

## Guiding principles for the 15-minute city in peripheral areas: the emc2 model.

Giovanni Fusco<sup>1</sup>; Meta Berghauser Pont<sup>2</sup>; Valerio Cutini<sup>3</sup>; Angelika Psenner<sup>4</sup>

<sup>1</sup>Université Côte d'Azur-CNRS-AMU-AU, ESPACE, France

<sup>2</sup>Chalmers University of Technology, SMOG, Sweden

<sup>3</sup>University of Pisa, DESTeC, Italy

<sup>4</sup>TU Wien, Department of Urban Design, Austria

giovanni.fusco@univ-cotedazur.fr, meta.berghauserpont@chalmers.se,  
valerio.cutini@unipi.it, angelika.psenner@tuwien.ac.at

### Abstract

The 15-minute City (15mC) is a novel urban planning approach aiming at affordable and sustainable mobility while enhancing urban life. Implementing this concept in car-dependent outskirts and suburbs poses significant challenges due to their lacking essential morphological features. Cities, especially in metropolitan areas, function as interconnected networks rather than standalone walkable neighbourhoods, complicating the implementation further. The Evolutive Meshed Compact City (emc2) offers a networked pedestrian-based 15mC model suitable for many European peripheries. The model relies on a set of guiding principles and detailed specifications, which are interrelated across different scales. To evaluate its potential in European metropolitan peripheries, a research design is proposed, focusing on its ability to facilitate a successful transition to a 15mC. Additionally, the paper compares the emc2 model with other proposed 15mC solutions.

### Keywords

15-minute City, Suburbs, Networked Densification, Pedestrian-Friendly Urban Form

### 1. Introduction: challenges for the 15-minute City in metropolitan peripheries

Developing a 15-minute City (15mC) represents a novel planning strategy aimed at fostering affordable and sustainable mobility. However, its objectives extend beyond mere transportation goals, encompassing the enhancement of overall city life and the prioritisation of human needs in urban planning. Indeed, the concept of the 15mC aligns closely with the Sustainable Development research agenda, which seeks to enhance quality of life while facilitating the energy and ecological transition of 21st-century cities. By promoting pedestrian-based proximity, the 15mC aims to enable inhabitants and city users to access destinations that fulfil most of their daily needs within a short walking distance (Moreno et al., 2021; EIT Urban Mobility, 2022). This shift is expected to reduce reliance on motorised traffic and render retail and services viable at a local scale.

Pedestrian-based proximity should not be narrowly interpreted solely in terms of short distances that are easily traversed on foot. Two additional considerations must be integrated into the framework. Firstly, the 15mC must recognize the multi-scalar nature of urban life by accommodating both short- and long-distance movement patterns. Secondly, it must ensure that pedestrian and non-pedestrian movement respects the well-being of pedestrians, both while walking and when stationary. This entails that the 15mC should harmonise functional considerations regarding pedestrian accessibility to destinations across different scales with the

broader affordances of public space to address a variety of human needs that arise from its usage.

Compact European cities have already implemented 15mC solutions with notable success, as evidenced by Paris and Barcelona. However, the transition to a 15mC is considerably more challenging in post-war car-dependent outskirts and suburbs due to stringent prerequisites concerning urban form and spatial organisation, aspects often overlooked in much of the European literature on the subject. In contrast, North American cities exhibit greater attention to retrofitting suburbia, as highlighted by the work of Duhnam-Jones and Williamson (2011). For instance, the city of Portland has tailored its 15mC policy to suit its diverse urban forms, including the retrofitting of suburbs with small retailers through accessory commercial units. We contend that European cities possess significant untapped potential to intervene in the physical form of their outskirts and suburbs and to implement ambitious 15mC policies.

In both Europe and North America, car-dependent outskirts and suburbs often lack several key morphological prerequisites for the 15mC: centrality, density, proximity to services and public transport, mixed land use, quality walking and cycling infrastructure, and attractive public spaces. These prerequisites significantly influence people's behaviours through intermediate concepts such as walkability, sense of place, ease of access, and vibrancy (Gehl, 2011; Dovey et al., 2017). We believe that interventions solely focused on improving pedestrian accessibility, without addressing these underlying morphological challenges, will struggle to successfully implement the 15mC in peripheral areas. What is required is a new coherent framework to guide interventions across the various facets of the 15mC.

Moreover, to successfully implement the 15mC concept in outskirts and suburbs, it's crucial to acknowledge that cities operate as open networks rather than as collections of self-sufficient "walkable neighbourhoods" or "urban villages." This is especially true in a metropolitan context, where multiple centres at different scales interact through infrastructural networks. These networks profoundly influence the localization of retail and services, which are only viable where human flows concentrate within a movement economy (Hillier, 1996).

The Evolutive Meshed Compact City (emc2) is being developed to offer a workable urban model capable of ensuring the necessary coherence of a 15mC strategy in urban peripheries. The model suggests distributing compact urban form as corridor development along pre-existing main roads connected to wider-range mobility options, thereby forming a meshed structure across the metropolitan area. This necessitates smart densification along these streets, which are further redesigned for pedestrians to transform into lively main streets. Presently, the emc2 model is the subject of a coordinated research effort by the authors and will be the focus of this paper.

The paper is structured as follows: Section 2 will delineate the emc2 model through its five overarching guiding principles. Section 3 will outline a research design aimed at evaluating the potential of the emc2 model in European metropolitan peripheries and identifying its strengths and weaknesses. This analysis aims to discern where the model is most effective in facilitating a successful transition to a 15mC in peripheral areas. Finally, Section 4 will conclude by examining the emc2 model in relation to other overlapping or sometimes competing models for organising urban space.

## **2. The emc2 model through its five guiding principles**

The emc2 model is a model of a networked pedestrian-based 15mC well adapted to the prevailing conditions of many peripheries and suburbs in European metropolitan areas. The model can be specified through the implications of a few guiding principles. Each principle, it

its turn, will allow us to identify more detailed specifications. Principles and detailed specifications imply each other, across scales and within a given scale. This systemic view of the organisation of urban space could eventually give rise to an even more detailed pattern language (Alexander et al. 1977; Mehaffy et al. 2020) for the 15mC in European metropolitan peripheries, which could serve as guidelines for decision makers, planners and urban designers.

**Principle 1. A meshed foreground network of main streets is the backbone of an uninterrupted system of pedestrian public space, enhanced by multimodality.**

The main components of the emc2 model are main streets, i.e. streets concentrating urban activity and pedestrian public life (Gehl, 2011). They correspond to what are normally identified as high streets in the UK, where they remain a central element even in a suburban context (Vaughan, 2015). This concept of main street should not be confused here with the one used in traffic engineering, corresponding to an arterial road, with high traffic capacity and long-range significance. At the same time, it is only by applying all the founding principles of the emc2 model that the concept of the main street can be understood. Every principle will add a new facet to it. Within this first principle, main streets will be barely defined as important elements of the street network and of the urban mobility system, characterised by a high potential of pedestrian flow.

