Designing Grid Cities for Optimized Urban Development and Planning

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immense forest of 50,000 trees—most of them planted along its 250 km of streets. It coincides almost exactly with the proposal conceived in 1859 by Ildefonso Cerdà, which today is still consolidating the city's most dynamic limits. What is the reason for the success of this plan? Perhaps the flexibility of a just norm over 150 years has helped identify Barcelona, as well as granting it the reputation as a well-planned and rational city. This is the most prominent value of the Cerdà Plan. Its ability of permanency in assuming changes of use, ordinances, an increase of its building potential, a succession of styles, construction processes, and ways of life mean practical success of a theoretical project, a view shared by experts and citizens.

Chapter 3

During the nineteenth century, capital cities in Latin America established a new generation of "green" grids, inherited from the tradition of Hispanic colonization that introduced new elements of modernity: technique, transport, and ecology. From hundreds of cases, it is worth paying attention to those that are most outstanding for embodying a number of characteristics: certain isolated condition, perfect geometrical layout, tram connection, "hygienist" inspiration, innovative engineering, new urban imaginary, etc. The brief presentation of some cases in Buenos Aires, México DF, Montevideo, and Sao Paolo leads the authors to assess the outstanding case of El Vedado in La Habana (1859) within its contemporary panorama. This is a canonical grid district settled in a vast and privileged area near the Caribbean Sea, with its quiet tree-lined streets and notable for its exquisite buildings. After 150 years, reviewing the transformation of this unique grid allows one to gain insight regarding the flexibility of urban grids, appreciate the splendour of its past, and explore the potential for its future.

Chapter 4

The first building of the Murattiano district fell in 1954. Since then, a constant devastation, that between 1963 and 1964 alone counts more than 200 building replacements. Maybe the deterioration of the Murattiano district had already been decided in its birth certificate. Still, has the example contained in their best works truly disappeared or can we recognize nowadays its effect in some pieces of architecture that have most recently been built in Bari? Before expressing a judgment about quality, it is necessary to identify a list of all those cases that during the second half of last century and the first years of the new one and therefore in very recent times witness the innovations that were introduced in the local architectural culture. Innovations

the past, the grid cities manage to evolve favoring the needs of its contemporary inhabitants. In this chapter, the authors try to understand some phenomena that characterize the transformation of the urban form of the grid city, highlighting its own ability to evolve between tradition and innovation. During these 200 years, the grid city, its buildings, and its public spaces were created, lived, and processed in multiple ways: built, replaced, drawn, renovated, restored. Here, the authors do not want to describe these planning and building tools, but they want to discuss the possible implications of the different transformation modes used in the grid city can have on urban and architectural perception of the physical space, the quality of life, and viability of these central places for the city's identity. The city of Bari, on the Adriatic Coast, in the South of Italy, is used as a case of study to represent concepts developed in the chapter.

The subject of the chapter is the transformation of the urban matrix in the Northern Serbian province of Vojvodina. Being placed at the crossroads of important trans-European corridors, this territory in Southern Pannonia has always been exposed to various influences and shifts of power, which have left a significant mark on their urban matrix. The most prominent period was certainly Habsburgs' rule in Southern Pannonia in the eighteenth and nineteenth centuries, which radically reshaped inherited organic medieval-oriental matrix into planned, orthogonal regulation. This, Habsburg legacy has influenced the urban development of these towns until today. The aim of this chapter is to present the outcome of Habsburg urban regulation and accompanied orthogonal imprint in four towns, selected as case studies. The previous periods, as well as the recent challenges, are also considered. In the conclusion, the uniqueness and identity of these towns is discussed, regarding the morphing and transformations of their urban patterns during the selected periods.

A catastrophic event, although often very painful, can provide a unique opportunity to experiment with new settlement models and improve the livability of a city or village. The reconstruction can, in fact, present a chance to reduce the effects of future disasters by improving the construction quality, avoiding hazardous locations,

while also improving spaces for emergency management from the community. This chapter examines cities that were based on orthogonal or grid reconstruction plans, characterized by streets intersecting at right angles to form blocks of regular size and spacing. The case studies allow for a comparative analysis and allow a technical evaluation of the experiences of the past from which the main settlement rules for future interventions can be extracted. The logic of the reconstruction has been linked to design criteria that reduce the vulnerability of the settlement.

This chapter considers the reconstruction operations that were carried out in Calabria following the earthquake of the late-eighteenth century. The author connects the physical and ideological role played by the orthogonal grid within the scope of this urban process to Foucault's concept of the device. Such a working hypothesis makes it possible to highlight the dual-domain in which lies political power, on one hand, and technical knowledge, on the other. This is a duplicity that is not resolved in the supremacy of either one domain or the other but, rather, in their huddle in a dialectical node: the political power that avails itself of the technical knowledge to reinforce itself and the technical knowledge that takes advantage of the political power to legitimise itself.

Might it be meaningful to think that an urban model such as the orthogonal grid layout, which has been a feature of cities for millennia, could still constitute a valid and practicable model today in the planning of contemporary cities? The authors believe that this reflection on the grid model might respond positively to earlier propositions, and these notes aim to supply a synthetic contribution to the book in that direction. In detail, in the first part of the chapter, an attempt is made to overcome a critical judgement as widespread as it is superficial that is traditionally applied to grid plan cities. The reflection is as follows: relationships between the physical form of the urban grid model and its evolutionary processes, its capacity of adhering to places and flexibility, its experimentations for a theory of special equality. In the second part of the chapter, setting out from the performance features of the model, the real conditions of the topicality of the grid plan are observed in contemporary experimentations of city planning.

This chapter develops the issue of establishing new transdisciplinary codes for the design of urban infrastructure of a grid city. In the networked and systemic vision of a grid city, it is necessary to find a direct connection between three levels of the infrastructural design process that today are separated: the urban design level, the grid design level, and the technical design level. The chapter explores innovative horizons to implement a new multilevel and integrated design code to shift the contemporary urban infrastructural project toward a much more complex system to generate multiple dimensions of urban quality: a system with which to promote the coexistence of different aspects: the infrastructural network design to achieve metabolic interactions between nature, resources, and communities; the technological-environmental interface design to enable multiple connections between spaces, buildings, and users; the grid design to activate physical and immaterial relationships between collective and private dimensions.

In the last decades, the concept of cultural landscape, in its physical and social dimension, has been stoked by the contribution of a new interpretation of "technology," understood as an innovative approach in the definition of new relationships between information, sustainability, and public space. It is a perspective that follows the changing cultural references of urban society, wondering which is the relationship between embodiment and location, between technological innovation and urban structure and how the digital and information revolution could influence and define the characteristics of urban aesthetics in the contemporary city. This chapter offers a key for reading these topics, starting from the analysis of the grid city's ontological space, its image between morphology and technology, between streets/buildings and infrastructure/landscapes, and finally, defining new ethical and dialogical interpretative approaches on sustainability and urban development, trying to find out the potentialities of the grid cities as complex public space systems.

