

CONNECT PEOPLE MOVEMENT AND STREET PATTERNS

INTEGRATED GUIDELINES FOR SUSTAINABLE NEIGHBOURHOOD DESIGN

Urban Morphology & Complex Systems Institute

2021

SERGE SALAT

URBAN MORPHOLOGY

COMPLEX SYSTEMS INSTITUTE &

CREDITS AND ACKNOWLEDGEMENTS

Developed by:

URBAN MORPHOLOGY
&
COMPLEX SYSTEMS INSTITUTE

With the support of:



Author: Serge Salat, Civil Administrator, Architect and Urban Planner; President of the Urban Morphology and Complex Systems Institute.

Suggested citation: Salat, Serge. 2021. Integrated Guidelines for Sustainable Neighbourhood Design. Urban Morphology and Complex Systems Institute 2021. © UMCSII.

This publication was elaborated in close collaboration with the UN Environment Programme (UNEP). The Cities Unit Team, within the Energy and Climate Branch provided inputs and conceptual direction throughout the development of this publication and coordinated the internal review process. The author would like to extend his special thanks to Martina Otto, Sharon Gil, André Confiado, Elsa Lefèvre and Margaux Ginestet for their support and inputs, and acknowledge the contributions from Esteban Munoz, Lily Riahi and Camille Marichy and Mateo Ledesma.

This publication was made possible thanks to generous support provided by the French Ministry of Ecological Transition. The publication benefited of the inputs of several Ministry Departments with special thanks to Virginie Dumoulin, Director, European and International Affairs Directorate (DAEI), Yves Laurent Sapoval, Advisor to the Director of the Department of Housing, Urbanism and Landscapes (DHUP), Hervé Boisguillaume, Sustainable City Project Director, and Thomas Guéret, Head of the Foresight Mission. The secondment was organized by Anne Amson, supported by Mathieu Gourmelon and Sandrine Gautier.

Research and external consultations were done by Alyssa Fischer, UNEP Consultant in the production of the report. The following partners were consulted in the development process: Deirdre Shurland, Valeria Braga, Kopieou Gouganou, Sue Riddlestone, Maria Cederborg, Chantel van Beurden, Zahra Kassam, Herman Pienaar, Veronica Hitosis, Federico Cartin

Arteaga, Cristina Gamboa Masdevall, David Tudgey, Thomas Osdoba, Kirstin Miller, Giselle Sebag, Monika Zimmermann, Thomas Gueret, Francois Menard, Sylvain Rotillon, Carly Koinange, Atifa Kassam Manji, Lara Morrison, Lois Arkin, Jacob Halcomb, and Evelyn Kasongo.

The author also extends its special thanks to Françoise Labbé, architect, urban planner, for her continuous insights and inputs on urban design and city form during the writing and for providing most of the report pictures. The report also benefited from exchanges on city form and sustainability with Fumihiko Maki, architect, Nils Larsson and the International Initiative for a Sustainable Built Environment (iiSBE), from the teaching invitation and studio work organized by Nirmal Kishnani and Wong Mun Summ at the National University of Singapore, and from the feedback and work of his most motivated students at Special School of Architecture in Paris.

The guidelines benefited from the inputs of the expert group discussions during the implementation of the pilot projects. Special thanks to Ecocity Builders, ICLEI Local Governments for Sustainability, La Fábrica, the League of Cities of the Philippines, and the Sustainable Cities Programme Brazil for their thoughts and inputs during the pilot development and implementation processes which strengthened the link between the proposed approach and its concrete application. The following cities have piloted the principles in this report: Renca, Chile; Bacolod, Philippines; Bogor, Indonesia; Cusco, Peru; Lalitpur, Nepal; Medellin, Colombia; Sao Paulo, Brazil.

Table of Contents

INTRODUCTION	2
THE PEOPLE MOVEMENT FRAMEWORK	3
THE STREET PATTERN	7
STREET PATTERN TYPES	8
STREET PATTERN BENCHMARKS	9
STREET PATTERN ECONOMIC PRODUCTIVITY <i>VERSUS</i> INFRASTRUCTURE COSTS	14
DESIGNING THE NEIGHBOURHOOD STREET PATTERN	16
RESPOND TO THE CONTEXT	16
DEFINE PERIMETER BLOCKS	1
COMBINE CURVE AND STRAIGHT STREETS	2
DESIGN A FORM-BASED HIERARCHY OF STREETS WITH DIVERSE PEOPLE CENTRIC WIDTHS AND LENGTHS	3
REFERENCES	31

CONNECT PEOPLE MOVEMENT AND STREET PATTERNS

INTRODUCTION

'Cities are their streets. Streets are not a city's veins, but its neurology, its accumulated intelligence' (Adam Gopnik¹).

Streets comprise 27 to 30% of developed cities land area². They are the major public spaces essential to urban vitality and healthy lifestyles. At least 50% of the neighbourhood land must be used for the public realm: 25 to 30% to be allocated to streets for well-connected street networks and 20 to 25% to squares, parks and open green spaces³.

Streets exert an immense influence upon our lives. They have multiple functions as links or places with commercial, economic, civic, ceremonial, political, cultural and social value. Street patterns establish the character of an area. The movements of people and the social interactions they produce define the nature of a place. The dense network of connected streets that runs through neighbourhoods in innumerable variations determines the townscape and the community life. Well-designed streets enhance safety, walkability, and accessibility while providing inhabitants with space to gather, supporting businesses, and hosting cultural events. Street patterns

also influence climate change, public health, social justice, inclusiveness and local economies.

Streets are the backbone of the local economy. When a fine mesh of walkable streets is replaced by large-scale roads for high-speed traffic, this is damaging for green mobility, health, social inclusion, and neighbourhood businesses. Streets have two key functions: place and movement. In recent developments, vehicle movement has often dominated the design of streets, resulting in many streets being out of context with their location and overly influenced by prescriptive standards. While roads are highways whose main function is to allow the movement of motor traffic, streets have several purposes whose 'place function' is the most important. We must draw a clear distinction between roads and streets as follows.

- Roads are communication routes whose main function is to facilitate car traffic.
- Streets have important roles in the public domain other than those related to automobile movement. Buildings and public spaces line them. While traffic facilitation remains a key activity, they support a range of

¹ Quoted in Speck 2017.

² 27% in New York City, for example. City of New York 2019.

³ In developing countries land allocated to streets is low, varying between 6 and 12%, compared to cities in developed countries, which average 29% (UN Habitat 2013a). In informal areas the proportion is even lower (UN Habitat 2015a). The insufficiency of street networks in developing cities is a liability. Lack of streets in cities has various implications in people's lives. It means that cities' ability to provide services,

such as safe water and adequate sanitation, is severely hampered. Water and sewerage systems are usually planned along existing street networks, and when these are non-existent, they make it difficult for authorities to provide these services. Establishing a coherent network of roads and streets both in new extension areas and already urbanized areas constitutes a key challenge for urban planning in cities in Africa, Asian, Latin America and the Caribbean (UN-Habitat 2013b).

social, recreational, retail and commercial functions.

For instance, comparing the use of a traditional street and of a new car-oriented road in Shanghai Huangpu District showed that the former was not only 15 times more fine-grained but also that activity was 10–12 times higher⁴. The fine grain structure of traditional street patterns makes it easy to move around walking. Local shops make it more convenient to purchase and socialize in daily life. In contrast, in Chinese new developments, few entrances, lack of stores and public passages through blocks make it difficult and unappealing to walk. A fine grain, flexible street pattern is also defining the potential of the massive investments in public transport. Ninety-five percent of public transport users arrive on foot or bike to transit stops or stations, so the street quality is a key

component of public transport efficiency and attractiveness.

This document comprises three guidelines sections.

THE PEOPLE MOVEMENT

THE STREET PATTERN

DESIGNING THE NEIGHBOURHOOD STREET PATTERN

The guidelines sections are completed by five series of in-depth case studies.

FERRARA STREET PATTERNS

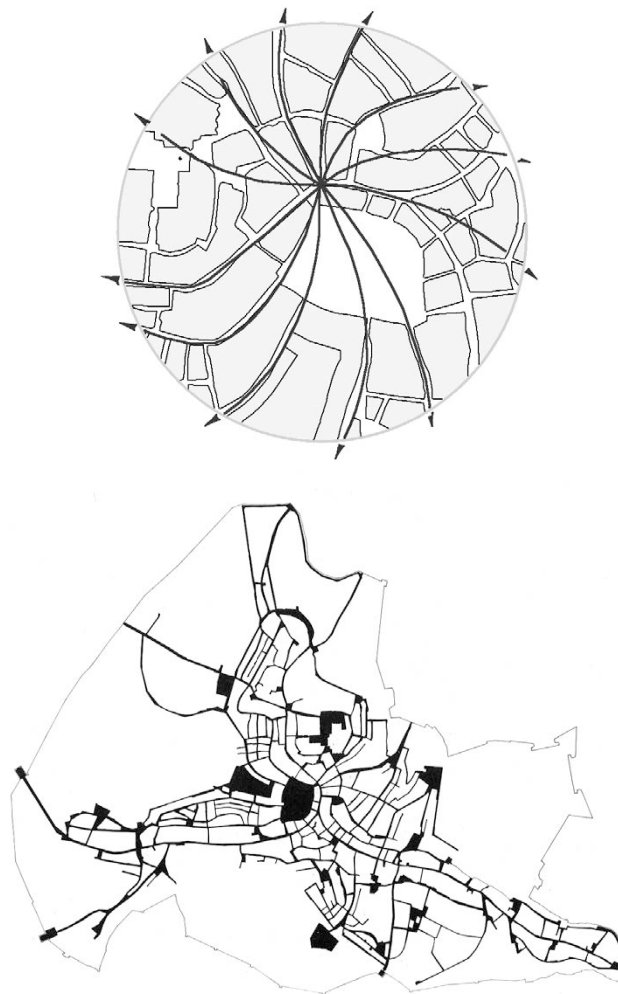
HISTORICAL EVOLUTION OF STREET PATTERNS IN PARIS

IRREGULAR LINKAGES: KYOTO, VENICE

AXIAL COMPOSITIONS: ROMA, TURIN, PARIS

STREET GRIDS: MANHATTAN, SAVANNAH, BARCELONA

THE PEOPLE MOVEMENT FRAMEWORK



⁴ Energy Foundation et al. 2017.

Sustainable design begins with understanding people patterns of motion. They allow them to access their daily needs including recreation and enjoying green space. Sustainable urban form has more to do with movement through space than with a static vision of the city shape. Historic neighbourhoods demonstrate that long-established motion patterns are also often capable of responding to changing requirements.

People movement lines connect internally the neighbourhood and link it to adjacent development. An integrated movement framework is a dense pattern of such activity lines for people, resources, and energy that make community life possible: roads, streets,

footpaths and transit routes; and service utilities networks (water, gas, electricity, etc.). These linkages allow neighbourhoods to work and relate to the city. None of these systems exists isolated. Besides moving us and servicing buildings, they establish the neighbourhood character. As much as architecture or landscape, they help determine the quality of places. Whatever their function, the links are integral to the urban fabric. The measure of their sustainability is not only their functional performance, but also their contribution to the quality and character of an urban area. The design of links is key for creating a sense of place.

Check list of Key Points to Consider When Establishing a Movement Framework

The contextual analysis is the basis of a movement framework. It needs to establish

1. How the new routes in the site will knit in with the existing ones?
2. The arrangement made for all forms of travel, with encouragement for walking, cycling and public transport.
3. How the lines of motion can benefit the area as a whole? For example, by the extension of bus lines or by more direct paths leading to the community centre.
4. How will transport options be offered at all stages of development?

A movement framework should provide access to neighbourhood amenities at walking distances. An urban rail station, bus stops, local shops, health centres and primary schools should be within a walking distance of 500 metres. A dense web of local amenities brings residents together, strengthens the community and discourages car use. The quality and continuity of routes are important. When busy roads or railway lines create obstacles, design should reconnect the urban fabric.