**Specification 1.1. Foreground mesh of main streets.** The foreground network within an urban street system is the set of the streets with the highest levels of configurational centrality across various scales (Hillier, 1996). As such, it is characterised by the configurational properties imparted to each street by the overall topology of the street network, regardless of the functions they serve. As noted by Hillier, streets with the highest configurational centrality are directly interconnected, forming a fully connected network. Typically, in large urban areas, a system of hubs and spokes emerges, where accessibility extends not only to the central hubs but also to the spokes, which channel 'through movement'

However, to maintain consistency with the principles of the 15-minute walking city, the foreground network within the emc2 model will intentionally exclude motorways and similar roads that prohibit pedestrian access and building entrances. Although these roads often possess high configurational centrality values at the metropolitan scale, they lack the frequent connections necessary to increase configurational centrality at smaller scales (Berghauser Pont et al. 2019). Research in space syntax and other configurational approaches indicates that defining a foreground network in this manner provides valuable insights into the distribution and intensity of pedestrian flows (Lerman et al. 2014; Berghauser Pont et al. 2019), which, in turn, correlates with the level of activity in adjacent buildings, particularly for retail and service establishments benefiting from increased pedestrian traffic.

The spatial structure of the foreground network is of paramount importance in the emc2 model. Firstly, to ensure continuity in pedestrian movement and in the distribution of pedestrian-based activities, the foreground network must be completely connected even when motorways are excluded from it; otherwise, car-based mobility becomes a necessity even for connecting relatively close places. Secondly, the network should be as meshed as possible, avoiding long tree-like structures, to create redundancy of connections and minimise spaces where pedestrians are too far away from a main street. Main streets in traditional central urban areas create meshes of around 400 metres in length (Mehaffy et al., 2010). This could serve as an objective for the most densely populated peripheral areas covered by the emc2 model. More realistically, in suburban and peri-urban peripheries, the sides of the meshed structure could be up to 1000-1500 metres long, while still keeping most of the inner area within a 10-minute walk from

several main streets. The foundational idea of the emc2 model for the peripheral 15mC is to place inhabitants and city users, wherever they are, at close walking distance from main streets.

**Specification 1.2. Uninterrupted public space system with pervasive pedestrian multimodality.** The interconnected and meshed foreground network could not serve as the backbone of the 15mC if it were not integrated within a wider system of public spaces for pedestrians. Uninterrupted public space is necessary throughout the urban area: all main streets should be walkable, along with the ordinary and capillary streets that feed into them, as well as the plazas, squares, and parks connected to them. Multimodality, especially transit and cycling, must be considered as options to enhance pedestrian accessibility beyond the 15-minute threshold and should not presuppose car use to access their networks. The ease of using cycling and transit for longer trips will reduce suburban areas' dependence on cars for integration into the metropolitan area (Newman and Kenworthy, 1999).

Pedestrian-based multimodality recognizes the necessity of long-distance travel within the contemporary city. However, whenever possible, both short- and long-distance patterns of movement within the city are supported by the same foreground street network. Transit options compatible with the main streets (such as streetcars and buses) can be integrated within them, as well as bicycle paths and some residual car traffic. The goal is to reinforce the centrality of main streets with transit routes without sacrificing pedestrian space within them. Over the last forty years, many European cities have used streetcar projects as means for the requalification of public space (MVG, 2008). While some of the most central axes have become completely pedestrianised (except for the presence of streetcar tracks), more peripheral streets have been able to accommodate requalified sidewalks, cycle paths, as well as residual space for car traffic. From this perspective, European projects differ from many North American counterparts, where light railway transit has been preferred to streetcars: the distance between stops is normally greater, speeds are higher, and, as a consequence, tracks are often physically protected from pedestrian crossing, thereby becoming, along with much more generous space for car traffic, a major obstacle to the pedestrian functioning of the street.

**Principle 2. The network of main streets develops synergies with ecological networks and with far-range mobility corridors and keeps its structure over time.**

The contemporary metropolis is, as a networked space, in need of a network urbanism (Dupuy, 2008). Following this premise, we see the network of main streets as one of the many networks of contemporary urbanisation, albeit the most important of them. As such, it should develop synergies (and avoid conflicts) with ecological networks (namely blue and green networks) and with far-range mobility corridors (highways, railways). From this principle, the network of main streets also gets the role of main intermediary structure between different networks of the contemporary metropolitan area.

**Specification 2.1. Green and blue ecological networks** are interconnected corridors of undeveloped land of ecological significance, as well as water bodies near them. Urban green spaces have the potential to provide crucial ecosystem services that lower health risks, increase the resilience and ecological integrity of cities, improve the health of residents, and create more equitable living spaces across the socioeconomic spectrum. Enough nearby green space benefit the physical and mental health of residents and can strengthen communal cohesion and belonging via a myriad of pathways (Hartig et al., 2014; WHO, 2016; Braubach et al., 2017; Dizdaroglu, 2021).

However, for such positive effects to occur, both the quantity and the qualities of such space must be sufficient. It is recognised that the ecological quality is also a function of the multiple

connections existing among the different green and blue areas. Accordingly, the attention is presently more on the creation of networked corridors of rich natural life than on the sheer size of urban parks. Indeed, green and blue corridors can count on specific topographic features structuring their continuity (a talweg, a ridge, the coast of a large waterbody). Renaturalization actions are sometimes needed to ensure continuity. More attention is also given to further connecting other green areas (public and private gardens, playgrounds, etc.) to the main ecological corridors, even if in a lighter way (through street trees and hedges, road crossing devices for small animals, etc.). Indeed, isolation of ecological patches seems to be more hampering than loss of contiguity: fragmentation per se could even have moderate positive effects (Fahrig, 2019) when ecological patches are not completely isolated.

Availability of connected green and blue areas in the suburbs doesn't imply accessibility to them. Synergies are created when easy connections are made for pedestrians to access these ecological corridors with pathways leading to the main streets, which remain the most accessible elements for inhabitants and city-users alike. Crossings and overlays are also possible but taking care of not disrupting neither the ecological functions of green space nor the human usage of public space.

**Specification 2.2. Mobility corridors** are necessary to ensure long-distance connections within a metropolitan area and beyond it, with further destinations. These corridors are made of motorways and railways serving the main centres of the metropolitan area. As such, they are a main concern of national and regional planning policies. Necessary as they are, they are made of infrastructural elements which are hardly compatible with pedestrian-friendly public space. There is ample research on the barrier effects of far-range transport infrastructure for pedestrian-based local street networks (for a review see Van Eldijk et al. 2022). The main point is the inter-scalar nature of mobility systems. Car and railway infrastructure aim at decreasing the impedance (travel time) to access destinations on the national and regional scales. But this infrastructure often does so by introducing physical barriers in mobility systems on a more local scale, increasing impedance for walking and cycling, to access destinations within neighbourhoods or among neighbourhoods. The emc2 model aims at minimising these disruptions, above all when they concern the most essential elements of the human-centred city: main streets. Whenever the latter enter in conflict with transportation infrastructure, overpasses and tunnels should be foreseen for these extra-urban elements, leaving the ground floor always for pedestrian main streets. The positioning of main streets and transportation infrastructure also need attention: parallel positioning in close proximity is problematic as it severs the main street from its pedestrian shed. Similar conflicts arise between ecological and mobility corridors, necessitating appropriate solutions, but with less compelling requirements (tunnels and overpasses can sometimes be acceptable for ecological continuity, as well as parallel positioning in proximity if the necessary connections are foreseen).