Preface

This book starts with reflections on foundations in two nineteenth-century towns. These plans reflect the technical skills of the architects and engineers to handle the growing need for city expansion in accordance to local needs.

As far as the 1813 foundation of 'Borgo Murattiano' in Bari is concerned, the engineer Gimma has designed a development plan with a square mesh and a rectangular mesh configuration. The King Joachim Murat issued the building regulations that provided that the City Hall would purchase those lands belonging to the district's perimeter.

On the other hand, the 1859 foundation designed by the engineer Idelfonso Cerdà for the expansion of Barcelona stands as a successful theoretical project due to its sharing with his students and the patrons of the city. What Cerdà did, to his credit, was to incorporate the knowledge of the territory in the geometry of his urban grid.

It is possible to notice contemporary foundations similar to Bari and Barcelona in the major cities of Latin America. Here, traditional urban design dating from the Spanish colonization, which was codified in the sixteenth century, was influenced by new solutions tested in North America. As regards smaller centres, in many cases new real estate market favours the introduction of modern elements due to the innovation of tram transport; in other cases, solutions that generally favour the dialogue between nature and city have been proposed.

As far as Bari's case is concerned, many essays focus their attention on the evolution of Borgo Murattiano as something that combines tradition and innovation. Particular reference is made to the process of its early architectural transformation from the second half of the twentieth century: as a matter of fact, the most significant figure is represented by the continuity between compositional principles of classicism during the Murat's period and those of the new expressive styles.

There are other essays that deal with Borgo Murattiano in Bari. They discuss the possibility of building a system of knowledge concerning the architecture of the "Borgo" in order to provide inspiration for future steps in its design, transformation and promotion. Furthermore, they focus their attention on its urban and architectural structure by analysing the plurality of its architectural forms in the urban landscape.

The general conclusion of these studies is a scientific method that enables the analysis of its design's dynamics.

The second part of this book considers the uniqueness and cultural identity in five towns in Northern Serbia. They have adopted an urban grid in the eighteenth and nineteenth century. Now they have been engaged in its conservation and new interpretation in the twentieth century.

Another area of great interest concerns the reconstruction of cities affected by catastrophic events with the implementation of an orthogonal urban plan. Particular attention was given to the historic centres of Calabria, a Southern Italian region, which was hit by an earthquake in the late eighteenth century.

The third part of this book considers the theme of contemporary architecture. Many questions arise concerning the ubiquity and modernity of the orthogonal grid that for millennia has characterized cities, and today still stands as a valid and profitable way of planning contemporary cities. This position is supported by reflections on the relationship between physical structure of the model and its evolution. The latter is meant as the capacity of adapting to the diversity of urban contexts in a flexible way. Furthermore, this idea is supported by reflections on the main features that have been observed in several modern city planning experiences.

The key theme of the project is the research on new transdisciplinary codes for urban infrastructure design in grid cities. Innovative steps have been taken to implement a new integrated multi-layer architecture which is able to guide contemporary urban design through a much more complex system. As a result, multiple dimensions of urban quality are generated.

Another significant subject is represented by the concept of cultural landscape, which extends the idea of urban public space both physically and socially. The aim of the project is to investigate grid cities' potential, as well as find common ground for seeking to create synergy between ethical dimension and technological innovation.

Finally, it considers the theme of the so-called "border places", which are urban spaces characterised in the same time by division and unification. They are nearly impossible to define due to their inner nature. In this part, the authors examine how future spatial organization will be structured in the contemporary scene, whether this organization is sometimes global or fragmented, considering the increase in the building of walls.

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Chapter 11
Cities With Grid Layout:
Ubiquitousness and Flexibility of an Urban Model

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ABSTRACT

Might it be meaningful to think that an urban model such as the orthogonal grid layout, which has been a feature of cities for millennia, could still constitute a valid and practicable model today in the planning of contemporary cities? The authors believe that this reflection on the grid model might respond positively to earlier propositions, and these notes aim to supply a synthetic contribution to the book in that direction. In detail, in the first part of the chapter, an attempt is made to overcome a critical judgement as widespread as it is superficial that is traditionally applied to grid plan cities. The reflection is as follows: relationships between the physical form of the urban grid model and its evolutionary processes, its capacity of adhering to places and flexibility, its experimentations for a theory of special equality. In the second part of the chapter, setting out from the performance features of the model, the real conditions of the topicality of the grid plan are observed in contemporary experimentations of city planning.

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1. INTRODUCTION

Might it be meaningful to think that an urban model such as the orthogonal grid layout, which has been a feature of cities for millennia, beginning with Mohenjo-daro (3300–1300 BC) in the Indus Valley civilization (today Pakistan) or with the first settlements of workers and supervisors of Kahun around the great pyramid of Illahun in Egypt (3.000 BC), could still constitute a valid and practicable model today in the planning of contemporary cities? Might we moreover believe that, in the light of its ubiquitousness in the long history of human settlements, it may still offer efficient performance characteristics when faced with the challenges of contemporaneity in the environmental, social, technological and aesthetic fields?

The authors believe that this reflection on the grid model might respond positively to earlier propositions, and these notes aim to supply a synthetic contribution to the book in that direction. In the afterword of the Italian edition (1993) of his perhaps best-known work, *Planning in the Public Domain: From Knowledge to Action* (1987) John Friedmann writes: "We are living in truly unusual and difficult times. The Euclidean way of thinking, with its straight lines and its angles measured with precision, is unlikely to prove adequate to the tasks facing us. What we need is a non-Euclidean, non-linear type of planning". This is the response made by Friedmann to one of the main criticisms of his book which "speaks of planning abstractly because contributions to urban planning, especially physical and urbanistic planning, are not discussed". Kevin Lynch too in his 1984 *A Theory of Good City Form*, translated in Italy in 1990, in the chapter on the *Three Normative Theories of City Form,* sees many examples of cities with a chequered plan ascribable to the first: the "cosmic or cosmogonic theory" of city form which refers – like the other two – to a metaphor which in Lynch's view better clarifies what a city is and how it functions. In the case of the "cosmic" urban model, the form of any settlement of a permanent nature proposes a magical copy of the divine universe which results in a use of the urban place and its crystalline form which reinforces and symbolizes power, as shown by the long history of western civilization and the vicissitudes of its contemporary cities. So in this urban model a connection is created between divinities, humans, rites and city plans. If it is devised by shamans, absolute monarchs, military hierarchies, this model cannot but be characterised as rigid, abstract and therefore unfit to adapt to the multiformity of the natural places and territorial contexts on which it is sometimes brutally superimposed. Moreover, its schematism and abstractness would show a desire to project a cosmic order on earth, politically legitimizing those who devised, designed and created it.