Permeability should not be confined within the development but should extend beyond its boundaries with continuities to wider city networks. To integrate the site into its environment, it is necessary to analyse existing entry points and linkages, both for movement and for infrastructure. Motion lines should connect

people and places by considering the needs of people to access jobs and key services. Getting the movement right affects the uses and activities, density, security, and impacts on nearby places. A successful movement framework

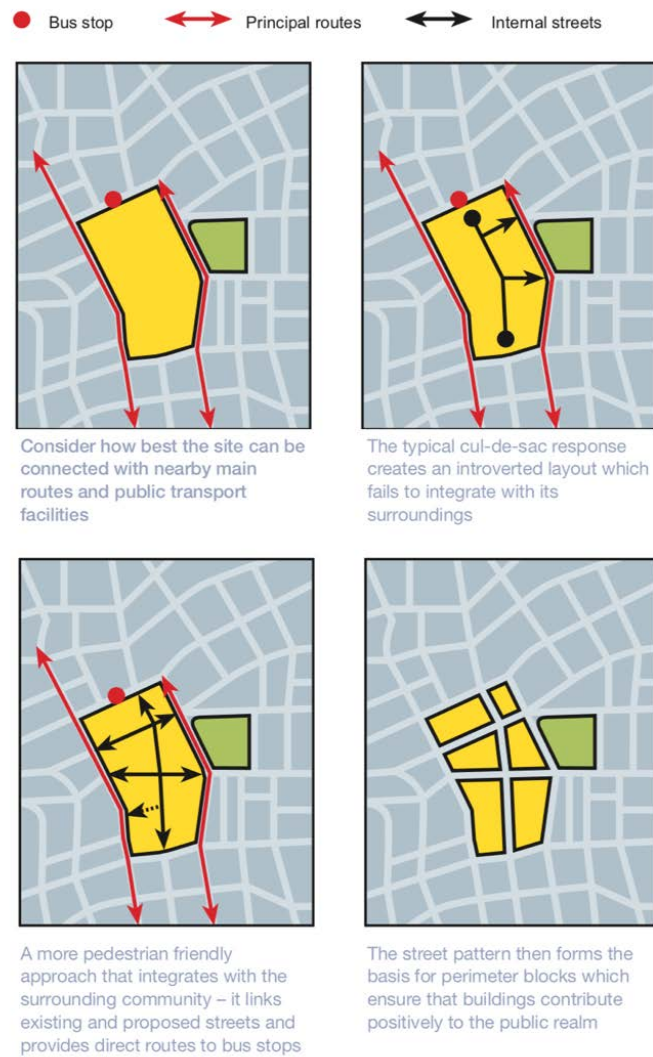
- offers the maximum choice to people.
- takes a full account of the movements that the development generates.
- establishes clear links with existing routes and facilities.

Each site being different, standard formula should be avoided. What suits a large suburban site will be distinct from a pocket site in downtown.

The movement framework should also provide convenient and continuous passage between and

within neighbourhoods. Routes should be available to all and as direct as possible. For this reason, 'gated estates' should be discouraged. The design should consider which levels of accessibility are appropriate for different street users. Permeability for pedestrians and cyclists should take precedence over vehicles. River or canal trails for walkers and cyclists can offer appealing links in and between areas. New streets should be seamlessly intertwined with the existing street network. They should follow existing lines of motion. Direct and attractive connections between key

facilities, avoiding dead ends, help to create more convenient and comfortable places. An assessment of how best to integrate the site into the wider motion network should aim to establish as many direct links as possible to the main streets. The more direct the links between the main streets, the greater the potential for mixed use (they do not have to be vehicular). Deciding which links are most important to extend into the scheme, will provide the basis for the internal movement structure.



The diagrams above show how to reconnect a street pattern by adding new streets. Source: Llevelyn Davies 2000.

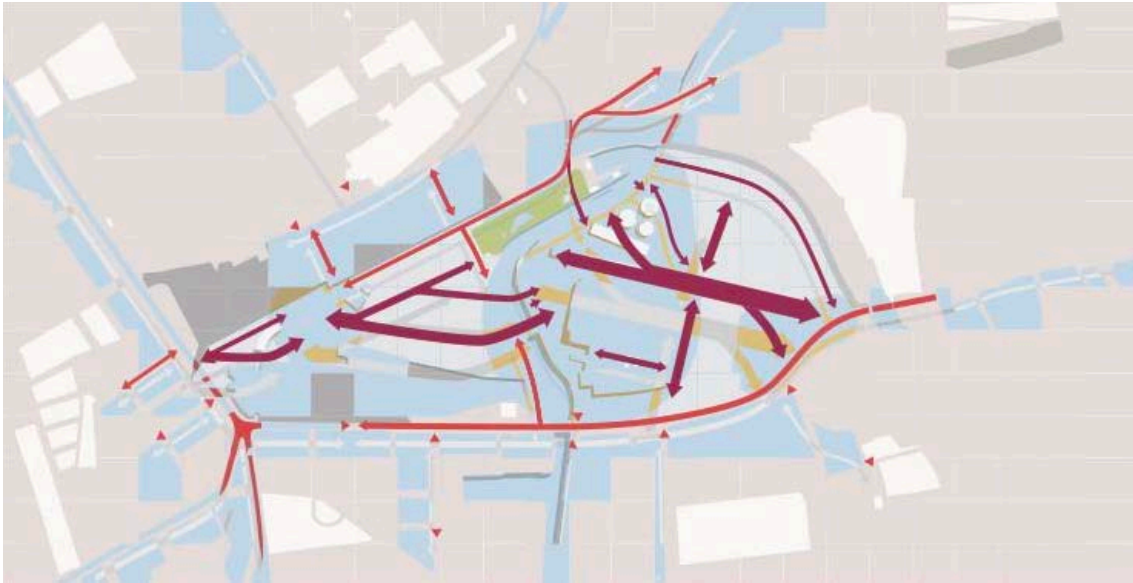
Neighbourhood development is an opportunity to improve linkages with transit systems, expanding the capacity and viability of these systems as a whole. Linkage to the wider city network is the most effective way to ensure that the community will be thriving⁵. The

more links are direct, the more successful will be the integration of new and old. Links should offer people the maximum choice in how to make their journeys, while encouraging walking, cycling and public transport.

⁵ Salat and Ollivier 2017

Kings' Cross Central lines of movement

King's Cross Central is a mixed-use, urban regeneration project in central London centred around a major transport hub.



The development added twenty new connective streets. This diagram illustrates the aim to create a network of safe pedestrian routes and other linkages, to help join places together and integrate the development with existing neighbourhoods and communities in Camden and Islington. Source: EDAW 2004.



A network of connected trails. Source: EDAW 2004.

THE STREET PATTERN



Street Patterns on one square mile.

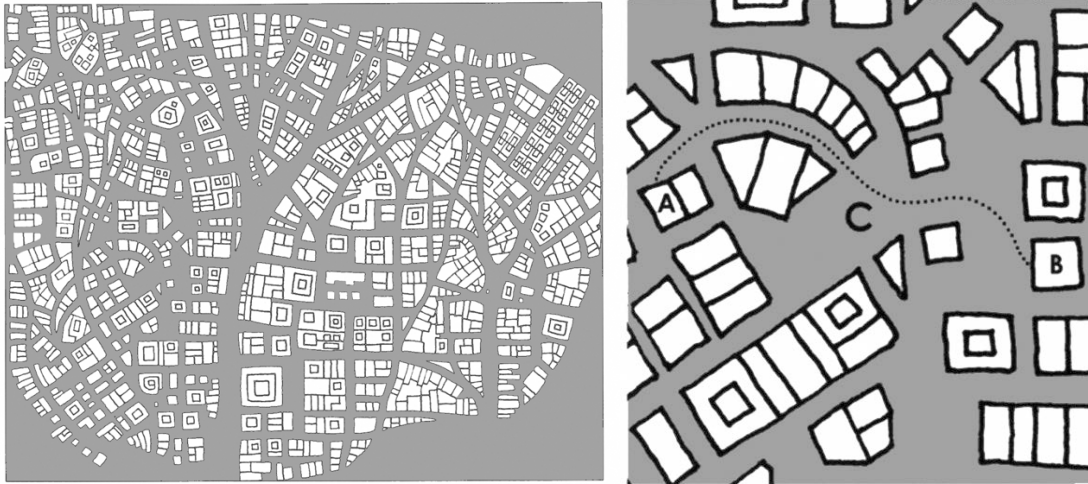
Cities have historically been organized around their streets. Streets have traditionally served three main purposes: mobility, trade and interpersonal interaction. The street, a public space with residential houses, commercial buildings and other structures on one or each side, has social and economic purposes which are integral to urban life⁶. Therefore, the traffic engineering approach of street functional classification should be avoided. This approach to transportation planning concentrates on vehicular traffic only. It strives to achieve a specialization of streets according to car movement. It ignores the other responsibilities of streets. Moreover, single intent roads attract auto traffic and large arterials tend to induce speed. Wide arterials dislocate neighbourhoods and disrupt the continuity of pedestrian experience.

The 'movement space' constituted by streets forms the connective tissue of public space – from the micro scale of circulation within buildings to the macro scale of

whole cities. The plots of private land surrounded by streets are like an island archipelago set in a public space sea. Just as every sea port, no matter how large or small, is directly connected to every other sea port, every access point to a plot of land or urban block leads to every other access point essentially through the medium of the public street system. Therefore, the street pattern contains the whole of the city. Streets, buildings and plots form a coherent and accessible system when

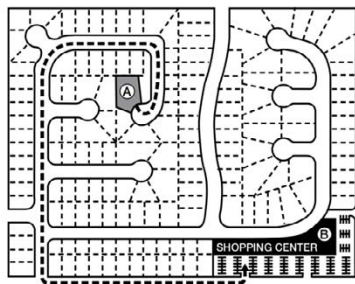
- The streets form a single contiguous network. Inside this system, top tier streets (boulevards) are all connected.
- All plots can be accessed from the street network.
- Buildings are directly linked to the exterior space.
- All buildings are joined to one or more plots.

⁶ UN-Habitat 2013b.

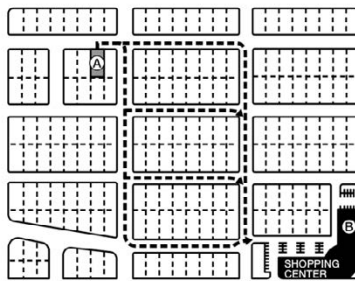


Source: Marshall 2005.

STREET PATTERN TYPES



(A) Conventional suburban hierarchical network.



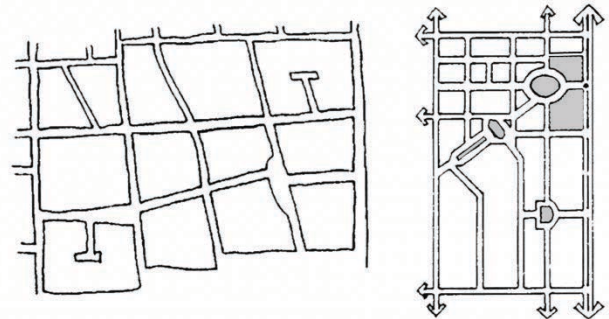
(B) Traditional urban connected network.

Traditional street patterns ensure good connectivity and a choice of routes for walking. To maximize walkability, developments should favour shorter blocks (60 m to 120 m) with multiple intersections. Source: ULI 2015.

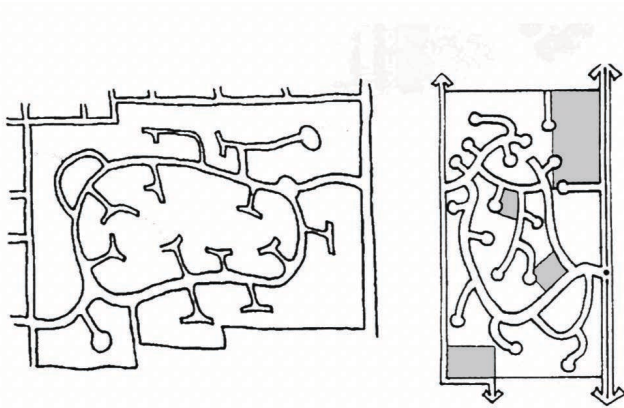
The great variety of street patterns can be summarized in three major types. Two have been invented in the 20th century to create car-centric cities.

- **The lattice or grid (regular or irregular) has been the basis of all cities for 5000 years.** Their origin is in ancient Greece and Roman Empire gridded cities. China and Japan have developed, for thousands of years, their model of gridded cities.

Central London irregular grids or those triangular in Paris are the result of a thousand years' evolution, combining planned linear streets and organic curved streets. Both the regular and irregular grids are non-hierarchical: their connectivity is continuous through scales. They present a high number of intersections per km² from 120 to more than 400.