Mobility corridors and main streets can also develop synergies. By creating multimodal synapses with city streets (railway stations, park & ride facilities, multimodal hubs) in a pedestrian-friendly environment, mobility corridors can feed the pedestrian flows on main streets and the use of their embedded transit and cycling systems. As a result, their movement economy is enhanced beyond the flows linked to their configurational potential within the street network. Specific design patterns are needed to ensure pedestrian-friendly connections between multimodal synapses and main streets.

**Specification 2.3. Structure preserving development.** All networks evolve over time: the network of main streets, green and blue networks, mobility corridor networks and even the network of ordinary streets serving new urban developments. Based on simple considerations of resource parsimony or on more theoretical considerations of system wholeness, complexity

and resilience (Gunderson and Holling, 2002; Alexander, 2003; Salingaros, 2005; Mehaffy and Salingaros, 2013), these developments have to be structure-preserving, adding new elements incrementally to old ones as much as possible. Research in urban morphology has already pointed out that urban development always combines permanence and change (Hanson, 1989; Panerai, 2013; Romice et al., 2020, Fusco et al., 2024): the street network and the plot system are the main morphological infrastructure, changing relatively slowly over the decades and even the centuries. Supported by this infrastructure, faster cycles of building construction and reconstruction can take place without losing the apparent continuity of a given settlement. Within this overarching consideration, the permanence of high streets is considered as an even more compelling principle. Not only the layout of main streets is rarely modified, but when new main streets add to the old ones, they do so by intensifying or widening the spatial extent of the foreground network and without degrading the status of the old main streets. Of course, despite this general rule, urban history presents cases of demoted main streets, sometimes happening when a new parallel street absorbs its functions (Caniggia and Maffei, 2017). In the fragile suburban contexts, the emc2 model recommends extreme caution when allowing such shifts in centrality, suggesting taking stock of all the potential of established main streets.

**Principle 3. Locally, the main street acts as an accessible, dense, and diverse centre for a neighbouring area.**

One of the most notable aspects of the emc2 model is its vision of main streets as central elements within suburban and peri-urban peripheries. This approach shifts the focus away from a collection of suburban villages acting as central points for their immediate surroundings and instead emphasises the interconnection of central axes across different villages to create a more distributed and linear centrality in metropolitan peripheries. This concept, described by Hillier (1996) as pervasive centrality, firmly establishes main streets as key components of the socioeconomic functioning of the suburbs.

**Specification 3.1. Main Street as an accessible linear centre.** We have already established that main streets are integral components of the foreground network at a broader scale, yet they are also easily accessible locally. This dual accessibility implies that main streets possess high configurational centrality, facilitating movement both at a mesoscale (beyond the 15-minute walking distance, through their connections with other elements of the foreground network) and at a more local scale (within the 15-minute walking distance, through their connections to ordinary streets and other local public spaces). This multi-scalar network centrality is crucial for generating business opportunities across various activities within the movement economy (see below).

The central role of main streets within a pedestrian shed is analysed by Mehaffy et al. (2010) in their examination of traditional urbanisation, and it is envisioned as a significant pattern in their new pattern language (Mehaffy et al., 2020). As a matter of fact, several post-war developments in European cities have struggled to maintain the vitality of their main streets and squares due to inadequate accessibility and multi-scale centrality within their layout and the larger urban area where they are situated. For a main street to function effectively as a local node within a broader centrality network spanning the entire metropolitan area, it must also serve as a bridging tie within the conurbation system, facilitating connections between neighbourhoods. This capacity, derived from their configurational properties, positions main streets as pivotal locations within the grid, acting as bottlenecks for most movement flows and thus suitable for catalysing the coalescence of local densification processes.

**Specification 3.2. Main street as a dense and diverse linear centre.** The favourable pedestrian accessibility of main streets, coupled with the presence of easily accessible

transportation connections, positions them as focal points for both spontaneous market-driven and planned selective densification. Main streets typically exhibit higher built-up densities than their surroundings and host a diverse range of activities and services. Public-receiving activities such as retail, public and private services, etc., are primarily situated along the main street or on plazas and squares connected to it. These activities on and around main streets benefit from the movement economy (Hillier, 1996; Berghauser Pont et al., 2019; Bobkova et al., 2019; Araldi, 2020; Froy, 2023): flows, concentrated on the main axes by the configuration of the street network, create opportunities for socioeconomic interaction and are a primary driver for the presence of retail and market-driven activities. The presence of these activities, in turn, enhances the utilisation of public spaces on main streets, fostering opportunities for additional services. Consequently, activities on main streets form a dense network (Salingaros, 2005; Mehaffy et al., 2020), with close spacing between them (multiple activities per 100 metres) and good intervisibility, well-suited to the fluidity of pedestrian movement within the walkable space.

In suburban areas, where car dependency undermines the pedestrian flow potential of main streets, locating public facilities such as administrations and schools on main streets within a pedestrian-friendly environment can enhance pedestrian flows and stimulate activities within the movement economy. However, in these suburban contexts, some degree of car access to these activities may still be necessary to maintain their local concentrations on main streets. Addressing car access raises concerns about mitigating the negative impact of car flows on main streets and identifying parking options that are compatible with pedestrian spaces on main streets.

**Principle 4. The main street is pedestrian-friendly and enhances public life.**

This principle ensures that main streets remain human-centred environments, fostering social interaction and well-being. Pedestrian-friendliness of main streets encompasses both ease of pedestrian movement (walkability) and opportunities for pedestrian stay, interaction, and a strong sense of place. Guidelines for designing street public spaces with a focus on human-centeredness exist (Stähle et al., 2022; ADEME, 2023), along with experiments proposing innovative temporary solutions through tactical urbanism (Bertolini, 2020; Lydon and Garcia, 2015). In what follows, we will emphasise what we perceive as the most compelling specifications, recognizing that extensive fine-tuning will be necessary to address local specificities and needs.

**Specification 4.1. Active built-up frontage on the main street.** Build-up frontages along main streets guide pedestrian movement, visually define perceived space, and provide opportunities for locating activities on the ground floor. The significance of visually defining the channel of movement in urban spaces has been underscored since the pioneering works of Cullen (1961) and Lynch (1959), extending further back to the contributions of Sitte (1889). Lynch (1959) posits that paths and edges are fundamental linear features that structure human perception and cognition of urban space; the former is experienced physically through walking, while the latter is primarily perceived visually. When the edge of a built-up frontage aligns with the path of a street, the imageability of the urban structure is notably reinforced, precisely the objective in the case of a main street. It is unsurprising that authors advocating for recommended urban patterns emphasise the importance of certain visual requirements. Firstly, buildings, whether adjacent or detached, align to create an urban frontage, fostering a street corridor effect (Alexander et al., 1977; Gehl, 2010). Secondly, setbacks are either minimal or absent to ensure a strong connection between the street and buildings. Lastly, terminated vistas can be employed to prevent the impression of endless peripheral axes (Mehaffy et al., 2020). To further enhance

the connection to outdoor spaces and provide pedestrians with a sheltered interface, arcades can be developed along the building frontage (Alexander et al., 1977; Mehaffy et al., 2020).