If these ideas arise from certain real elements, it is not hard to call them into question because it is believed that they are of a theoretical nature and not wholly justified when subjected to scrutiny. In fact it will be argued that the grid may be

flexible and under certain conditions alter form, overcome schematism and rigidity, by adapting to the topography of places. Again, it is possible to demonstrate that the chequered layout is an urban model which if in some cases is associated with direct control of the space and the community living there (one thinks of military encampments or colonial cities), in many other cases it is identified with planning intentions in which space and law are connected. It is well known that in a passage in his *Politics* (book II) Aristotle indicates Hippodamus of Miletus as the one who contrived, in the legendary grid plan for his city (Figure 1), an ordered subdivision of urban space into blocks, thus overcoming the situation produced by history and by the organicism of the first *polis* to introduce an egalitarian spatial order that allowed all citizens equal conditions of settlement in all areas of the city. On this subject Luigi Mazza maintains (2013) that we are looking at a model in which "a technique of zoning is a model of constitutional order", a scheme of the spatial representation of *isonomia*; the citizens' equality before the law. Space and law are linked here because the grid does not recognise arbitrariness of choices of spatial conformation but acknowledges rationality as a value. Once again, Mazza sees the design of Idelfonso Cerdà's plan of Barcelona as founded on a *Theory of spatial equality*.

If it is true that the town planning schemes of chequered layout cities, set out on the interweave of orthogonal street axes, are formed within the innumerable variants of the relationship which exists, as Enrico Guidoni (1978) has taught us, between *street as void* and *block as fullness*, the great spreading of this urban model in every age and at every latitude shows a feature that is probably distant from the stigmatization of abstract urban model, demonstrating on the contrary a ductility able to accept the very high combinatorial number of conforming solutions of space that the street/block relationship has permitted over three millennia of urban evolution. Hierarchizing the street axes that constitute the road network in an orthogonal manner and working on the innumerable typological solutions of the blocks (terraced houses, courtyard houses, single block buildings, etc.), in the 18th and 19th centuries a rich multiplicity of urban expansion experiences outside the city walls took place, which evince undeniable planning experimentation around the grid model. And during the long experience of the Modern Movement when the grid layout made "the leap of scale" from the dimension of the block as fullness to a more or less extended urban network within which to experiment with the new settlement principles of the free plan and the paratactic composition of the city, Le Corbusier, Van Esteren and Costa reinterpreted the grid model, opening the way to contemporary experimentation that is still going on.

On this subject, an enlightening thesis is maintained by Stanford Anderson in his contribution to the 17th Triennial of Milan in 1986, directed that year by Luigi Mazza, a defined thesis of the "semi-autonomy of the physical form of the city". Anderson

responds to the cultural provocation thrown down by Mazza to the authors taking part in the International Participation section that he was directing, a provocation according to which the physical form and social processes are not determined univocally but are wholly *contingent*. But looking carefully at the functioning of contemporary cities against the background of their more or less long and more or less complex history, the urban forms through the descriptions of certain emblematic cases of cities with grid layout (Manhattan, New York and Savannah in Georgia) have constituted from time to time a bond or a potentiality for urban transformations that have responded to the needs of the communities living there. "These inherited conditions of support and bond influence new end purposes and meanings and preserve, at least in part, the original conception". So, Anderson maintains, the relationship between city forms and social processes is not totally random; there are possible relations between the two entities. The theory is also backed up by the reference made to the urbanistic events of the public residential quarter of Puitt-Igoe in St. Louis (an actual urban syndrome), which in a short time passed, after the second world war, from the condition of innovative social housing model to a district so depressed and socially marginalized as to call for the radical solution of demolition. If physical forms and social processes are really wholly random and mutually autonomous, what need would there have been to demolish that quarter whose spatial subdivisions – ingenuously inspired by communitarianism – in fact amplified phenomena of insecurity and deterioration already in progress in the quarter? We may then conclude that in a wholly negative key the affair demonstrates that more than complete autonomy of physical form and social processes, it is more prudent to speak of "semi-autonomy of the physical form" of the city. All this will be useful in the need to look at the urban phenomenon of grid plan cities, approaching a complex phenomenon that cannot be investigated with ideological or reductionist visions.

Another cultural position that claims greater attention to the complexity and pluralism of the experience of chequered cities plan is that of Manuel de Solà-Morales (1978) who, though granting Leonardo Benevolo and Francoise Choay the merit of having investigated the dialectic of the tensions latent in the 19th century city between "reformer progressives" and "culturist utopians", evinces a certain neglect in pointing out the specific theoretical content of the multiple contributions which in that century the chequered plans of urban expansion put forward, especially in the Mediterranean area (Trieste, Turin, Barcelona, Bari, etc.).

In the first part of the article an attempt will be made to overcome a critical judgement as widespread as it is superficial which is traditionally applied to grid plan cities, a judgement which, though it has certain legitimate foundations appears at the least not very reflective, therefore of little use in constructing a process of assessment of the usability today of this model of spatial order. The reflection is

as follows: *relationships between the physical form of the urban grid model and its evolutionary processes, its capacity of adhering to places and flexibility, its experimentations for a theory of special equality.* Whereas in the second part of the article, setting out from the performance features of the model, the real conditions of topicality of the grid plan are observed in contemporary experimentations of city planning.