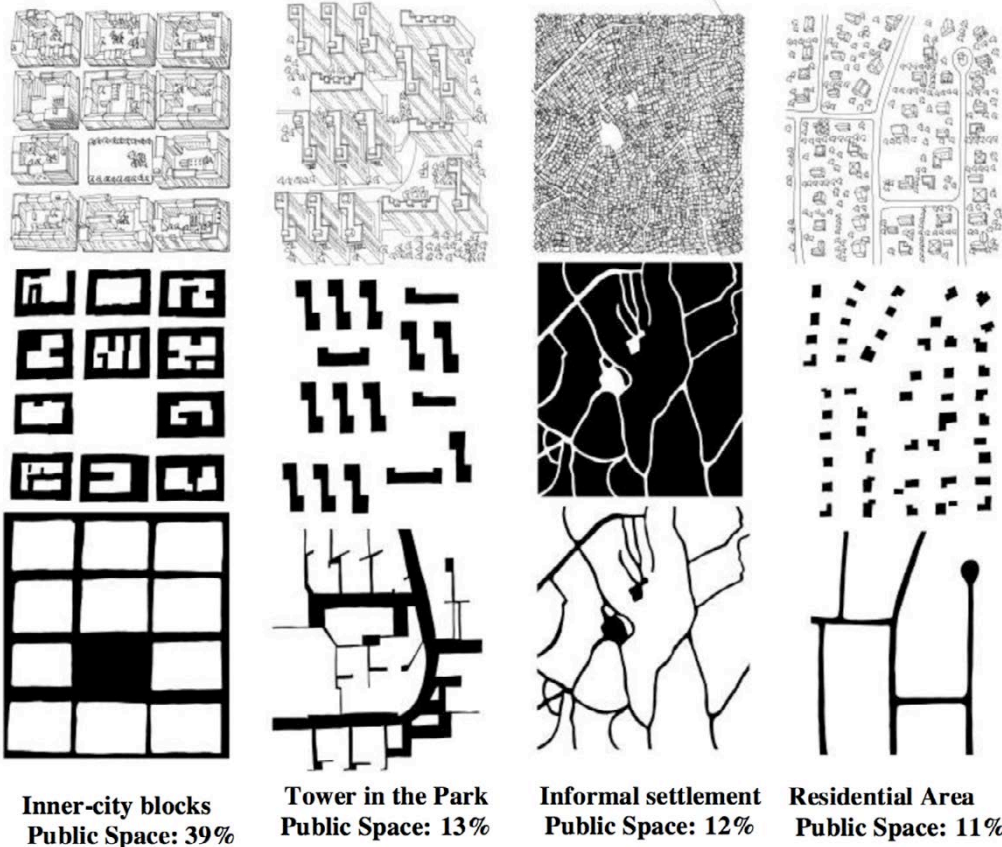
- **Tree structures have been engineered for suburban car-oriented areas in the 20th century.** Disconnected cul-de-sacs and loops are attached to collectors. They connect to arterials in a command and control hierarchy. Traffic constraints allow streets to connect only to immediately higher or inferior levels. Connecting to streets of the same level is prevented. Compared to lattices/grids, these tree structures are highly disconnected and encourage social and spatial segregation.



The basic blocks and roads are oversized: from 400 metres to 800 metres for the blocks, and between 60 and 100 metres for the roads. Most vehicular traffic is on the edge of the superblocks. The centre is reached by short and dead-end internal streets. Most of China urbanization over the last 30 years has sprawled with superblocks that are detrimental for access and increase congestion and infrastructure costs.

- **Superblock structures.** Modernist architects such as Le Corbusier have invented them in the 1920s.

Dense patterns of connected streets are the only ones to ensure a sufficient provision of public space.



STREET PATTERN BENCHMARKS

Benchmark: Street Density and Connectivity

The shape of a connected street pattern may be orthogonal or more irregular. Its virtues are the same. Jacobs (1993), Salat et al. (2011) and UN Habitat (2015b) recommend street crossings every 100 metres

or fewer. Alexander, Ishikawa, and Silverstein (1977) give similar advice. This high density of street intersections is observed in cities like Paris, New York, London, Rome, Tokyo, Seoul, where it creates a strongly interconnected public realm⁷. More connections must be created through a fine-grained

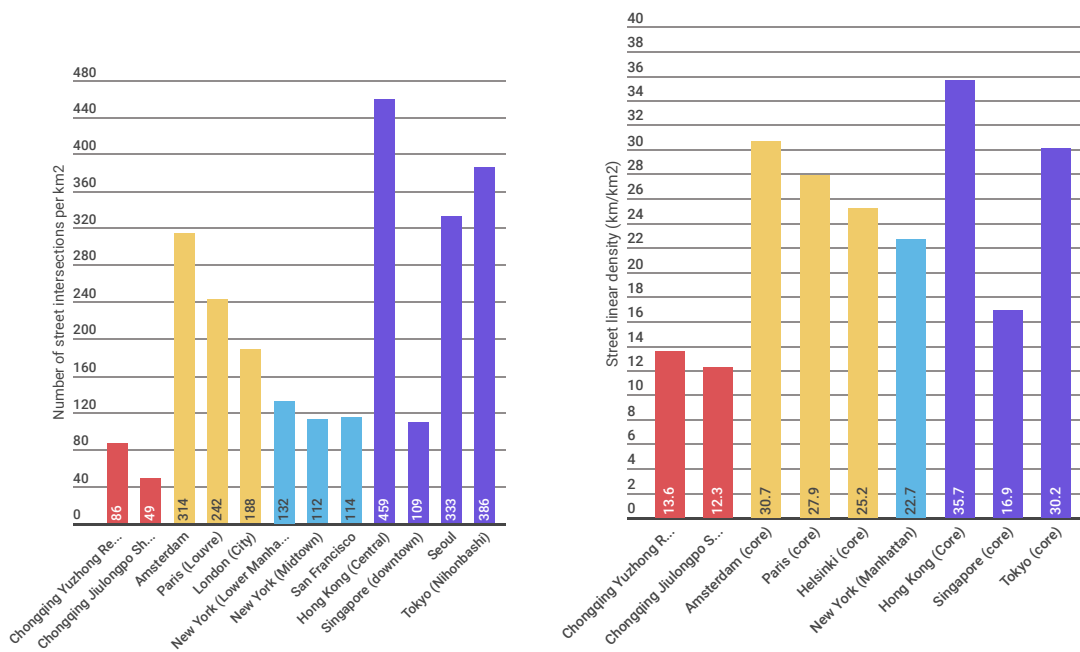
⁷ It is the opposite of wide arterials and super blocks derived from outdated modernist principles of the

beginning of the 20th century that pervade most recent urban developments in emerging countries.

urban texture. Small urban blocks surrounded by a dense network of streets promote greater fluidity and ease of access than huge blocks fed by highways. The grain of the urban texture is 50 m in Tokyo and Kyoto. It is 120 m in the historical centre of the European cities, in Hong Kong, and in Melbourne city centre.

An 80 m to 100 m grid spacing provides an optimal network for the needs of pedestrians and vehicles under most circumstances. This corresponds to **100 to 130 street intersections per square kilometre**. Street patterns should comprise at least **18 kilometres of streets per square kilometre**. The size of the resulting

development blocks should be checked against the proposed uses and building types, and adjusted accordingly. In central areas where pedestrian activity is intense, a grid spacing of 50 m to 70 m constitutes an optimal circulation network: 50 m is the spacing of the grid in Japanese cities, including Tokyo; 70 m is the spacing of the Roman Empire cities. The latter is remarkably resilient. It still today forms the grid of Mediterranean cities after two thousand years of evolution. In Manhattan, the width of blocks is 60 m along the north-south avenues while the length along the east-west streets is between 160 and 260 m, ensuring a high permeability of the urban fabric.



Venice
688



Toledo
420



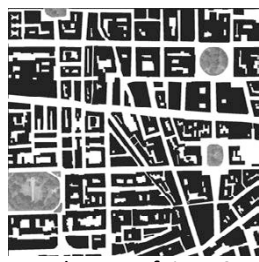
Florence
255



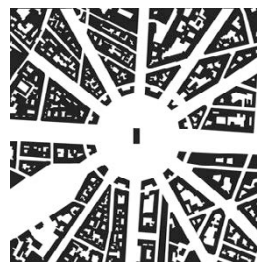
Turin
191



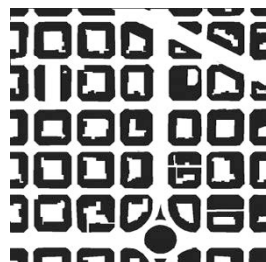
Amsterdam 17th c.
195



London Mayfair 1735
165



Paris Étoile
133



Barcelona Cerda plan
103



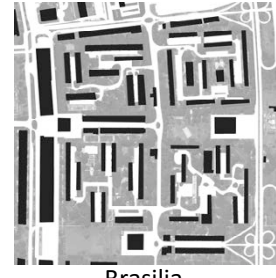
Manhattan
120



Washington
48



Washington suburbs 36



Brasilia
41



Beijing South
16



Beijing South
13



Shanghai Liangyang 27



Shanghai Pudong
17

Number of intersections per square kilometre in different street patterns. Source: Urban Morphology and Complex Systems Institute.

A unique grid may not be convenient for organizing the urban form. Variety and flexibility in the dimensions and shapes of grids is advisable to follow the topography. The juxtaposition or overlay of multiple grids offers interesting possibilities. For instance,

Marunouchi in Tokyo and many neighbourhoods in Seoul present 'tartan' grids. Topography, orientation, uses, etc., are all part of the definition of the appropriate grid structure for a development.



Tokyo Nihonbashi



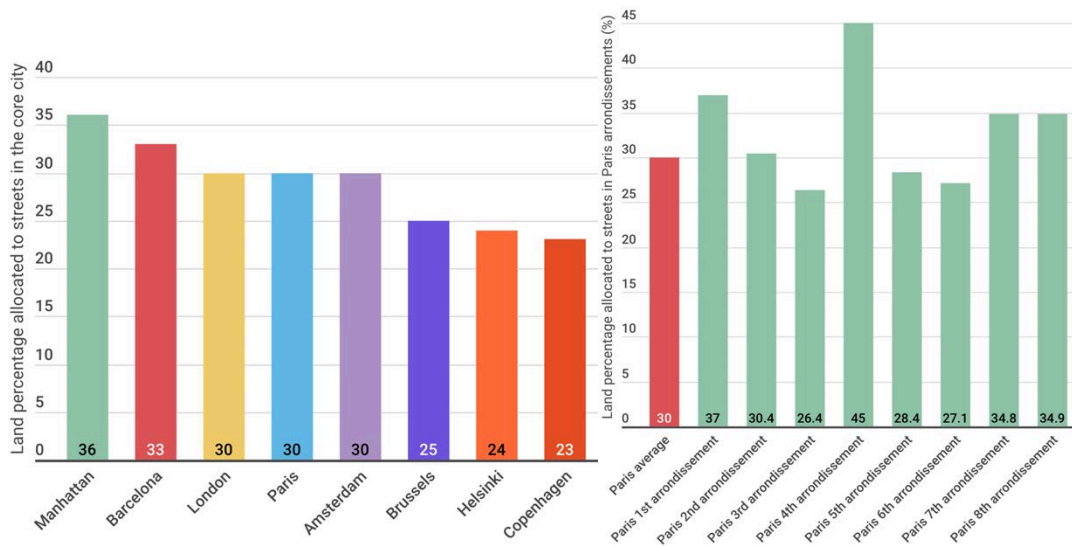
Seoul

Street Patterns on 1 square mile.



Seoul has a high connectivity. A grid of large regular streets is connected by a variety of small irregular alleys. The city offers alternative routes and pedestrian lanes.

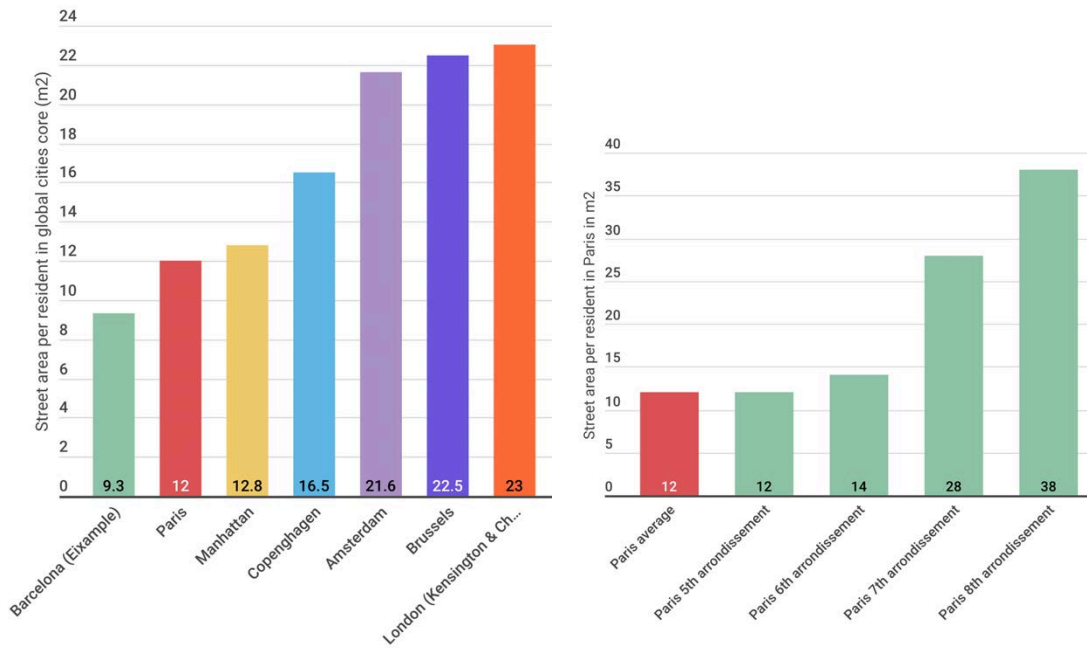
Benchmark: Land Allocated to Streets



Left: International comparison of land allocated to streets in the core city in percentage of the total land area.