The build-up frontage also results in higher building density, offering opportunities for both living and working along main streets. A functional requirement for buildings along main streets is to accommodate activities, particularly on the ground floor. The challenges of having ground-floor residential units along busy main streets could be addressed by a simple prescription: ground floors are designated for activities. Regarding residential opportunities, an urban frontage on main streets consisting of mid-rise buildings (2 to 5-6 floors) could provide housing options often lacking in suburban areas, such as small to mid-sized flats. These options could complement the larger units found in suburban housing developments and social housing complexes. This housing shortage is well-documented in the North American context (Parolek, 2020) and is a structural barrier to achieving social and generational diversity in many European suburbs. As for high-rise buildings, they pose challenges on peripheral and suburban main streets. Outside the compact fabric of central city perimeter blocks, high-rises tend to be freestanding constructions, weakly connected to the public space of the main street and disrupting the urban frontage. Specific retrofitting strategies may be necessary to integrate existing high-rise buildings into the active urban frontage of peripheral and suburban main streets.

**Specification 4.2. Main Street as a walkable environment.** The focus here is on the layout and organisation of public space. Main streets should provide ample pedestrian space to accommodate groups of people walking comfortably. This entails prioritising pedestrian space, ensuring frequent ground-level pedestrian crossings that cater to all users, including children, the elderly, and the physically impaired, and incorporating street trees to offer shade and thermal comfort (Jacobs, 1993). There are compositional differences among three types of main streets:

- Large urban boulevards, wider than 30-40 metres, can feature spacious sidewalks (5 metres and more), accommodate multiple modes of transportation, and include several rows of trees. However, efforts should be made to mitigate the separation between opposing sidewalks.
- Urban avenues (20-30 metres wide) may need to compromise on multimodality and vegetation presence to ensure ample pedestrian space but are generally easier for pedestrians to cross.
- Unplanned main streets (typically less than 15-20 metres wide and irregular) often stem from the development of faubourgs or linear villages along what Caniggia and Maffei (2017) term a matrix route. These streets may consider pedestrianisation or shared spaces as options and should minimise on-street parking.

Shared spaces with clear pedestrian priority can serve as an alternative to expansive sidewalks, even on larger main streets, as demonstrated by Mariahilfer Straße in Vienna. However, in suburban contexts, car parking may be deemed necessary, necessitating compromises. To prioritise pedestrian use, a limited amount of short-term surface parking could be allocated on side streets or behind retail premises.

**Specification 4.3. Main street as a hub for social interaction with soft interfaces.** As discussed in Principle 3, the intensity of public life is strongly influenced by the role of the street within the broader street network. Bolin et al. (2021) demonstrated in a comprehensive European study that more central streets—those with higher levels of network centrality—in dense neighbourhoods experience greater movement and co-presence. However, the social and economic objective of main streets extends beyond facilitating pedestrian flow; it aims to encourage as much of this movement as possible to transition into social interaction and lingering.

Analysis of traditional urban forms provides invaluable insights into features that go beyond mere presence of built-up frontages. Active interfaces between buildings and streets are essential for urban vitality and natural surveillance. The vitality of street life is enriched by spatial relationships between private and public spaces (Gehl, 2010; Jacobs, 1961), facilitated by the adjacency and permeability of buildings directly accessible from the street. This relationship is elucidated in the interface maps drawn by Hillier and Hanson (1984) to explore the relationship of building entrances and public space in terms of movement and potential encounter. Co-presence and interaction are favoured in traditional streets (Shu, 2000), where the density of entrances and shallow topological depth between private and public spaces foster street vitality, safety, and social control.

Many recommendations can be gleaned from the preceding discussion:

- Facades along main streets should always be "soft" and active, engaging pedestrians with opportunities for interaction such as doors to enter, windows to look at, and recesses allowing for sitting (Gehl, 2010; Dovey and Wood, 2015; Fusco et al., 2024). Blank walls and opaque fences should be avoided.
- Urban furniture, both public and private, should encourage lingering and interaction, while pockets of activity should be developed in recesses of the urban frontage (such as setbacks within private lots or extensions of public space), away from pedestrian movement and car parking (Alexander et al., 1977).
- Layered spaces at building edges add depth to public/private interfaces (Shu, 2000; Gehl, 2010; Mehaffy et al., 2020): setbacks used for public activities and open verandas of bars, shops, and restaurants provide additional opportunities for social interaction and leisure.
- "Eyes on the street" are fostered by buildings facing the street, featuring balconies and windows above the ground floor (Jacobs, 1961), thereby enhancing the safety of public space usage.

All these features have been observed by the aforementioned authors in urban environments that are particularly successful in terms of utilisation and liveliness of public space, what Gehl (2010) defines as intensity of public life. The goal of the emc2 model is simply to ensure that these morphological elements supporting main street public life in peripheral and suburban areas, albeit combined differently to accommodate local specificities, are maximally present.

**Specification 4.4. Main street as a beacon for shared urban values.** Main streets serve as the embodiment of urbanity within each sector of the metropolitan area. Hosting key functions and frequented public spaces, and bordered by significant buildings, they are imbued with human meaning, anchoring community values for inhabitants and city users across a wider area. They represent the enduring presence of the community over historical time (Griffiths, 2015) and serve as an implicit agreement regarding expectations for any urban intervention in the physical layout and functioning of urban space (Gourdon, 2001).

These fundamental considerations can have far-reaching implications for design preferences and necessitate community engagement in any proposed transformation of the streetscape or public space layout of main streets. Therefore, greater attention may be warranted to use materials, proportions, and details that resonate with the local context and cultural preferences along main streets. The historical origins of main streets, whether they evolved spontaneously as faubourgs or were planned as avenues, can significantly contribute to the sense of place, complementing the design and functional considerations highlighted in Specification 3.2. Main streets will also serve as natural venues for ephemeral events, such as local markets, cultural or sporting events, and community or political gatherings. Organising these events to reclaim street space for pedestrians (Bertolini, 2020; Lyndon and Garcia, 2015) could be one of the

initial actions to implement to catalyse the transition of present-day peripheral main streets to the desired levels of urbanity outlined in the emc2 model.

Ensuring equal attention to all users of the main street, regardless of age and ability, through the provision of appropriate urban furniture and the removal of architectural barriers, not only enhances the quality of public space but also reflects important shared values. This stands in contrast to the current imbalance in the use of peripheral arterial roads, which often prioritise car drivers at the expense of neglected pedestrians.