2. THE GRID MODEL IN HISTORY

2.1 Unprecedented Relationships Between Physical Form of the Model and Evolutionary Processes

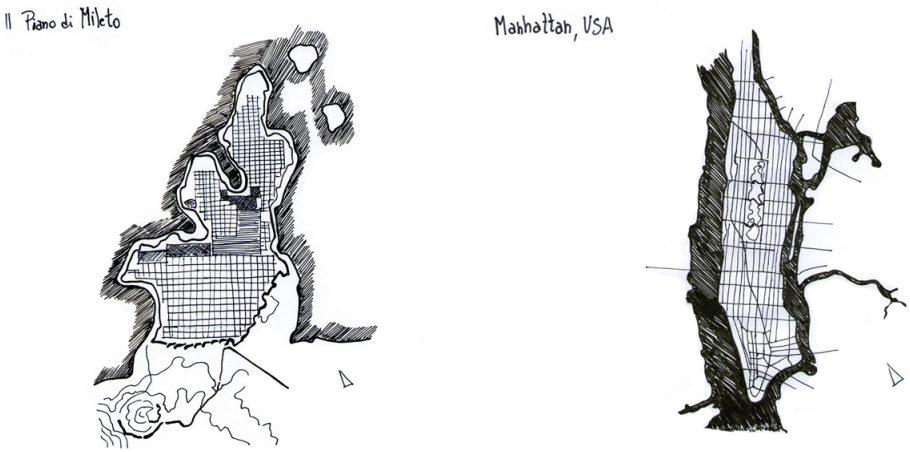
The power of a model ubiquitous in time and space, which stretches from ancient civilizations and passes by way of Greek and Roman settlements to mediaeval *bastides*, renaissance cities with their theories of the ideal city, right down to plans for contemporary cities, with a new power and a testimony of the model's flexibility. We may return to the thesis championed by Anderson who finds in certain grid plan cities unprecedented relationships between physical form and processes. The analysis sets out from the case of Savannah, in Georgia (United States), which shows with evidence how the grid physical form (without predetermined boundaries) facilitates more than other forms the unfolding of determined processes of social interrelation in space. The project began with the founding of a colony (1733-1856) of citizens-farmers in an egalitarian position which is reflected in the plans of the city and the region of Savannah. A complex plan, rendered modular by the grid, with several nuclei (known as *Pavilions*) with a high degree of self-sufficiency and a high level of diversification in every scale. Anderson shows how much this complexity has adapted over time to the systematic physical and social transformations, which have not changed the model but rather have demonstrated its capacity to absorb changes as time passes. A complex but comprehensible physical form, characterised by systematic seriality.

A further example is the network of rectangular blocks of the 1811 Commissioner's Plan of Manhattan (Figure 1): great simplicity – at the limit of schematism – of the urban network but at the same time differentiation among the streets and the segments of the blocks, which permitted survival of the human dimension, integrated with the more commercial one of the great city. In fact the Plan envisaged the imposition on the elongated island of Manhattan of an orthogonal network of great dimensions; a gigantic grid of perpendicular and rectilinear streets: 12 avenues which run the whole length of the island from north to south and 155 streets, at right angles to the former, which run from one side to the other of the two rivers. A totalizing matrix

which, having filled every space of the grid, would allow complete control over the future activities of Manhattan island, giving rise to no less than 2028 blocks, and would make the sale and purchase of land faster and easier, another significant aspect of the model. Obviously the network is hierarchized inasmuch as the lower number of streets running N-S imply a section suitable for great flows of vehicle traffic; whereas a greater street section is overlooked by the short sides of the blocks, with a dense aggregation of buildings, almost all residential, on the long side. In the first place "the street layout of the grid is the only open element that exists right from the start as a space of relationship" and generates the whole urban conformation thereof; followed by the great project of Central Park in the second half of the 19th century by the great landscape architect Frederick Law Olmsted. A strict rectangle taking the place of no less than 150 blocks, but with an internal alteration of three typologies of landscape in accordance with an internal gradient of naturalness: woodland, meadowland, parkland.

But it is the hierarchization of the street network that gives the different character of the urban frontages, so that the public space of the city is structured along the 12 avenues: the towers housing the headquarters of great multinationals, institutions, museums, theatres, office buildings; while along the streets, shorter and of more modest section, the strong thrust of service industry expansion is resisted by a more domestic urban dimension linked to the residential façades and to traffic less frenetic than that of the great N-S thoroughfares.

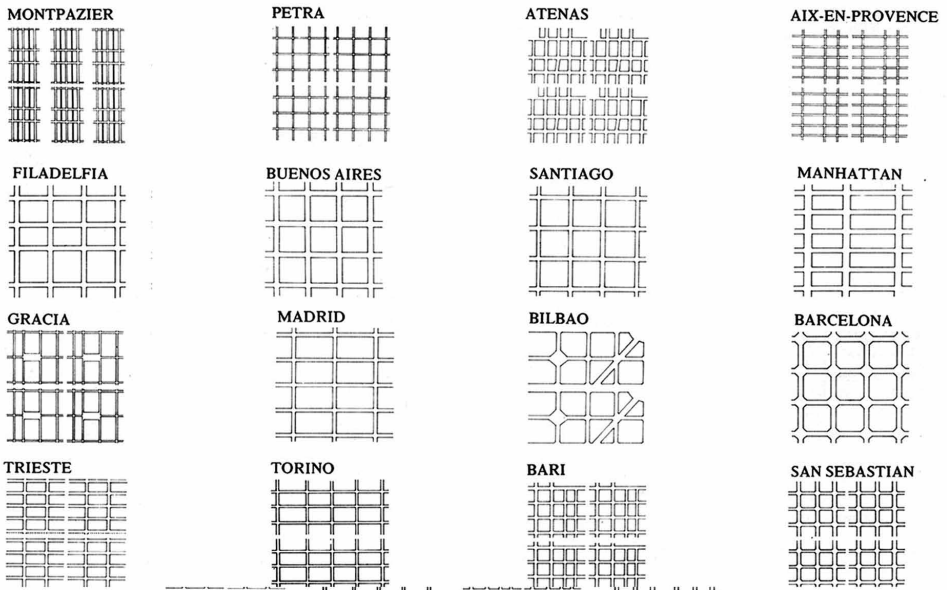
Figure 1. Plan of grid cities: Miletus and Manhattan
Source: Designed by Giovanna Mangialardi.



In a work of the late '70s Manuel de Solà-Morales (1978) went even farther with what Anderson describes in the case study of Manhattan in New York, comparing dozens of expansion plans for European and South American cities in the 19th century. The Catalan scholar shows us how through these plans the theorization of traffic problems and the techniques for subdividing urban land are developed. A methodology that would be normalized in many grid plan cities which have, in numerous Mediterranean, Spanish, Italian and French experiences, a heritage of reflections on the modern city, setting out from the area to be urbanised and from the type as basic element for the block. From the interaction between these, the typological order and infrastructural organization of the cities will derive.

Moreover in "Why 22 x 22?" Solà-Morales dialogues long-distance with Leòn Krier who, in the same number of *Lotus International (Figure 2)*, had published a provocative revision of the blocks of the Ensanche of Barcelona, subdividing the internal space of Idefonso Cerdà's *manzana* in smaller sized modules done as an exercise by his Design students. Further proof of the vitality of a model which precisely by virtue of its degree of open meta-design system still lends itself to undergo mutations and new combinatory forms.

Figure 2. Comparison of grid cities
Source: The Urban Block, Manuel de Solà-Morales, Lotus 19, 1978.