Right: Land allocated to streets at arrondissement scale in Paris.

Source: Urban Morphology and Complex Systems Institute.

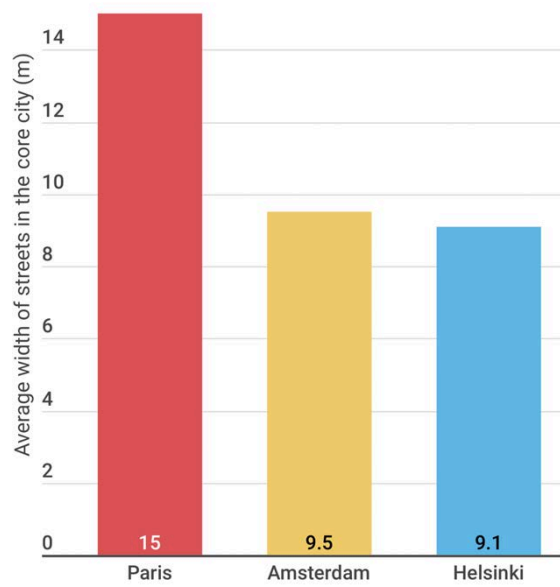


Left: International comparison of street area per resident in the core city.

Right: Street area per resident at arrondissement scale in Paris.

Source: Urban Morphology and Complex Systems Institute.

Street Width Benchmarks



International comparison of average street width in the core city.

Source: Urban Morphology and Complex Systems Institute.

Paris key benchmarks for streets – Inner Paris scale and district scale (3rd district)

Inner Paris (*intra muros*)

105.4 km² with the woods/84.5 km² without the woods (8,450 ha)

2.148 million inhabitants

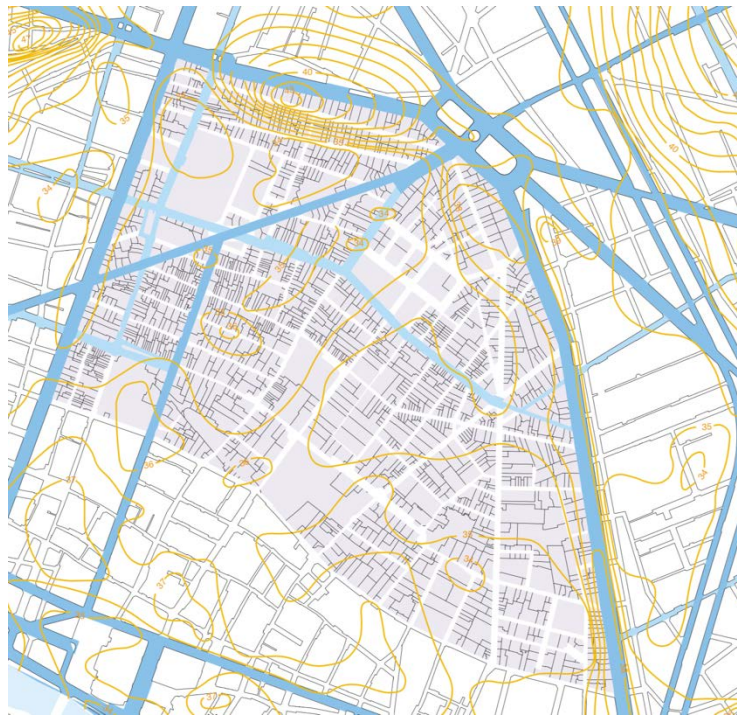
1,453 km of streets

17.20 km of streets/km²

27% of land is streets

Average street width: 15 m

Paris 3rd district



Paris 3rd district street networks and plot patterns. Source: APUR.

117 ha including 26.4% for streets

Population: 34,115 inhabitants

Density: 29,158 inhabitants/km²

26.3 km of streets

22.5 km of streets/km²

Average street width: 13.7 m

STREET PATTERN ECONOMIC PRODUCTIVITY *VERSUS* INFRASTRUCTURE COSTS

Superblock patterns are much less connected and less walkable than other urban forms and are inefficient for economic density and infrastructure costs⁸.

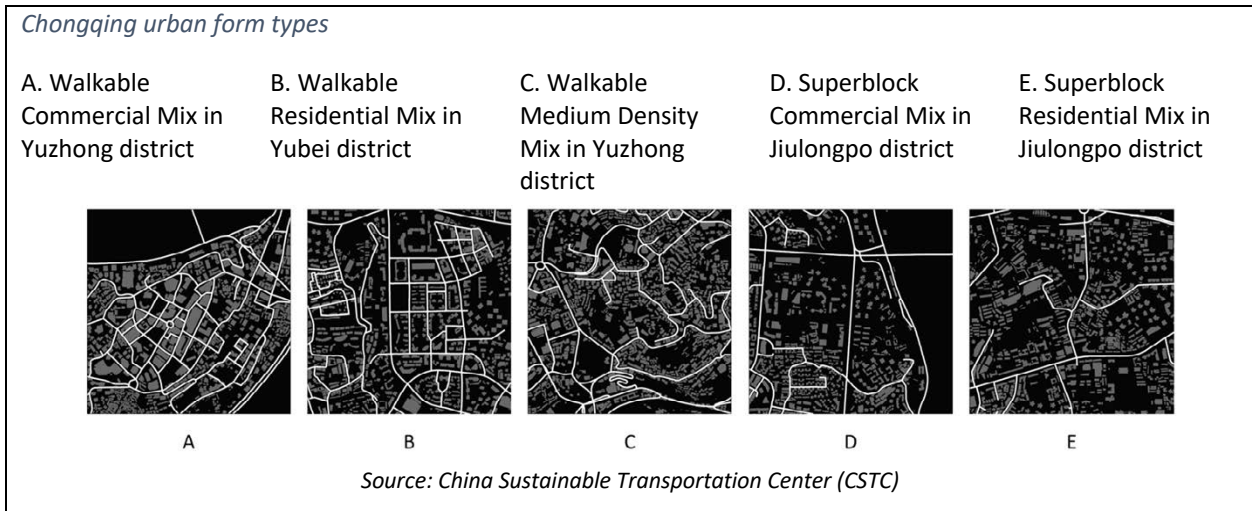
More street intersections in an urban area allow for many points where vehicles, cyclists and pedestrians

can move in different directions across the blocks thus reducing connection distances and increasing urban interaction. Quite the opposite, coarse urban fabric is pedestrian unfriendly and car oriented.

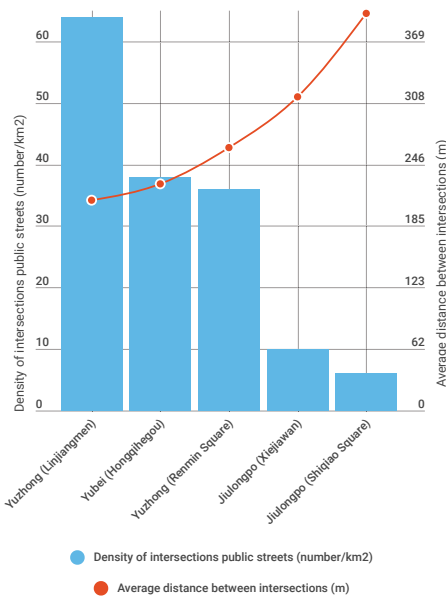
⁸ This section draws on World Bank. 2019.

An example is Chongqing's recent developments where density of intersections drops below 10 and the length of streets falls to 5 km per km² when counting only those with public access, Economic density is significantly lower (about 16 times) in residential superblocks than in Chongqing's mixed-use walkable

areas and cost of street infrastructure per unit of GDP increases up to 11 times, as shown in the charts below. To increase economic agglomeration and walkability while reducing infrastructure costs, cities must transform their urban form to walkable mixed-use patterns. They must plan with small blocks and mixed use.



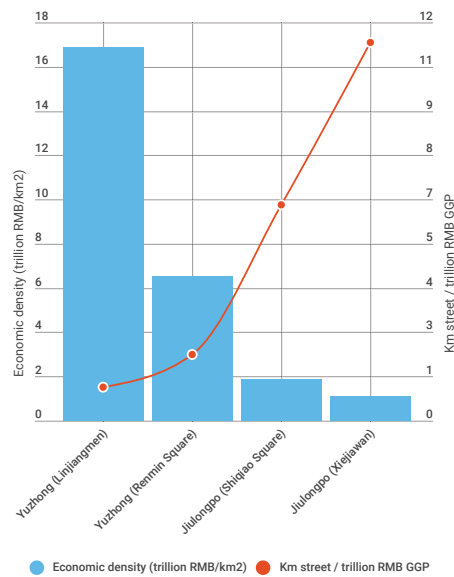
Density of intersections and average distance between intersections in Chongqing five urban form types



The chart above compares the connectivity of Chongqing five main urban form types (from left to right A, B, C, D, E as shown in the maps above). While intersection density is above 60/km² in Chongqing centre walkable commercial district (A), it is divided by 10 and drops to around 6/km² in new residential districts based on superblocs like Jiulongpo (E). Even when these new districts have a commercial function (D) the density of intersections is only 10/km².

Source: Urban Morphology and Complex Systems Institute

Economic density and length of streets per unit of GDP in four Chongqing urban form types



The chart above compares the economic productivity of urban land and costs of infrastructure (using street length per unit of locally generated GDP as a proxy).

From left to right A, C, D, and E are compared). Chongqing connected commercial urban fabric in the city center (A) generates more than 8 times GDP/km² of urban land than the weakly connected commercial urban fabric based on superblocs (D). Comparing commercial urban fabrics, A and D (Yuzhong Lingjiangmen and Jiulongpo Shiqiao Square on the chart), shows that the productivity of urbanizing the land (proxy is km of streets per unit of GDP) is five times weaker in disconnected superblocs than in connected walkable urban fabrics.

Data from China Sustainable Transportation Center (CSTC) and Chongqing Statistical Yearbook

DESIGNING THE NEIGHBOURHOOD STREET PATTERN

The structure of a street pattern can take a variety of forms, from formal grid layouts to more irregular arrangements. It should create a distinctive urban form

with landmarks and vistas that provide good orientation and navigation.

RESPOND TO THE CONTEXT

Street patterns should be design-driven and context-sensitive. They should not be the product of standard approaches. They should avoid the application of rigid models. Continuing a grid structure may maintain

connectivity. Or it may be more appropriate to adapt a present network to respond to important external factors such as views, topography or building lines.

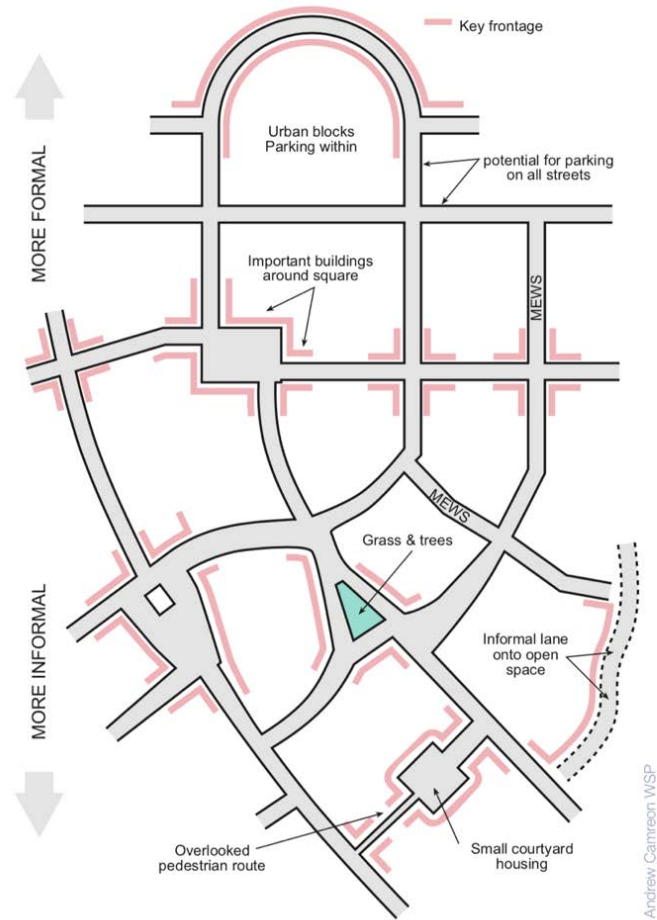


Diagram illustrating a range of street and place typologies. Source: The Government of Scotland 2010.