**Principle 5. The inside of the mesh is well connected to the main streets and accommodates functions outside of the movement economy.**

This last principle addresses the areas within the mesh of main streets and how to establish walkable connections to incorporate them into the pedestrian shed surrounding the main streets, thereby expanding the potential clientele for their activities. In broad terms, urban functions that do not primarily serve the needs of the movement economy are situated within the mesh. These may include residential developments, urban parks, as well as industrial and agricultural areas.

**Specification 5.1. Meshed Network of Local Streets.** Local streets should be as meshed as possible, facilitating the efficient distribution of both pedestrian and motorised traffic while delineating blocks. Suburban and peri-urban areas in Europe often fall short in this regard, with numerous local streets branching off from main axes without effectively delineating small-sized blocks (100-150 metres maximum). Local loops can be implemented to discourage through-traffic, a strategy recently employed even in the regular urban grid of Barcelona's city centre to foster more pedestrian-friendly environments on local streets. The interconnectedness of local streets can also facilitate future development of new main streets, enhancing the density of the foreground network. This is particularly evident when a former suburban area transitions into a more central and densely populated settlement: establishing a new main street is often more feasible by catalysing densification and mixed-use development on an existing local street within a meshed network, rather than creating a new right-of-way through costly expropriation procedures. The redundancy of the meshedness of main and local streets enhances the morphological resilience of the model (refer to Specification 2.3): the foreground network of main streets can grow organically, enabling the city to function as a complex adaptive system.

**Specification 5.2. Interconnected Capillary Pathways.** Pathways that serve a few buildings or a housing subdivision, or traverse parks and playgrounds, are interconnected (though not necessarily meshed) for pedestrians and, whenever feasible, for cyclists. They may explicitly prohibit larger vehicles to create tranquil pedestrian sanctuaries. These pedestrian interconnections offer shortcuts across areas delimited by main streets, facilitating easier pedestrian access to the latter. However, it's important to note that the spatial configuration of the background network of alleys and pathways is the most culture-specific aspect of the street network (Habraken, 1998; Hillier, 2012), balancing privacy and publicness in residential areas. According to Hillier, the interstitial part of the background network serves a conservative function in urban space, aimed at maintaining and reinforcing existing social structures, in contrast to the generative role and serendipity of the foreground network of main streets. While its morphology generally allows for more control, its configuration is highly contingent upon the cultural context it seeks to uphold: the embedded rules governing patterns of movement and interaction are heavily influenced by existing cultural systems.

**Specification 5.3. Distributed Parks in the core of the mesh.** Neighbourhood parks and community gardens, not directly involved in the movement economy, can thrive within a semi-

pedestrian environment at the core of the mesh of main streets. The concept of situating a park at the heart of a neighbourhood originated in previous urban models, namely the Garden City (Howard, 1902), and the Neighbourhood Unit (Perry, 1929), and resonates in contemporary works on pattern languages (Mehaffy et al., 2020). However, in the Garden City paradigm, we are dealing more with a large central park for a mid-sized city of 32,000 inhabitants than with distributed parks within neighbourhoods. The central parkway of Welwyn, UK, is a good example of the implementation of this Garden City guideline. Distributed local parks provide an additional amenity within a short walking distance for inhabitants and city users, complementing the 15-minute city offer. Of course, larger green spaces in the periphery remain crucial to support multi-scalar interactions between local parks inside the mesh and larger green areas and rural land. This calls for effective connections of the local parks to the green and blue networks (Specification 2.1).

**Specification 5.4. Integration of Activity Areas into the Urban Fabric.** When the interior of the mesh includes an activity area (industry, logistics, or intensive urban farming zone), it should be treated as an integral part of the urban space, with interconnected local streets facilitating pedestrian and bicycle access to the main streets. Specific access routes may be designated for heavy truck traffic, linking directly to nearby motorways without traversing the main streets. Examining the case of the Greater Manchester Area, Froy (2023) illustrates how logistical and industrial activities can leverage direct access to regional and national infrastructure, albeit at the expense of the multi-scale balance of the urban street network configuration. Therefore, it's crucial to ensure comfortable pedestrian and bicycle access to encourage employees to walk or cycle to local main streets and partake in the activities offered there, be it after work or during breaks. In contrast, large retailers should maintain a direct, pedestrian-friendly interface on the main street and contribute to its allure, even if their premises extend further into the mesh. While this specification draws less directly from empirical observations of best practices, it logically follows from the guiding principles of the emc2 model.

To wrap up this section, let's refine the concept of the main street within the emc2 model: it stands as a pivotal element of the street network, primarily catering to pedestrian movement while accommodating various modes of transportation to varying degrees. It serves as a catalyst for a diverse array of retail and service offerings, fostering vibrant public life within its vicinity. Moreover, it functions as an attractive focal point for a broader area, presenting opportunities for further urban densification given its inherently higher density compared to its immediate surroundings. By integrating its five guiding principles, the emc2 model proposes a meshed network of main streets as the foundational organising principle of the 15mC. This approach ensures pervasive centrality, even in peripheral and suburban areas, while capitalising on potential synergies with ecological and transportation networks.

### **3. An empirical research design to assess the potential of the emc2 model**

Planning normally intervenes in the existing city, and contemporary urban peripheries in Europe are more or less prone to the requirements of the emc2 model. We will thus present a framework to assess the potential of contemporary urban peripheries to develop the emc2 model. Indeed, many European urban outskirts already possess incipient networks of main streets, which could serve as the backbone of the peripheral 15mC, as foreseen by the emc2 model. Beyond the model specification presented in the previous section, our research design consists of the following five steps.

The first step aims at assessing the potential of the emc2 model at the scale of whole metropolitan areas. The usual way of assessing 15mC potential in metropolitan areas is

relatively functional (Moreno et al. 2021, EIT Urban Mobility 2022): analysts look for possible local centres based on concentrations of urban functions (possibly divided in several categories to assess the presence of all of them) and define 15mC potential based on pedestrian sheds calculated around these centres. Within the emc2 model, functional concentrations are not a guarantee of the proximity-based 15mC, but rather a result of other requirements. What we want to assess is the potential for a given street to be a main street and of the resulting network of main streets to be as meshed as possible. Activities integrated along pedestrian-friendly main streets seem much more apt to induce pedestrian-based movement and public life than those randomly agglomerated within a given spatial extent. Researchers will thus first assess the pedestrian foreground street network, using the multi-scale configurational approach by Berghauser Pont et al. (2019): we calculate street centrality at different scales and identify both city streets (making up the pedestrian foreground network within and beyond the 15m radius) and main neighbourhood streets (complementing the foreground network within the 15 radius). We further assess the built-up streetscape of these main streets to ensure the presence of an urban frontage, of a sufficient built-up density and of setbacks and street cross-sections compatible with a pedestrian-friendly environment. After having checked these morphological pre-conditions, we assess the functional requirements: concentration of proximity-based activities (retail and services) and enough population in pedestrian sheds around the main streets. Clearly, part of the foreground network in peripheral and suburban areas lack many of the other morphological and functional features of the main streets, suggesting possible planning strategies to further connect the existing network of main streets by taking advantage of the already present configurational potential. In other instances, the foreground network could not be meshed enough, suggesting the presence of weak ties and possible strategies to reinforce them. These metropolitan-wide assessments will be carried out on six European metropolitan areas: the French Riviera, Lille-Roubaix-Tourcoing, Vienna, the Versilia conurbation, Florence and Gothenburg.

