblenou confirmed this finding:"The 'low cost' model did have to be revised upwards. There is also an element of perception. 'If people see a space which has been urbanized and landscaped for pedestrian […], they don't think why not put cars on it; if the carriageway is maintained, even putting flowers pots and paint on it, they see it as wasted for traffic'" (*elPeriódico*, October 4, 2018).

urban level (in particular the Urban mobility plan) can be important, since the necessity to coordinate the implementation of the strategy at the urban and the local level. As a matter of fact, the time scheduling of the measures foreseen in these plans can be used to determine the order in which the SM will be implemented in the various districts of the city.

A third issue concerns the importance of horizontal governance. In the case of Poblenou, after the initial two-week workshop, the functional implementation of the SM was launched without communicating it to residents, who were poorly involved in the process. Protests arose, and a participation process had to be activated, in order to mediate between the theoretically ideal SM and the requests of the residents. A certain degree of flexibility turned out to be necessary to implement the ideal theoretical SM model in a real, already built neighbourhood, and to foster acceptance of the SM by residents.

> From September to December 2016, we worked hard to adapt the theoretical/perfect idea of the SM to reality, which means that the bus can pass through the SM, that there is a road which is not necessary for vehicular traffic and will be completely closed without making a boucle, and so on. We worked to adapt the theory to reality (officer of Barcelona's Department of Ecology, urban planning and mobility – Communication and participation Division).

Conclusion

The SM approach is an interesting attempt to re-interpret and update a key principle of neighbourhood planning – separation of access and cut-through traffic – so to apply it to the existing city, with the aim to improve quality and liveability of public spaces at the neighbourhood level, and reduce the modal share of private motorised vehicles in the whole city. Still, the analysis of the implementation process of the SM model in Barcelona highlighted some critical aspects.

This paper has focused attention on the relationship between the SM implementation at the neighbourhood scale and the city scale, addressing three main issues.

The first concerns the coherence and temporal coordination of the implementation of the SM at the urban and local level: it has been found that tactical and reversible solutions can be useful to a

structural implementation of the single SM. However, until the main network of thoroughfares is not re-organized (in terms of bus routes, cycle lanes, availability of car parks, etc.), the implementation of SMs in single neighbourhood can be quite complicated. In terms of temporal progression of the realization of the SMs, the experience of Poblenou showed that a quick transition from the functional to the structural implementation of each SM is essential to assure that SMs are really vibrant. This implies that an incremental realization of structural SMs is to be preferred than a rapid spreading of functional SMs throughout the city.

Secondly, the SM model seems to be more easily accepted when applied to urban areas which show a clear and physically evident hierarchy between main and secondary streets (such as Gracia and Ciutat Vella in Barcelona), than to homogeneous street networks such as the Cerdà grid. One of the key objectives of the SM approach is to increase spatial justice, reducing the core-periphery gradient (in line with the original equity purposes of the Cerdà grid; Neuman [2011]); on the contrary, quite paradoxically, the implementation of the Poblenou SM ended up triggering off a number of conflicts and discriminations, between: residents in SMs and residents in neighbourhoods not yet redesigned as SMs; residents and activities inside a SM and those located at its verges; residents and visitors of a SM; car drivers and non-motorized citizens; pedestrians and cyclists. In this sense, the SM strategy can be seen as an experience that tests the resistance and resilience of the Cerdà grid (Sardà 2018).

Thirdly, these issues mean that the governance of the strategy must meet certain requirements, relating to temporal synchronization of its implementation at urban and local level, scheduling of progressive realisation of SMs, involvement of population, flexibility in the application of the SM ideal model to real contexts. In fact, the SM strategy has evolved and changed from its first application in 2006, trying to find the most suitable solutions for the urban and neighbourhood context.

The implementation of the SM strategy to a large city as Barcelona can only be a long process. In this sense, it is possible that some of the highlighted criticalities can be due to the

intermediate phase of implementation reached by the project. Still others are only prospective: they seem likely to occur when more SMs will be implemented but have to be thereafter verified. It will be interesting to monitor citizens' level of satisfaction in Barcelona when SMs will be implemented on a wider part of the city. It will also be possible to complement the qualitative, interview-based approach adopted in this paper with a more quantitative approach, so to measure the effects of the SM strategy on traffic volumes, noise, air pollution, house prices, etc.

In conclusion, the SM model involves questions ranging from multi-scale vertical coordination to multi-sectorial horizontal governance, from socio-spatial justice to public participation, from tactical local solution to strategic urban approaches. In other words, it clearly shows how complex the issue of the liveability of a neighbourhood can be for urban design.

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References

Adams, T., E. M. Bassett, and R. Whitten. 1929. "The Radburn project: the planning and subdivision of land." In *Committee on Regional Plan of New York and its environs, Volume 7,* 264-269. New York: New York Regional Planning Association.

Alawadi, K., and O. Benkraouda. 2018. "What Happened to Abu Dhabi's Urbanism? The Question of Regional Integration". *Journal of Urban Design* 23 (3): 367–94. doi.org/10.1080/13574809.2017.1361786.