DEFINE PERIMETER BLOCKS

Street patterns defining perimeter blocks integrate access and movement. Fine-grain street networks and small blocks offer multiple, direct and convenient routes between destinations. They make efficient use of land. They provide generous and connected public

space and are a universal way for creating quality places across many cultures. Within this street/perimeter block structure, urban designers have freedom to create innovative layouts.

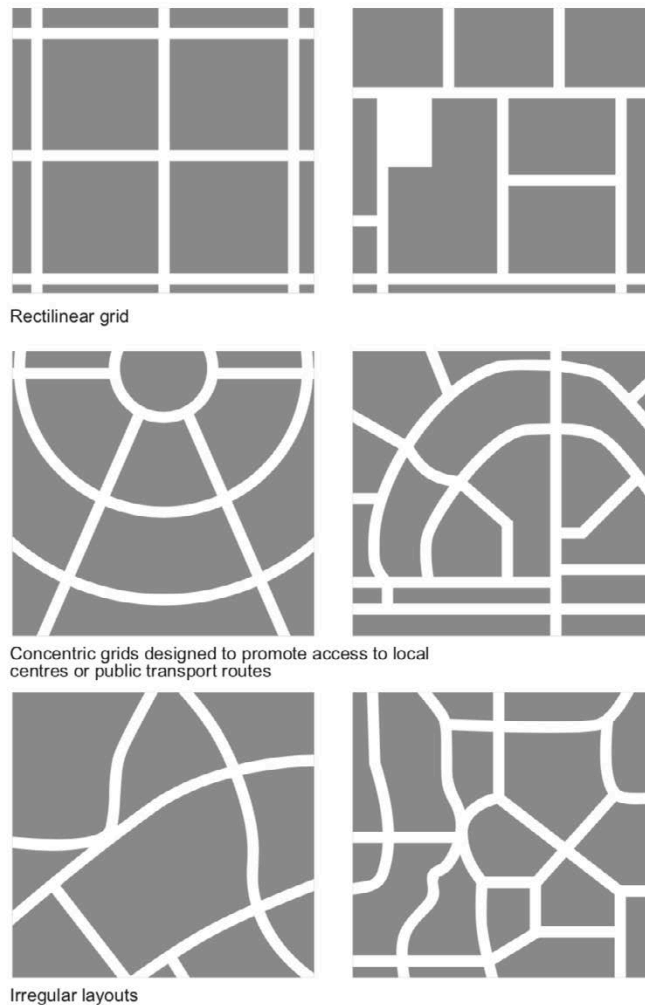


Diagram illustrating variations in street patterns and block structures. Layouts don't need to be regular but they must be fine grain and connected. Source: The Government of Scotland 2010.

COMBINE CURVE AND STRAIGHT STREETS

Short and curved or irregular streets can contribute to distinctiveness and a sense of place. They may also be appropriate to integrate topographical or other site constraints, or to introduce variation and streetscape interest⁹. However, designs that employ excessive curves should be avoided, as they make pedestrian and

cyclist access less straightforward. A balanced pattern uses a combination of irregular and straight streets that maximize connections between places and can meet the needs of those who prefer direct routes. Car-oriented cul-de-sac networks are strongly discouraged¹⁰.

⁹ The Government of Scotland 2010.

¹⁰ Short cul-de-sac may occasionally be required because of topography, boundary or other constraints. Caution must, however, be exercised when planning for cul-de-sac, as they concentrate traffic impact on a small

number of dwellings, require turning heads that are wasteful in land terms and lead to additional vehicle travel and emissions, particularly by service vehicles (The Government of Scotland 2010).

Check list for defining the street hierarchy ¹¹

Movement hierarchy

- Traffic volume
- Number of dwellings served
- Vehicles accommodated
- Direct access or not to individual properties

Visual hierarchy

- Scale (the distance between building fronts)
- Enclosure (as determined by the relationship between building heights and street width)
- Carriageway and footpath widths
- Street trees which can subdivide a street into different zones

Planning should establish a form-based hierarchy of streets rather than a progression of vehicle flows. The aim should be

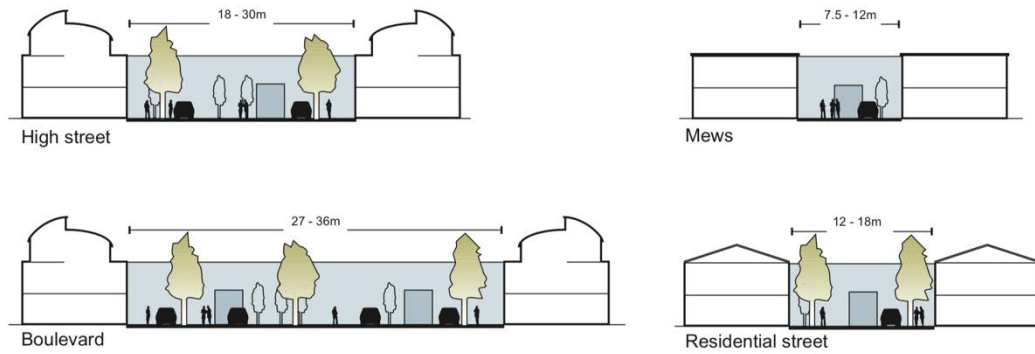
- To adapt traffic volumes and public transport.
- To direct development with active fronts on the main axes.
- To reduce speed of traffic and noise.
- To provide parking.
- To foster walkability and cycle movement
- To create a safe, comfortable and healthy environment.

Street patterns should present a variety of lengths and widths. The highest proportion should be narrow streets. At least 70% of streets should be less than 12 m wide. Interior neighbourhood streets should be narrow. Wide streets planted with trees should be allocated to the outer boulevards where they serve as promenades, ensure traffic between districts and delimit the neighbourhoods. For instance, Paris

boulevards were built where the successive fortifications once stood. Avenues in New York City and in Paris, are 30 metres wide and in Paris 70% of streets are less than 12 m wide.

In a well-balanced street pattern, major through traffic is handled with multiple two to four-lane streets and with pairs of one-way streets. These through streets would also supply space for transit systems from local buses to BRT lines. Auto-free streets that accommodate bikeways, pedestrian shopping areas, and dedicated transit lanes complement the through streets. Finally, a network of local streets providing local access to parcels with bike lanes and generous sidewalks completes the network. Street sections must be adapted to each of their segments. Designers should identify streets whose key function is place rather than movement. These include residential areas and some high streets. Their design should enhance and promote a sense of belonging.

¹¹ This box draws on English Partnerships and Housing Corporation 2007.



A form-based hierarchy of medium scaled streets with ample pedestrian space. Source: The Government of Scotland 2010.

Width between buildings is a key dimension. It needs to balance function with aesthetics. Bioclimatic effects should also be considered. Hot and dry climates need shadowing with narrow and tall streets. In Italy town like Bologna or Florence and in Maghreb medinas, streets are usually 4 times higher than wide. In contrast, wider streets are needed in hot and humid climates to let the breezes flow and cool the urban fabric. Design principles for streets in hot and humid climates are detailed in the chapter 'Design with nature'. Designers must consider the variety of activities taking place on the street and the scale of the buildings on either side. The distance between facades in streets typically ranges from 10 m to 18 m, although many streets are significantly narrower and work well. Rigid width standards should be avoided. The design of new streets should consider the relationship between scale and the nature of the space created.

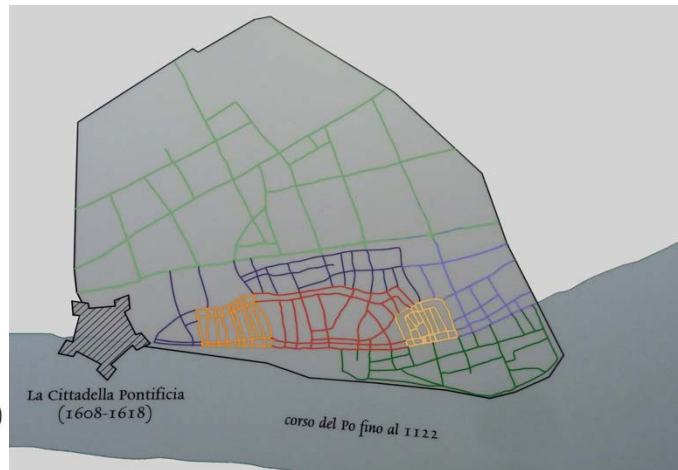
Street widths should be kept appropriate. Neighbourhoods should not be segregated by large highways but delineated and linked by 30 – to 33-metre wide boulevards with a median landscaped part. These boulevards should allow for street trees, bicycle paths and wide pedestrian sidewalks. If traffic is to move through a neighbourhood on narrow streets at speeds of 30 kilometres an hour, the street curvature radius at the corners should be designed with these roadway widths and speeds. It can be as small as seven or even five metres. Higher radius or widths are invitations for cars to go faster, which is not desirable within neighbourhoods with small children and pedestrians.

Street length can also have a significant effect on the quality of a place. Recognizing and framing points of view and landmarks can help give a neighbourhood identity and orientate people. Long streets risk encouraging high traffic speeds. They require careful design to slow traffic.

CASE STUDY: FERRARA STREET PATTERNS

Ferrara is a city in Emilia-Romagna, northern Italy, capital of the Province of Ferrara. In the extensions to Ferrara by the house of Este, created around 1500, the streets strike a compromise between a continuous tunnel effect and a division into distinct units. The architect Biagio Rossetti created powerful perspectives while avoiding symmetrical palace fronts. He designed breaks between the vertical brick planes with green spaces and cross views of courts and gardens. This lets light into the street and gives pedestrians a sense of rhythm and integrity from the blocks and the buildings. The reinforcement of block corners by white marble pilasters contributed to the perception of an urban corridor defined by clearly articulated individual units.

-  Il *castrum* bizantino (VII-VIII sec.)
-  Il quartiere del Borgo di Sopra (X-XI sec.)
-  L'espansione medievale (XI-XII sec.)
-  L'«Addizione Adelarda» (XII-XIII sec.)
-  Il Borgo di Sotto (XIV sec.)
-  L'«Addizione di Borso» (1441-1462)
-  L'«Addizione di Ercole I» (1492-1505)



Left: Ferrara, Medieval street, *castrum*. Middle: Renaissance entrance to the medieval city. Right: Renaissance street, Corso Ercole I d'Este. Photos: © Françoise Labbé.



Ferrara. Biagio Rossetti extensions.



Ferrara. The reinforcement of block corners by white marble pilasters. Photos: © Françoise Labbé.



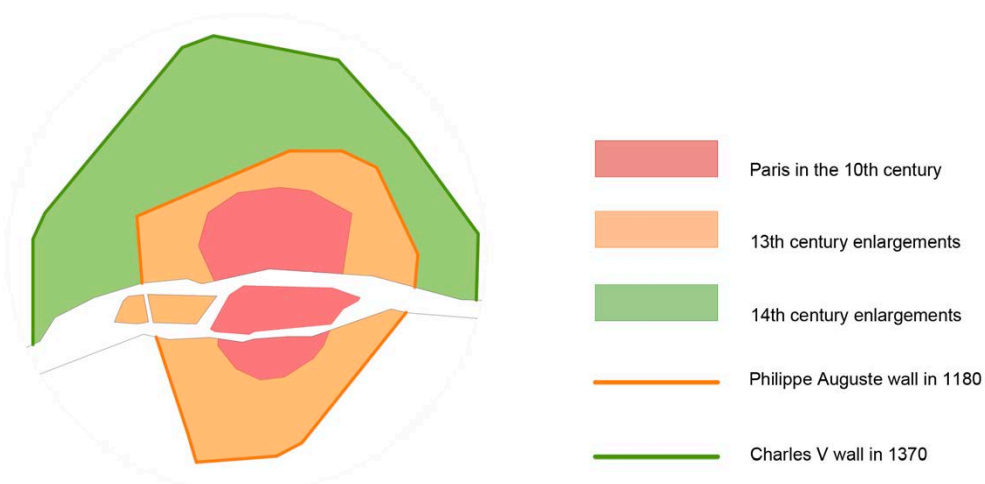
A map of Ferrara, c. 1600.