A second step of the analysis aims at understanding the historical genesis of the observable networks of main streets, inherited from planning or from spontaneous growth, including pre-existing rural settlements and faubourgs. The identification of the persistence of peripheral and suburban main streets over more than a century of urban history will be a main goal of the analysis. Within selected test areas, the historical formation of the observable forms and functions will be assessed through the study of old cadastral documents, above all in Vienna, where old cadastral documents include usage data. From the understanding of the underlying long-term and short-term dynamics, and considering the present situation of the test areas, possible implications for the implementation of the emc2 model can be identified, as well as the evolutive potential of the model over time. These analyses will also reveal insights into different spatial qualities in existing linear settlements, which will inform further phases of the research.

The third step of the research design studies the relations of the network of main streets of the emc2 model with other fundamental networks, mainly the multi-modal mobility network and the green/blue ecological network. The goal is to understand synergies and conflicts related to the different networks. The interaction of pedestrian movement and use of public space with car flows, as well as with bicycle and transit options will be assessed through the development of an agent-based model on a test area of the French Riviera. The synergies with the green and blue ecological networks and the implications on the ecosystem services effectively produced for inhabitants and city-users will be particularly assessed in Gothenburg, Sweden. These applications should also identify the implications for the functioning of the 15mC in the metropolitan peripheries and produce more detailed specifications for the emc2 model.

The fourth research step will zoom on peripheral test areas, which will have been previously selected because they are already organised around more or less well functioning main streets. Their fine-grained assessment will include their present form and human usage, and their possible transformations, through fieldwork, morpho-functional analysis, 3D-models and interaction with local authorities. Researchers will assess details of public space layout, organisation and usage, building façades, use of building ground-floors and of their pertaining open areas, etc. At this scale, the concentration of activities can be assessed through their capacity to create a pedestrian-based web characterised by small distances, intervisibility and ease of pedestrian reach. As the test areas are particularly favourable to emc2 solutions, this phase of the research aims at understanding the observable advantages and drawbacks of these almost-emc2 examples, quantifying their contribution to the objectives of the 15-minute city, and identifying possible improvement for a full emc2 implementation.

In a last research step, researchers will look for generalisation, to pass from what is learned on a given case study to what could be applied to all case studies and, beyond, to all European cities wishing to implement the emc2 model. The assessment of the theoretical model in the light of the obtained results is an essential aspect of generalisation of findings. A second objective of this final phase is to produce assessment and intervention guidelines for the use of urban practitioners. To include all the scales of the analysis (metropolitan, sector-wide and local) and to respect the coherence of the overall model, guidelines could be produced in the form of a pattern language (Alexander et al. 1977, Mehaffy et al. 2020).

#### **4. Discussion: the emc2 and other models to organise the 15-minute city**

The emc2 model distinguishes itself from other seemingly related models designed to structure proximity-based cities or offer alternatives to car-dependent urban sprawl.

Transit-oriented development (TOD, as exposed by Cervero et al. 2004) is an urban planning and design approach that revolves around creating mixed-use, pedestrian-friendly communities centred on public transportation hubs, such as train stations, subway stops, or bus terminals. TOD emphasises the strategic placement of residential, commercial, and recreational spaces within walking distance of public transportation facilities, aiming to incentivize residents to use transit instead of relying on private vehicles. A foundational principle of TOD is densification and the mix of uses around transit nodes. This mix of uses not only facilitates residents in meeting their daily needs without long-distance travel but also aligns with the ethos of the pedestrian-based 15mC.

Densification is pivotal for the very viability of TOD. Increased residential and commercial densities around transit nodes justify (and pay for) the significant capital costs of new high-performance transit infrastructure and provide an alternative to urban sprawl. This density is intended to foster vibrant street life and economic vitality. Design of public space is identified as an important aspect among the different Ds of the TOD model (Cervero and Cockelman 1997, Ogra and Ndebele 2014). However, design quality alone overlooks the configurational aspects that contribute to the success of pedestrian environments, particularly concerning natural movement flows within the street network topology. The extra-flows produced by the transit hub, regardless of pedestrian configurational potential, are deemed sufficient to ensure the viability of retail and service within the TOD scheme.

Despite its well-intentioned elements, the TOD model appears to clash with the networked fabric of the pedestrian-centred 15mC. Human scale considerations are primarily concentrated around the relatively distant hubs, relying on high-capacity transit to bridge the gaps between them. This approach disrupts the continuity of pedestrian flow and restricts opportunities for

the development of retail and services to specific nodal points. In comparison to the emc2 model, TOD seems more suited to structuring metropolitan growth when demographic demand justifies it and financial resources are available to establish new high-performance transit lines. In Europe, the ambitious Grand Paris Express project and the concurrent development of dense urban hubs around its stations stand out as exemplary instances of coherent TOD (Bove and Cornut, 2024).

TOD presents itself as a capital-intensive alternative to suburban sprawl, while emc2 is more akin to a low-cost retrofitting strategy for suburbs. Its aim is to provide suburbanites with a 15mC environment through limited densification around requalified main streets. However, there is potential for profitable hybridization between the TOD and emc2 models. Both envision the presence of a network of rapid transit, but for emc2, the distinction between streetcar and railway lines is crucial. Streetcars can seamlessly integrate with the pedestrian multimodality of main streets, whereas railways are more efficient in connecting a large metropolitan area. However, they must be integrated within a pervasive network of pedestrian-based main streets and cannot be solely relied upon to create a pedestrian-friendly environment.

The Neighbourhood Unit (NU), introduced by C. Perry (1929), holds a significant position in urban planning history and can be viewed as an initial response of pedestrian-based cities to the disruptive influence of automobile systems. This model underscores the establishment of self-contained residential neighbourhoods equipped with various amenities and services within walking distance. Consequently, it remains a relevant option for addressing the challenges posed by the contemporary 15mC. The classical Neighbourhood Unit is designed to be compact and pedestrian-friendly, with a distinct boundary that delineates it from surrounding areas. This setup aims to promote pedestrian mobility within the neighbourhood while reducing the necessity for long-distance travel. Unlike the emc2 model, the NU model relinquishes the traditional centrality role of main streets, allowing them to serve as arterial roads encircling the neighbourhood. Organised around a hierarchical street network, the NU model features major arterial roads on the periphery and interconnected smaller streets within. This design aligns with the principles of traffic engineering, which were emerging in the 1920s, facilitating regulated traffic flow and fostering a sense of enclosure and safety within the neighbourhood.

Each neighbourhood unit encompasses a centrally located public space, such as a park, square, or playground, serving as a focal point for community activities and gatherings. Surrounding this space are vital civic services for the community, including schools, libraries, churches, and healthcare facilities. Interestingly, Perry's original model recognized that retail and commercial services required the through-flows facilitated by cars and thus situated them along the surrounding arterial roads, complete with necessary parking facilities. However, post-war European implementations of the NU model, often seen in social housing projects, deviated from Perry's approach by placing retail and commercial services within the core of the neighbourhood and its civic centre. Consequently, these market-based activities, heavily reliant on the movement economy, encountered challenges due to the low configurational potential of their locations within the mesh, away from the main axes. Additionally, they suffered from the gradual impoverishment of the housing projects.