And, C. M. L., and K. H. Ahn. 2003. "Is Kentlands Better than Radburn?: The American Garden City and New Urbanist Paradigms." *Journal of the American Planning Association* 69 (1): 50–71. doi.org/10.1080/01944360308976293.

Birch, E. L. 1980. "Radburn and the American Planning Movement The Persistence of an Idea." *Journal of the American Planning Association* 46 (4): 424–439. doi:10.1080/01944368008977075.

Botteldooren, D., L. Dekoninck, and D. Gillis. 2011. "The Influence of Traffic Noise on Appreciation of the Living Quality of a Neighborhood." *International Journal of Environmental Research and Public Health* 8 (3): 777–798. doi:10.3390/ijerph8030777.

Brody, J. 2016. “How ideas work: memes and institutional material in the first 100 years of the neighborhood unit.” *Journal of Urbanism: International Research on Placemaking and Urban Sustainability* 9 (4): 329–352. doi:10.1080/17549175.2015.1074602.

Buchanan, C. 1964. *Traffic in Towns. The Specially Shortened Edition of the Buchanan Report.* Harmondsworth: Penguin Books.

Cakmak, S., M. Mahmud, A. Grgicak-Mannion, and R. E. Dales. 2012. “The influence of neighborhood traffic density on the respiratory health of elementary schoolchildren.” *Environment International* 39 (1): 128–132. Doi:10.1016/j.envint.2011.10.006.

Erickson, A. T., and A. R. Highsmith. 2018. “The Neighborhood Unit: Schools, Segregation, and the Shaping of the Modern Metropolitan Landscape.” *Teachers College Record* 120 (3): 1–36.

Ewing, R., and E. Dumbaugh. 2009. “The Built Environment and Traffic Safety: A Review of Empirical Evidence.” *Journal of Planning Literature* 23 (4): 347–367. doi:10.1177/0885412209335553.

Grammenos, F., B. Craig, D. Pollard, and C. Guerrera. 2008. “Hippodamus Rides to Radburn: A New Model for the 21st Century.” *Journal of Urban Design* 13 (2): 163–176. doi:10.1080/13574800801965643.

Houston, D., J. Wu, P. Ong, and A. Winer. 2004. “Structural Disparities of Urban Traffic in Southern California: Implications for Vehicle-Related Air Pollution Exposure in Minority and High-Poverty Neighborhoods.” *Journal of Urban Affairs* 26 (5): 565–592. doi:10.1111/j.0735-2166.2004.00215.x.

Howley, P., M. Scott, and D. Redmond. 2009. “Sustainability versus liveability: an investigation of neighbourhood satisfaction.” *Journal of Environmental Planning and Management* 52 (6): 847–864. doi:10.1080/09640560903083798.

Jacobs, J. 1961. *The Death and Life of Great American Cities*. New York: Random House.

Johnson, D. L. 2002. “Origin of the Neighbourhood Unit.” *Planning Perspectives* 17 (3): 227–245. doi:10.1080/02665430210129306.

Kan, H. Y., A. Forsyth, and P. Rowe. 2017. “Redesigning China’s superblock neighbourhoods: policies, opportunities and challenges.” *Journal of Urban Design* 22 (6): 757-777. doi:10.1080/13574809.2017.1337493.

Kawamura, K., and S. Mahajan. 2005. “Hedonic analysis of impacts of traffic volumes on property values.” *Transportation Research Record* (1924): 69-75. doi:10.1177/0885412210386540.

Lee, C. M., and B. Stabin-Nesmith. 2001. “The Continuing Value of a Planned Community: Radburn in the Evolution of Suburban Development.” *Journal of Urban Design* 6 (2): 151–184. doi:10.1080/13574800120057827.

Mehaffy, M. W., S. Porta, Y. Rofè, and N. Salingaros. 2010. “Urban nuclei and the geometry of streets: The ‘emergent neighborhoods’ model.” *URBAN DESIGN International* 15 (1): 22–46. doi:10.1057/udi.2009.26.

Mehaffy, M. W., S. Porta, and O. Romice. 2015. “The ‘neighborhood unit’ on trial: a case study in the impacts of urban morphology.” *Journal of Urbanism: International Research on Placemaking and Urban Sustainability* 8 (2): 199–217. doi:10.1080/17549175.2014.908786.

Middleton, D. A. (2009). *Growth and expansion in post-war urban design strategies: CA Doxiadis and the first strategic plan for Riyadh Saudi Arabia (1968-1972).* Doctoral dissertation. Georgia Institute of Technology.

Mukhija, V., and D. Shoup. 2006. “Quantity versus Quality in Off-Street Parking Requirements.” *Journal of the American Planning Association* 72 (3): 296–308. doi:10.1080/01944360608976752.

Mumford, L. 1961. *The city in history: Its origins, its transformations, and its prospects*. New York: Harcourt.