Ferrara, Corso Ercole I d'Este. Photo by Rapallo.

CASE STUDY: HISTORICAL EVOLUTION OF STREET PATTERNS IN PARIS

Street patterns around the Châtelet



Development of Paris in the Middle Ages. Structured by three successive walls, the first arrondissement could sum up the history of Paris. The first inhabitants gathered on the Ile de la Cité from Antiquity. In the Early Middle Ages, a village, enclosed by a defensive wall, was born on the right bank around the Saint-Germain-Le-Rond church. At the start of the 13th century, housing estates multiplied within the walls of Philippe Auguste. During the 13th and 14th centuries, parallel streets outside the enclosure appear. To the north, two radials (Montmartre and Montorgueil streets) stand out and, soon, urban growth requires a new wall, which will be erected by Charles V.

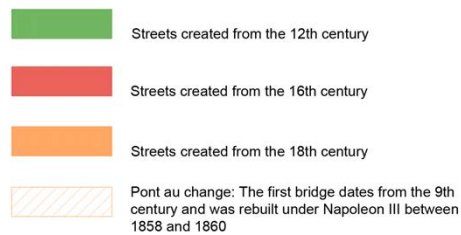


1. Map of the Châtelet neighbourhood (1137) in Paris from La Mare and Coquart.

2. Map of the Châtelet neighbourhood (approx. 1700) in Paris. The city is gradually becoming denser and new traffic axes are created. But at this time the Grand Châtelet is still here and seems more imposing than before.



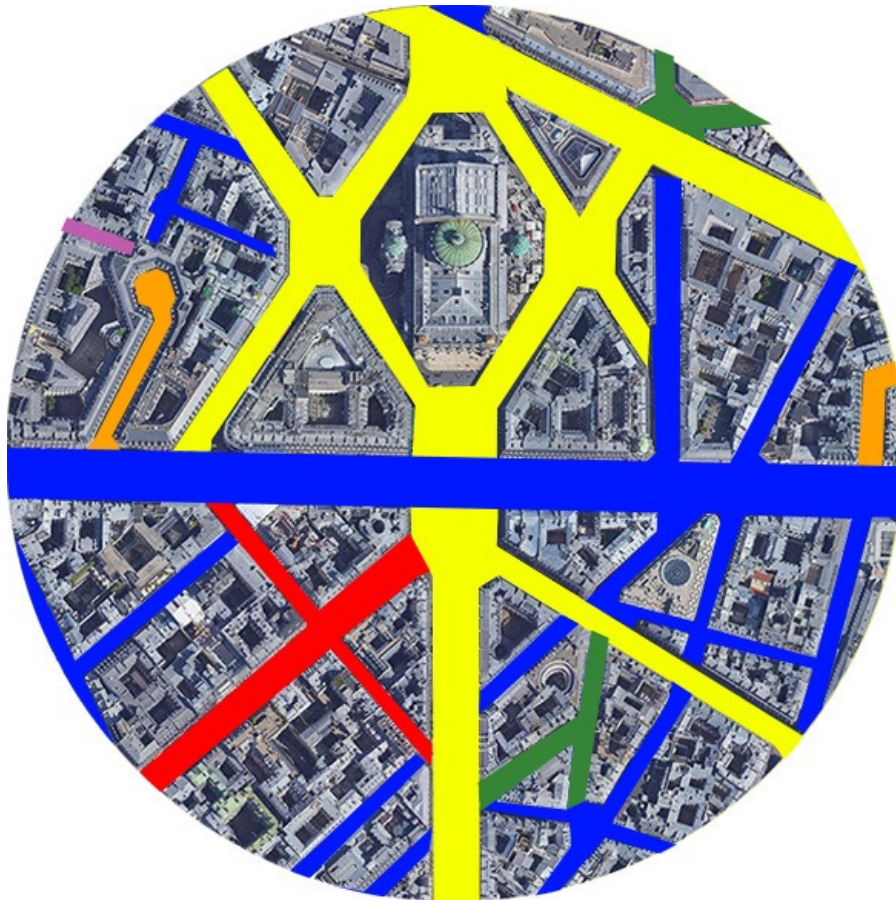
3. Map of the current Châtelet neighbourhood in Paris from the cadastre. On this map, we can see some of the street openings made under Haussmann and which mostly lead to the square.



Left: In white, the constructions and in black, the circulation spaces and interior courtyards.

Right: Street formation by centuries. In the 16th century, Paris 1st arrondissement concentrated the major works of royal power, place des Victoires and place Vendôme. Private constructions also multiplied and, at the end of the 18th century, speculative housing estates appeared. After the French Revolution, the rue de Rivoli is traced. Its buildings make up a sequenced ensemble. Under the Restoration and the July monarchy, the transformations remained modest. On the other hand, the works of Haussmann redefine the centre of Paris: opening up of the Boulevard de Sébastopol, extension of the rue de Rivoli, development of the Place du Châtelet. Since the openings of Haussmann, the parcel fabric has been maintained. However, the streets present today are not all due to the works of Haussmann, some are much older.

Châtelet neighbourhood, in Paris, in a 300 m radius circle. Drawings and analyses by Perrine Combes, École Spéciale d'Architecture, Paris.

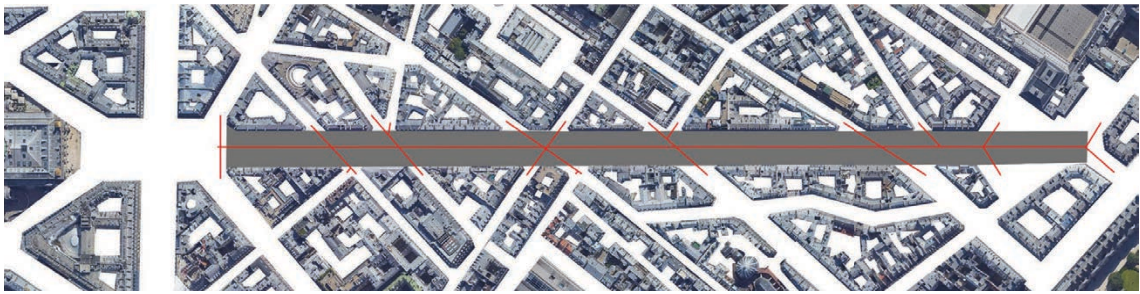


■	Bourbons (1589-1792)
■	First Empire (1804-1815)
■	Valois (1815-1848)
■	Second Empire (1852-1870)
■	Third Republic (1870-1940)
■	Fifth Republic (from 1958)

Avenue de l'Opéra, Paris

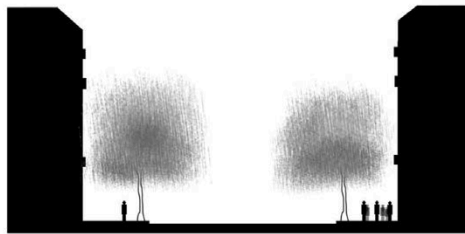
On May 3, 1854, August 24, 1864, and June 27, 1876, it was decreed that an avenue connecting the Royal Residence of the Louvre to the Palais Garnier be created. Completed in 1876, this wide rectilinear avenue offers a perspective with the Opéra Garnier as a point of view. The visual continuity of the Haussmannian facades reinforces the directional push. The avenue being narrower than the facade of the Opera House, the Avenue was not planted to preserve the perspective.

- Aspect ratio: 0.7.
- Average width: 30 m.
- Length: 698 m.
- With 9 intersections, the avenue is highly connective.



Avenue de l'Opéra, Paris. Drawings by Colin Laubretton, École Spéciale d'Architecture, Paris.

Boulevard Haussmann, Paris



Boulevard Haussmann, Paris. Drawings by Colin Laubretton, École Spéciale d'Architecture, Paris.

Initiated in 1864, the work on Boulevard Haussmann was not completed until 1926 once the last section was finished. The boulevard is not straight, but in the shape of an elbow. Due to its length, it offers a convex effect. An alignment of

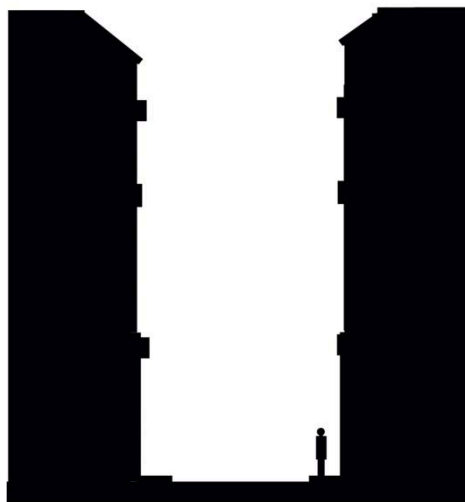
shafts on both sides reduces this width by creating a slightly more intimate opening. The aspect ratio of 0.7 shows that the height of the buildings roughly matches the width of the street, establishing a situation of equilibrium.

- Average width: between 30 m and 33 m.
- Aspect ratio: 0.7.
- Length: 2.53 km.
- With 19 intersections, the boulevard is highly connective.

Rue Louis-le-Grand, Paris

Created in 1703 under the orders of Louis XIV, the street was cut off by the Avenue de l'Opéra in 1876. With an aspect ratio of 2.1, the street is narrow.

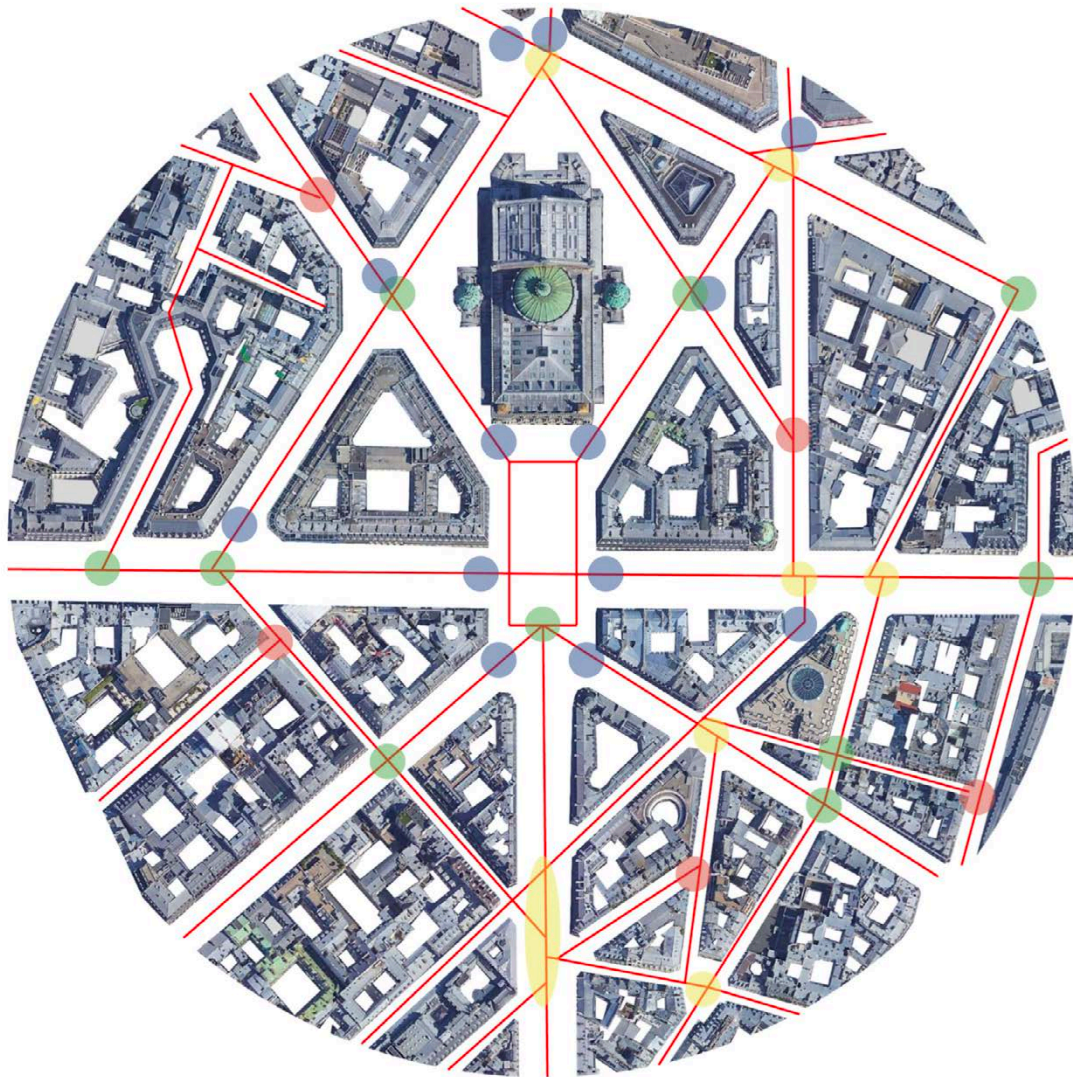
- Aspect ratio: 2.1.
- Average width: 10 m.
- Length: 370 m.
- With 5 intersections, the street is weakly connective.