What appears most problematic with the NU model is its pursuit of a self-contained settlement within a broader metropolitan context. This vision, later revived by the urban village ideal, contradicts the networked nature of cities and overlooks the intricate overlap and intertwining of catchment areas for various urban services, as noted early on by Alexander (1965) and later elucidated by network-based theories (Hillier 1996, Salinger 2005, Mehaffy et al. 2010). NU implementations in European outskirts have consequently experienced a continual erosion of

their proximity-based offerings and have become increasingly reliant on car-based mobility, which could better integrate the networked nature of cities.

Finally, the emc2 model shares intriguing similarities with Alexander's pattern language (Alexander et al. 1977), particularly concerning the detailed specifications of Principle 4. However, when examining the urban model that emerges from this pattern language at larger scales, it appears to align more closely with the NU model. Alexander designates local transport areas approximately one-mile wide as zones for pedestrian and bicycle movement (pattern #11). Like the NU model, these areas are delineated by ring roads for car traffic (pattern #17), while maintaining one side open to connect with the surrounding countryside forming a broad ecological network.

At the heart of these local transport areas lies a pedestrian promenade (pattern #31), which, interestingly, is not the primary commercial axis but rather a pedestrian-friendly public space linking short shopping streets (pattern #32). These streets, in turn, create a dispersed network of shopping nodes (pattern #19). Two main distinctions emerge when comparing this approach to the emc2 model. Firstly, akin to the NU model, Alexander's model envisions pedestrian-friendly zones for short distances as distinct modules, relying on automobiles (and transit, as in pattern #16) to connect them within a broader urban framework. Secondly, it overlooks the observable pattern of ribbon development seen in retail and service sectors, which is heavily influenced by the movement economy and was already well-documented by contemporary urban geographers (Berry 1967). Instead, it proposes a more dispersed form of retail, lacking support from the configurational properties of the network.

In response to these general shortcomings of the NU and of Alexander's model, the emc2 model seeks to reconnect with more traditional patterns of street centrality. It aligns with a broader movement evident in European cities (and beyond) aimed at reclaiming existing streets for the public realm, following decades of prioritising motorised traffic management (Bertolini, 2020; Norton, 2015). However, this doesn't imply that the emc2 model is always the optimal solution for European metropolitan areas. Unique historical heritage and topographical constraints have given rise to distinct patterns of agglomerated villages, often situated on hilltops, ridges, or along hill-flanks. Even on flat terrain, agglomerated villages that once punctuated rural spaces have subsequently been integrated into wider peri-urban contexts, creating local pedestrian-friendly areas, alongside more linear settlements and faubourgs. In all these scenarios, there's potential for hybridization between the emc2 model and urban village concepts. This could involve revitalising main roads that connect villages, fostering a more pervasive centrality across the region.

We emphasise that the geographic scope of the proposed emc2 model primarily encompasses the suburban and peri-urban peripheries within European metropolitan areas. While the guiding principles and some detailed specifications are broadly applicable, others may be more context-specific to European urbanisation. This reflects the primary domain of expertise of the authors.

### **Acknowledgements**

The emc2 project is funded by ANR (France), FFG (Austria), MUR (Italy) and Vinnova (Sweden) under the Driving Urban Transition Partnership, which has been co-funded by the European Commission.

### **References**

ADEME (2023) *La rue commune. Guide méthodologique pour la transformation des rues ordinaires*. Paris: Agence de l'Environnement et de la Maitrise de l'Energie. Available at: [www.ruecommune.com](http://www.ruecommune.com)

- Alexander C. (1965) A City is Not a Tree. *Architectural Forum*, vol. 122(1), 58-61 et vol. 122(2), 58-62, <http://www.bp.ntu.edu.tw/wp-content/uploads/2011/12/06-Alexander-A-city-is-not-a-tree.pdf>
- Alexander, C. et al. (1977) *A pattern language: towns, buildings, construction*. New York: Oxford University Press
- Alexander, C. (2003). *The nature of order: An essay on the art of building and the nature of the universe* (Vol. 2). Center for Environmental Structure.
- Araldi, A. (2020) Towards an Integrated Methodology for Model and Variable Selection Using Count Data: An Application to Micro-Retail Distribution in Urban Studies. *Urban Science*, 4, 21; <https://doi.org/10.3390/urbansci4020021>
- Berghauser Pont, M., Stavroulaki, G., Marcus, L. (2019) Development of urban types based on network centrality, built density and their impact on pedestrian movement. *Environment and Planning B: Urban analytics and city science*, 46(8): 1549–1564.
- Bertolini, L. (2020) From “streets for traffic” to “streets for people”: can street experiments transform urban mobility? *Transport Reviews*, 40(6), 734-753.
- Berry, B. (1967) *Geography of Market Centers and Retail Distribution*. Englewood Cliffs, NJ: Prentice Hall.
- Bobkova, E. et al. (2019) Structure of Plot Systems and Economic Activity in Cities: Linking Plot Types to Retail and Food Services in London, Amsterdam and Stockholm. *Urban Science*, 3, 66. <https://doi.org/10.3390/urbansci3030066>
- Bolin D. et al. (2021). Functional ANOVA modelling of pedestrian counts on streets in three European cities. *Journal of the Royal Statistical Society Series A*. 2021;00:1–23. <https://doi.org/10.1111/rssa.12646>
- Bove, S., Cornut, B. (2014) Successfully developing the station areas: toward a TOD strategy for Ile-de-France? *Note Rapide Institut Paris Région*, 55, pp. 1-6.
- Braubach, M. et al. (2017) ‘Effects of Urban Green Space on Environmental Health, Equity and Resilience’, in Kabisch, N. et al. (eds) *Nature-Based Solutions to Climate Change Adaptation in Urban Areas: Linkages between Science, Policy and Practice*. Cham: Springer International Publishing, pp. 187–205.
- Caniggia, G., Maffei, G. (2017, original in Italian 1979) *Interpreting basic buildings*. Florence: Alinea.
- Cervero, R., Cockelman, K. (1997) Travel Demand and the three Ds : Density, Diversity and Design. *Transportation Research-D*, Vol. 2, No. 3, pp. 199-219
- Cervero, R. et al. (2004) *Transit-Oriented Development in the United States: Experiences, Challenges, and Prospects*. TCRP Report 102, Washington: Transportation Research Board.
- Cullen, G. (1961) *The Concise Townscape*. Oxford: Architectural Press.
- Dizdaroglu, D. (2021) Developing Design Criteria for Sustainable Urban Parks. *Journal of Contemporary Urban Affairs*, 6(1), pp. 69–81.
- Dovey, K., Pafka, E., Ristic, M. (eds.) (2017) *Mapping Urbanities. Morphologies, Flows, Possibilities*. London: Routledge.
- Dovey, K., Wood, S. (2015) Public/private urban interfaces: type, adaptation, assemblage. *Journal of Urbanism*, 8(1), pp. 1-16.
- Dunham-Jones, E., Williamson, J. (2011) *Retrofitting suburbia, updated edition: Urban design solutions for redesigning suburbs*. John Wiley & Sons.
- Dupuy, G. (2008) *Urban Networks—Network Urbanism*. Amsterdam: Techne Press.
- EIT Urban Mobility (2022) *±15-Minute City: Human-centred planning in action*. TU München. [www.eiturbanmobility.eu/wp-content/uploads/2022/11/EIT-UrbanMobilityNext9\\_15-min-City\\_144dpi.pdf](http://www.eiturbanmobility.eu/wp-content/uploads/2022/11/EIT-UrbanMobilityNext9_15-min-City_144dpi.pdf)
- Fahrig, L. (2019) Habitat fragmentation: A long and tangled tale. *Global Ecology and Biogeography*, 28 (1), 33–41. <https://doi.org/10.1111/geb.v28.110.1111/geb.12839>.
- Froy, F. (2023) Learning from architectural theory about how cities work as complex and evolving spatial systems, *Cambridge Journal of Regions, Economy and Society*, 115, <https://doi.org/10.1093/cjres/rsad024>