Moreover the option of the chequered plan model in 18th and 19th century expansion was not exclusive and sometimes also allowed experimentation involving "hybridization" with the radial urban model, as seen in Pierre L'Enfant's Plan for Washington (1791) and Daniel Burnham's for Chicago (1910), to mention only two *grand récits* of modern city planning. In these experiences the ascendency of great "baroque" axialities were crossed with chequered layouts in a preoccupation about achieving smooth traffic flow without giving up the settings of great architectonic backdrops. Quaroni in his 1968 Plan of Bari, following an analogous process of hybridization, set out over the city's historical radial system of roads which, coming from the agricultural hinterland, converged in the loading areas of the port, a series of N-S and E-W orthogonal axialities that prolong on a territorial scale, in his *city-region*, the geometrical axes of the chequered layout of Borgo Murattiano as a cultural matrix superimposed on the original natural one.

2.2 Adaptation to Places and Flexibility of a Spatial Model

The case of the plan of the city of Priene shows how a Hellenic city with a Hippodamian type of layout can be moulded on rough topography by keeping the longitudinal streets transversal to the slope of the hills as substructures that serve as containment to the areas of the residential blocks, while the smaller transversal streets that cross the larger are often terraced to overcome the difference in height. What the grid of Priene teaches, set on sloping terrain, was expressly exploited by Agostino Renna in designing the city plan of the new town of Monteruscello in the Province of Bari in the 80s, to accommodate the population evacuated from the historic quarters of the ancient city of Pozzuoli in the Phlegraean Fields, afflicted by problems of bradyseismic phenomena and the serious consequences thereof.

A scarcely in-depth knowledge of the actual techniques and construction methods of a Roman Centuriation shows how fallacious and generic is the accusation that regular grid plans are abstract and schematic. In the territory north-east of Padua is one of Europe's most extensive areas of Roman Centuriation, there already being the city of Patavium (present day Padua). On setting out the Cardi and Decumani, the land-surveyors did not make the *umbilicus agri* coincide with the *umbilicus urbis*: the latter was moved out of town and positioned in a form all the more barycentric with regard to the great area to be subdivided into centuries for cultivation. But even more relevant is the fact that the Decumani were inclined with respect to the ideal east-west direction by about 14.5 degrees in such a way as to follow the lines of maximum slope of the terrain and thus favour the draining of irrigation water towards the lagoon, ensuring the duration and efficiency of the works carried out. Roman pragmatism is comparable only to the ability to structure in sub-modules a century whose side measures 700 metres: the subdivision of the land, convex shaping of the

fields for better cultivation, creation of an integrated system of roads between farms, and canals for draining water, always tree-lined (Zancanella & Vedovato, 1981).

The construction of Milton Keynes may instead be considered as a contemporary grid plan urban model, adhering to the forms of the territory. Designed in 1967, three years after the other high density new town of Runcorn, Milton Keynes was built in a barycentric position between London and Birmingham and between Oxford and Cambridge, for over 200.000 inhabitants on an area of 8.900 hectares. The city plan is a sort of new Centuriation, a network whose side measures 1 kilometre and is set, as may be seen in perhaps one of the best known town-planning images of the post-war period, over the topography of the places, taking into account the reliefs, the woods, the waterways and pre-existent features. "A characteristic of the plan is the contrast between the regular order of the street grid and the interweave of the different designs produced by environmental features and by the distribution of activities". The plan aims at diversities: typological for residence, hierarchy of use of the mobility networks (road traffic, rail, pedestrian) and for the altimetry of the terrain, now hilly, now flat (Gaeta, 2013).

2.3 Justice and Rationality in Urban Grid Plans

For centuries the grid scheme has been a practical and simple compositional module for military encampments or the founding of colonial cities. An example of the latter is given in the Laws of the Indies issued by Philip II of Spain in the 16th century. Places of political and military control of entire communities, rigidly planned by means of building rules and regulations. But we have already mentioned Aristotle's reference to Hippodamus's plan for Miletus and his reference to isonomy. In the same way Luigi Mazza (1993) introduces his careful description of the experience of Idelfonso Cerdà for the Barcelona expansion plans in the second half of the 19th century, speaking of a precise political programme: "the grid, as we shall see, has various technical justifications, but it is above all a spatial model functional to a precise political programme aimed at several results. The main one is that of offering the least fortunate social groups a healthy and dignified living environment that is also less costly, inasmuch as the expansion is designed to reduce land speculation…". But the fascinating elements of Cerdà's great experience are the "virtuous" circularity between justice and rationality, that union which Mazza emphasises between ethical-political motives and the search for technical efficiency. Paraphrasing Alexander (1986) we might say that the Cerdà Plan is an example created at a time of the paradigm of *technical efficiency* and the paradigm of *social justice*, among the three that he identifies as fundamental to a history of modern town-planning thought. At the same time a territorial grid was used in the *Land Ordinance* desired by T. Jefferson in 1785 which permitted measurement and colonisation of the entire

territory of the newly founded United States of America and in which a form of democracy was represented, born in the great American "frontier" territories on the ideals of freedom, property and conquest (Secchi, 2005).

3. PERFORMANCE FEATURES OF THE URBAN GRID MODEL

It is therefore reductive to interpret the urban form as a static town-planning transcription of an ideological, political or economic design. It derives instead from a concatenation of events and the interaction of multiple systems which cannot be viewed individually but which make of the city and its spatial conformation a complex and dynamic system, also subject to external perturbations (Innes & Booher, 2010).

Study of the complexity of urban space therefore calls for an approach that includes various dimensions of model analysis, not only physical but also social, political, economic and environmental. In fact, the city is defined in literature as a complex system (Portugali et al, 2012; Portugali, 2016), which is to say a system formed by parts between which there are reciprocal relationships active that are not directly knowable, and due to its dynamicity evolve in an ongoing way towards states different from the previous one (Batty, 2016). So, to describe the grid model as rigid and/or abstract and difficult to adapt to natural contexts with complex orographies, or to describe the schematism as projection of cosmic order (Friedman, 1987) associated with authoritarian forms of government, only renders trite the complexity of the urban dynamic and of the process of its structure formation.

The structure of the city may instead be seen as the result of the protracted action in time of multiple factors which were often capable of positively exploiting, preserving and triggering virtuous processes linked to a recognizable plan. This is the case with the urban grid model found in numerous successful cases described in this contribution, but this does not exclude other classic models studied, such as the organic, radial or linear model (Vincenti, 2010).

Although one speaks of urban complexity, according to Franco et al. (1996) and Sala and Cappellato (2004), historical analysis shows how "the city tends to behave in the same way in response to analogous urgings towards adaptation and structural economic character, growing through the progressive assembly of units of settlement which, from the viewpoint of spatial organisation, appear as in copies of the global organism". So, study of examples of the grid model identified in this analysis and the recurring performance features helps to define the outlines and describe certain salient aspects of cases that have had success over the years or have been reinvented, justifying their corroboratory value.

Inasmuch as it is a recurrent scheme, the grid model has been identified with many ideological values such as the fair distribution of value, as described above, or the symmetry of urban design, but it takes on stratified meanings in relation to the epoch of creation or to the geographical contexts in which the model is inserted.