Rue Louis-le Grand, Paris. Left: Section. Right: Rue Louis-le-Grand seen from rue Danielle-Casanova.



Rue Louis-le Grand, Paris. Drawings by Colin Laubretton, École Spéciale d'Architecture, Paris.



- Regular intersection
- Irregular intersection
- Aperture of streets
- Closure of streets

Typology of street intersections around Paris Opéra House. Drawings by Colin Laubretton, École Spéciale d'Architecture, Paris.



1. Rue de la Paix towards Vendôme column



2. Rue D'Antin towards Avenue de l'Opéra



3. Street Edouard VII from Avenue de l'Opéra

The end of the Haussmann breakthroughs (Avenue de l'Opéra, Boulevard Haussmann) and many streets near the Palais Garnier offer a point of view on one of the Opera House facades or angles. As for the streets that existed before Haussmann's modifications, few of them have focal points at their ends. An exception is Rue de la Paix, offering a perspective towards the Place Vendôme, and the Vendôme column.

CASE STUDY: IRREGULAR LINKAGES IN KYOTO AND VENICE

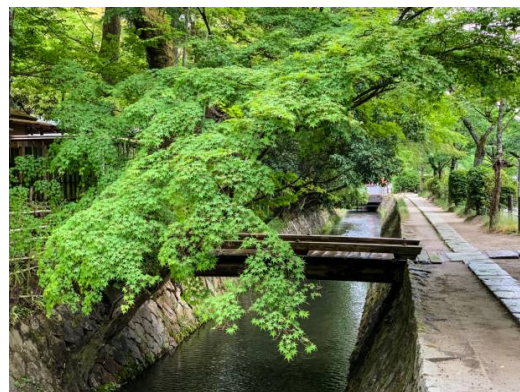
This brief comparison shows how irregular wandering streets shaped by the topography and water courses (along a canal in Kyoto; along the Grand Canal in Venice) share common features in different cities. Both are highly connective paths that connect many transverse small streets. Both are very popular routes for walking due to their irregularity and the path of constant discovery they create along with seasonal variations and connections to nature in Kyoto.

Kyoto

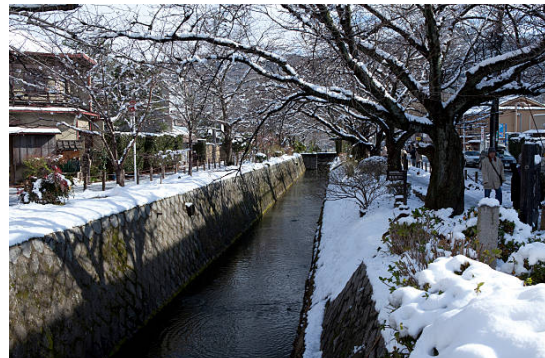


Kyoto: The path of the philosophers (length: 1.35 km). Drawing: Françoise Labbé.

The Philosopher's Walk (Tetsugaku-no-michi) is a pedestrian path that follows a cherry-tree-lined canal in Kyoto, Japan between Ginkaku-ji and Nanzen-ji. First opened in 1890 and extended again in 1912, the path follows the course of a shallow irrigation channel bringing water from the Lake Biwa Canal.



*The philosopher's path is a linkage within the city that relates people to nature and to different seasonal experiences.
Left: spring. Right: summer.*



Left: autumn. Right: winter.

Venice

The perpendicular streets along Strada Nova connect houses and hidden plots. They punctuate the wandering along the main street.



Venice: Strada Nova (length 380 m). Drawing: Françoise Labbé.



Chiesa di Santa Fosca along Strada Nova. Photo: Didier Descouens.



Chiesa di San Felice along Strada Nova. Photo: Wolfgang Moroder.

CASE STUDY: AXIAL COMPOSITIONS IN ROMA, TURIN AND PARIS

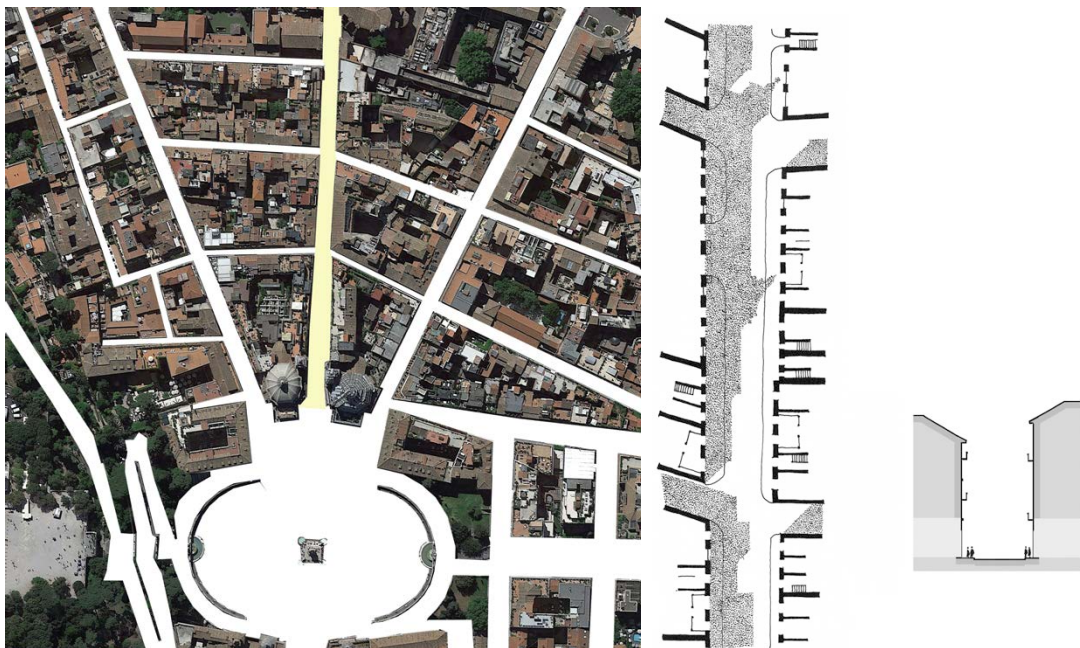
Roma

The Trident

The Trident was the first major urbanistic intervention carried out in Roma at the start of the Renaissance. It became the model for European Baroque urbanism. The composition seamlessly integrates the existing urban fabric irregular blocks. Bernini and Fontana adapted the churches to the space for which they were intended.

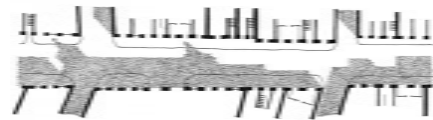


The Trident in Roma. Drawing: Françoise Labbé.





Via del Corso is 1,625 m long and is one of the long, straight and regular streets of Rome that structure the city on a large scale.



Roma, Piazza del Popolo. The entrance of the Tridente from Piazza del Popolo, defined by the 'twin' churches of Santa Maria in Montesanto (left, built 1662-75) and Santa Maria dei Miracoli (right, built 1675-79). The Via del Corso exits between the two churches. Photo: Patrick Landy.



Roma, Via del Corso.



Ippolito Caffi, 1839/1860, The 'moccoletti al corso'.

Turin

Via Po

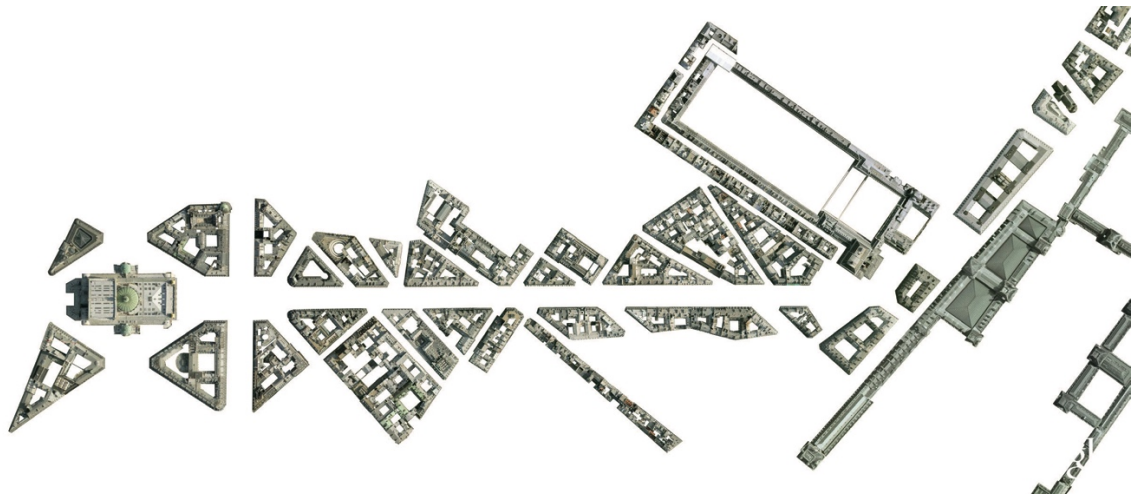
The 1,600 m long continuous Baroque axis is made of a succession of sequences (220 m, 700 m and 680 m) expanding or contracting space, and thus playing with perspectives and focal points.



Turin, Via Po. Drawing: Françoise Labbé.

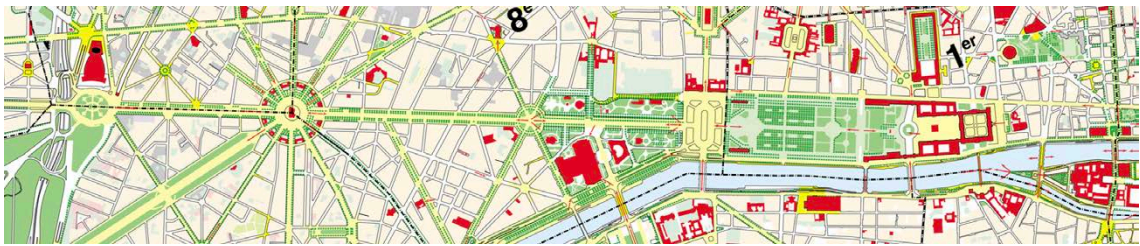
Avenue de l'Opéra

Several monumental compositions belonging to different centuries and reigns (Louvre, Palais Royal, Opéra Garnier) are articulated by axes and rotations, while being in the irregular continuity of the Haussmannian urban fabric.



Avenue de l'Opéra in Paris.

Avenue des Champs-Élysées

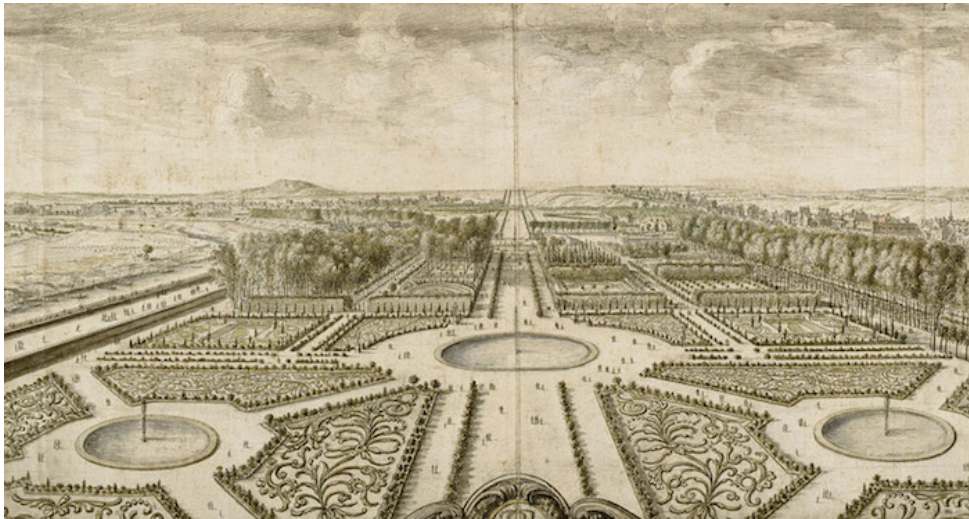


The Grand Axis of Paris with Avenue des Champs Élysées extending the axis of Tuileries Garden. Source APUR.