- Fusco G., Venerandi A., Chaumery C., Dardelet-Doya Ph. (2024) *Formes résilientes, urbanisme et métropole. Learning from Nice*. Les Cahiers POPSU, Paris: Editions Autrement.
- Gehl, J. (2011) *Life between buildings. Using public space*. Washington: Island Press.
- Gourdon, J.-L. (2001) *La rue – Essai sur l'économie de la forme urbaine*. La Tour d'Aigues: Editions de l'Aube.
- Griffith S. (2015) 'The High Street as a Morphological Event', in Vaughan L. (ed.) *Suburban Urbanities. Suburbs and the Life of the High Street*. London: UCL Press, pp. 32-50.
- Gunderson, L., Holling, C. (2002) *Panarchy: Understanding transformations in human and natural systems*. Washington: Island press.
- Habraken, N. (1998) *The Structure of the Ordinary. Form and Control in the Built Environment*. Cambridge, MA: MIT Press.
- Hanson, J. (1989) *Order and Structure in Urban Space: A Morphological History of the City of London*. PhD thesis, University of London.
- Hartig, T. et al. (2014) Nature and Health. *Annual Review of Public Health*, 35(1), pp. 207–228.
- Hillier B. (1996) *Space is the Machine*. Oxford: Oxford University Press
- Hillier B. (2012) 'The Genetic Code for Cities: Is It Simpler than We Think?' In J. Portugali et al. (Eds.) *Complexity Theories of Cities Have Come of Age*. Berlin: Springer, pp. 129-152.
- Hillier B., Hanson J. (1984) *The Social Logic of Space*. Cambridge: Cambridge University Press.
- Howard, E. (1902) *Garden-Cities of Tomorrow*. London: Swan Sonnenschein & Co.
- Jacobs A. (1993) *Great Streets*. Cambridge, MA: MIT Press.
- Jacobs J. (1961) *Life and Death of Great American Cities*. New York: Vintage.
- Lerman, Y., Rofe, Y., Omer, I. (2014) Using space syntax to model pedestrian movement in urban transportation planning. *Geographical Analysis*, 46: 392–410.
- Lydon, M., Garcia, A. (2015) *Tactical urbanism: Short-term action for long-term change*. Washington: Island Press.
- Lynch, K. (1959) *The Image of the City*. Cambridge, MA: MIT Press.
- Mehaffy, M. et al. (2010) Urban nuclei and the geometry of streets: The 'emergent neighborhoods' model. *Urban Design International*, 15(1), <https://doi.org/10.1057/udi.2009.26>
- Mehaffy, M. et al. (2020) *A New Pattern Language for Growing Regions: Places, Networks, Processes*. Portland: Sustasis.
- Mehaffy, M., Salingaros, N. (2013) Towards Resilient Architectures I: Biology Lessons. *Metropolismag.com*, March 2013. <http://www.resilience.org/stories/2013-03-25/toward-resilient-architectures-i-biology-lessons/>
- Moreno, C., Allam, Z., Chabaud, D., et al. (2021) Introducing the "15-Minute City": Sustainability, resilience and place identity in future post-pandemic cities. *Smart Cities*, 4(1), 93-111.
- MVG, 2008, *The Modern Tram in Europe*, Münchener Verkehrsgesellschaft, Munich, <http://www.reconnectingamerica.org/assets/Uploads/The-Modern-Tram-in-Europe.pdf>
- Newman, P., Kenworthy, J. (1999) *Sustainability and Cities: Overcoming Automobile Dependence*. Washington: Island Press.
- Norton, P. (2015) 'Of love affairs and other stories'. In S. Zavestoski & J. Agyeman (Eds.), *Incomplete streets. Processes, practices, and possibilities*. London: Routledge, pp. 17–35.
- Ogra, A., Ndebele, R. (2014) 'The Role of 6Ds: Density, Diversity, Design, Destination, Distance, and Demand Management in Transit Oriented Development (TOD)'. In S. Bahga and A. Singla (Eds.) *Proceedings of the Neo-International Conference on Habitable Environments*, CreateSpace, pp. 539-546.
- Parolek, D. (2020) *Missing Middle Housing Thinking Big and Building Small to Respond to Today's Housing Crisis*. Washington: Island Press.
- Panerai, P. (2013) 'Eloge de la trame'. In F. Scherrer & M. Vanier (Eds), *Villes, Territoires, Réversibilités*, Paris: Hermann, pp. 139-150.
- Perry, C. (1929) 'The Neighborhood Unit'. In *Regional Survey of New York and Its Environs*, vol. 7. New York: Committee on Regional Plan of New York and Its Environs.

- Romice, O., Porta, S., Feliciotti, A. (2020) *Master Planning for Change – Designing the Resilient City*. London: RIBA Publishing
- Salingaros, N. (2005) *Principles of Urban Structure*. Amsterdam: Techne Press.
- Shu, C. (2000) Housing layout and crime vulnerability. *Urban Design International*, 5(3-4), pp. 177-188.
- Sitte, C. (1965, original in German 1889) *City Planning According to Artistic Principles*. London: Phaidon.
- Ståhle, A. et al. (2022) *Designguide för Smarta gator Optimized*. KTH, Chalmers, VTI, Spacescape, Sweco & White Arkitekter. Available at: <https://www.smartagator.se>
- Van Eldijk, J., Gil, J., Marcus, L. (2022) Disentangling barrier effects of transport infrastructure: synthesising research for the practice of impact assessment. *European Transport Research Review*, 14, 1 (2022). <https://doi.org/10.1186/s12544-021-00517-y>
- Vaughan, L. (ed.) (2015) *Suburban Urbanities. Suburbs and the Life of the High Street*. London: UCL Press.
- WHO (2016) *Urban green spaces and health*. Copenhagen: WHO Regional Office for Europe.