This is demonstrated by multiple examples, some already cited. Over and above the ancient references to Hippodamus of Miletus, with the design of the city of Miletus in 479 BC, considered among the first examples of a city planned in accordance with a general planimetry employing a regular and homogeneous orthogonal grid, or centuriation of the territory for creation of the castrum, the military encampment of the ancient Romans, the chequered plan is found in Italy in the historic centres of Aosta, Turin etc., and in many 19th century expansions in Europe, such as Borgo Murattiano in Bari and the 1967 extension of Barcelona. But also in the town-planning schemes of the main American cities such as Washington in 1791, New York in 1811 and Chicago in 1909, the grid plan was chosen to optimise spatial distribution of the blocks and maximise the use and yield of the land. In the 20th century the use of the grid plan found further expression in the foundation of the capitals of the African colonies Kinshasa, Niamey and Lusaka; and then Brasilia in South America and Chandigarh in India (Mittner, 2008). The most recent cases are influenced by the idea that the city be functionally correlatable to a machine, a utopian vision that began to take root in those years and also derived from an increasingly pervasive integration of technological innovations. In this vision the city is imagined as a system comprising distinct and autonomous parts based on a dense system of links that guarantee the overall functioning and coordination of activities and various functions.

The grid urban structure therefore increasingly assumes a role of connection and intensification of relationships in which to ensure the movement of people and goods through a regular infrastructural and technological hierarchy, jointly with a rational use of space, becoming a symbol of democratic access to resources and guaranteeing the best conditions of quality of life and individual freedom. This model persists today and is found in the planning of newly founded cities, with great technological innovations, more commonly known as smart cities.

But what are the features that guarantee the topicality and flexibility of the model demonstrated by its ubiquity in history and in space?

The persistence of the model's performance, aesthetic, social and environmental features, efficacious in the face of the challenges of contemporaneity, is certainly a great strongpoint. The interconnected regular grid urban tissue has represented a substantial element for the city, setting out from the orthogonal network as spatial device for the foundation and subsequent expansion thereof.

The recognisability, or better, the mental image of space as it is methodologically defined by Kevin Lynch (Lynch, 1960), is an interesting element to analyse in the urban grid plan model. In accordance with a perceptive approach, both the city understood in experiential terms and terms of urban enjoyment due to the distribution and subdivision of a mixture of functions, and the city understood in terms of perspective views and physical structure, due in some cases to the hierarchy of the streets and to the permeability of the structure forming the blocks, or to the perspective backdrops (Unwin, 1909), are recurring elements in urban models of a recognisable regular grid and represent an unequivocal strongpoint thereof. In support of this we underscore how in many chequered plan cities the street prospect is closed by elements of historical artistic value (for example the Teatro Petruzzelli as perspective view of Via Nicolò Putignani in Borgo Murattiano of Bari, nineteenth century expansion), adding a monumental and scenic character to the plan and enriching the urban space with broader meanings.

Flexibility is another feature of the grid plan, only apparently rigid, and is founded on the relation between block and urban fabric, becoming inter-scalar and modular, using hierarchical relationships or different modules which cover the block but maintain its perceptual and structural homogeneity. There are in fact numerous strongpoints that have found applications regarding dimensional variability in relation to population and density or to the complementary relationship with practicability. Flexibility is also understood from the functional viewpoint, oriented towards the mixing of zones that are residential, services or functions of urban value, thanks to the model's capacity for the reiteration of homogeneous zones but also for free configuration of the block within the established boundaries (Reale, 2012). The grid plan was also chosen for the reconstruction of Lisbon, after the destructive earthquake of 1755, as a model of resilience, of flexibility for the orography of the territory and of enlightened innovation. Known as the Pombalino Plan, since it originated with the Marquis of Pombal who, with the engineer Manuel da Maia, handled the reconstruction of Lisbon, it was in fact an urbanistic modernisation of the city which followed a grid plan created by a network of longitudinal and transversal streets crossing at right angles, still visible today though incorporated into the city's urban expansion (Rossa, 2010).

Moreover, it should not be neglected that the city, and consequently its physical and management structure, remains nonetheless a social organism characterised by specific and interdependent functions which at this point cannot do without connection infrastructures capable of supporting a high degree of connectivity. This last factor influences a new reinterpretation of the model in a modern key, and more precisely in a technological key, also linked to infrastructures and connectivity. So another factor that emerges from the description of the grid model is its strategic relationship with technological requisites and environmental sustainability (Williams et al., 2010).

For example the grid structure, together with the urban morpho-typology and other correlated factors, influences the meteorological variables such as wind speed and cloudiness, which produce effects on the intensity of the heat island phenomenon, on cooling and on sustainability, since they modify respectively atmospheric turbulence and solar radiation (Akbari, Bell et al., 2008).

Therefore the efficiency of the method as spatial layout is demonstrated by the stabilisation in time of a population in a determined place. This spatial form belongs to multiple cultures and its plasticity has permitted adaptation of the urban fabric to numerous topographies, sometimes losing the feature of homogeneity but preserving the function of interconnection and structuring of an open system (Mittner, 2008). In the next section we shall look at some of the best-known examples of grid models that demonstrate the usability, innovativeness and topicality of the model.

4. USABILITY AND TOPICALITY OF THE MODEL: SOME CASES OF EXCELLENCE

Examples of grid plan cities all over the world supply concrete cases of formal, functional, performative and technical features of the model, as listed above, and of its flexibility and spatial and temporal ubiquity. On this subject we shall describe some cases whose characteristics and relationships with the model and its benefits have been made clear. In the selection, not exhaustive but certainly varied, we have identified: the city of Chandigarh, North India, a new town designed by Le Corbusier and created in the 1950s to a regular and defined scheme; the case of the Barcelona expansion plan and its reinterpretation in a modern key with the *Superilles* Plan; cases of ephemeral town-planning on a regular grid; and the case of Masdar, a smart city under construction in the Arab Emirates, extremely hi-tech, which follows the regular scheme in a key of environmental and energy sustainability.