Avenue des Champs-Élysées in Paris. Source: APUR.

From 1666, Louis XIV commissioned André Le Nôtre, the King's gardener, to transform the Tuileries garden, and to open a path to facilitate the road to Versailles. In the axis of the Palace, Le Nôtre extended the central axis of the garden by a wide path bordered by a double row of elm trees.



The Champs-Élysées as designed by Lenôtre.



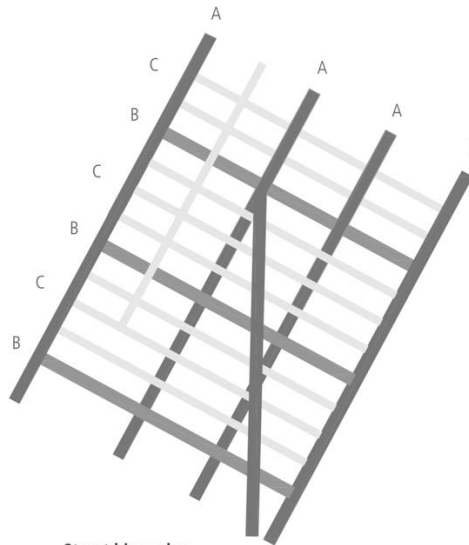
Avenue des Champs-Élysées in the 19th century.

Hausmann modernized the western section, which ran from Rond Point to the Étoile, into a boulevard. He rebuilt its eastern section, from the Tuileries to the Rond Point, where it passed through park areas with wide tree-line sidewalks. The 70-metre wide section had a central roadway of approximately 27 metres flanked by two 15-metre medians with narrow side roadways and wide sidewalks. Each median was originally planted with two rows of trees and lines with light fixtures, while the sidewalks on each side held an additional row of trees.

CASE STUDY: STREET GRIDS IN MANHATTAN, SAVANNAH AND BARCELONA

Manhattan

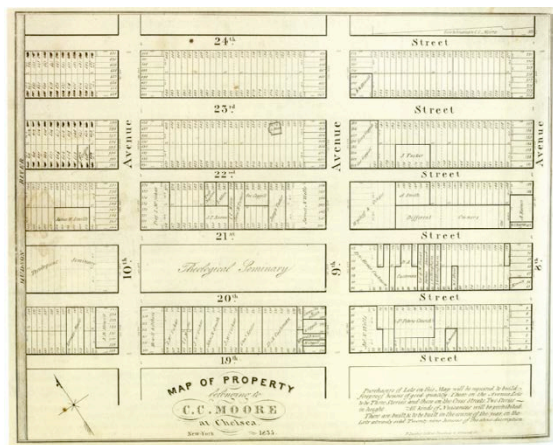
Legibility of the pattern as a whole is of paramount importance. In Manhattan, the avenues are sharply distinguished from the cross streets. Each avenue has a strong identity, with Fifth Avenue articulating the whole perception of Manhattan. The relative width of the avenues and streets, the various block lengths and widths, the building heights and frontages, all tend to reinforce this differentiation. Thus, the overall street pattern is given form, character, and directionality.



Street hierarchy

- A: Avenues 30m
- B: Major cross streets 30m
- C: Standard cross streets 18m

Manhattan grid. Source: UN Habitat 2015c.



Left. Detail of Manhattan Commissioner's map of 1811. Right. Map of Charles Moore Estate in 1835, which eventually became Chelsea.



The 'Sanitary & Topographical Map of the City and Island of New York', commonly known as the Viele Map, was created by Egbert Ludovicus Viele in 1865.



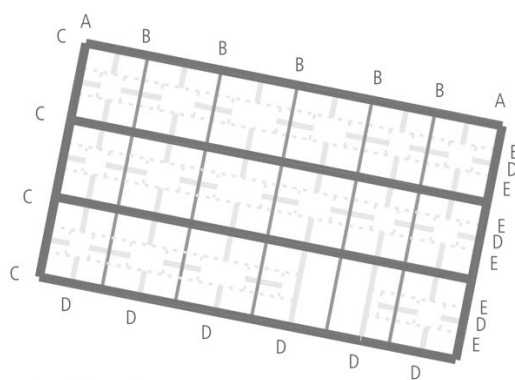
George Schlegel (artist) George Degen (publisher). Manhattan in 1873. The Brooklyn Bridge was under construction from 1870 until 1883.



Fifth Avenue connects 135 streets in Manhattan.

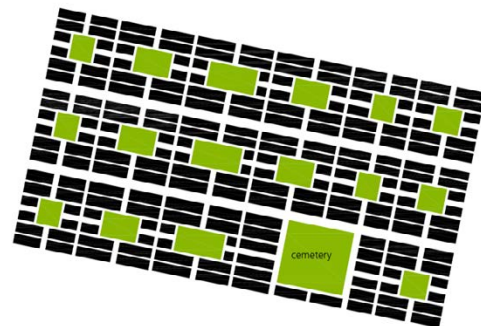
Manhattan grid – established by the Commissioners’ Plan of 1811 – extends through the peninsula with avenues parallel to the Hudson and East Rivers. The topography was abrupt, ‘an island of hills’, and it was regraded to accommodate the grid. Manhattan’s grid creates diversity in street widths and block dimensions. Although block widths are constant (60 m), their lengths vary. The 30 m wide, NE-SW Avenues, connect on average 135 streets. The tempo of intersections (every 80 m) is like that of the Roman Empire grid. The 30 m wide major cross streets and the 18 m wide standard cross streets link on average 16 avenues. The ample rhythm of intersections is like that of European 19th century urban extensions. The pattern has proved extremely flexible. It has accepted many variations to the initial 1811 Plan without losing its essence: Madison and Lexington Avenues; Broadway; Central Park; the broadening of Park and Lenox Avenues; neighbourhood squares and superblocs (Columbia University, United Nations, Grand Central station, NY Public Library and recently Hudson Yards). Although the original plan did not regulate alignments, the pairing of block and plot sizes with common brownstone housing typologies ensured maximum land coverage and resulted in a continuous street frontage. Property owners were involved through the imposition of charges to pay for the street costs.

Savannah



Street hierarchy

- A/C: Main streets: 24-26m
- B: Standard streets. 10m
- D: Module main streets. 16m
- E: Module standard street: 8 m



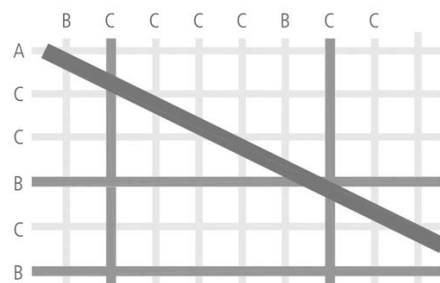
Left. Savannah grid. Source: UN Habitat 2015c. Right. Open spaces and facilities in Savannah. Eight building blocks surrounding a central local square compose the basic units. The square, the core of the unit, served originally as town meeting area and a centre of business. Markets or churches were grouped around the square, in blocks of different sizes and shapes, enhancing the public space vibrancy.



Savannah historic district. Photo: Photoartel. Savannah River Street. Photo: Aude.

General James Edward Oglethorpe laid out the plan of Savannah in 1833. Savannah is the oldest city in the U.S. state of Georgia. Following the usual practice for port cities, Savannah is parallel to the riverfront. The grid is orientated with the cardinal points. Main streets 24–26 m wide compose the larger grid. They are directed in the E-W direction and carry the main vehicular traffic. Standard streets are 10 m wide and are oriented in the N-S direction. This grid defines modular units (wards) centred around a central park or square. The streets within the ward are 18-10 m wide. They penetrate the unit and border the central square. The clarity of the general plan creates a legible structure. The units provide public spaces and facilities at the local scale. The central position of the squares within the modules results in civic spaces easily controlled and monitored by the neighbours. The module introduces a scale that breaks the monotony of a simple grid. It can be repeated facilitating urban growth. The urban squares compose a network of interconnected public green spaces.

Barcelona



Street hierarchy
 A: Avenues 50m
 B: Major streets 30m
 C: Standard streets 20m

Barcelona grid. Source: UN Habitat 2015c.



Barcelona Example grid.

The *Eixample*, a district designed by Cerdà in 1860, covers 7.46 km² with the density of 36,000 people/km². The grid extends parallel and perpendicular to the sea. The corners of the square blocks match the cardinal points and, therefore, all the facades have direct sunlight throughout the day, showing the importance that the designer gave to solar exposure. The scheme takes full advantage of predominant wind directions (sea-land breeze) to facilitate oxygenation and cleanse the city air.

The *Eixample* encompasses different scales: the avenues connect the territory, while the streets define the locality. The grid created an orderly and flexible framework, while regulation modifications could respond to changing requirements. The identity of the city is maintained through the adjustment of the grid to the pre-existing city fabric and the incorporation of urban elements and areas (Gràcia, Sant Andreu, Rambla Poblenou, Clot). The generous dimension of streets and avenues has given great flexibility and adapted well over time. The initial homogeneous configuration of the street has evolved into many different street sections and typologies. The mix of uses without zoning and the high density create a vibrant city. The main business and commercial areas are around the most identifiable urban spaces such as Passeig de Gràcia.

REFERENCES

Alexander, C., S. Ishikawa, and M. Silverstein 1977. *A Pattern Language: Towns, Buildings, Constructions*, Oxford University Press, New York.

City of New York 2019. *One NYC 2050. Building a Strong and Fair City*.
<https://onenyc.cityofnewyork.us/wp-content/uploads/2020/01/OneNYC-2050-Full-Report-1.3.pdf>

Energy Foundation, CSTC & Gehl 2017. *Changing Cities in 5 Steps. A guide to achieving livable & sustainable cities*.
<http://www.efchina.org/Reports-en/report-lccp-20170816-en>

English Partnerships and Housing Corporation 2007. *Delivering Quality Places. Urban Design Compendium 2*.

Jacobs, A. B. 1993. *Great Streets*, The MIT Press.

Llvelyn Davies 2000. *Urban Design Compendium*.

Marshall, S. 2005. *Streets & Patterns*. Spon Press.

Salat, S. with Labbé, F. and Nowacki, C. 2011. *Cities and Forms: On Sustainable Urbanism*. Paris: Hermann.

Salat, S., Ollivier, G. P. 2017. *Transforming the urban space through transit-oriented development: the 3V approach* (English). Washington, D.C.: World Bank Group.
<http://documents.worldbank.org/curated/en/647351490648306084/Transforming-the-urban-space-through-transit-oriented-development-the-3V-approach>

Speck, J. 2017. 'Ten rules for cities about automated vehicles.'
<https://www.strongtowns.org/journal/2017/10/17/10-rules-for-cities-about-automated-vehicles>

The Government of Scotland 2010. *Designing Streets. A Policy Statement for Scotland*.
<https://www.gov.scot/publications/designing-streets-policy-statement-scotland/>

ULI (Urban Land Institute) 2015. *Building Healthy Places Toolkit: Strategies for Enhancing Health in the Built Environment*. Washington, DC.

UN Habitat 2013a. *Planning and design for sustainable urban mobility: global report on human settlements*.
<https://unhabitat.org/planning-and-design-for-sustainable-urban-mobility-global-report-on-human-settlements-2013/>

UN-Habitat 2013 b. *Streets as Public Spaces and Drivers of Urban Prosperity*.

UN Habitat 2015a. *Habitat III Issue Paper n. 11 on Public Space*.
http://habitat3.org/wp-content/uploads/Habitat-III-Issue-Paper-11_Public-Space-2.0.compressed.pdf

UN Habitat 2015 b. *Discussion Note 3. Urban Planning. A New Strategy of Sustainable Neighborhood Planning: Five Principles*.
<https://unhabitat.org/a-new-strategy-of-sustainable-neighbourhood-planning-five-principles>

UN Habitat 2015c. *Planned City Extensions: Analysis of Historical Examples*.
<https://unhabitat.org/planned-city-extensions-analysis-of-historical-examples>

World Bank. 2019. *Chongqing 2035: Spatial Transformation Strategy: Increasing Efficiency and Livability by Promoting Compact and Human-Centered Development*. Supporting Report 1. Washington, DC: World Bank.