Neuman, M. 2011. “Centenary paper: Ildefons Cerdà and the future of spatial planning: The network urbanism of a city planning pioneer.” *Town Planning Review* 82 (2): 117-144. doi:10.3828/tpr.2011.10

Oliver, A., and D. S. Pearl. 2017. “Rethinking sustainability frameworks in neighbourhood projects: a process-based approach.” *Building Research and Information*, 46 (5): 1–15. doi:10.1080/09613218.2017.1358569.

Ortolani, C., and M. Vitale. 2016. “The importance of local scale for assessing, monitoring and predicting of air quality in urban areas.” *Sustainable Cities and Society* 26: 150–160. doi:10.1016/j.scs.2016.06.001.

Patricios, N. N. 2002. “Urban design principles of the original neighbourhood concepts.” *Urban morphology* 6 (1): 21-36.

Perry, C. A. 1929. “The Neighbourhood Unit”. In *Committee on Regional Plan of New York and its environs, Volume 7*, 20-141. New York: New York Regional Planning Association.

Perry, C. A. 1939. *Housing for the Machine Age*. New York: Russell Sage.

Podjapolskis, R. 2017. “Supermanzanas bajo sospecha: el proyecto de Superislas para Ensanche frente a su alternativa”. Paper presented at the IX Seminario Internacional de Investigación en Urbanismo, Barcelona-Bogotá, June, 2017.

Porta, S., V. Latora, F. Wang, S. Rueda, E. Strano, S. Scellato, and L. Latora. 2012. “Street Centrality and the Location of Economic Activities in Barcelona.” *Urban Studies* 49 (7): 1471–1488. doi:10.1177/0042098011422570.

Rohe, W. M. 2009. “From Local to Global: One Hundred Years of Neighborhood Planning.” *Journal of the American Planning Association* 75 (2): 209–230. doi:10.1080/01944360902751077.

Rueda, S. 2009. *El urbanismo ecológico: un nuevo urbanismo para abordar los retos de la sociedad actual*. http://www.upv.es/contenidos/CAMUNISO/info/UrbanismoEcologicoSRueda.pdf.

Rueda, S. 2014, *Ecological Urbanism: Its Application to the Design of an Eco-neighbourhood in Figueres*. Barcelona: Agència d'Ecologia Urbana de Barcelona.

Rueda, S. 2017. “Les superilles per al disseny de noves ciutats i la renovació de les existents: el cas de Barcelona.” *Regió Metropolitana de Barcelona: Territori, estratègies, planejament* (59) : 78-93.

Salat, S., L. Bourdic, and F. Labbe. 2014. “Breaking Symmetries and Emerging Scaling Urban Structures: A Morphological Tale of 3 Cities: Paris, New York and Barcelona.” *International Journal of Architectural Research* 8 (2): 77–93. doi:10.26687/archnet-ijar.v8i2.445.

Sardà, J. F. 2018. “Cerdà/Barcelona/Eixample: 1855-2017… A Work in Progress”. In *Designing Grid Cities for Optimized Urban Development and Planning*, edited by G. Carlone, N. Martinelli and F. Rotondo, 19-38. Hershey: IGI Global.

Scoppa, M., K. Bawazir, and K. Alawadi. 2018. “Walking the superblocks: Street layout efficiency and the sikkak system in Abu Dhabi”. *Sustainable cities and society* 38, 359-369. doi.org/10.1016/j.scs.2018.01.004

Sharifi, A. 2016. “From Garden City to Eco-urbanism: The quest for sustainable neighborhood development.” *Sustainable Cities and Society* 20: 1–16. doi:10.1016/j.scs.2015.09.002.

Shoup, D. C. 1999. “The trouble with minimum parking requirements.” *Transportation Research Part A: Policy and Practice* 33 (7-8): 549–574. doi:10.1016/S0965-8564(99)00007-5.

Siksna, A. 1998. “City centre blocks and their evolution: A comparative study of eight American and Australian CBDs.” *Journal of Urban Design* 3 (3): 253-283. doi:10.1080/13574809808724429.

Silver, C. 1985. “Neighborhood Planning in Historical Perspective.” *Journal of the American Planning Association* 51 (2): 161–174. doi:10.1080/01944368508976207.

Speranza, P. 2016. “Using parametric methods to understand place in urban design courses.” *Journal of Urban Design* 21 (5): 661–689. doi:10.1080/13574809.2015.1092378.

Speranza, P. 2017. “A human-scaled GIS: measuring and visualizing social interaction in Barcelona’s Superilles.” *Journal of Urbanism: International Research on Placemaking and Urban Sustainability* 11 (1): 1–22. doi:10.1080/17549175.2017.1341426.

Talen, E. 2017. “Social science and the planned neighbourhood.” *Town Planning Review* 88 (3): 349–372. doi:10.3828/tpr.2017.22.

Tetlow, J., and A. Goss. 1968. *Homes, towns, and traffic*. New York: Praeger.

Zhang, M. 2013. “On the Cul-de-Sac vs. Checker-Board Street Network: Search for Sustainable Urban Form.” *International Review for Spatial Planning and Sustainable Development* 1 (1): 1–16. doi:10.14246/irspsd.1.1_1.