The first authoritative example of a "flexible" grid model is therefore Chandigarh (Figure 3), a singular experience of founding a new town in India, designed by Le Corbusier in 1951. A plains city at the foot of the Sivalik mountain chain, set between two waterways, its rectangular orthogonal network is organised on great urban islands (about 1330 m x 800 m) called Sectors. The plan is organised around an east-west road, which supplies access to the main public buildings, and two north-south roads of greater section, connected with regionally practicable thoroughfares, while the Capitol is positioned at an extremity, close to the mountains. Parallel to the road traffic grid, within the urban islands, Le Corbusier had envisaged a network of pedestrian precincts with areas of parkland, subsequently created with discontinuity. An extraordinary project, implemented and functioning and positively recognised by the citizens, it is an example of flexibility as well as the emblem of a strong

relationship with the nature within which the city is inserted. In the view of A. Clementi (2016) this city may be seen today as an operation of Urban Landscaping dictated precisely by the climatic grid, as well as a preview of sustainability. The complexity of the planning model, imposed and extraneous to local tradition, has not only forged new identities but has also given rise to numerous sustainable architectonic, environmental and landscaping solutions: green infrastructures both for embellishing the city and for improving environmental performances and reducing atmospheric and acoustic pollution. With the additional role of matrix of urban development, as an architectonic device able to confer a unitary image in line with Le Corbusier's precepts of "*Cité Radieuse*".

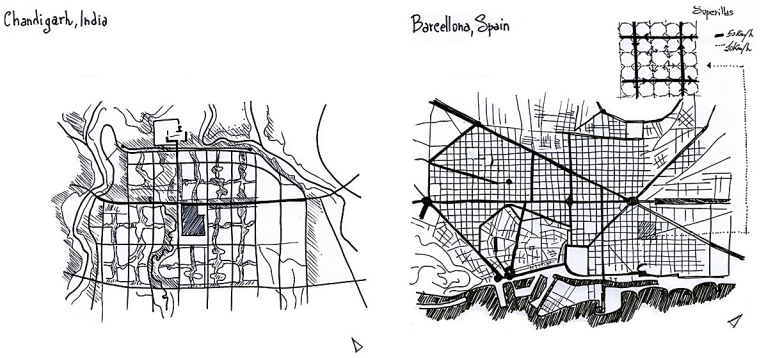
In detail, Le Corbusier's Plan for Chandigarh envisaged *Sectors* to be set out on an orthogonal network of streets, imagined as quite other than rigid. In confirmation of this, during a day of study on Chandigarh at which some of the most important contemporary Indian scholars and architects took part, B.V. Doshi declared: "I don't believe there's a need to demolish the myth that Le Corbusier's plan was rigid. Le Corbusier did not want it to be so. He was a designer of systems. He worked on the idea of interaction, initiative and choice of inhabitants, control on a large scale and freedom on the small scale. Thinking of this one brings to mind Jai Singh, the founder of Jaipur. Le Corbusier's plan drew up a flexible structure". The flexible structure then is identifiable for example in the importance given to the linear parks that occupy a considerable area in relation to the overall urbanised area of 114 square kilometres, or in the envisaging of a non-building zone about 300 metres wide in the lee of the valley dug out by the seasonal river Sukhna Choe, earmarked for the inhabitants' leisure time. There was also the importance attributed by Le Corbursier to various functions such as integration into the orthogonal network of the commercial streets of the districts. Everything is organised. By definition of the orthogonal street infrastructures and by the presence of green areas, designed and diversified to supply citizens with recognisability and orientation in space. The result of this detailed study was an abacus of types of spaces and relationships between streets and buildings, contained in the *Plan d'Arborisation* which still today gives the necessary instructions regarding choice of trees, on the basis of direction, of sunlight on the streets, of density, height and colour. Moreover the plan of Chandigarh is an excellent example of the inter-scalar and strong relationship between town plan and territory, which although it is a grid identifies powerful relations of continuity. Le Corbusier himself (1972) in "Way of thinking of town-planning" thus describes the transition: "Through town-planning and architecture, the environment and landscape may enter the city, or build a determining figurative and spiritual element of the city". Moreover, the plan of the city is focussed above all on the conforming relationship of emptiness on fullness and on the relation between them, more than on definition of the individual buildings. So he pays attention to the city grid, unvarying in time, coupling the urban scale with the territorial.

The force of temporal ubiquity and absolute flexibility is represented by Barcelona, already mentioned, where its urban model representative of the 19th century is reprised here as an example of topicality and absolute flexibility of a model reinterpreted in a contemporary key with the very recent Superilles Programme of 2016 (Figure 3). Ildefonso Cerdà's expansion plan in the second half of the 19th century responded to the needs of a growing Barcelona, putting forward a precise plan of orthogonal grid based on a square block of 113 metres with the corner smoothed to facilitate visibility and road traffic and about 20 metres of street section subdivided into spaces for pedestrians and others for carriages. The grid is correlated to a high density brick-faced building along the block, whose multi-storey edifice in line occupied the block in different forms and percentages. The rest of the block was organised as a garden. In function of the distribution of the buildings in the block and the combination of the blocks, spaces for common use were formed. The orthogonal grid of streets and blocks persisted over the years though the block was gradually rendered more dense by the great demand for settlements, increasing both the limit of occupation and, in consequence, increasingly closing the internal atrium, and also the maximum height by exceeding the initially envisaged limit (Gaeta et al., 2013). The plurality of aggregative solutions and building types in the Manzana with differentiated densities, continues today to show the topicality of the urban scheme of the Barcelona expansion, described in its evolution to date, thanks to an ability to reinvent itself and hit on the need for innovation in a model acknowledged as one of the most exemplary among regular grids.

In detail, the new plan was much desired by the Ajuntamento de Barcelona which set aside 10 million for the Superilles Programme, in which the first Superilla has already been inaugurated in the Poblenou quarter. The rethinking of the idea of city, with the pedestrian as leading figure, envisages a re-modulation of Cerdà's *Ensanche* in new macro-blocks to configure new spaces of cohabitation in accordance with an organisational model of the urban fabric designed first and foremost for residents. The project is driven by the administration's wish to limit vehicle traffic, which at the moment occupies 60% of public space, and thus reduce carbon dioxide emissions by 30%, increasing liveability and the quality of city life.

The idea consists of seeing the 19th century grid as an "innovative urban device" which permits organisation of traffic flows in the *Ensanches,* with view to increasing the greater part of public and private traffic flow, by dedicating the included spaces to the (almost) exclusive use of residents, pedestrians and cyclists, with an approach that is shared and transparent, as well as being integrated with the local schools of architecture. In detail, it is planned that public and heavy vehicle traffic is diverted to the outside in selected nine-block areas, so that it runs along perimeter roads of the macro-block. By contrast, inside the Superilla cars are obliged to maintain a maximum speed of 10 km/h on a single lane and pedestrian controlled traffic zones,

Figure 3. Plan of grid cities: Chandigarh and Barcelona
Source: Designed by Giovanna Mangialardi.



preventing dangers for pedestrians, as well as ensuring the possibility of reinventing public spaces. This means, for instance, new designs and pavings of public spaces, slow lanes, or the removal of car parks in crossroads. As a consequence, integration of green spaces and areas devoted to community use will be encouraged into important parts of the city.

The grid plan is suitable for many other cases, such as megacities, or the preservation of small and medium-sized European cities. Rahul Mehrotra e Felip Vera, together with the Harvard academic community, describe the case of the Kumbh Mela (Figure 4) at the 15th International Architecture Exhibition at the Venice Biennale. Kumbh Mela is an "ephemeral" and "temporary" city that was built on an orthogonal grid plan to welcome the Hindu pilgrimage in a city in continuous movement. The Hindu pilgrimage is celebrated every three years in different contexts. The "Kinetic City" was built in two weeks up to three months before the event along the banks of the river, on an area that is covered with water. It enabled to effectively host seven million people who took part in the religious gathering. It was then destroyed by the monsoon. Therefore, the grid plan is chosen due to its flexibility and regularity, as well as functional, space, time and organizational reasons. As a matter of fact, the plan enables to facilitate the management and logistics of the nomadic city that can be built, demolished and reconstructed very quickly. The materials used are lightweight, local and easy to assemble. They are mechanically constructed in order to ensure quick assembly and disassembly. The materials are designed for partial reuse and recycling at the end of the disassembly process for the next event, or alternatively, they can be used by local economies. They can as well be partially left abandoned and then absorbed by the river, which erases every trace of the grid, so that after the monsoon season the area is suitable for cultivation for the next 12 years. Hence, the case of the Kumbh Mela highlights another feature of the grid plan that shows

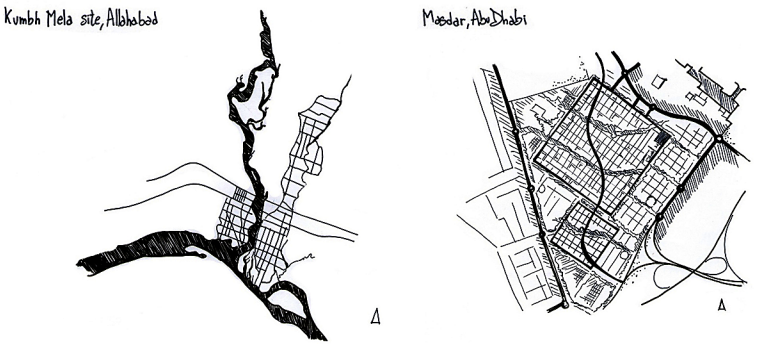
a new trend linked to the construction of new megalopolis or emergency shelters with different methods, materials and technologies. Ephemeral urbanism through the implementation of the grid plan stands as an opportunity to test new forms of urban planning and management that take into account the growing acceleration of metropolitan metabolism, as well as temporary and cultural forms of identity that they realise. In short, it seems that this urban model is implemented again in the third millennium.

This plan was already used in the ephemeral settlements of Egyptian workers during the construction of the Great Pyramids of Giza, or in the Roman *Castra* for the legions camp during military campaigns. The same Roman centurions will find them on a territorial scale (this time) on their return home, when in a period of peace the cultivable parcels of Roman Centuriation (Centuratio) in the Padania area were assigned to them. To sum things up, it is a millennial constructive custom.

The Italian architect Carlo Ratti also mentions this urban grid plan in relation to the integration of new technologies into the traditional geometric scheme; according to his future vision, the plan is to be adapted to lightweight technologies, sensor technology and networks (so-called "smart dust"). If the urban model is noninvasively applied to the existing structure, it can be considered as added value that enables to optimise resource and improve traffic flow and services. Given the population growth limits and the existence of many empty dwellings, in line with what Ratti has repeatedly stated, the grid plan focuses its attention more on redevelopment of existing buildings rather than on new construction.

As far as smart cities are concerned, in line with the idea of spatial and temporal ubiquity, the grid plan is still an example and a model for the foundation of new planned cities. This is the case of Masdar (Figure 4), the satellite town of the United Arab Emirates, which is located a few miles from Abu Dhabi. Masdar was designed for about 50,000 people in 2006 by Foster and Partner; today its construction is currently in progress. Strict principles regarding environmental and energy sustainability are being applied for its construction. Consequently, Masdar will achieve energy self-sufficiency, as well as be a symbol of innovation in many aspects. Principles of sustainability have shaped and influenced the urban project. As a matter of fact, a grid plan was implemented to better meet the needs of the project, as well as orient the design choices concerning the organization of the buildings, functional alternatives and the type of energy production. The square shaped city plan is based on a platform for urban infrastructures. It is surrounded by a wall, which prevents access to any means of transport outside the city. The regular urban layout is oriented along the North-East and South-West axes. Thus, natural ventilation is exploited to cool the desert air in a bioclimatic way. Furthermore, heavy shading of the façades is achieved by integrating traditional principles of Arab city planning, which have been aware of energy saving and sustainable relationship with the local community, into state-

Figure 4. Plan of grid cities: Kumbh Mela and Masdar
Source: Designed by Giovanna Mangialardi.



of-the-art technologies for environmental sustainability. The climatic features of the area gave rise to urban morphologies and passive strategies that reinterpret Arab architecture in a modern way. Specifically, the weather conditions have an influence on the urban network, the width of the streets, and the prevailing winds; they also integrate sun protections, articulate the various relationships between solids and voids, and ultimately, they design climatic transition zones. To sum things up, the innovation lies in the following fields: The plan, Bioclimatic architecture strategies, Energy efficiency solutions, Renewable energy production, Water saving, Recycling of waste, Priority to public transport or choice of private transport vehicles working through a magnetic system (not producing emissions). It is estimated that the city will consume 75% less energy and will not produce CO2 emissions, having a near-zero environmental impact. This allows Masdar to be considered as a new planned smart city drastically different from the nearby oil-based Abu Dhabi. The grid plan is reinterpreted in a more innovative way by showing the flexibility of the model and the potential to adapt it to different architectural styles.

5. CONCLUSION

In conclusion, the authors of this work agree with what Aldo Rossi claimed concerning the grid plan in his famous 1982 book The Architecture of the City: "by using those disciplines to which I have just referred, we are working toward a broader, more concrete, and more complete analysis of urban artefacts. The city is seen as the human achievement par excellence; perhaps, too, it has to do with those things that can only be grasped by actually experiencing a given urban artefact" (Rossi, 1982: 33). Urban artefacts are too complex and articulated in time and space

to be ideologically and abstractly described. The results of this work confirm that urban grid plans have been implemented without considering the city as a place of the human condition, which is represented by its monuments, neighbourhoods, and residences in all urban phenomena emerging from the inhabited space. "We believe the reverse to be true, that the whole is more important than the single parts, and that only the urban artefact in its totality, from street system and urban topography down to the things that can be perceived in strolling up and down a street, constitutes this totality" (Rossi, 1982: 35).

The argument presented in this paper is that grid plans should be analysed more carefully in order to understand its contribution to processes of innovation in modern cities.

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